INTRODUCTION AND ACKNOWLEDGMENTS

The phacopid trilobites form a widely diverse group which first appeared in North America during the early Chazyan (Lenoir limestone). From then until the close of the Hamilton, they form an element in almost all faunas, and an occasional straggler extends their range into the Chemung. Their history in North America, therefore, is shorter than in Europe, where they first appeared in the early Ordovician and continued into the early Mississippian. Little is known of their history in other parts of the world, although members of the group are found in the Paleozoic strata of Burma, Australia, and China, and form a prominent element in the Devonian faunas of South Africa and South America.

The present investigation which deals with the North American representatives of the Phacopidacea was made possible by grants from the National Research Council and the Penrose Bequest of The Geological Society of America. Its progress has been facilitated by the courteous co-operation of many persons and institutions. Among the latter, the writer is especially indebted to the United States National Museum, the Peabody Museum, Yale University, the Carnegie Museum, the Maryland Geological Survey, and the Museum of Comparative Zoology for loan of specimens for study; to the New York State Museum, the American Museum of Natural History, and Walker Museum for placing their collections at his disposal. Especial thanks are due Dr. G. Arthur Cooper of the United States National Museum, for his kindness in photographing the types in the Museum collections, and also Mr. M. S. Chappars of Walker Museum for photographic assistance. Dr. E. O. Ulrich of the United States National Museum generously allowed the writer to describe new material on which he had previously begun investigation; coauthorship of these species is indicated in the text. Finally, to the many persons who have assisted in other ways, grateful thanks are extended.

The first serious attempt in North America to describe trilobites was made by Jacob Green in 1832. His *Monograph of the trilobites of North America* contained descriptions of several common phacopid species, and others were described between 1830 and 1840. Plaster casts of the holotypes of his species are still preserved in several museums, and some of the holotypes are figured for the first time in the present work.

Green was followed almost immediately by T. A. Conrad and James Hall. The first volumes of the New York Survey contain descriptions of a few species, but not until after 1860 did phacopid trilobites begin to appear often in the literature. About this time the results of investiga-

tions pursued by Hall in Wisconsin, Indiana, and western New York were issued. Subsequently (1888) Hall and Clarke published Volume 7 of the *Paleontology of New York* in which were described and figured no less than 27 phacopid species. To this may be added the work of Walcott and Girty in the southwest and western States. Abundant new species have been described subsequently from many regions; a few of the more important contributions are those of Clarke in Gaspé, New York, and Maine; of Weller in Illinois and New Jersey; of Swartz, Ohern, and Maynard in Maryland; of Cooper in Gaspé; and of Raymond in Vermont and Virginia. Many other writers have made smaller contributions from a wide variety of localities.

The available types of all North American species previously described have been examined during this investigation. Typical material from the localities and stratigraphic horizons which yielded the types has been studied to establish whether the described species represent the common forms. In some cases desirable personal examination has been impossible. Some types have been destroyed by fire, others lost or mislaid, and still others confused with other specimens, leaving their identity in doubt. In all species, the status of the type has been indicated in an attempt to delineate as closely as possible the status of all phacopid species in North America and to furnish all available information about them. Reallocation of many old species and description of new ones is intended to arrange the North American species in their proper systematic relationships.

SUMMARY OF PREVIOUS WORK

GENERAL STATEMENT

The homogeneity of the Phacopidacea has made taxonomic treatment a matter of some difficulty. The paleontological literature of the past hundred years contains many attempts to classify the group. As knowledge of trilobites, particularly the phacopids, has increased, the classification has been repeatedly refined. Only within the past 30 years, however, has a serious attempt been made to present a systematic classification of the family which would indicate the relationships of the component groups within it.

The primary basis for the systematic separation of the Phacopidacea from the remainder of the Trilobita was first defined by Quenstedt (1837, p. 343), who set apart all trilobites with 11 thoracic segments and aggregate eyes. He suggested no family or generic names.

Two years later, Emmrich (1839, p. 18) proposed the generic name *Phacops*. As the diagnostic features of the new genus he referred to the aggregate ("granuloso-reticulati") eyes, the thorax with 11 segments, and the cutting of the lateral cephalic margins by the hinder branches of the facial sutures. He included species of very divergent nature within

the genus, giving it the scope of a modern family. Emmrich did not include *Cryphaeus* Green in *Phacops* but did include such different species as *Phacops bufo* Green, *Calymene anchiops* Green, *Dalmanites hausmanni* (Brongniart), and *Acaste downingiae* (Murchison).

Goldfuss (1843) attempted the first division of *Phacops*. This was one of a long series of attempts to divide the genus which has continued to the present. Unfortunately, Goldfuss, like many of the early writers, based his taxonomy on features of little real morphological importance. He erected the genus *Acaste* for species with well-developed glabellar lobation, 11 thoracic segments, and aggregate ("netzflaching kornig") eyes but included within it species which did not conform to this pattern. His restriction of the genus *Phacops* was somewhat more successful, as he deleted from it most of the dalmanitid species and placed them in *Asaphus*.

Emmrich (1844, 1845) divided *Phacops* into two groups. The one, *Phacops s. s.*, included the species with a compact form; the other, *Dalmannia*, included the dalmanitids which former authors had usually assigned to either *Phacops* or *Asaphus*. He changed the spelling of *Dalmannia* to *Dalmania* in 1845.

Burmeister (1843, 1846) in his admirable treatise *The organization of trilobites* again placed all phacopid trilobites in the genus *Phacops* but separated them into a number of groups based on structural features. He used criteria which have since formed the basis of some of the major divisions of the family.

Hawle and Corda (1847) divided the phacopids into four genera. They failed to appreciate the homogeneity of the group and thus assigned *Asteropyge* and *Metacanthus* to one group of trilobites and *Odontochile* and *Phacops* to another.

Barrande (1846, 1852, 1872) discarded Hawle and Corda's principles of classification and divided the phacopids into two genera—*Phacops* (genotype *Calymene latifrons* Bronn) and *Dalmanites* (genotype *Trilobus caudatus* Brunnich). He gave much the same scope to *Phacops* as later writers have given to the subfamily Phacopinae. He also allocated to *Dalmanites* a host of species which had little in common except more or less complete cephalic segmentation.

Salter (1864) held that the phacopids included only one genus—*Phacops* —which consisted of several subgenera (*Phacops s. s.*, *Trimerocephalus*, *Acaste*, *Chasmops*, *Odontochile*, *Dalmania*, and *Cryphaeus*). He made no attempt to explain their systematic relationships.

In North America, Green (1832) made no attempt to provide a comprehensive taxonomic scheme. Hall and Clarke (1888), however, arranged the Devonian species especially in a logical systematic pattern. They restricted the use of *Phacops* to those species with obsolete lobation and expanded the genus *Dalmanites* to include a large number of subgenera,

most of them new. For the orthodox species of Devonian age they proposed the genus *Hausmannia*, subsequently found to be preoccupied by *Odontochile* Hawle and Corda. Their usage of the genus *Chasmops* was also incorrect, as this must be restricted to certain members of the Pterygometopinae. The remaining valid subgenera were *Odontocephalus*, *Corycephalus*, and *Coronura*. Oehlert (1889) later added *Probolium*, and Clarke the subgenus *Synphoria* (1900).

Contributions of North American workers during the subsequent three decades consisted principally of species description. The most outstanding work of this period was Clarke's description of many new Devonian phacopids from Gaspé and Maine (1908, 1909). This unique and interesting fauna, although essentially distinct, contains elements which ally it with the typical Devonian of the New York area.

Subsequently Twenhofel (1914, 1928) has noted and described species of distinctly European affiliation from the Ordovician and Silurian of Anticosti. McLearn (1918, 1924) has described the Silurian fauna of Arisaig which contains some interesting phacopid species. More recently (1930) Cooper has described several new species and established one new genus (*Calyptaulax*) from the Ordovician rocks of Gaspé.

RECENT SYSTEMATIC REVISIONS

The work of several European workers during this period has been noteworthy. Following the publication of Volume 7, Paleontology of New York, no definite revision of the entire group was attempted until 1905. At that time F. R. C. Reed gave a short, but very complete résumé, and divided the group into three subfamilies on the basis of structural features and evolutionary relationships. In erecting this classification, he proposed criteria which today are considered fundamental in the division of the group.

Reed (1905, p. 9) thought that the pentamerous segmentation of the cephalon was a primitive feature and thus considered the early dalmanitids the forerunners of the more specialized younger phacopids. He divided the Phacopidae into three branches, which he believed to be phylogenetic in nature. Branch A included the dalmanitid species, which he divided into three groups; Branch B, the stock which culminated in *Phacops s. s.*; Branch C, the "somewhat distinct and disconnected branch of the Phacopidae of which the earliest types are included in the subgenus *Pterygometopus.*"

As summarized, Reed's (1905, p. 11) revised classification of the family, after removal of the preoccupied and invalid names, was as follows:

"I. Subfamily Dalmanitinae nov.
1. Genus Dalmanites
Subgenera Dalmanitina nom. prop.
Dalmanites *s. s.*

Group Synphoria
Asteropyge
Odontocephalus
Corycephalus
Malladaia
Coronura
Probolium
Cryphina
II. Subfamily Phacopinae nov.
1. Genus Phacops
Subgenera Phacopidella nom. prop.
Phacops s. s. (Somatrikelon)
Trimerocephalus
III. Subfamily Pterygometopinae nov.
1. Genus Pterygometopus s. s.
Chasmops
Homalops
Monorakos."

Reed was evidently influenced by the example of Salter and other early writers because of his adherence to one genus and several subgenera within each subfamily. The retention of the name *Somatrikelon* was unnecessary, as it has no taxonomic standing; the same may be said for *Homalops*.

Reed's classification of the family was the first to place its component genera in a reasonable relationship. Perhaps the chief criticism which may be advanced is his conservatism. He held that *Dalmanites* and *Odontochile* were congeneric, a conclusion which has since been shown to be incorrect. His inclusion of *Asteropyge* and *Cryphina* in the group *Synphoria* was not upheld by the diagnosis of the group given by Clarke (1894, 1900), and he failed to recognize the establishment of *Synphoria* (Clarke, 1900) as a subgenus of *Dalmanites*. He also made the subgenus *Phacopidella* too inclusive, an error which he later recognized and corrected.

These errors and omissions were of minor importance when compared to the service rendered in bringing the Phacopidae into a workable taxonomic scheme, and Reed's contribution to the taxonomy of the family is a most valuable one.

Wedekind (1911, 1914) also suggested a systematic revision of the group, but later his scheme was fundamentally modified. Perhaps his primary contribution was an indication of the importance of morphological features which had escaped the attention of previous writers, especially the subcephalic furrow in the Phacopinae.

The classification of the austral Phacopidacea found in South America, South Africa, and the Falkland Islands has been discussed especially by Clarke (1913), Kozlowski (1923), and Reed (1907, 1925).

In 1926, the Richters published a paper describing the Upper Devonian phacopids in great detail. Their contribution to the taxonomy of the family was significant. They have refined methods of classification, particularly among the Phacopidae, and for the first time have set up

adequate criteria for the separation of the closely related genera within it. Their systematic arrangement is as follows:

"Family Phacopidae
Subfamily Phacopinae Reed, 1905
Genus Phacops
Subgenera Phacops *s. s.*
Nephranops
Cryphops
Trimerocephalus
Dianops
Subfamily Dalmanitinae
Genus Phacopidella
Genus Asteropyge
Subgenera Asteropyge *s. s.*
Comura
Metacanthus."

They have more recently (1931) redefined *Dalmanites* and *Odontochile* and have proposed a new subgenus of *Phacops* (*Eocryphops*).

The genus *Phacopidella* has been divided as follows:

"Genus Phacopidella
Subgenera Phacopidella *s. s.*
Ductina."

Their chief contribution has been a refinement of the taxonomic usage of subcephalic features and manner of eye obsolescence in the Phacopinae. Their principles appear to be sound and have been used in this paper wherever possible.

Reed (1927, p. 351, 352) again summarized the status of the Phacopidae and discussed the contributions made to the taxonomy of the family since 1905. He suggested few changes, and this latter arrangement was fundamentally the same as his former one.

"Subfamily Dalmanitinae
Genus Dalmanites *s. s.* (Hausmannia)

Subgenera Dalmanitina *s. s.*
Cryphaeus (Asteropyge)
? Comura
Metacanthus
Cryphina
Coronura
Odontocephalus
Corycephalus
Anchiopella
Probolium
Acastella
Proboloides
Synphoria
Subfamily Phacopinae
Genus Phacops
Subgenera Phacops *s. s.*
Reedops
Phacopina
Phacopidella *s. s.*
Dianops

Trimerocephalus, *s. s.*
Nephranops
Cryphops
Portlockia
? Denckmannites
Bouleia
Dereimsia
Acaste *s. s.* (Acastina nom. prop.)
Calmonia
Pennaia
Subfamily Pterygometopinae
Genus Pterygometopus
Chasmops
Monorakos
? Josephulus
Incertae sedis.
Typhloniscus."

The present writer's studies have convinced him that a systematic arrangement somewhat more complicated than that proposed by previous workers is necessary. This new scheme was published in 1935, and subsequent work has suggested no major changes. Explanation of the criteria used is given later on in the present volume. The present classification may be summarized as follows:

Superfamily PHACOPIDACEA Delo
Proparia with schizochroal eyes and 11 segments.
Family PHACOPIDAE Corda (emend. Delo)
Phacopidacea with reduced or obsolete anterior glabellar furrows, compact body form, and, in most cases, a small rounded pygidium.
Subfamily PHACOPINAE Reed
Phacopinae with the two anterior pairs of glabellar furrows nearly or entirely obsolete, a more or less swollen glabella, a subcranial furrow, and, in most cases, rounded genal angles. The eyes vary in size and position and may be entirely absent.
Genera *Phacops s. s.* Emmrich
Eophacops Delo
Reedops R. and E. Richter
Trimerocephalus McCoy
Eocryphops R. and E. Richter
Cryphops R. and E. Richter
Nephranops R. and E. Richter
Dianops R. and E. Richter
Bouleia Kozlowski
Dereimsia Kozlowski
Subfamily PHACOPIDELLINAE Delo
Phacopidae with the two anterior pairs of glabellar furrows nearly or entirely obsolete; no subcranial furrow. The eyes vary in size and position or may be entirely absent.
Genera *Phacopidella* Reed
Denckmannites Wedekind
Dienstina R. and E. Richter
Ductina R. and E. Richter
Adastocephalum Mitchell

Subfamily ACASTINAE Delo

Phacopidae with the anterior glabellar furrows lightly impressed, the third usually the deeper and wider. The pygidium is usually rounded but may be mucronate.

Genera *Acaste s. s.* Goldfuss
Acastella Reed
Scotiella Delo
Kloucekia Delo
? *Ormathops* Delo
Phacopina Clarke
Acastoides Delo

Subfamily CALMONIINAE Delo

Phacopidae with the anterior pairs of glabellar furrows reduced, the third always deep and wide. Cuticular ornamentation consisting of cephalic, pygidial, or axial spines, always present.

Genera *Calmonia* Clarke
Pennaia Clarke
Anchiopella Reed
Proboloides Clarke
Probolops Delo
Schizostylus Delo
Typhloniscus Salter

Family DALMANITIDAE Delo

Phacopidacea with flattened body form, well-defined glabellar lobation, large cephalon and pygidium, and, in most, large eyes.

Subfamily DALMANITINAE Reed

Dalmanitidae with unmodified glabellar lobation, large cephalon with genal spines, and a large depressed pygidium, in most species mucronate.

Genera *Dalmanites* Barrande
Dalmanitina Reed
Odontochile Hawle and Corda
Heliocephalus Delo
Eudolatites Delo

Subfamily SYNPHORIINAE Delo

Dalmanitidae with more or less coalesced and elevated glabellar lobes. Spinose ornamentation of the cephalon and pygidium is a common feature.

Genera *Synphoria* Clarke
Probolium Oehlert
Corycephalus Hall and Clarke
Odontocephalus Conrad
Coronura Hall and Clarke
Malladaia Oehlert
Anchiopsis Delo
Dalmanitoides Delo
Trypaulites Delo
Synphoroides Delo n. gen.

Subfamily ASTEROPYGINAE Delo

Dalmanitidae with unmodified or partially coalesced glabellar lobes, and genal spines. The pleura are spinose. The pygidium, in most species, has five pairs of lateral spines or lappets (seven in *Cryphina*).

Genera *Asteropyge* Hawle and Corda
Metacanthus Hawle and Corda
Cryphina Oehlert

Kayserops Delo
Greenops Delo
Hadrorakos Delo
Cryphaeoides Delo
Comura R. and E. Richter

Subfamily PTERYGOMETOPINAE Reed

Small Dalmanitidae with a tendency toward hypertrophy of the first pair of glabellar lobes and reduction of the second, or hypertrophy of the first and second pairs and reduction of the third. The pygidium is of moderate size, in most species rather convex, never mucronate.

Genera *Pterygometopus* Schmidt
Chasmops Schmidt
Monorachus Schmidt
Calyptaulax Cooper
Eomonorachus Delo
Achatella Delo
Calliops Delo

Incertae sedis

Genus *Zeliszkella* Delo

PRINCIPLES OF CLASSIFICATION

Features of taxonomic value vary considerably among the trilobites, and those of great importance among the Phacopidacea may be absent or valueless in other superfamilies. This is likewise true among the different groups comprising the superfamily. In general, however, the writer follows the principles enunciated by Raymond (1921, p. 349–352) and by the Richters (1926, p. 6–8, 126–132).

It is thought that well-defined glabellar lobation is primitive within the Phacopidae. This conclusion is supported by the morphology of the oldest Phacopidacea known—*Phacops nicholsoni* Salter and *Phacops llanvirnensis* Hicks, from the Skiddaw Slates (lower Ordovician) of the British Isles, and *Dalmanites atavus* Barrande from Stage D 1 gamma of the Bohemian Basin. These species have complete glabellar lobation and convex, nonmucronate pygidia. In contrast, species in which the glabellar lobation is obsolete may be considered as specialized.

Hence the fundamental basis for classification is an evolutionary one. Features of the cephalon, particularly segmentation of the glabella and general cephalic proportions, are usually considered of major importance. The general nature of the glabellar lobation in the Phacopidacea (considered in a broad sense) is of paramount importance, however, only in the delineation of families and subfamilies. For example, the Dalmanitidae and Phacopidae are separated on the basis of major cephalic features plus a generalized body and pygidial pattern. Subdivision within the Phacopidae is not based primarily on the glabellar lobation, but this feature is very important in the Dalmanitidae.

Hence it is seen that no hard and fast general rule can be formulated

for a systematic division of the superfamily. The writer will attempt to differentiate, however, between features of little more than specific importance and those of rather general application.

The Phacopidacea are separated into two broad groups. That comprising the Phacopidae is characterized by a convex glabella, more or less obsolescence of the anterior two pairs of glabellar furrows, and a small pygidium; the other—the Dalmanitidae—by more or less complete glabellar lobation, moderately convex or flattened cephalon, and a relatively larger pygidium which, in most, is subtriangular.

The subfamilies of the Dalmanitidae are differentiated on somewhat different grounds. The major difference between the Dalmanitinae and Synphoriinae lies in the nature of the glabellar lobation, but the Asteropyginae are separated because they possess a multispinose pygidium.

Division within the subfamilies shows more variation. Genera within the Dalmanitinae are differentiated, in most cases, according to the number of pygidial annulations, although the presence or absence of an anterior cephalic border in combination with this feature is of value. *Heliocephalus* is an exception to this rule, as it is based on the spinose nature of the cephalic margin.

The Synphoriinae are separated on the basis of ornamentation, either cephalic or pygidial (*Probolium, Odontocephalus, Corycephalus, Coronura, Dalmanitoides*), or aberrant features of pygidium and cephalon (*Anchiopsis, Trypaulites*).

The nature of the glabellar lobation and general body form has been used in classifying the Asteropyginae, but the fundamental features are cephalic. In this case, several characteristics are used in conjunction. It is to be emphasized that the presence or absence of a terminal pygidial spine is of importance only in combination with other features.

Division of the Pterygometopinae is based primarily on the nature of the cephalon, although pygidial features are of value in some genera.

The subdivision of the Phacopidae into subfamilies cannot be made in the same uniform fashion as that of the Dalmanitidae. The general obsolescence of the anterior glabellar furrows in the Phacopinae and Phacopidellinae necessitates the use of features other than cephalic lobation. Hence these two subfamilies are differentiated on the absence (Phacopidellinae) or presence (Phacopinae) of the marginal subcranial furrow. A generalized pygidial pattern is found in both. The angle between the dorsal furrows of the cephalon is of no generic importance.

The Acastinae show the same fundamental glabellar pattern throughout and are easily separated from the Phacopidellinae and Phacopinae by the presence of the anterior furrows, although they are reduced. The austral Calmoniinae are differentiated from the boreal Acastinae chiefly because the former possess cuticular ornamentation and atavistic tendencies.

Genera within the Phacopinae are separated entirely on cephalic features. *Reedops* has a typically phacopid glabella, but the subcranial furrow is not developed beneath it, and the eyes of most species are small. *Eophacops* likewise has the subcranial furrow developed only laterally, but the frontal lobe is not highly swollen. *Phacops s. s.* and all other genera of the Phacopinae have a fully developed subcranial furrow. They are separated from one another partially by the position of the furrow relative to the adjacent facial suture and partially by such characteristics as the shape of the furrow, the length of the cephalic doublure, the nature of the eyes, and the relative convexity of the cheeks and border. In some genera the nature of the pygidium and the position of the facial sutures are of importance. Aberrant glabellar convexity (*Dereimsia*), or peculiar cephalic ornamentation (*Bouleia*), may be of value.

In the Phacopidellinae, which do not possess a subcranial furrow, the nature of the glabellar lobation, and size and position of the eyes are of primary importance.

The Calmoniinae are divided largely on the basis of "ornamentation," all showing some spinosity. *Calmonia* possesses three pairs of lateral pygidial spines, short exsert genal spines, a narrow axial lobe, and may possess a rostral spine. *Pennaia*, by contrast, has six pairs of pygidial spines and a nuchal spine. The thoracic segments and some of the anterior pygidial segments have a median spine. The pygidium is mucronate. *Proboloides* is separated from *Probolops* on the nature of the anterior spine, and the same criterion is used for *Schizostylus*.

Separation of the genera within the Acastinae is based almost entirely on the nature of the cephalic lobation, although the characteristics of the pygidium are important, and cephalic ornamentation is of value in combination with other features.

In summary, it appears that general body form is important in the differentiation of large groups. The feature of greatest importance and broadest application seems to be the nature of the cephalon, as pointed out previously by Raymond (1921, p. 350). Pygidial features are, in most cases, of secondary importance.

EVOLUTIONARY DEVELOPMENT

As in many other groups, the nature of the ancestors of the phacopid trilobites is conjectural. This hypothetical ancestor (or ancestors) probably possessed well-developed pentamerous cephalic segmentation, 11 thoracic segments, and a nonmucronate pygidium. The species from strata of early Ordovician age in the Bohemian Basin and British Isles may be considered as closely related to it.

Only the principle of radial divergence appears to account for the abrupt appearance of the diverse phacopid strains present in the Ordo-

vician. As early as Chazyan time, the pterygometopids had penetrated into North America, and their history is more or less parallel to that of the European forms. Contemporaneous with these are the dalmanitid species, represented in the Ordovician of Europe by *Dalmanitina socialis* (Barrande). A third well-defined strain is the acastid which appears to have the potentialities necessary for development into the specialized phacopids of the Silurian and Devonian.

The origin of the Asterpyginae is much less clear. Their sudden appearance, unique morphology, and apparent lack of resemblance to previous forms represent one of the unsolved problems with which the group is replete.

The oldest species referable to the superfamily are of lowest Ordovician age (Stage D 1 gamma of the Bohemian Basin; Skiddaw slates of the British Isles). They exemplify the features of two distinct groups. Hence the proparian ancestor of the Phacopidacea must be sought in strata of Cambrian age.

Phacops llanvirensis Hicks (1875, p. 187, Pl. 9, figs. 3–4) from the Skiddaw slates (early Ordovician) of the British Isles appears to be allied to the genus *Ormathops*, found in Stage D 1 gamma of the Bohemian Basin. This particular group appears to have been approaching its end, even at this time, and probably disappeared without giving rise to any of the later Phacopidacea.

Phacops nicholsoni Slater (1866, p. 486, Figs. c, d), also from the Skiddaw slates, seems to be a pterygometopid and is assigned tentatively to the genus *Calyptaulax*. It is the oldest known species of the Pterygometopinae and illustrates the characteristic features of the subfamily.

It seems, then, that the structure of the pterygometopids was already defined in oldest Ordovician time. There seems little reason to suppose that this group gave rise to any of the later Phacopidacea. The evolutionary development within the subfamily is discussed elsewhere.

The genus *Ormathops*, containing *D. atavus* Barrande and its allies, is found in Stage D 1 gamma (Lowest Ordovician) in Bohemia. In these strata several species show the fundamental characteristics of the genus and illustrate migration and obsolescence of the eyes. It has been suggested that this feature may not be regressive in *Ormathops* but rather progressive, the species with larger and more centrally located eyes representing the more specialized stages of generic evolution. If this were the case, one would expect to find species in the next higher zone which evidence a relationship to these older species. This is not true. The genus suddenly disappears, and it is believed that Stage D 1 gamma marks its last appearance. *Ormathops* gave rise to no younger forms, and the eye-obsolescence was probably an inherent characteristic of the group.

Divergent species which may have given rise to the later Phacopidacea appear in Stage D 2 in Bohemia. One of these—*D. socialis* Barrande—is generally considered to have been the ancestor of the Dalmanitidae. The type of structure illustrated by this species is found in trilobites which are widespread throughout strata of Ordovician age in Europe, and such forms are believed to have given rise to the typical *Dalmanites* of the Silurian. *Dalmanites* in turn antedated *Odontochile* of the Devonian. The aberrant structures found in the Devonian Synphoriinae and Asteropyginae are modifications of the characteristics of the true dalmanitids and may be considered as offshoots from them. Their appearance, coming as it does near the close of dalmanitid history, appears to have marked a last flurry of racial evolution before extinction. Genera of the type of *Heliocephalus* (Silurian) were merely local branches from the main stem of dalmanitid evolution and had no real phyletic significance.

The second type of structure to appear in Stage D 2 is exemplified by *D. phillipsi* Barrande. The body is compact and transversely convex; the pygidium small. The glabellar lobation is suppressed anteriorly, but the third glabellar furrow is of normal proportions. The eyes are rather small. Variations of this type of cephalic structure are found among the early Phacopidae. It is believed that this group led to the more specialized types exemplified by *Phacops s. s.* and its allies.

The chief characteristics of *D. phillipsi* are found in several boreal genera of Ordovician, Silurian, and Devonian age. The youngest boreal representatives of the group occur in the Lower Devonian (Oriskany) strata of North America and have been assigned to the genus *Phacopina*. *Acaste* has a somewhat different structure but is a variation of the fundamental type.

There is no record of the Silurian history of the austral descendants of the Acastinae. The Devonian Calmoniinae retain the fundamental pattern of compact form, reduced anterior glabellar furrows, and small pygidium. Their spinose ornamentation and atavistic tendencies (as shown by the development of prosutural spines) are thought to be the result of racial senility and provincial environment. Nor can the evolution of the main phacopid stock be traced with entire satisfaction. A factor causing much confusion is the stratigraphic and geographic distribution of the group. The Phacopidellinae are thought to be an early offshoot from the main phacopid stem (evidenced by lack of a subcranial furrow), which developed in a parallel fashion to the true Phacopinae. The Silurian species are confined to the Bohemian Basin, and it is not until Devonian time that the group reached the northern region.

The oldest members of the genus *Phacops* appear in the lower Silurian strata of the Bohemian Basin and are also found in the younger Silurian of Australia. They do not appear, insofar as known, in strata older

than the Middle Silurian of Anticosti, in North America. They are very widely distributed in rocks of Devonian age throughout both the northern and southern hemispheres (western Asia, northern India, Europe, Asia Minor, North and South America, Australia). This distribution suggests that *Phacops* originated in the Tethyan region and from there migrated widely during Silurian time.

SYSTEMATIC DESCRIPTION

In the systematic description, an attempt is made to bring the North American species into a workable arrangement in conformity with the current taxonomic scheme. It seems necessary, in the interests of clarity, to repeat briefly family and generic definitions, to point out principles of generic allocation of species, and to differentiate between features of generic and specific importance. The number of species involved has made it impossible to examine all specimens reported from various horizons and localities. Hence, in most cases, the ranges given are those of the types. It has also become apparent that many citations of species in the literature are incorrect. This is particularly true of citations of well-known species of rather generalized pattern from the New York district. Many of these have been reported as having a wide geographic distribution. In most cases, when examination of the types has been possible, the specimens from outside the seaway of the type locality have been distinct. For example, it has been found that, although the Lower Devonian dalmanitids from Tennessee, Mississippi, Oklahoma, and Missouri are very closely related, none of them are conspecific with forms in the New York region.

These circumstances make the writing of a synonymy rather difficult, and in most cases only important references which seem reliable are listed.

Species are arranged alphabetically within each genus. Invalid or poorly established species are also described, and an explanation of its status is appended for each. In most cases, specific descriptions have been rewritten in the interest of brevity, and an attempt has been made to emphasize the features which are of differential importance.

Principles of classification within each genus are also discussed briefly. Only those genera with representatives in North America are discussed.

Subclass TRILOBITA

Order PROPARIA

Superfamily PHACOPIDACEA Delo 1935

Proparia with schizochroal eyes, large free cheeks, and 11 thoracic segments.

Family PHACOPIDAE Hawle and Corda, 1847, emend. Delo, 1935

Phacopidacea with reduced or obsolete anterior glabellar furrows, compact body form, and, in most, a small rounded pygidium.

Subfamily PHACOPINAE Reed, 1905

Phacopidae with the two anterior pairs of glabellar furrows nearly or entirely obsolete, more or less swollen glabella, subcranial furrow, and, in most, rounded genal angles. Eyes vary in size, position; may be entirely absent.

OCCURRENCE: Ordovician (one species), Silurian, Devonian.

DISTRIBUTION: Eurasia, Australia, North and South America.

In addition to those occurring in North America, the following genera are referred to the subfamily: *Eocryphops* R. and E. Richter, 1931; *Cryphops* R. and E. Richter, 1926; *Trimerocephalus* McCoy, 1849; *Nephranops* R. and E. Richter, 1926; *Dianops* R. and E. Richter, 1923; *Bouleia* Kozlowski, 1923; *Dereimsia* Kozlowski, 1923. The genus *Portlockia* McCoy, 1846, is considered invalid because of confusion concerning the genotype.

Genus *Phacops* Emmrich, 1839

Calymene of early authors; *Portlockia* (pars) McCOY, 1846, 1851; (*Somatrikelon?* McMURTIE, 1819); *Phacops* (*Phacops*) SALTER, 1864; R. AND E. RICHTER, 1926.

GENOTYPE: *Calymene latifrons* Bronn, 1825 (p. 317, pl. 2 figs. 1–8). *Phacops* (*Phacops*) *latifrons* Salter, 1864 (p. 18, pl. 1, figs. 9–16).

GENERIC DIAGNOSIS: Typical Phacopinae with rounded genal angles (short spines in a few species); glabella inflated, protuberant; subcranial furrow continuous, separated from facial suture by a narrow marginal ridge; hinder edge of furrow sharp, the higher; cephalic doublure slightly convex.

OCCURRENCE: Silurian and Devonian.

DISTRIBUTION: Eurasia, North and South America, Australia.

REMARKS: *Phacops* is represented in North America by one Silurian and numerous Devonian species. All these represent the typical conservative stock of the Phacopinae. Closely related and aberrant genera such as *Cryphops* and *Dianops* which illustrate eye migration and obsolescence are found in Europe, and peculiar forms such as *Bouleia* and *Dersimsia* are found in the Devonian strata of Bolivia. None of these is present in North America, nor is the stratigraphic range in North America so extended as in Europe. Only one species is known from the Upper Devonian (Chemung) of North America, whereas the genus is represented by more than half a dozen species in the Upper Devonian strata of Europe and by one distinct species in the Basal Carboniferous of England, Belgium, and Germany. *Phacops* is also common in the Silurian strata of Europe but absent from North America except on the Island of Anticosti.

The conservatism of the North American species has made differentiation somewhat difficult, with the result that stratigraphic ranges and geographic distribution of many species have been loosely drawn. The most notable case of this type is the common *P. rana* (Green) from the Hamilton of the New York area, which has been widely misidentified. Critical comparative work is gradually establishing these species on a sound and useful basis.

Phacops apparently arrived in North America as a migrant from Europe during the Silurian and spread widely in the Devonian seas.

Phacops bufo (Green, 1832)

Calymene bufo GREEN, 1832, Mon. Tril. N. Am., p. 41.
Phacops bufo HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 26, pl. 8, figs. 25, 26.

This species cannot be considered valid because the holotype is so poorly preserved that no specific features can be discerned. The exact horizon and locality are unknown.

Phacops cacapona Hall, 1861

P. cacapona HALL, 1861, Prelim. Notice Tril., N. Y. State Cab., 15th Ann. Rept. (advance pub.), p. 68.—HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 27, pl. 8, figs. 19–24.

The types of this species are in the American Museum of Natural History (Cat. Nos. 4968/1 and 4968/2; old No. 5500/1 and 5500/2). There are five specimens in all; four of them are labelled No. 4968/1. Of these, one apparently is identical with *P. cristata* var. *pipa*. A second enrolled specimen is of the type of *P. rana* and from its general appearance may be from the Falls of the Ohio. The remaining two specimens are of the type of *P. rana*. No. 4968/2 is also typical of the *P. rana* group. All these are labelled as coming from the Hamilton formation, Cacapon River, Virginia. Under the circumstances, this species must be considered invalid until further collections are available from the type localities.

Phacops cristata Hall, 1861

(Plate 1, figures 4, 5)

P. cristata HALL, 1861, Prelim. Notice Tril., N. Y. State Cab., 15th. Ann. Rept. (advance pub.), p. 67.—HALL AND CLARKE, 1888, p. 14–18, pl. 6, figs. 1–13, 16–29; pl. 8A, figs. 1–4.

Glabella convex, protuberant, broadly rounded in front. Dorsal furrows straight; genal spines somewhat upturned, stout. First and second lateral furrows and lobes normal for the genus, third lateral and nuchal furrows deep distally and coalesced mesally in a broad sulcus; third lobe obsolete mesally. Nuchal ring elevated, spinose.

Genal area large. Eyes with about 60 facets, reach glabellar level, rather short. Posterior cephalic margin rather strongly curved.

Glabellar ornamentation consists of low, blunt tubercles which are somewhat separated; usually not apparent on casts. Lateral margins indistinctly pustulose.

Thororachis rather narrow. Each annulation bears a short median spine, represented by nodes on immature individuals.

Pygidium very broadly rounded, convex, rachis moderately arched, indistinct terminally, composed of six distinct and two indistinct annulations. There are four or five furrowed ribs which curve uniformly to the border. Grooves deep, furrows only moderately distinct, on casts visible only on first and second ribs. Surface smooth.

TYPES: No holotype designated. Types include N. Y. State Mus. Nos. 13883/1 to 13883/13; Am. Mus. Nat. Hist. Nos. 4071/1, 4071/2. This description based on N. Y. State Mus. Nos. 13883/1, 13883/8, 13883/11, 13883/13, which are herein designated as cotypes.

OCCURRENCE: Devonian. Oriskany, Schoharie, Onondaga formations. New York and adjacent States, Ohio, Indiana, ? Missouri.

REMARKS: The Onondagan representatives of the species were first described and figured by Hall as *P. bombifrons* (1862, p. 95; 1876, Pl. 6) but were placed subsequently in *P. cristata* by Hall and Clarke (1888, p. 14).

The species differs from *P. rana* particularly in the presence of genal spines and complete coalescence of third glabellar lobe. The eyes are situated farther forward on the cheek; in *P. rana* they touch the margin of the postmarginal furrow. The tuberculation of the glabella is much more conspicuous, and the nuchal ring is spinose instead of smoothly granulated. *P. rana* has no rachial spines, and the pygorachis and pleural ribs are much less prominent.

It differs from *P. logani* in the presence of genal spines, obsolete anterior glabellar

furrows and third lobe, presence of nuchal and rachial spines, proportionally wider pygidium, and pygorachis which reaches the posterior margin.

It most nearly resembles *P. cristata* var. *pipa* but differs in the presence of larger genal spines, nuchal and rachial spines, larger eyes, relatively narrower pygidium on which the ribs curve uniformly (in *pipa* they make an abrupt bend near the dorsal furrows and curve uniformly from this to the border), and obsolescence of the glabellar ornamentation on casts.

It cannot be confused easily with any other Devonian species in North America.

Phacops cristata var. *pipa* Hall and Clarke, 1888

(Plate 1, figures 6, 7)

Phacops cristata var. *pipa* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 18, pl. 8A, figs. 5–18.

Glabella as in *P. cristata*, but with ornamentation somewhat more scattered and usually visible on casts. Third lobes obsolete; nuchal and third lateral furrows coalesced mesally. Nuchal lobe elevated, with a row of low tubercles.

Eyes rather short, not attaining glabellar level, fewer than 45 facets, set well forward, leaving a considerable space between them and the postmarginal furrow. Genal spines short, rather blunt. Posterior cephalic margin rather straight.

Thororachis nonspinose; otherwise as in *P. cristata*.

Pygidium relatively wider than in *P. cristata*, otherwise essentially the same except that the ribs describe an abrupt bend near the dorsal furrow, thence extending uniformly to the margin.

TYPES: No holotype has been designated. Cotypes include N. Y. State Mus. Nos. 13884/1 to 13884/8.

OCCURRENCE: Devonian. Onondaga limestone. New York and adjacent regions, Ohio, Ontario, Indiana.

REMARKS: Hall and Clarke described this variety by noting differences between it and *P. cristata s. s.* The most obvious difference is in the eyes, which have distinctly fewer facets, are shorter, and lower. There is no distinctive difference in the size of the genal spines, as in some individuals these are large, in others very small. The presence of the glabellar ornamentation is also variable. The most marked difference is in the nonspinose nuchal lobe and thororachis. Differences in the pygidium are matters of degree entirely, and only specimens in which the variation is extreme are readily differentiated.

Phacops hudsoniscus Hall, 1861

(Plate 1, figure 16)

P. hudsoniscus HALL, 1861, Pal. N. Y., vol. 3, p. 355, pl. 73, figs. 26–28.—GIRTY, 1899, U. S. Geol. Survey, 19th. Ann. Rept., pt. 3, p. 571, pl. 61, figs. 4 a–d.

Glabella protuberant, rounded. Eyes well below glabellar level. First and second furrows posteriorly concave, finely impressed lines; third deeper distally, very shallow and elevated mesally, anteriorly convex. Nuchal furrow the same, somewhat more distinct mesally. Third lobe low but distinct, does not reach glabellar level but is continuous and tuberculated. Nuchal lobe long, rising well above glabellar level, topped by short median spine. Entire surface of glabella highly tuberculose.

Palpebral lobes separated from eyes by definite groove. Eyes low, never more than three facets in any vertical row, about 35 in all. Postmarginal furrow deep, separated from eye by a ridge between the furrow and the continuation of the palpe-

bral furrow which encircles the hinder side of eye. Genal angles rather narrowly produced. Margin minutely pebbled.

Thororachis marked by distal tubercles as in *P. logani;* pleura and top of rachis very finely pebbled.

Pygidium with rounded outline, convex, rachis blunt, not reaching posterior margin, composed of six or seven annulations. There are three definite and one indistinct pairs of furrowed ribs about twice as wide as the grooves. Ribs and border finely pebbled, rachis finely mottled.

TYPES: Original type material missing. Type material described by Girty, entire specimen with test, U. S. Nat. Mus. No. 34124.

OCCURRENCE: Devonian. Helderbergian of New York and adjacent areas; Haragan formation of Oklahoma;? Birdsong shale of Tennessee. Girty's types from T.2S, R.8E, Atoka Quadrangle, Oklahoma.

REMARKS: Hall's type material is missing, and the figures and descriptions of it (Pal. N. Y., 1861, vol. 3, p. 355, pl. 73, figs. 26–28) are insufficient to differentiate it from the material described by Girty. The specimens from the Birdsong shale of Tennessee appear to grade into *P. logani* var. *birdsongensis* without any perceptible break. Most of these, however, lack the highly elevated and spinose nuchal lobe cited by both Hall and Girty.

This species differs from all other species of *Phacops* in the small eyes set low on the cheeks. It differs from all except *P. logani* and its varieties in the nature of the glabellar lobation and distal knots on the thoracic annulations.

Phacops iowensis Delo, 1935

(Plate 1, figures 18, 19)

Phacops iowensis DELO, 1935, Jour. Pal., vol. 9, no. 5, p. 422–423, pl. 48, figs. 4, 5.

Glabella narrowly curved in front, moderately convex for the genus; third pair of lateral furrows very distinct, curved anteriorly; second pair discernible; third glabellar lobes broadened mesally, conspicuously tuberculate. Eyes large, with 35 to 40 facets; bounded posteriorly by a tuberculated, ridgelike swell in cheek area in front of posterior marginal furrow. Entire cephalon covered with sharp tubercles of various sizes.

Thorax strongly tuberculated.

Pygidium with six to seven moderately narrow, strongly arched pygorachial annulations, four to five pairs of pleural ribs. Rather prominent tuberculation on all ribs and annulations, and irregularly distributed around the posterior border.

Type: Holotype. An almost complete individual, somewhat crushed but retaining one side of the cephalon intact. State Univ. Iowa No. 9-266.

OCCURRENCE: Devonian. Cedar Valley formation, Linn Junction, Iowa.

REMARKS: This species was proposed for specimens from the Devonian strata of Iowa and adjacent regions which had been allocated previously to *P. rana* (Green). Specimens from the Devonian of the Milwaukee area and from northern Michigan, if not conspecific, differ only slightly from it. There has been no opportunity to compare these specimens with the holotype, but the pygidia seen possess the same high convexity, with prominent ribs ornamented with conspicuous tubercles. At least some of the Michigan specimens from the Traverse formation represent an undescribed new species.

P. iowensis differs from *P. rana* in the narrower anterior curve of the glabella, fewer eye facets (*P. rana* averages about 50), larger third glabellar lobe, highly arched pygidium, and prominent ornamentation. It differs from *P. logani* in the more conspicuous ornamentation, more convex pygidium, and angular, tuberculate pleural

ribs. It superficially resembles *P. raymondi* from the Haragan formation of Oklahoma, but the latter has a wider, smooth genal border, less elevated eyes with a larger number of facets, an elevated and tuberculose nuchal lobe, and relative absence of pygidial ornamentation.

Phacops logani Hall, 1861

(Plate 1, figures 8, 9)

P. logani HALL, 1861, Pal. N. Y., vol. 3, p. 353, pl. 73, figs. 15–25.—CLARKE, 1900, N. Y. State Mus., Mem. 3, p. 21, pl. 1, figs. 1–5.—WELLER, 1903, N. J. Geol. Survey, vol. 3, p. 321, pl. 40, figs. 3, 4.—? CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 103, 118, pl. 10, figs. 1–4, 7–9.

Glabella broadly rounded in front, moderately elongate, quite protuberant; eyes large, with about 65 facets; genal spines incipient. First and second furrows usually indistinctly apparent; third deeper distally, lightly impressed, and curved forward mesally. Third lobe rises almost to level of glabella. Nuchal lobe broad, usually bearing a prominent central tubercle and two pairs of small lateral ones.

The thororachial annulations end in blunt knots, with small granules on the annular surface.

Pygidium uniformly rounded, about as broad as long, with a blunt, prominent rachis which ends abruptly well within the margin, and consists of eight or nine annulations. There are from four to five furrowed ribs. Surface finely granulose.

TYPES: Holotype, a complete individual, N. Y. State Mus. No. 13885/2. Paratypes, a complete cephalon, N. Y. State Mus. No. 13885/3. Eye and cheek with test, N. Y. State Mus. No. 13885/1.

OCCURRENCE: Devonian. Helderberg formation. New York State and adjacent territory; ? Gaspé; Oklahoma; Missouri; Tennessee.

REMARKS: *P. logani* differs from *P. cristata* and *P. cristata* var. *pipa* in the complete third lobe, sharper and more closely crowded tuberculation, and incipient genal spines. The pygidium is less broadly rounded, and the rachis does not reach the posterior margin.

It differs from *P. rana* in the more protuberant and narrowly rounded glabella, incipient genal spines, higher and more complete third lobe, sharper tuberculations, and higher nuchal lobe. The blunt prominent pygorachis and furrowed ribs differentiate the pygidium.

The distal knots distinguish it from all other species except *P. hudsoniscus*, which possesses very low eyes with about 35 facets. The third glabellar lobe does not attain the glabellar level, and there are one or two fewer pygidial ribs and annulations.

Differences between this species and *P. iowensis* and *P. raymondi* are discussed with descriptions of these species. Varieties of *P. logani* are found in strata of Helderbergian age throughout the eastern, central, and southwestern States, and in Gaspé. Distinctive differences are discussed under the varieties described.

Phacops logani var. *birdsongensis* Delo n. var.

(Plate 1, figures 13–15)

Glabella broadly rounded, protuberant. Lateral furrows distinct, third furrow complete, third lobe rather depressed. Nuchal furrow very narrow, nuchal lobe broad, elevated well above glabella, nonspinose.

Genal spines incipient, usually visible only on casts. Genal area rather wide, genal angle rather sharply curved.

Eyes small, well below glabellar surface, bounded below by a smooth, vertical

cheek surface and behind by a narrow, rounded ridge. There are about 45 facets. Postmarginal furrow narrow, deep.

Glabella thickly covered with low tubercles and granules, nuchal lobe and posterior border thickly granulated.

Each thororachial annulation bears distal knots. Surface of rachis and pleura thickly granulated.

Pygidium convex, broadly rounded. Rachis prominent, terminating well within margin, composed of eight broad annulations. There are five pairs of broad, furrowed ribs at least twice as wide as the grooves, the posterior pair indistinct. Entire surface including border, thickly granulated.

TYPE: A complete enrolled specimen. Peabody Mus. No. 15192.

OCCURRENCE: Devonian. Birdsong shale, (Linden formation), Swaynes Mill, Tennessee.

REMARKS: This variety differs from typical *P. logani* in the nontuberculose nuchal lobe, smaller eyes, almost obsolete genal spines, and widespread ornamentation.

At the type locality other specimens appear to be essentially like the form described above but show distinct variation in the number of eye facets. Some of these which are apparently very close to typical *P. logani* have 65 or 70 facets, others from 40 to 50, and still others only 30. The variety described above seems, therefore, to represent a stage between typical *P. logani* and *P. hudsoniscus*. Yet it differs from the Oklahoma "*P. hudsoniscus*" described by Girty (1899, p. 571, Pl. 71, fig. 4 a-d) in the higher third glabellar lobe, nonspinose nuchal lobe, larger number of facets, one more annulation, and one more pair of ribs.

Phacops logani var. *gaspensis* Clarke, 1907

(Plate 1, figures 10–12)

P. logani var. *gaspensis* CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 165, 2 text figures; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 119, pl. 10, figs. 5, 6, 10–16.

Glabella broadly rounded in front, with moderate protrusion. No trace of genal spinules. Genal surface of moderate size. First and second lateral furrows usually not discernible on casts, third furrows and third lobe as in *P. logani*. Eyes small, do not reach the glabellar level; set well forward on the cheek, with an appreciable interval between them and the postmarginal furrow. Glabella covered with conspicuous separated tubercles. No nuchal spine; nuchal lobe rises to glabellar level.

Thororachial annulations bear distal knots as in *P. logani*.

Pygidium very broadly rounded, with very long anterior sliding planes set at a conspicuous angle with the articulation planes. Rachis of moderate width, tapers gradually, does not reach the posterior margin, and consists of seven to nine annulations. There are four or five furrowed ribs which may bear granules on both branches.

TYPES: Cotypes. Complete pygidium, N. Y. State Mus. No. 13885E/1. Cephalic cast, N. Y. State Mus. No. 13885E/3. Casts of several individuals on slabs, N. Y. State Mus. No. 13885E/2.

OCCURRENCE: Devonian. Grande Greve limestone, Gaspé.

REMARKS: Although superficially similar to *P. longani s. s.*, this variety shows constant differences which may be summarized as follows: 1. Usually larger size; 2. smaller eyes set farther forward on the cheeks; 3. no nuchal spine; 4. wider pygidium with angular anterior margin. Of lesser importance are the absence of genal spinules, which in many cases cannot be discerned on *P. logani*, the more broadly rounded glabella, and the nature of the glabellar ornamentation.

It differs from *P. logani* var. *birdsongensis* n. var. in the sparser glabellar tuber-

culation, less elevated nuchal lobe, larger number of pygorachial annulations, and relatively wider pygidium.

The variety cannot be confused with *P. hudsoniscus* because the latter has a very low elongate visual area, and a pygidium essentially indistinguishable from that of *P. logani*. There is no other species with which it can be easily confused.

Phacops nupera Hall, 1843

(Plate 1, figure 17)

Calymene nupera HALL, 1843, Geol. N. Y., pt. 4, p. 262, fig. 116.
Phacops nupera HALL, 1876, Pal. N. Y., Illust. Dev. Foss., pl. 8, fig. 26.
Phacops nupera HALL AND CLARKE, 1888, Pal. N. Y. vol. 7, p. 27, pl. 8, fig. 27.

This species was named by Hall from a specimen found in a loose slab of Chemung sandstone along Chemung Creek, New York. Examination of the type shows no features of specific importance, except that the third glabellar lobe appears to be somewhat more developed than in typical *P. rana*. Otherwise there are no features which might distinguish it from a poorly preserved *P. rana* except the stratigraphic position.

TYPE: Holotype, cast of an entire individual, with cephalon partially broken, and pygidium almost entirely missing; in a fine limy sandstone slab. Am. Mus. Nat. Hist. No. 4969/1.

OCCURRENCE: Devonian. Chemung sandstone, Chemung Creek, New York. From a loose slab in the creek bed.

REMARKS: The writer cannot recognize this as a valid species on the basis of the holotype. It shows no features of diagnostic value, and mere occurrence in a different formation is not a valid basis for specific differentiation. Redefinition and establishment of the species must await the finding of further better preserved material.

Phacops orestes Billings, 1860

(Plate 1, figures 22-25)

Phacops orestes BILLINGS, 1860, Can. Nat. Geol., vol. 5, p. 65, figs. 10, 10a.
P. (Portlockia) orestes TWENHOFEL, 1928, Geol. Survey Canada, Mem. 154, p. 335, pl. 50, figs. 11, 12.

This is a rather typical *Phacops* with a continuous subcranial furrow, crenulated laterally. Frontal slope vertical as viewed in profile, nuchal lobe elevated, third lobe depressed, fused with frontal part of glabella. Genal angles rather narrowly rounded; genal margin wide. Postmarginal furrow straight, narrow, extends to slightly outside the eye. Eyes large, depressed below glabellar level. Palpebral lobes broad, smooth, as high as the eye, separated from palpebrum by a narrow furrow which continues backward and downward around base of eye so that the swollen lateral margin is quite wide.

All glabellar furrows present, the first in two parts; anterior segment very near edge of glabella, almost parallel to dorsal furrow, opposite anterior end of eye; posterior segment concave backward. Second furrow concave backward, directed obliquely backward distally. Third furrow deep distally, turning forward abruptly proximally and dying out against the posterior slope of the glabella, thus delineating the triangular, depressed central part of the third lobe, which is not otherwise separated from the frontal part of the glabella. Nuchal furrow very narrow; nuchal lobe very wide, broadly convex anteriorly, moderately elevated. Ornamentation consists only of minute pebbling.

Thororachis moderately broad and elevated. Annulations somewhat sinuous, with low distal nodes.

Pygidium broadly rounded, highly convex, resembling that of *P. logani* in general outline. Rachis of moderate width and height, gradually becoming obsolete well within posterior margin, composed of six to seven annulations, the terminal ones rather indistinct. There are four very broad, very low ribs which are marked by broad, very shallow furrows and merge with the very wide smooth border. They are separated by very narrow and shallow grooves. Fourth rib very short, poorly defined; first groove the longest, extending only half the distance from the dorsal furrow to margin. Surface smooth.

TYPES: This description based on typical material collected by Twenhofel, Peabody Museum No. 3063/93.

OCCURRENCE: Silurian. Gun River and Jupiter River formations; East Point and other localities, Island of Anticosti.

REMARKS: This species is superficially much like the representatives of *Eophacops* found in strata of the same age but differs in the presence of a complete subcranial furrow, the vertical rather than anteriorly sloping glabella, and longer pygidium with more rachial annulations. The smooth surface and indistinct pleural ribs differentiate it from all Devonian species.

Phacops rana (Green, 1832)

(Plate 1, figures 1, 2)

Calymene bufo var. *rana* GREEN, 1832. Mon. Tril. N. Am., p. 42, casts 11, 12.
Phacops rana HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 19–26, pl. 7, figs. 1–11; pl. 8, figs. 1–18; pl. 8A, figs. 21–33.

Glabella moderately inflated for the genus, slightly protruding with almost vertical frontal slope. Genal angles nonspinose. Eyes large, rising to glabellar level, averaging about 45 to 50 facets, with six in vertical rows. First lateral furrows obsolete; second apparent on some casts; third deep distally, continuous across glabella, curving forward mesally; nuchal ring long. Third lobe represented by two low distal nodes in the dorsal furrows, and a central, elliptical, tuberculated node which rises almost to the level of the glabellar surface. Posterior cheek field short. Ornamentation consists of low tubercles, mostly rather elliptical, of various sizes, the larger centrally located on the glabella. Smaller tubercles elongate crosswise on nuchal ring and genal margins. Cheeks marked by large, low, confluent pebbling.

Thororachis rather wide; annular crests covered with low elliptical tubercles as on nuchal ring. Posterior surface of pleura granulated outside line of flexure.

Pygidium very broadly rounded, width equalling almost twice the length, convexity moderate. Rachis composed of six or seven annulations, the last indistinct, tapers uniformly and terminates at the margin. There are four distinct pairs of low, broad, unfurrowed ribs, with one or two additional indistinct pairs apparent on the test but not on casts. Entire surface sparsely pebbled.

TYPE: Holotype, a complete individual with test, N. Y. State Mus. No. 13887/1.

OCCURRENCE: Devonian. Hamilton beds or their stratigraphic equivalent. New York region, central States, Ontario. Type specimen from Seneca, Ontario County, New York; probably from the Moscow shale.

REMARKS: This unique species has been misidentified often in the literature, and few of the published synonymies of the species are dependable. Hence only two references which are thought to be reliable have been given.

All species of *Phacops* which occur in beds of Hamilton age are not *P. rana*, although it has been the custom to refer all forms with similar superficial appearance to

this species. Collections from the Traverse beds of Michigan and the Devonian of the Milwaukee area contain species which are distinct yet have been referred to *P. rana*. A similar situation prevailed in the Cedar Valley formation of Iowa previous to the description of *P. iowensis* Delo (Delo, 1935b, p. 422). Likewise, the *P. rana* described from the Devonian of Nevada cannot be considered as conspecific with *P. rana s. s.*

There seems little doubt that some of the forms referred to this species from Virginia are varietally distinct, as are those in the Silica shale of Northern Ohio and southern Michigan (Stewart, 1927, p. 58).

No definite conclusions can be drawn concerning these slightly divergent forms without large collections from the various localities. Hence no attempt is made to do more than point out their presence and indicate the limits of *P. rana.*

The species differs from *P. cristata* and its variety *pipa* in the complete third glabellar lobe, lack of genal spines, and larger eyes. The thorax is distinguished from *P. cristata* by absence of central spines, and the pygidium primarily by the unfurrowed ribs.

It may be distinguished from *P. logani* and its varieties by the nature of the third glabellar lobes, less protuberant glabella, lack of knots along the rachis, greater pygidial width, and unfurrowed ribs. *P. iowensis* from the Cedar Valley formation may be distinguished by the larger cheek field, sharper tuberculation, and furrowed pygidial ribs.

Phacops rana var. *milleri* Stewart, 1927

(Plate 1, figure 3)

STEWART, 1927, Ohio Geol. Surv., ser. 4, Bull. 32, p. 58, pl. 5, figs. 14–17.

General cephalic features indistinguishable from those of *P. rana.* Eyes large, containing 80 to 130 facets, usually more than 100, arranged in vertical rows.

The thorax shows no features of varietal importance.

Pygidium indistinguishable from that of *P. rana,* with seven or eight rachial annulations and five or six broad, rounded ribs, the posterior pair incipient.

TYPES: Cotypes. Three complete enrolled specimens of different sizes and a single eye, Ohio State University, No. 16266.

OCCURRENCE: Devonian. Silica shale, Silica, Ohio, and throughout the silica shale in Ohio and Michigan.

REMARKS: Although the number of eye facets usually may not be considered as diagnostic, the uniformity of this feature in the present instance makes it a valid differential feature. In comparing this variety with *P. rana s. s.*, the original author wrote as follows:

"An examination of typical specimens shows that they uniformly possess a greater number of corneal lenses in the eye than is common to the species *Phacops rana.* Hall states that the average number of eye facets in the normal adult of *Phacops rana* is between 40 and 50 for each eye and that the variation lies between 30 and 88. He adds further that eyes showing more than 65 and less than 40 lenses are unusual. Of the numerous cephala of our variety which have been studied in no case was the number of lenses found to be less than 80, and the greatest number was 130. In four specimens chosen at random 107, 114, 116, and 120 lenses respectively were counted. Eyes showing more than 100 lenses are much more common than eyes showing less.

A second evident departure from the species is seen in the arrangement of the lenses in vertical rather than in diagonal rows. In normal adults 18 vertical rows are present in contrast to the 11 diagonal rows in normal adults of *Phacops rana.* In rare cases 16 rows occur. The scleral cavities, moreover, are distinctly shallower in most specimens so that the lenses stand out from the surface more conspicuously. These differences are considered sufficient basis for the establishment of a new

variety for this form. In all other specific relationships no differences could be found." (Stewart, 1927, p. 59.)

Phacops raymondi Delo, 1935

(Plate 1, figures 20, 21)

DELO, 1935, Jour. Pal., vol. 9, no. 5, p. 423, pl. 48, figs. 2, 3.

Glabella protruding anteriorly in a sharp curve; anterior marginal ridge wide; subcranial furrow narrow, continuous. Second pair of lateral furrows easily discernible; third pair interrupted mesally and curved forward slightly; third pair of glabellar lobes narrow, depressed below the glabellar level, indistinctly detached, bearing a row of widely spaced, tuberculose granules; distal portions of lobes indistinctly detached from mesal portion, each bearing a large tubercle. Nuchal furrow narrow; nuchal lobe long, highly arched, bearing a prominent mesal tubercle and a number of scattered smaller tubercles. Posterior marginal furrow conspicuous, curving forward laterally around a raised, tuberculate cheek area behind eye. Palpebral lobes broadly swollen, higher than palpebrum. Eyes large, with about 90 facets, separated from cephalic border by a broad, shallow furrow. There is a rudimentary knot just within margin of general angle. Entire cephalon, except for genal and lateral margins, covered with prominent tuberculous ornamentation, most prominent on the glabella.

Thororachis prominent, each annulation bearing small scattered tubercles.

Pygidium with narrow, very prominent pygorachis, consisting of seven plus one or two annulations, ending abruptly; dorsal furrows well defined; five plus one pairs of well-defined pleural ribs; anterior three indistinctly furrowed, bearing small granules; interpleural furrows deep, distinct.

TYPES: Holotype. An almost complete individual. University of Oklahoma No. A10,304. Paratype. University of Oklahoma No. A10,305.

OCCURRENCE: Devonian. Haragan formation, sec. 20, T.2S, R.3E, Arbuckle Mountain region, Oklahoma.

REMARKS: This species was proposed for specimens allocated previously to *P. logani*. It differs from the latter in the more pointed glabella, the wider frontal marginal ridge, narrower subcranial furrow, absence of distal knots on the thororachial annulations, and narrower, more prominent pygorachis. There appears to be no other species in that area with which it easily may be confused.

P. raymondi also resembles *P. iowensis* superficially but differs in the wider, smooth genal border, less elevated eyes with more numerous facets, elevated and tuberculose nuchal lobe, and relative absence of pygidial ornamentation.

Genus *Reedops* R. and E. Richter, 1925

Phacops of early authors; *Reedia* WEDEKIND, 1911, 1914, (preoccupied by *Reedia* Ashmead, 1904); *Phacops* (*Reedops*) R. AND E. RICHTER, 1925.

GENOTYPE: *Phacops bronni* Barrande, 1852 (p. 519, pl. 20, figs. 15–17). *Reedia b.* Wedekind, 1911 (p. 322). *P.* (*Reedops*) *b.* R. and E. Richter, 1925 (p. 243).

GENERIC DIAGNOSIS: Frontal lobe markedly protuberant; subcranial furrow absent in front; doublure convex anteriorly, concave posteriorly; eyes small, well forward; otherwise like *Phacops*.

OCCURRENCE: Silurian and Lower Devonian.

DISTRIBUTION: Europe, North America.

REMARKS: Known principally from the Upper Silurian and Lower Devonian strata of the Bohemian Basin and the Kellerwald district of Germany, this genus is represented in North America by only one species. This lone representative is not en-

tirely characteristic, as species assigned to *Reedops* normally have small eyes and the glabella protrudes prominently. This is not the case in *R. deckeri* which has large eyes and a moderately protuberant glabella.

Reedops deckeri Delo, 1935

(Plate 1, figures 26–28)

Reedops deckeri DELO, 1935, Jour. Pal., vol. 9, no. 5, p. 421–422, pl. 48, fig. 1, text-fig. 1.

Subcranial furrow absent in front, anterior marginal ridge between suture and subcranial furrow flattened. Cephalon moderately convex for genus, not conspicuously protuberant in front; first pair of lateral furrows distinct; second pair very distinct; third pair deep, continuous; third lobe strongly detached, depressed, with a pair of depressed distal tubercles. Nuchal furrow about as prominent as third pair; nuchal lobe broad, elevated about to level of glabellar surface. Eyes large, with about 140 facets, occupying anterior portion of cheeks, not attaining glabellar level; separated from cephalic border by a narrow furrow. Posterior border furrow very conspicuous, surrounding a long tuberculated cheek area behind the eyes.

Thororachis highly arched, each annulation bearing a distal pair of knots, similar to those in *P. logani*.

Pygidium moderately convex, broadly rounded, with narrow, elevated pygorachis not reaching posterior margin, and consisting of seven plus two annulations; five pairs of broad, flat, indistinctly furrowed pleural ribs, last pair indistinct; interpleural grooves narrow, but distinct.

Entire carapace covered with closely set granulations, coarsest on cephalon, covering all but anterolateral cephalic border. Finer granulation scattered thickly over each thoracic and pygidial border. Each branch of the furrowed pleural ribs bears a row of granules.

TYPE: Holotype. Incomplete individual with test. University of Oklahoma No. A10,301. Paratype. Incomplete individual with test. University of Oklahoma No. A10,302.

OCCURRENCE: Devonian. Haragan formation, sec. 30, T.2S, R.3E., Arbuckle Mountain region, Oklahoma. Found also in the Birdsong shale of Tennessee.

REMARKS: Allocation of this species to *Reedops* was made with some hesitancy because it has large eyes, a flattened frontal border, and the frontal lobe does not protrude conspicuously. Typical species of the genus from the Bohemian Basin have a conspicuously protuberant glabella, very small eyes flattened against the cheeks, and no trace of a frontal border.

However, it agrees more closely with *Reedops* than with any other genus, as it cannot be assigned to *Phacops* because of the incomplete subcranial furrow and curved doublure.

R. deckeri may be distinguished easily from most North American species by the very large cheek field between the eye and postmarginal furrow, the low-set eyes, the thickly distributed uniform granulation, and the knots along the rachis. Although sometimes confused with *P. logani*, the long cheek field behind the eye, finer glabellar ornamentation, much wider pygidium, and unfurrowed ribs are distinctive.

Genus *Eophacops* Delo, 1935

Phacops WELLER, 1907; *Phacops* (*Portlockia*) MCLEARN, 1918, 1924; FOERSTE, 1919; TWENHOFEL, 1928; COOPER, 1930; REED, 1931; *Phacops* (*Phacopidella*) REED, 1906.

GENOTYPE: *Phacops handwerki* Weller, 1907 (p. 271, pl. 24, figs. 6, 7).

GENERIC DIAGNOSIS: Small Phacopinae with subcranial furrow present laterally,

frontal lobe not overhanging anterior cephalic margin, eyes large, cephalic doublure concave.

OCCURRENCE: Ordovician and Silurian.

DISTRIBUTION: Europe and North America.

REMARKS: This genus includes small, rather primitive phacopids in which the frontal lobe curves gently downward to the anterior margin and does not overhang as in *Phacops s. s.* The dorsal furrows of the cephalon do not diverge markedly as in most of the later genera of the Phacopinae. The eyes are large, rising at least to the glabellar surface or slightly above it. The facial suture is discernible.

Eophacops is represented in North America by one Ordovician and several Silurian species. From the evolutionary viewpoint it is probably an offshoot of the "pre-*Phacops*" portion of the "*Phacops*" sequence and appears to have affinities with the acastid stock. Differentiation between species is difficult because of their generalized pattern, mode of preservation (almost all are casts), and lack of ornamentation.

Eophacops cerviculata Ulrich and Delo n. sp.

(Plate 2, figure 9)

Glabella phacopid without trace of first furrows; second furrows indicated by very fine, short, somewhat oblique impessions near the posterior corners of glabella; third very deep at dorsal furrows, almost obsolete in center, curved forward around an inconspicuous central node which represents the third lobe and is coalesced with the glabella. Remainder of third lobe depressed, giving glabella a bottle-neck appearance. Nuchal furrow very wide, depressed. Nuchal lobe rises to glabellar level. Top of eye reaches glabellar level. Convexity of upper surface almost uniform. Thorax unknown.

Pygidium broadly rounded, rachis very prominent, posterior end high, abrupt. First annulation very prominent, second less so, remainder indiscernible. First pleural rib very prominent, second visible, varying in distinctness depending on presevation; no others visible.

TYPES: Cotypes. Casts of cephala and pygidia. U. S. Nat. Mus. No. 79134.

OCCURRENCE: Silurian. Whiteoaks sandstone (Median), 1 mile northwest of Chamberlain, Tennessee.

REMARKS: This species differs from others of the genus in a somewhat more elongate glabella, depressed third lobe, and very prominent pygidial rachis.

Eophacops handwerki (Weller, 1907)

(Plate 2, figures 1-4)

Phacops handwerki WELLER, 1907, Bull. Chicago Acad. Sci., Nat. Hist. Surv., vol. 4, pt. 2, p. 271, pl. 24, figs. 6, 7.

Cephalic width almost twice the length; frontal margin and genal angles smoothly rounded; no appreciable frontal border. Eyes large, extending from third lobe forward for about two-thirds glabellar length, narrowly separated from anterolateral margin. Viewed in profile, maximum convexity is opposite center of eyes. Third furrow anteriorly convex in plan, shallow but complete mesally; third lobe low; nuchal lobe elevated slightly above glabellar level. Surface smooth. Thororachis equals about one-third thoracic width; each annulation bears a pair of prominent distal knots.

Pygidium small, convex, with prominent blunt rachis which extends almost to smoothly rounded posterior margin. One rather well-defined and one indistinct annulation are discernible; pleural lobes smooth except for indistinct first pair of ribs. No ornamentation discernible.

TYPES: Holotype. Cast of entire individual. Walker Mus. No. 10749. Paratype. Cephalic cast. Walker Mus. No. 10749.

OCCURRENCE: Silurian. Niagaran (Racine). Chicago Drainage Canal, near Lemont, Illinois.

REMARKS: This species differs from others allocated to the genus from the central States in details of proportion only. It must nearly resembles *E. mancus* (Foerste) but differs in a relatively shorter and wider cephalon, shorter eyes, and more convex glabella.

It differs from *E. matheri* n. sp. in the shorter cephalon, more broadly rounded frontal margin, and longer eyes. The pygidium associated with the latter is well segmented.

In *E. cerviculata* n. sp. there is one more distinct rachial annulation and one more distinct pleural groove; the rachis is shorter, and the pygidium more broadly rounded.

E. pulchellus (Foerste) has a more rounded and tapering glabella.

Eophacops matheri Delo n. sp.

(Plate 2, figures 7, 8)

Phacops cf. *pulchellus* KINDLE AND BREGER, 1904, Ind. Dept. Geol. Nat. Res., 28th Ann. Rept., p. 484, pl. 24, figs. 10–12.

Cephalon very much like that of *E. mancus* and *E. handwerki*, but the third furrow is very wide and shallow, the nuchal furrow not so wide, very shallow, appearing to rest on the anterior flank of the nuchal lobe. Third lobe narrow, low, about at level of frontal, which is highest near posterior end and slopes smoothly anteriorly. Nuchal lobe very broad, highly elevated above glabella. Eyes do not reach glabellar level.

The thorax is unknown.

Pygidium very broadly rounded behind, with very prominent, rather narrow rachis which ends abruptly almost at posterior margin; composed of six or seven annulations; almost the entire rachis is annulated. There are four distinct flat ribs and one or two very faint ones, separated by narrow shallow grooves.

TYPES: Holotype. Pygidial cast, U. S. Nat. Mus. No. 62364. Paratypes. Two cephalic casts, one much larger than the other and with eyes broken. U. S. Nat. Mus. No. 62364.

OCCURRENCE: Silurian. Niagaran dolomite, Connors Mills, Hamilton County, Indiana.

REMARKS: The holotype differs from all other species of the genus in the large number (six to seven) of annulations and ribs (four to five). The paratypes differ from *E. mancus* which they most closely resemble, in the more highly elevated nuchal lobe, lower eyes, less depressed third lobe, and wider third furrow.

Eophacops mancus (Foerste, 1919)

(Plate 2, figure 6)

Phacops (*Portlockia*) *mancus* FOERSTE, 1919, Ohio Jour. Sci., vol. 19, no. 7, p. 399, pl. 18, fig. 3.

Cephalon typical for the genus. No trace of cephalic border. Anterior furrows barely discernible. Third furrows continuous, convex anteriorly, shallow mesally. Third lobe a low ridge straight across the glabella, depressed well below the surface. Nuchal furrow no wider than the third; nuchal lobe elevated to highest level of frontal lobe, not convex posteriorly. Eyes extending from first furrows to post-

marginal furrow, with 10 or more facets in highest vertical row. Surface apparently smooth.

The thorax and pygidium are unknown.

TYPE: Holotype, a complete cephalic cast. U. S. Nat. Mus. No. 87127.

OCCURRENCE: Silurian. Cedarville dolomite, Eastern Mills Quarry, southwest of Springfield, Ohio. Foerste cites a second specimen as coming from the basal portion of the Cedarville at Euphemia, Ohio.

REMARKS: The cephala of species of *Eophacops* seldom give good evidence for specific differentiation. The absence of a narrow cephalic border and somewhat shorter eyes appear to separate this species from *E. handwerki*. It differs from *E. matheri* in the less elevated nuchal lobe, higher eyes, and more depressed third lobe.

Eophacops marklandensis (McLearn, 1918)

(Plate 2, figure 5)

Phacops (Portlockia) marklandensis MCLEARN, 1918, Ottawa Nat., vol. 32 (May), p. 35; 1924, Geol. Surv. Canada, Mem. 137, p. 171, pl. 28, figs. 1–4.

"Compared with *P. (P.) elegans* (Sars and Boeck) this species has a still more reduced basal (third side pair) lobe and smaller tubercles at its extremities. It differs in a similar manner from *P. (P.) stokesi* (Milne-Edwards) and in addition in the presence of well-developed, although not highly elevated tubercles at the extremities of the thoracic axial segments. Compared with *P. (P.) orestes* (Billings), the basal lobe and tubercle are much more reduced, the thoracic-axial tubercles are more strongly developed, and the axial segments relatively more slender. The glabella is somewhat depressed, with first pair of side furrows short and weakly impressed. The second pair are short, weakly impressed, and almost straight. The pygidium has 4 pairs of ribs on the pleural lobes, divided distally by median sulcus. The fourth pair are faint. The axis of the pygidium is divided into about 8 rings.

Dorsal shield, width 14 mm., length 20 mm.
Cephalon, width 14 mm., length 6 mm.
Pygidium, width 9 mm., length 5 mm."

TYPES: Holotype, a cast. Peabody Mus. No. 483. Paratype, a cast, cephalon with most of thorax attached, Victoria Memorial Mus. No. 6001.

OCCURRENCE: Silurian. Ross Brook formation (zone B, rare), Arisaig (coast section), Nova Scotia.

REMARKS: The types of this species have not been seen. Examination of McLearn's figures and a new photograph of the paratype indicate that it differs from other members of the genus in the more sharply defined second lateral furrows, the narrow, poorly defined third lobe depressed well below the glabellar surface, and the anteriorly wider glabella, although the last feature may be due to crushing. It has more ribs (four) than *E. primaevus* (two to three) and more rachial annulations.

Inasmuch as the subcephalic features have not been seen in any of the specimens because they are preserved as casts, allocation to *Eophacops* must be somewhat tentative until the nature of the subcranial furrow can be observed.

Eophacops primaevus (Clarke, 1908)

(Plate 2, figures 11–13)

Phacops primaevus CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 73, 5 figures.
Portlockia primaevus COOPER, 1930, Am. Jour. Sci., 5th. ser., vol. 20, p. 385, pl. 5, figs. 1–4, text-fig. 6.

Cephalon small, about twice as wide as long, showing characteristic features of the genus. Subcranial furrow crenulated laterally; no genal spines apparent. Sutures intersect the genal margins very obliquely.

Third lateral furrows very deep at dorsal furrow, shallow for mesal half, curve forward prominently to outline the third lobe which is low, anteriorly convex, narrow, and does not attain the glabellar surface. Nuchal furrow shallow, rather narrow, about same width and depth as the third when viewed in profile. Nuchal lobe elevated only slightly above glabellar surface, convex anteriorly but not posteriorly, of only moderate length. Eyes rise only to glabellar level, with six facets in longest vertical row. No ornamentation is apparent.

A single thoracic segment shows a prominent rachis equalling about one-third the total width, with very steep high flanks; zone of flexure abrupt.

Pygidium about twice as wide as long. Rachis prominent, extends to posterior margin, gradually reduced in height and width; the posterior two-thirds essentially smooth. One complete rib and a second indistinct one are present; the first groove extends almost to the margin, the second only half way, the third visible for only a very short distance near the dorsal furrow. Remainder of pleural surface smoothly convex.

TYPES: The location of the holotype is unknown. Plesiotypes figured and described by Cooper (1930, p. 385, pl. 5, figs. 1–4) form the basis for this description. They include a cranidium, an incomplete thoracic segment, and the right half of a pygidium, all with test. Peabody Mus. No. 12885.

OCCURRENCE: Ordovician. Zone F4 (Richmond?), Cape Blanc, Gaspé.

REMARKS: This species is unique in that it is the only Ordovician representative of the genus in North America. The remainder occur in strata of Silurian age.

It differs from *E. marklandensis* from Arisaig (Silurian) in the less well-defined second lateral furrows, apparently smaller eyes, and fewer pygidial annulations and ribs.

Eophacops? pulchellus (Foerste, 1885)

(Plate 2, figure 10)

Arionellus sp. FOERSTE, 1885, Bull. Sci. Lab. Denison Univ., vol. 1, p. 114, pl. 14, fig. 3.

Phacops pulchellus FOERSTE, 1887, Bull. Sci. Lab. Denison Univ., vol. 2, p. 99, pl. 8, figs. 4, 20, 21.

Cephalon semicircular, with rounded genal angles. Glabella highly convex, the anterior portion appearing rounded in plan, posterior portion depressed and greatly narrowed behind third furrows, which are continued across the mesal portion as an indistinct groove. There seem to be no other cephalic features which separate this species from others allocated to *Eophacops*. The thorax is unknown.

Pygidia allocated to the species by Foerste are broadly curved in outline, with a prominent, abruptly terminated rachis composed of about nine annulations, each of which bears a median tubercle. There are seven or eight furrowed ribs, none posterior to rachial terminus. All specimens seen are very small. Foerste cites the following measurements: length of cephalon, 6 mm.; width of cephalon, 9.6 mm.; length of pygidium, 7 mm.; width, 12 mm.

TYPES: These are casts of cephala and pygidia.

OCCURRENCE: Silurian. Clinton group, Soldiers Home Quarry, Dayton, Ohio.

REMARKS: Although cited from other localities, no specimens from other localities seem to be conspecific with the types. The characteristic features appear to be the rounded glabellar outline and great number of pygorachial annulations.

Subfamily ACASTINAE Delo, 1935

Small, compact Phacopidae in which the anterior glabellar furrows are lightly impressed, the third pair usually deeper; eyes in most species small; pygidium small, rounded; mucronate in some species.

OCCURRENCE: Ordovician to Devonian.

DISTRIBUTION: Europe, eastern North America, South America.

REMARKS: The subfamily includes the generalized phacopids, some of which appear to have been the forerunners of the later Phacopinae and Calmoniinae.

A certain generalized pattern is found in all members of the Acastinae. It appears to possess the potentialities necessary for the type of structure exemplified by the later, more specialized phacopids. The rather convex glabella with weakly impressed anterior furrows can be conceived as lending itself readily to expansion and to obsolescence of the furrows.

The writer does not believe that the more specialized Phacopinae were derived directly from the older species of the Acastinae. It seems plausible to suppose, however, that the structure exhibited by *Dalmanites phillipsi* Barrande illustrates that of the hypothetical ancestors of the Phacopidae *s. s.* It is because of this apparent evolutionary relationship that he places the Acastinae within the family Phacopidae.

Genus *Acaste* Goldfuss, 1843

Calymene BUCKLAND, 1837, MURCHISON, 1837, and early authors; *Acaste* (pars) GOLDFUSS, 1843; *Phacops* (*Acaste*) SALTER, 1864; *Phacopidella* (pars) REED, 1905; *Dalmanitina* (pars) MCLEARN, 1918.

GENOTYPE: *Calymene? downingiae* Murchison, 1837 (p. 655, pl. 46, fig. 5). *Phacops* (*Acaste*) *downingiae* SALTER, 1864 (p. 24, pl. 2, figs. 17–36.

OCCURRENCE: Silurian.

DISTRIBUTION: Europe, North America.

REMARKS: This genus is represented in the Silurian rocks of North America by a single species which appears to be indistinguishable from the typical *A. downingiae* (Murchison) of the British Isles. It has been found only in northeastern Maine and the St. Lawrence region and apparently was a Silurian migrant fom the region of northwestern Europe. Like the single representative of *Phacops* in the strata of this region, it failed to reach the interior of the continent.

Acaste downingiae (Murchison, 1839)

(Plate 2, figure 23)

Calymene downingiae MURCHISON, 1839, Sil. Syst., p. 655, pl. 14, figs. 3, a, b.
Phacops (*Acaste*) *downingiae* SALTER, 1864, Mon. Brit. Tril., p. 24, pl. 2, figs. 17–36.
Acaste downingiae BASTIN AND WILLIAMS, 1913, U. S. Geol. Survey, Eastport Folio, p. 7, 9, pl. 21, fig. 3.

Comparison of the specimens collected and figured by Bastin and Williams, with the figures of Murchison and Salter, shows no apparent differences. The cephalon shows the typical glabellar pattern with the lateral furrows diverging from a common point, rounded genal angles, and a smooth surface.

The pygidium is nonspinose, bluntly pointed, with a narrow border. Rachis rather narrow, extending to the posterior border, composed of five distinct annulations and a short terminus. There are four pairs of rather flat ribs which show very faint furrows. Surface smooth.

TYPES: The material figured by Bastin and Williams consists of several casts and impressions in dark shale. U. S. Nat. Mus. No. 90007.

OCCURRENCE: Silurian. Pembroke formation, Leighton Cove, Washington County, Maine.

REMARKS: This seems to be the only occurrence of the species in North America, although it is a common element of the Silurian fauna of the British Isles. The North American specimens are apparently indistinguishable from those in the British Isles.

Genus *Phacopina* Clarke, 1913

Phacops CLARKE, 1890, 1913.
Phacops (*Phacopidella*) CLARKE, 1900, 1907.

GENOTYPE: *Phacops braziliensis* CLARKE, 1890 (p. 15, pl. 1, figs. 1, 2).

GENERIC DIAGNOSIS: Small Acastinae with glabella moderately convex; anterior furrows indistinct; third deep; dorsal furrows subparallel; pygidium blunt, convex.

OCCURRENCE: Lower Devonian.

DISTRIBUTION: North and South America.

REMARKS: There is some doubt that all the species assigned to this genus are congeneric. All are preserved as casts and the subcephalic details cannot be seen. The pygidium is known only in the genotype, and more material must be studied before the limits of the genus can be determined with accuracy.

The unexpanded glabella and multiannular pygidium exclude *Phacopina* from the Phacopinae. On the other hand it illustrates the fundamental glabellar pattern of the acastids in what appears to be an advanced stage of specialization. For this reason it is believed that it represents the last stage of development of the acastid stock.

Phacopina anceps Clarke, 1890

(Plate 2, figures 24, 25)

Phacops anceps CLARKE, 1890, Archiv. Mus. Nac., vol. 1, pl. 1, fig. 3.
Phacopina anceps CLARKE, 1913, Serv. Geol. Min. Brazil, Mon., vol. 1, p. 153.

Cephalon small, convex; outline rounded; genal angles nonspinose; glabellar surface smooth, abrupt in front, dorsal surface level from front to back when viewed in profile. Although broken, eyes apparently rise to glabellar surface. Dorsal furrows subparallel. First lateral furrows obsolete; second almost indiscernible; third represented by elongate distal pits. Nuchal furrow shallow, straight, deeper distally. Nuchal lobe same length throughout, narrow, rises to glabellar level. Surface smooth.

The thorax and pygidium are unknown.

TYPE: Holotype. An incomplete cephalic cast. N. Y. State Mus. No. 13880/1.

OCCURRENCE: Devonian. Onondaga limestone, Decewville member, Cayuga, Ontario.

REMARKS: This species was first figured by Clarke in conjunction with his studies of trilobites from the Devonian strata of Maecuru, Brazil. Subsequently (Clarke, 1913, p. 149, 151) he erected the genus *Phacopina* (genotype: *P. braziliensis* Clarke) for the group including *P. anceps*, *P. correlator*, and *P. nylanderi*. *P. anceps* differs from *P. nylanderi* in greater convexity, relatively lesser width, and presence of the second lateral furrows. *P. correlator* differs in the complete first and second furrows, curving dorsal furrows, and anteriorly convex nuchal lobe.

Phacopina chapmani (Williams and Breger, 1916)

(Plate 5, figure 13)

Phacopidella chapmani WILLIAMS AND BREGER, 1916, U. S. Geol. Surv., Prof. Paper 89, p. 287, pl. 22, figs. 1, 3.

Inasmuch as the types of this species are poorly preserved, the original description is cited below.

"Cephalon elongate-paraboloid, angular in front. Length 4.25 millimeters; width 5.5 millimeter; greatest width opposite the occipital furrow. Genal angles broadly rounded. The glabella is elongate, expanding slightly in width from the

occipital ring forward. The frontal lobe of the glabella is much longer than wide; its width is only half the total length of the cephalon. The frontal lobe is most tumid between the eyes. Anteriorly it descends, merging into the general convexity of the shell. The posterior half of the frontal lobe is marked by an angulated ridge, which, with the elongation of the cephalon and the gibbous form, seems at first to be due to bilateral compression in the rock; but the presence of a similar ridge in *Phacopidella anceps* Clarke, a flatter species, and the absence of such a ridge in *P. brasiliensis*, a gibbous species, together with the variability in outline and convexity of the cephalon in the different species, have led to the belief that the characters indicated are to only a slight extent due to compression. This angulated ridge dies out over the third glabellar lobe before reaching the occipital groove. The first and second glabellar furrows and lobes are totally lacking on the clean internal mold. The third pair of furrows are represented as deep transverse pits which do not quite meet medially, forming an incomplete furrow. The occipital furrow extends across the glabella as a wide groove, the ends of which are developed into transverse pits of the third pair of lateral furrows. Between these two pairs of pits the third glabellar lobes are developed as a narrow ring which is somewhat thinner than the occipital ring. The palpebral lobes are minute; the eyes are large and strongly elevated. They extend to the midlength or slightly in advance of the midlength of the cephalon and occupy a width equal to 0.8 the length of the cephalon. The facial suture is faint and extends very nearly horizontally from behind the eyes, reaching forward but little. The free cheeks are steeply inclined. The border is rather thin."

TYPES: Holotype. A somewhat distorted cephalic cast. Paratype. An incomplete pygidial cast. U. S. Nat. Mus. No. 59882.

OCCURRENCE: Devonian. Chapman sandstone. Edmunds Hill, Chapman Township, Aroostook County, Maine.

REMARKS: The original authors (Williams and Breger, 1916, p. 288) note that the species is particularly characterized by the narrowly elongate glabella and elongate outline of the cephalon. It differs from *P. anceps* in this, in a narrower third lobe, and in a distally deeper nuchal furrow. *P. nylanderi* Clarke, also from the Chapman sandstone, is much broader, lacks the median angulation, and the genal angles are sharper.

Phacopina? correlator Clarke, 1900

(Plate 2, figures 27-29)

Phacops correlator CLARKE, 1900, N. Y. State Mus., Mem. 3, p. 20, pl. 2, fig. 9.
? *Phacops* (*Phacopidella*) *correlator* CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 84, 226, pl. 10, figs. 17, 18.
Phacopina correlator CLARKE, 1913, Serv. Geol. Min. Brazil, Mon., vol. 1, p. 153.

Cephalon small, rather wide, abrupt anteriorly, with rounded genal angles, and eyes which reach glabellar crest. First lateral furrows narrow curved impressions, outlining a transversely elliptical frontal lobe. Second furrows shorter, curved slightly forward proximally, opposite middle of eye. Third furrows deepest, curve forward abruptly proximally. Nuchal furrow convex forward; nuchal lobe convex anteriorly and long mesally, rises to glabellar level. Surface smooth.

The thorax and pygidium are unknown.

TYPES: Holotype. A mold of left half of a cephalon; plastotype of same. N. Y. State Mus. No. 13882/1.

OCCURRENCE: Devonian. Oriskany, Becraft Mountain, New York.

REMARKS: This species differs from *P. anceps* Clarke, the genotype of Phacopina, in the long first and distinct second lateral furrows, the rounded frontal lobe, and the long, anteriorly convex nuchal lobe. The cephalon is also relatively broader.

The specimens from Gaspé figured by Clarke and referred to this species (1908, pl. 10, figs. 17, 18) do not appear to be conspecific with the type. The nuchal ring is straight, the eyes proportionally larger, the cheek field behind the eye is shorter, and

the anterior furrows not distinct. Possible allocation to a distinct species, however, must await the finding of more complete material.

Phacopina nylanderi Clarke, 1907

(Plate 2, figure 26)

Phacops (Phacopidella) nylanderi CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 166, 1 figure; 1909, N. Y. State Mus., Mem. 9, pt. 2, p. 96, pl. 22, fig. 1.
Phacopina nylanderi CLARKE, 1913, Serv. Geol. Min. Brazil, Mon., vol. 1, p. 153.

Cephalon very small, convex, lateral and frontal margins describing a uniform curve, no distinct border apparent. Dorsal furrows subparallel, diverging slightly. Eyes apparently of moderate size, broken in the type. First and second lateral furrows obsolete, the anterior portion of the glabella uniformly convex, not protuberant; third furrows straight, interrupted mesally; third lobe very low and narrow. Nuchal furrow narrow, shallow; nuchal lobe narrow, low. Surface smooth.

The thorax and pygidium are unknown.

TYPE: Holotype. A cephalic cast. N. Y. State Mus. No. 13886e/1.

OCCURRENCE: Devonian. Chapman sandstone, Edmunds Hill, Maine.

REMARKS: This small species illustrates rather typically the characteristic structure of *Phacopina*. It is relatively somewhat wider than *P. anceps* Clarke, and the second lateral furrows are entirely obsolete; in the latter they are indistinctly visible. Clarke (1909, p. 96) remarks that the cheeks apparently bore genal spinules, but his figure fails to show this, and the holotype shows no trace of them. The species differs from *P. correlator* in the obsolescence of the first and second furrows, straight nuchal lobe, and subparallel dorsal furrows.

Genus *Scotiella* Delo, 1935

Dalmania HALL, 1860, and early authors; *Dalmanites* BASSLER, 1915; *Dalmanitina* MCLEARN, 1918, 1924.

GENOTYPE: *Dalmania logani* HALL, 1860 (p. 156, fig. 18). *Dalmanites logani* BASSLER, 1915 (p. 385). *Dalmanitina logani* MCLEARN, 1924 (p. 167, pl. 27, figs. 3–6).

GENERIC DIAGNOSIS: Acastinae with moderately convex cephalon; dorsal furrows almost parallel; anterior glabellar furrows faint to obsolete, first directed obliquely backward, second horizontal, third wide and deep, interrupted mesally; eyes large; short genal spines may be present. Pygidium moderately convex, rounded, with or without short spine.

OCCURRENCE: Ordivician and Silurian.

DISTRIBUTION: North America, northwestern Europe.

REMARKS: *Scotiella* may represent an intermediate offshoot of the acastid sequence which appeared in western Europe during the Middle Ordovician and reached North America in the Lower Silurian. The known North American species are confined to the St. Lawrence and Appalachian areas.

Features of importance are the almost obsolete anterior glabellar furrows, subparallel dorsal furrows, and small pygidium with few ribs.

Scotiella logani (Hall, 1860)

(Plate 2, figures 14–17)

Dalmania logani HALL, 1860, Can. Nat. Geol., vol. 5, p. 156, fig. 18.
Dalmanitina logani MCLEARN, 1918, Ottawa Nat., vol. 32, p. 32; 1918, Am. Jour. Sci., ser. 4, vol. 45, p. 130; 1924, Geol. Surv. Canada, Mem. 137, p. 167, pl. 27, figs. 3–6.

Cephalon about twice as wide as long; genal angles rounded; dorsal furrows straight, diverging only slightly. Glabellar surface evenly and slightly convex.

Anterior two pairs of furrows almost obsolete; third deep and rather wide distally; very indistinct mesally, straight. Nuchal furrow wider distally, curving forward slightly mesally. Postmarginal furrow straight, of moderate width and depth. Third lobes short. Nuchal lobe anteriorly convex, not elevated, of moderate length. Thorax unknown.

Pygidium very convex, narrowly rounded, with a very short acute terminal spine. Rachis prominent, rather broad anteriorly, reduced uniformly in height and width, not connected with terminal spine; consists of four to six annulations. There are four to five rather prominent, unfurrowed rounded ribs which die out against the rather narrow border of uniform width. Surface smooth.

4—8-27-40 — Delo (GSA) 9427 p. 76 CA

TYPES: The location of Hall's cotypes, a fragmentary cephalon and complete pygidium, is unknown. Plesiotypes figured and described by McLearn (1918) include several fragmentary cephalic casts (Victoria Mem. Mus. Nos. 6210, 6211; Peabody Mus. No. 480) and a pygidial cast (Victoria Mem. Mus. No. 5998). Pygidial casts otherwise figured herein from Peabody Museum.

OCCURRENCE: Silurian. Stonehouse formation (zones *a* and *b*, rare; zone *c*, very common), coast section of Arisaig, Nova Scotia.

REMARKS: This species shows a great deal of variability in the distinctness of the anterior two pairs of glabellar furrows and grades more or less indistinguishably into the variety *conservatrix* in which the anterior furrows are distinct and fully formed. The pygidium is easily differentiated from that of other species allocated to *Scotiella* because of the presence of the terminal spine.

Scotiella logani var. *conservatrix* (McLearn, 1918)

(Plate 2, figures 18-20)

Dalmanitina logani var. *conservatrix* McLEARN, 1918, Ottawa Nat., vol. 32 (May), p. 33; 1918, Am. Jour. Sci., 4th ser., vol. 45, p. 129; 1924, Geol. Surv. Canada, Mem. 137, p. 168, pl. 27, figs. 1, 2.

ORIGINAL DESCRIPTION: "This variety only differs from *D. logani* (Hall) by having all the glabellar furrows well impressed, but all gradations exist between them. Compared with *D. downingiae* (Murchison) the frontal lobe is a little higher, the third side lobes a little smaller, and the glabellar surface variably tuberculose. The pygidium is mucronate and with a proportionately more slender and tapering axis. The cephalon is a little more than twice as wide as high. The maximum width is about 22 mm. The average pygidium is 13 mm. wide and 8 mm. long."

TYPES: Holotype. A fragmental cephalic cast. Peabody Mus. No. 472. Paratype. A glabellar cast. Victoria Mem. Mus. No. 5999.

OCCURRENCE: Silurian. Stonehouse (rare in zones a–c) and Moydart formations (very rare in zone a), coast section of Arisaig, Nova Scotia.

REMARKS: Accompanying pygidia typical of *S. logani* are casts of others which are less convex, more broadly rounded, and without a terminal spine. Rachis very high and narrow, gently tapering, prominent terminally, composed of seven to eight annulations. Pleural ribs indistinct, total five in number, the anterior three pairs broad, furrowed, the posterior two pairs simple. Although McLearn describes the pygidium of the variety *conservatrix* as mucronate, the writer could discern no other pygidia in the collections which appeared to differ definitely from those of *S. logani*. It is suggested, therefore, that these may be the pygidia of *S. logani* var. *conservatrix*.

Scotiella obsoleta Ulrich and Delo, n. sp.

(Plate 2, figures 21, 22)

Cephalon moderately convex, rather narrowly rounded in front. Genal angles rounded. Dorsal furrows straight. Anterior two pairs of glabellar furrows obso-

lete; third in two parts, each about one-third the width of glabella, wider proximally, slightly concave anteriorly, very deep, of moderate width. Axial portion of glabella moderately convex. Nuchal furrow very wide, especially mesally, the distal pits about one-fourth the length, curving forward. Second lobes very faintly discernible as slight swellings along anterior edge of third furrows. Third lobe has no anterior height mesally, increases in width very rapidly distally. Nuchal lobe rises to glabellar level. Viewed in profile, the posterior two-thirds of the glabella is level, drops rather abruptly in front. Eyes apparently rose to glabellar level.

No ornamentation visible. Cephalon, 12 mm. wide, 7 mm. long; glabella, 7 mm. long, 4 mm. wide at posterior end, 6 mm. wide at anterior.

A series of pygidial casts which apparently belong to these cephala are small, nonspinose, broadly pointed behind, with curved lateral margins; most convex at the anterior end, sloping rather abruptly as viewed in profile. Rachis almost one-third the total width at anterior end, extends to inner edge of posterior border. Average size about 9 mm. wide and 5 mm. long.

There are three prominent annulations which occupy the anterior half of the rachis, none discernible on posterior half, which ends abruptly. The three pairs of ribs are flat, furrowed, twice as wide as the grooves, dying out at the inner edge of the moderately wide border.

TYPES: Cotypes. Casts of separated cranidia and pygidia; one complete cephalic cast, in sandstone. U. S. Nat. Mus. Nos. 79128 and 79130.

OCCURRENCE: Silurian. Whiteoak sandstone, one mile northwest of Chamberlain, Tennessee.

REMARKS: There is little doubt that this species is congeneric with *S. logani* (Hall) and *S. logani* var. *conservatrix* (McLearn) from the Stonehouse formation of Arisaig. It differs, however, in the much smaller size and smaller number of pygorachial annulations. There is no other species described from the Appalachian area which may be confused with it.

Family DALMANITIDAE Delo, 1935

Phacopidacea with flattened body form, well-defined glabellar lobation, large cephalon and pygidium, and, in most, large eyes.

Subfamily DALMANITINAE Reed, 1905

Dalmanitidae with unmodified glabellar lobation, large cephalon with genal spines, and large depressed pygidium, in most species mucronate.

OCCURRENCE: Ordovician to Devonian.

DISTRIBUTION: Eurasia, North and South America, Africa, Australia.

REMARKS: The subfamily includes the orthodox stock of dalmanitids from which sprang, apparently, the aberrant and often highly ornamented forms embraced by other subfamilies of the Dalmanitidae. In North America it is first represented in the Silurian and disappears before the Middle Devonian.

Genus *Dalmanites* Barrande, 1852

Dalmannia EMMRICH, 1844 (pars); *Dalmania* EMMRICH, 1845 (pars), and BARRANDE, 1852 (pars); (preoccupied by *Dalmannia* DESVOIDY, 1830, Diptera); *Dalmanites* BARRANDE, 1852 (pars); *Hausmannia* HALL AND CLARKE, 1888 (pars); *Synphoria* VAN INGEN, 1901; *Dalmanites* REED 1905 (pars); *Dalmanites* R. AND E. RICHTER, 1931.

GENOTYPE: *Trilobus caudatus* BRUNNICH, 1781 (p. 392, 1 pl.). *Asaphus longicaudatus* Murchison, 1839 (p. 656, pl. 14, figs. 11–14). *Phacops (Odontochile) longicaudatus* var. *a.* Salter, 1864 (p. 55, pl. 3, figs. 19–21, non 22–28). *Dalmanites longicaudatus* of later authors.

GENERIC DIAGNOSIS: Dalmanitinae with an elongate nondenticulate hypostoma and genal spines. The pygorachis has from 10 to 16 annulations; the pygidial doublure is narrow, and a terminal spine is present in most species.

OCCURRENCE: Silurian and Lower Devonian.

DISTRIBUTION: World-wide.

REMARKS: *Dalmanites* was established by Barrande (1852, Add., p. 919) as a nomenclatural substitute for the preoccupied *Dalmonia* Emmrich. It had been described previously as *Dalmannia* by the same author, but Barrande was evidently unaware of this circumstance as he did not refer to it. He committed the error of assigning far too wide a latitude to the genus, including within it a large number of dalmanitid species of Ordovician, Silurian, and Devonian age. Later writers too numerous to list here perpetuated this mistake. Hall and Clarke then proposed the subgeneric name *Hausmannia* in 1888 for dalmanitid species of the type of *D. caudatus* and *D. hausmanni* but retained the name *Dalmanites* in a very broad sense and included within it a number of Devonian subgenera. Reed subsequently separated the more primitive species and assigned them to a new genus, *Dalmanitina*.

R. and E. Richter (1931, p. 141) have recently redefined *Dalmanites* and have noted its intermediate position in the phylogenetic sequence *Dalmanitina* (Ordovician), *Dalmanites* (Silurian and Lower Devonian), *Odontochile* (Lower Devonian).

Confusion concerning the identity of the genotype was discussed by the writer in 1935, and it must be emphasized here that *D. caudatus* (Brunnich) is the genotype, not the "*D. caudatus*" of Salter, Brongniart, and later writers.

Although many of the Devonian dalmanitid species in North America belong to the genus *Odontochile*, *Dalmanites* is represented in the Helderbergian. This is contrary to the statement made by the writer in 1935 in which he restricted the genus to the Silurian. Subsequent study, especially of new collections, has convinced him that species of *Dalmanites* are present in the Helderbergian rocks of North America. This is not true in Europe or in South America and South Africa, and the North American fauna is unique in this regard.

Dalmanites aspinosus Weller, 1903

(Plate 3, figure 18)

Dalmanites aspinosus WELLER, 1903, N. J. Geol. Survey, Pal., vol. 3, p. 252, pl. 22, fig. 15; SWARTZ, OHERN AND MAYNARD, 1913, Md. Geol. Survey, Lower Devonian, p. 131, 499, pl. 91, fig. 16.

Cephalon and thorax unknown. Pygidial margins gently curved; terminus nonspinose, narrowly curved; width to length about 3 to 2. No apparent pygidial border. Rachis of moderate width, with at least ten annulations and a short nub. There are nine to ten angular ribs which become higher near the margin and have a gentle anterior and steep posterior slope. Anterior six ribs gently curved, more abruptly near the margin; posterior ribs become progressively straighter. Grooves slightly wider than ribs.

TYPE: Holotype. An impression of the left side of a pygidium. Walker Mus. No. 10242.

OCCURRENCE: Devonian. Decker Ferry formation, Wm. Nearpass Quarry, 2 miles south of Tri-States, New York.

REMARKS: In his original description, Weller gives the number of rachial annulations as 16 and the number of ribs as 10. He also remarks that the ribs are furrowed. The holotype has not been seen, but the plastotype at Walker Museum shows only 12 annulations as an absolute maximum, and the ribs are not furrowed. It is believed that the finding of more material will reveal that a narrow border was present but not apparent on the holotype because of poor preservation.

This species differs from most others in the absence of a terminal spine. It differs from *D. stewartae* n. sp. in less rounded lateral margins, less obtuse terminus, absence of a lateral border, and larger number of ribs. *D. praenuntia* is much smaller and has a truncated terminus. *D. retusus* has broad ribs and narrow grooves and a much more rounded outline.

Dalmanites bassleri Delo n. sp.

(Plate 3, figures 10, 11)

Cephalon and thorax unknown. Pygidial margins sigmoid, border of moderate width. Terminal spine as wide as long, tapers rapidly to a sharp point, and equals one-third or more of the total pygidial length. Rachis rather broad, consisting of 10 or 11 annulations, and terminates abruptly at the base of the spine. There are six to eight pairs of furrowed ribs which bend rather abruptly distally and terminate against the inner edge of the border. The branches are subequal in size and length, the ribs wider than the grooves; on casts about the same width. Ornamentation consists only of fine granulation.

TYPE: Holotype. A complete pygidium with spine broken. U. S. Nat. Mus. No. 79113.

OCCURRENCE: Silurian. St. Claire limestone, at Cason Mine near Batesville, Arkansas.

REMARKS: This species is very close to *D. halli* from the Waldron shale of Indiana. The pygidium differs primarily in that the pleural rib branches of *D. bassleri* are subequal and in the anterior five or six ribs both extend from rachis to border. In *D. halli*, the posterior branch in no case reaches the rachis, and the anterior branch extends to the border in only the two anterior ribs.

It differs from *D. howelli* n. sp. from the St. Claire limestone in the sigmoid lateral margins, the longer, wider spine, more abrupt rachial terminus, wider rachis, two fewer ribs, and two to three fewer annulations.

With pygidia of both *D. bassleri* and *D. howelli* occur detached cephala. No complete individuals have been found, so that the proper specific allocation of the cephala is in doubt. The cephalon which appears to agree most nearly with the pygidium described above is moderately convex with a flat, pointed, and upturned frontal process produced from a border of uniform width. The process, measured from the inner edge of the border, is as long as the frontal lobe, and its base is half as wide. The genal spines are broken. The base of the eyes is level with or slightly above the glabellar surface, and the cheeks are rather wide. The nuchal lobe is smooth. This cephalon differs from *D. halli* in the elevation of the eyes; from *D. vigilans* in the shorter frontal process.

Dalmanites bicornis (Hall, 1877)

(Plate 3, figure 16)

Dalmania bicornis HALL, 1877, N. Y. State Mus. (doc. ed.), 28th. Rept., pl. 33, fig. 18.

Dalmanites bicornis HALL, 1879, N. Y. State Mus. (mus. ed.), 28th. Rept., p. 196, pl. 33, fig. 18; 1882, Ind. Dept. Geol. Nat. Hist., 11th. Rept., p. 342, pl. 35, fig. 18.

This species is incompletely known. The holotype is the subcephalic margin of a cephalon and bears an anterior process consisting of a short stout base and two stout, sharply pointed processes diverging at right angles. Larger fragments of the species have not been found.

TYPE: The location of the type is unknown.

OCCURRENCE: Silurian. Niagaran (Waldron shale), Waldron, Indiana.

Dalmanites bisignatus Clarke, 1900

(Plate 3, figures 22, 23)

Dalmanites bisignatus CLARKE, 1900, N. Y. State Mus., Mem. 3, p. 19, pl. 2, figs. 6–8.

The cephalon and thorax are unknown. Pygidium decidedly triangular, without terminal spine. Rachis narrow, extends to the base of the spine, and is composed of 14 or 15 annulations. Each of these bears a median pair of rather prominent tubercles; those in the anterior half bear two additional pairs of smaller lateral tubercles. There are 10 or 11 pairs of ribs which curve backward near the margin, the posterior pair parallel with the rachis. The anterior three or four pairs of ribs are lightly furrowed, and a few small scattered pleural tubercles are present.

TYPES. Holotype. A pygidial impression. N. Y. State Mus. No. 13367/1. Paratypes. Pygidial casts. N. Y. State Mus. Nos. 13367/2, 13367/3.

OCCURRENCE: Devonian. Oriskany formation, Becraft Mountain, New York.

REMARKS: *D. bisignatus* closely resembles three other species from strata of Devonian age. It differs from *D. litchfieldensis* n. sp. (Helderbergian) in the regular rather than irregular ornamentation of the rachis, the furrowing of only the anterior three or four pairs of ribs, and the possession of one more annulation and one more pair of ribs. *D. mississippiensis* n. sp. (Helderbergian) has three or four more annulations and two more pairs of ribs, all of which are furrowed. *D? veiti* (Oriskanian) has no terminal spine, all the annulations bear a row of tubercles, and the ribs are more completely ornamented.

Dalmanites brevicaudatus Foerste, 1909

(Plate 5, figure 4)

D. limulurus var. *brevicaudatus* FOERSTE, 1909, Jour. Cincinnati Soc. Nat. Hist., vol. 21, no. 1, p. 35–36, pl. 2, figs. 20 a–c.

Cephalon essentially like that of *D. halli* with a short, triangular, rounded frontal process. Genal spines broken but appear to have been short. Eyes extended well above the glabellar surface. The thorax is unknown.

Pygidium triangular, the margins almost straight. Terminal spine short, acute, somewhat upturned; border narrow. Rachis long, equalling about seven-eighths the pygidial length, composed of seven or eight distinct annulations and a short terminus. There are five or six pairs of furrowed ribs. No trace of ornamentation preserved.

TYPES: Cotypes. Two pygidial casts, U. S. Nat. Mus. No. 84920.

OCCURRENCE: Silurian. West Union formation, northwest of Marius, Lewis County, Kentucky. Several casts of cephala and pygidia from the Bisher formation, northeast of Manchester, Adams County, Ohio, are in the collections of the U. S. Nat. Mus. No. 88860.

REMARKS: There appears to be nothing specifically characteristic in the cephalon of this species, but the specimens seen were not very well preserved, and better material might show fine shades of differentiation. Although the species were originally described as a variety of *D. limulurus*, it appears to be even closer to *D. halli*, and for this reason has been elevated to specific rank. The pygidium is distinctive because of the very long rachis and very short spine, the almost straight margins, and narrow border. No other species of *Dalmanites* shows this assemblage of characters.

Dalmanites brevigladiolus Foerste, 1919

(Plate 4, figures 11, 12)

D. brevigladiolus FOERSTE, 1919, Ohio Jour. Sci., vol. 19, no. 7, p. 401, pl. 18, figs. 4 a–e.

Cephalon characteristic for the genus with a gently rounded anterior margin bearing a median process which is short, flat, terminally rounded, and of moderate width. Nuchal lobe high; genal angles broken. Thorax unknown.

Pygidium broadly triangular with a narrow border and a short, very broad, blunt terminal spine. Rachis extends to base of spine, composed of 11 or 12 annulations. There are six to seven pairs of coarse, prominently furrowed ribs, with a distally larger posterior branch and very steep posterior flank; they bend backward abruptly near the border, the posterior two or three pairs almost parallel to the rachis.

TYPES. Cotypes. An incomplete cephalon and several pygidia. U. S. Nat. Mus. Nos. 87034.

OCCURRENCE. Silurian. Holophragma zone, Lilley member of West Union formation, Zink Quarry, Hillsboro, Ohio.

REMARKS: The difference between this species and others of the same general age is primarily one of degree. Thus the anterior process of *D. brevigladiolus* is more pointed than that of *D. limulurus* but broader and more tapering than that of *D. vigilans*.

The pygidium illustrates other features of differentiation, especially the nature of the terminal spine which is relatively much wider than that of *D. limulurus* at the base, does not taper so rapidly, and is terminally blunter; in comparison with the spine of *D. platycaudatus* it is wider and shorter. The very coarse ribs with abrupt backward curve are characteristic of this species alone.

Dalmanites carlwegi Tansey, 1923

(Plate 3, figure 34)

D. carlwegi TANSEY, 1923, Mo. Bur. Geol. and Mines, ser. 2, vol. 17, p. 209, pl. 56, fig. 2.

The cephalon and thorax are unknown.

Pygidium definitely triangular in outline with gently rounded margins and a smooth border of medium width. Rachis depressed convex, narrow, gently tapering, composed of 12 annulations and a short nub which is moderately abrupt behind. Terminal spine begins as a low ridge on the posterior border, is short, acute, upturned. There are 10 or 11 high, rounded ribs which are wider than the grooves as 3 to 2. The anterior six are lightly furrowed, the furrows represented on the posterior ribs by a narrow nongranulated line. Surface smooth except for fine granulation.

TYPES: Holotype. A pygidium without test. U. of C. No. 28504. Paratype. An almost complete pygidium with test. U. of C. No. 21143.

OCCURRENCE: Devonian. Bailey limestone, Little Saline Creek, St. Genevieve County, Missouri.

REMARKS: This species most closely resembles *D. taffi* n. sp. from the Haragan formation but differs in a relatively wider rachis with fewer annulations, fewer ribs, and possession of a distinct border of moderate width. It differs from *D. huntonensis* n. sp. in the uniformly curved margins, wider rachis, and more indistinctly furrowed ribs, and may be distinguished from *D. slocomi* Stewart by the relatively higher ribs which are not distinctly furrowed and the lack of tubercular ornamentation on the rachis.

Dalmanites caudatus var. *jupiterensis* Twenhofel, 1928

(Plate 4, figure 6)

D. caudatus jupiterensis TWENHOFEL, 1928, Geol. Surv. Canada, Mem. 154, p. 335, pl. LX, fig. 2.

Cephalon depressed convex, width twice the length. Genal angles broken. Border continuous, smooth, wide, rather flat; bends downward in a shallow trough in front and supports a slight, rounded frontal protrusion half as wide as the frontal lobe.

Frontal lobe twice as wide as long, anterior margin almost straight, lateral angles abrupt (probably crushed). Second furrows are narrow straight lines, continued to dorsal furrows as very shallow grooves. They appear to trend slightly backward distally, making the first lobes appear to flare outward. Third furrows longer, meet dorsal furrows fully, very slightly concave anteriorly. Nuchal furrow a narrow line at either side for about same distance as third pair, very shallow in mesal third, rising to level of axial glabellar surface. Second and third lobes progressively lower than the first, rather flat, equilateral, equal in width. Nuchal lobe broad, flat distally, arched mesally, with a posterior node.

Axial portion of glabella depressed below frontal lobe, which is about same height as nuchal. Eyes of moderate height, rise only slightly above glabellar surface. Palpebral lobes very low, depressed convex, about one-third height of eye below its crest. Cheek area, between eye base and border short, low; eyes long. Postmarginal furrow narrow. Sparsely distributed tubercles cover the glabella; remainder of surface very minutely pebbled.

The thorax unknown. Pygidium too poorly known for specific differentiation.

TYPE: Holotype. Peabody Mus. No. 223, an incomplete cephalon with genal angles broken.

Dalmanites coxius Clarke, 1907

(Plate 4, figure 25)

Dalmanites coxius CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 154, 1 figure; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 103, pl. 7, fig. 1.

The cephalon and thorax are unknown.

Pygidium about as wide as long, with slightly curved and somewhat sinuous margins, and a short triangular terminus. Rachis narrow, composed of 12 to 14 annulations and a short nonannulated terminus. There are 12 broad, very slightly furrowed ribs, which curve very gently and die out upon the narrow border. Terminal spine about one-fifth total length. Surface finely granulated.

TYPE: Holotype. A pygidial cast. U. S. Nat. Mus. No. 14772.

OCCURRENCE: Devonian. St. Albans Beds "between Cape Gaspé and Cape Rosiers," Gaspé.

REMARKS: This species is represented only by the holotype. It most nearly resembles *O. micrurus* in general outline but differs in the narrow border, distinctly fewer annulations, and fewer and broader ribs on which the furrows are almost indiscernible. There is no other species with which it easily may be confused.

Dalmanites danae Meek and Worthen, 1865

(Plate 3, figures 24, 25)

Dalmania danae MEEK AND WORTHEN, 1865, Proc. Acad. Sci. Philadelphia, p. 264.
Dalmanites danae MEEK AND WORTHEN, 1868, Ill. Geol. Surv., vol. 3, p. 363, pl. 6, figs. 1 a–f.
Dalmanites danai SAVAGE, 1913, Ill. Geol. Surv. Bull. 23, p. 106, pl. 8, figs. 16, 17.

Cephalon broadly rounded, margin smooth, border very narrow; genal spines short, curved slightly. Postmarginal and lateral furrows well defined. Frontal lobe transversely elliptical, twice as wide as long. First furrows slightly sinuous; second anteriorly convex; third likewise; nuchal furrow curved forward mesally, backward distally, producing rounded third lobes. Nuchal lobe slightly elevated, of moderate length. Eyes small, extending from first furrows to middle of second lobe, separated from postmarginal furrow by almost their own length. Fixed cheek area very large. Ornamentation not preserved. Thorax incompletely known; apparently shows no specific features.

Pygidium with evenly rounded margins. Terminal spine rounded, sharp, and although broken its proportions indicate that it equals about one-third the entire pygidial length. Rachis rather narrow, uniformly tapering, composed of 11 or 12 annulations, and continued as a prominent rounded ridge into the spine. Cross grooves straight, well defined. Pleural areas depressed. There are at least seven pairs of broad, prominently furrowed ribs and one single pair, the latter parallel to the rachis. Furrows as long and almost as large as grooves; rib branches subequal in height and width, dying out on narrow border by obsolescence of grooves and furrows. Surface smooth.

TYPES: Holotype. Cast of an entire individual with fragmentary thorax. Paratype. A pygidial cast with spine broken. U. of Illinois No. 11635.

OCCURRENCE: Silurian. Edgewood formation. Illinois, Missouri.

REMARKS: This species is unique in the very narrow frontal border, small eyes set well forward, and short genal spines. The large pygidial furrows and rachis continued into the terminal spine also differentiate it from other Silurian species of *Dalmanites* except from *D. verrucosus* Hall, which is highly ornamented and occurs in younger strata.

Dalmanites gaveyi Clarke, 1907

(Plate 4, figure 24)

D. gaveyi CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 160, 1 figure; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 43, 128, pl. 8, figs. 8, 9.

Cephalon gently arched with short, acute genal spines and generalized glabellar lobation. The rather narrow anterior margin marked by a short, flat, rounded, prowlike extension. Cephalic surface finely granulose.

A portion of the thorax is present but shows no specific characteristics. The pygidium is unknown.

TYPES: Cotypes. An incomplete cephalon with most of the test exfoliated. N. Y. State Mus. No. 13379e/1. Cephalon and fragmentary thorax. N. Y. State Mus. No. 13379e/2.

OCCURRENCE: Devonian. Grande Greve limestone, division 2, near Grande Greve, Graspé.

REMARKS: This species is characterized by simplicity of structure and ornamentation rather than by any single feature which might be of diagnostic value. Clarke's figures are somewhat restored. The short, acute genal spines and narrow margin in combination with the simple anterior process differentiate it from all other Devonian species.

Dalmanites halli Weller, 1907

(Plate 3, figures 6-9)

Dalmania vigilans HALL, 1877, N. Y. State Mus. (doc. ed), 28th. Rept., pl. 33, figs. 1-4.

Dalmanites vigilans HALL, 1879, N. Y. State Mus. (mus. ed.), 28th. Rept., p. 193, pl. 33, figs. 1–4; 1882, Ind. Dept. Geol. Nat. Hist., 11th. Rept., p. 339, pl. 33, fig. 9, pl. 35, figs. 1–4.

Dalmanites halli WELLER, 1907, Bull. Chicago Acad. Sci., Nat. Hist. Surv., vol. 4, pt. 2, p. 195.

Cephalon almost twice as wide as long, moderately convex with long genal spines reaching to sixth thoracic segment. Border wide. Frontal process short, abruptly rounded, half as wide as frontal lobe. Frontal lobe wider than long; nuchal ring elongate; base of eyes below glabellar level. Glabellar surface very finely granulose, with small scattered tubercles.

Thoracic pleura produced distally, subacuminate, recurved. Each rachial annulation has a low node at either end.

Pygidium small with somewhat sigmoid lateral margins; they widen posteriorly into the sharply triangular terminal spine which equals about one-third the total pygidial length. Rachis composed of 10 to 11 annulations and extends to the base of the spine. There are six pairs of prominently furrowed ribs; the anterior branches taper away from the rachis, only the anterior two reaching the border, whereas the posterior branches are widest at the border and in no case reach the rachis. Entire surface minutely granulose.

TYPE: Holotype. A complete individual with test. N. Y. State Mus. No. 13399e/1.

OCCURRENCE: Silurian. Waldron shale, Waldron, Indiana.

REMARKS: The name *D. halli* was proposed by Weller as a substitute for the "*D. vigilans*" described by Hall from the Waldron area. Hall had originally described *D. vigilans* from the Niagaran limestone and later referred the Waldron specimens to it.

The primary differences are in the elevation of the eyes, as those of *D. vigilans* have their base level with the glabellar surface. The anterior process is also much longer in *D. vigilans* and is upturned.

Dalmanites huntonensis Ulrich and Delo n. sp.

(Plate 3, figures 26, 28)

The cephalon and thorax are unknown.

Pygidium a rounded triangle; with terminal spine broken it appears broadly truncated, the lateral margins forming a double inward curve about two-thirds the distance from the anterior end. Rachis low, ends abruptly, composed of 14 annulations and a very short terminus. There are 11 pairs of ribs which are rather flat on top; posterior pair very short, incipient; all but the posterior two furrowed. Posterior branch of each rib ends at inner edge of the very broad doublure, which on all specimens observed makes a row of bumps on both ribs and grooves. This may be an accident of preservation. Anterior grooves same width as ribs; posterior grooves twice as wide. Border continuous, the posterior branches of the ribs dying out upon it; on casts the ribs are angular, only the first four showing furrows. Terminal spine short, very slender, acute, produced from border but connected to rachial terminus by a low angular ridge. The spine is upturned on one paratype. Surface smooth.

TYPES: Cotypes. Two complete pygidia, U. S. Nat. Mus. No. 19036.

OCCURRENCE: Devonian. Haragan formation, Atoka Quadrangle, Oklahoma.

REMARKS: This species is characterized by the double curve of the lateral margins, the distinctly furrowed ribs, and the slender terminal spine. It may be distinguished from *D. taffi* n. sp. by the more elongate rachis, double curved marginal outline, and

nature of the ribs. It also resembles *D. carlwegi* but differs in marginal outline, relatively narrower rachis, two more rachial annulations, and the distinctly furrowed ribs.

Dalmanites illinoisensis Weller, 1907

(Plate 4, figure 15)

D. illinoisensis WELLER, 1907, Bull. Chicago Acad. Sci., Nat. Hist. Surv., vol. 4, pt. 2, p. 275, pl. 25, figs. 1-2.

The cephalon and thorax are unknown. Pygidial margins curved, sigmoid, with a uniformly very wide, flat border; length to width as 5 to 4. Terminal spine equals almost one-third the total length, the anterior half triangular, the posterior half slender, acute, rounded. Rachis depressed convex, of moderate width, tapers gently; composed of 13 to 14 wide, flat annulations, separated by very narrow grooves, the last two indistinct. There are eight or nine pairs of broad, furrowed ribs which are about twice as wide as the grooves. The furrows extend to the border, and the posterior branch of the rib increases in height distally. No ornamentation is visible.

TYPES: Cotypes. Two pygidial casts, one complete (U. of C. No. 6835) and one without the terminal spine (U. of C. No. 9913).

OCCURRENCE: Silurian. Niagaran limestone, Lemont, Illinois.

REMARKS: This species is distinctly larger than most other species in the Silurian of North America. The pygidium is much like that of *D. danae* Meek and Worthen in size but differs in the wider margin and triangular spine which is not a continuation of the rachis. The broad, even ribs which are bifurcate, very wide border, elongate spine and larger size differentiate it from all other North American species of the genus.

Dalmanites? latus Ohern and Maynard, 1913

(Plate 4, figure 16)

Dalmanites latus SWARTZ, OHERN AND MAYNARD, 1913, Md. Geol. Survey, Lower Devonian, p. 502, pl. 93, fig. 2.

This species is represented by a cast of a somewhat distorted pygidium in sandstone. Lateral margins uniformly rounded; no terminal spine or lateral border present. Rachis of moderate width, tapers rapidly, is composed of 15 to 16 annulations and a short nonannulated nub and extends to the posterior margin. The second annulation bears a tubercle on the right end; apparently the entire surface was occupied by a row of tubercles.

There are 13 pairs of prominent, furrowed ribs, which are about as wide as the intervening grooves; greatly curved distally, the posterior ones almost semicircular, and a fourteenth pair which is parallel to the rachis and extends beyond its terminus. Traces of tuberculate ornamentation are apparent on several of the anterior ribs.

TYPE: Holotype. A distorted pygidial cast in sandstone. Md. Geol. Survey coll., uncatalogued.

OCCURRENCE: Devonian. Oriskany formation, Cumberland, Md.

REMARKS: The holotype appears to have been distorted by lateral pressure. Its rounded outline is sufficient, however, to distinguish it adequately from species with similar ornamentation but more distinctly triangular outline. The closely crowded, furrowed ribs are distinctive. Only the holotype is known.

Dalmanites limulurus (Green, 1832)

(Plate 3, figure 1)

Asaphus limulurus GREEN, 1832, Mon. Tril. N. Am., p. 48, cast. no. 16.
?*Asaphus caudatus* GREEN, 1832, Mon. Tril. N. Am., p. 50, cast. no. 17.

Asaphus wetherilli GREEN, 1832, Mon. Tril. N. Am., p. 57, cast. no. 20.
Asaphus limulurus HALL, 1843, Geol. N. Y., pt. 4, p. 101, figs. 1, 2, tab. org. remains 10, figs. 1, 2.
Phacops limulurus HALL, 1852, Geol. N. Y., vol. 2, p. 303, pl. 67, figs. 1–8.
Dalmanites limulurus GRABAU AND SHIMER, 1910, N. Am. Index Foss., vol. 2, p. 325, fig. 1641—SWARTZ AND PROUTY, 1923, Md. Geol. Surv., Silurian, p. 714, pl. 35, figs. 17–21—GOLDRING, 1931, N. Y. State Mus. Handbook 10, p. 333, fig. 49h.

Cephalon wider than long with broad border. Genal spines extend to about fourth thoracic segment; anterior marginal process about half the width of frontal lobe, broadly rounded, no longer than width of margin; cheek area broad. Surface finely pebbled.

Thorax shows no features of specific importance except low distal nodes on rachial annulations. Pleura distally produced, acute, recurved; surface finely pebbled.

Pygidial margins sigmoid; border rather narrow, widening posteriorly into a broad, elongate spine which tapers slowly and equals almost half total pygidial length. Rachis broad, tapers gently, blunt posteriorly, composed of nine or ten annulations, separated by narrow grooves. There are seven or eight gently curved furrowed ribs separated by wide grooves. Surface finely pebbled.

TYPES: The holotype has been lost. Neotype. Incomplete specimen retaining test. N. Y. State Mus. No. 13381. (Original of *A. wetherilli* Green).

OCCURRENCE: Silurian. Niagaran (Lockport formation). Neotype from Rochester, New York. General range includes New York and adjacent States.

REMARKS: Green described three species in his *Monograph of North American trilobites* which seem to be conspecific. One of these he referred to *A. caudatus*, another to *A. limulurus*, and a third to *A. wetherilli*. But *D. caudatus* is found only in the British Isles, and all the species, judging by the casts, are the same.

The holotype of Green's *A. limulurus* has been lost. The cast (no. 16) is a pygidium and shows prominent, rather sharp, rounded nodes on the distal extremities of the pygorachial annulations. These appear too sharply defined to be natural, and no species with nodes of this nature is known from Silurian rocks of North America.

The holotype of *A. wetherilli* has been preserved and represents the type of *Dalmanites* found commonly in the Lockport formation. The close resemblance between these three species was subsequently recognized by Hall, and he designated *limulurus* as the preferred specific name in both 1843 and 1852.

D. limulurus closely resembles no other distinct species but is closely related to two forms which occur in rocks of about the same age.

D. limulurus var. *lunatus* Lambert differs primarily in proportion, possesses a narrower cheek, wider and longer frontal process, more triangular terminal spine, and larger posterior rib branches.

D. brevigladiolus Foerste differs in the more pointed anterior process, broader and blunter terminal spine.

Dalmanites limulurus var. *lunatus* Lambert, 1904

(Plate 3, figure 2)

Dalmanites lunatus LAMBERT, 1904, Bull. Geol. Soc. Am., vol. 15, p. 482, pl. 44, figs. 1–3, 5.

Width to length as 2 to 1½. The cephalic proportions are essentially the same as in *D. limulurus*. Eyes large, with a pronounced basal groove. Cheek area between the eye and border narrow; in *D. limulurus* wide. A rounded, flat, frontal process is present, its total length equalling about half the length of the frontal lobe. Genal spines broken. Nuchal lobe broad and elevated.

Pygidium relatively broader than in *D. limulurus*. Length and width of the

terminal spine about equal, whereas in *D. limulurus* the spine is twice as long as wide. Rachis rather narrow, flattened, composed of nine or ten annulations. There are six pairs of ribs, the anterior four pairs conspicuously furrowed. The posterior branch becomes very much larger distally than the anterior, which does not reach the inner edge of the border. The posterior two pairs of ribs are represented by the posterior branch alone.

No conspicuous ornamentation discernible.

TYPES: Cotypes. Pygidial casts, U. S. Nat. Mus. No. 79120. Plesiotype, cast of an entire individual with only terminal spine and genal spines broken. U. S. Nat. Mus. No. 79127.

OCCURRENCE: Silurian. Littleton, New Hampshire; upper Clinton shale, above the ore bed, Clinton, New York.

REMARKS: This variety is very close to *D. limulurus* (Green) but differs in matters of proportion. The primary differences may be summarized as follows:

D. limulurus var. *lunatus*	*D. limulurus*
Frontal process wider and longer	Shorter and narrower
Cheeks narrow	Cheeks wide
Terminal spine width and length equal	Length twice the width
Posterior rib branches much the larger	Branches almost equal

Careful comparison with specimens from the Silurian strata at Littleton, New Hampshire, has convinced the writer that the specimens from Clinton, New York are the same. This comparison is based on pygidial features alone, but these are usually sufficient to differentiate species or varieties within the genus.

Dalmanites lingulifer Ulrich and Delo n. sp.

(Plate 3, figures 29, 30)

The cephalon and pygidia on which the following description is based are detached, and there is no absolute means of proving that they belong together.

Cephalon incomplete; genal angles broken.

Frontal lobe long, produced in a narrow curve in front. Lateral border wide, narrows to less than half its width at the anterolateral corners of frontal lobe, then widens into a wide, elongate, gently tapering, spatulate extension, only 4 mm. of which remains unbroken. Eyes extend from first lateral furrows to center of third lateral lobe and have a deep basal furrow. Surface of glabella, palpebral lobes, and cheeks just below the eyes, finely granulose; border and remainder of cheeks smooth. Thorax unknown.

Pygidium triangular, margins almost straight, border of moderate width. Rachis depressed convex, about one-fifth total width, composed of 14 annulations; terminus distinct but tapers into a low rounded ridge. There are nine or ten pairs of prominent ribs which curve rather abruptly distally and are separated by grooves of equal width when the test is present. The anterior ribs show a distinct furrow. Terminal spine equals about one-fourth the total length, is slender, rounded, and upturned at an angle of about 30 degrees.

All rachial annulations bear numerous small granulose tubercles of various sizes, and each branch of the furrowed ribs bears an irregular row of granules which become smaller and more abundant near the thickly pebbled border.

TYPES: Holotype. A pygidial impression and cast showing terminal spine, U. S. Nat. Mus. No. 79032. Paratypes. Incomplete cephalon with test U. S. Nat. Mus. No. 79032. Two pygidia with test but without terminal spine. U. S. Nat. Mus. No. 79032.

OCCURRENCE: Devonian. Haragan formation, Arbuckle Mountain region, Oklahoma. Holotype from near center Sec. 21, T. 1S, R. 8E., Atoka Quadrangle; paratypes (cephalon) from west side of N. W. ¼, Sec. 21, T. 1S., R. 8E., (pygidia) near center Sec. 8, T. 1S., R. 8E.

REMARKS: This species is characterized by the antero-lateral narrowing of the cephalic border and the broad frontal extension.

The pygidium differs from related species in the more definitely triangular outline with straight borders and prominent ribs. It differs specifically from *D. taffi* in the wider and relatively longer rachis.

Dalmanites litchfieldensis Delo n. sp.

(Plate 5, figure 14)

Cephalon and thorax unknown. Pygidium as wide as long, with a short, acute, triangular terminus. Rachis narrow, low, terminally about half as wide as at anterior end, composed of 15 annulations and a short, indistinctly annulated nub. Each flat annulation bears an irregular row of tubercles of more than one size, larger ones twice as large as the smaller. They do not show on casts. Cross-grooves deeper distally, especially near posterior end.

There are 12 pairs of gently curved, angular ribs, the last one indistinct. These are faintly grooved, on test, on the anterior gentler slope, especially along the distal half of the rib. Posterior slope steep, capped by a single row of tubercles which are larger on the proximal half; on the distal half they become smaller and more numerous. Border granulose.

TYPES: Cotypes. Two pygidia with test in place, termini missing. U. S. Nat. Mus. No. 79089.

OCCURRENCE: Devonian. Helderbergian, Sallsburg Quarry, Litchfield, New York.

REMARKS: This species differs from *O. micrurus* in much smaller size, ornamentation of rachis, and fewer annulations and ribs. It is superficially similar to *D. bisignatus* but differs in the irregular annular ornamentation, furrowing of most of the ribs instead of the anterior three or four, more annulations, and one more pair of ribs. It may be distinguished from *D. mississippiensis* n. sp. by the possession of three or four fewer annulations and two fewer pairs of ribs.

Dalmanites longispinus Delo n. sp.

(Plate 3, figure 32)

Cephalon and thorax unknown. Pygidium very small, with a very long slender spine which equals more than half the total length. Rachis of moderate width, composed of 10 annulations. There are five to six pairs of straight ribs, which are distinctly furrowed and wider than the grooves. The anterior branch is the larger near the rachis, both are subequal throughout most of their length and reach the lateral border. No ornamentation is visible.

TYPE: Holotype. Pygidial cast in shale and a fragmentary counterpart. U. S. Nat. Mus. No. 62921.

OCCURRENCE: Silurian. Dennys formation, 2 miles east of Dennysville, Maine, on the south side of Duck Harbor.

REMARKS: This species was originally referred to "*D. longicaudatus*" Murchison (Eastport Folio, pl. 16, fig. 29) but cannot be conspecific with it because it has from four to six fewer rachial annulations. There is no North American species which it resembles because of the long, slender terminal spine, and it most closely resembles "*D. longicaudatus*" Murchison = *D. caudatus* (Brunnich).

Dalmanites howelli Delo n. sp.

(Plate 3, figures 12, 13)

Pygidium rather uniformly convex; rachis and dorsal furrows not prominent; margins gently curved. There are 12 or 13 flat rachial annulations separated by very narrow grooves; rachial terminus not abrupt. The ribs number nine or ten, are very wide and flat with narrow, shallow furrows extending to the margin. Grooves narrow. Terminal spine sharply pointed and short, the length from the rachial terminus equals about one-fourth the total length. Ornamentation consists of fine granulation.

TYPE: Holotype. A pygidium with most of test in place. U. S. Nat. Mus. No. 79117.

OCCURRENCE: Silurian. St. Claire limestone, Cason Mine, near Batesville, Arkansas.

REMARKS: The pygidium described above differs from that of *D. bassleri* n. sp. in the lesser elevation of the rachis, less abrupt rachial terminus, two to three more rachial annulations, two more pairs of ribs, less sigmoid lateral margins, and much shorter spine. It differs from *D. vigilans* in larger number of annulations and ribs.

There occur with these pygidia, but detached from them, two types of cephala, one of which is described in the discussion of *D. bassleri* n. sp. The other is tentatively allocated to *D. howelli*. n. sp. and is characterized by a wide lateral border which narrows somewhat at the corners of the frontal lobe, then is produced abruptly into a broad flat process half as wide as the glabella. The process is wider than long and appears to have been broadly rounded. The genal spines are broken, the base of the eyes is below the glabellar surface, and the cheek is relatively narrow. The nuchal lobe is elevated and bears a central tubercle (U. S. Nat. Mus. No. 79117). This differs from *D. vigilans* in the lesser elevation of the eyes and from *D. halli* in the broader frontal process and narrower border at either side of it. It differs from the cephalon discussed with *D. bassleri* in the lesser elevation of the eyes, broader and shorter frontal process, narrower cheek, tubercle on the nuchal lobe, and narrowed border at either side of the process.

It is realized that this allocation must be tentative until an entire individual is found. Hence both species are based on pygidial features to alleviate confusion concerning the identity of the holotype should this tentative allocation be incorrect.

Dalmanites mississippiensis Delo n. sp.

(Plate 3, figure 31)

Cephalon and thorax unknown. Pygidium distinctly triangular, very convex, with steep flanks and a border of uniform width. Although broken, the base of the terminal spine indicates that it was triangular, short, and acute. Rachis narrow, very long, composed of 17 to 18 annulations, gently tapering, and extends almost to the posterior margin. On casts the annulations show indications of a row of distinct tubercles; the test shows a row of tubercles and closely crowded granules.

There are 14 pairs of prominent ribs which are about the same width as the grooves and die out abruptly and evenly at the border. The anterior 11 are distinctly furrowed. Entire surface of ribs and border thickly granulated.

TYPES: Cotypes. Two small pygidia, one almost entirely exfoliated, the other complete. U. S. Nat. Mus. No. 79083.

OCCURRENCE: Devonian. (Helderbergian), Yellow Creek, Mississippi.

REMARKS: This differs from similar species in the distinctly larger number of annulations and ribs. It may be distinguished from *D. bisignatus* Clarke by the

distinctly furrowed ribs and nature of the rachial ornamentation; from *D. litchfieldensis* n. sp. in lack of tubercles on the ribs.

Dalmanites platycaudatus Weller, 1907

(Plate 3, figures 14, 15)

D. platycaudatus WELLER, 1907, Bull. Chicago Acad. Sci. Nat. Hist. Surv., vol. 4, pt. 2, p. 272, pl. 25, figs. 3-5.—WALTER, 1927, Iowa Geol. Surv., vol. 31, p. 279, pl 23, fig. 10.

Cephalon moderately convex, wider than long, with elongate genal spines which extend back to the fifth or sixth thoracic segment. Lateral border of moderate width, produced anteriorly into a short, flat, narrowly rounded process about half the width of the frontal lobe and twice as long as the border width. Glabella rather narrow, lateral furrows incomplete, nuchal lobe broad and elevated. Eyes of moderate size and rise about one-third their height above the glabellar surface. The thorax exhibits no features of specific importance.

Pygidial margins gently curved. Terminal spine very long, flattened, equaling more than half the total length, rather narrow at base; margins subparallel throughout most of its length. Rachis of moderate width, depressed convex, composed of nine broad annulations. There are six or seven furrowed ribs which are about the same width as the grooves and curve conspicuously near the border. No ornamentation visible.

TYPES: Cotypes. Cast of an entire individual with frontal process and much of thororachis broken. U. of C. No. 9877. Cast of complete pygidium. U. of C. No. 9878. Impression and plaster counterpart of almost complete cephalon. U. of C. No. 10752.

OCCURRENCE: Silurian. Niagaran limestone, near Lemont, Illinois.

REMARKS: This species differs from all others described from the Silurian of North America in the narrow glabella, long genal spines, and elongate, flattened terminal spine.

Dalmanites praenuntia Stewart, 1923

(Plate 3, figure 17)

D. praenuntia STEWART, 1923, Mo. Bur. Geol. and Mines, ser. 2, vol. 17, p. 267, pl. 71, fig. 19.

Cephalon and thorax unknown. Pygidium a truncated triangle, with almost straight lateral margins and a wide, broadly re-entrant terminus; border smooth. Rachis depressed convex, gently tapered, narrow, abrupt behind, does not reach the margin by its own posterior width, composed of 11 annulations and short nub which are covered with small tubercles and granules. There are 10 or 11 pairs of ribs, about the same width as the grooves, all completely furrowed; furrows are distinct but very narrow, extending the entire length of the rib, the anterior branch dying out at the inner edge of the border, and the posterior continuing almost to the margin. Surface granulose.

TYPE: Holotype. Cast of a complete pygidium. U. of C. No. 27536.

OCCURRENCE: Little Saline limestone (Devonian), Little Saline Creek, St. Genevieve County, Missouri.

REMARKS: This species is superficially similar to two species from the Devonian strata of New York State. Of these, *Odontochile emarginatus* differs in the larger number of rachial annulations, the less square-cut terminus, and prominent ornamentation. *Odontocephalus coronatus* may be distinguished by fewer rachial annulations,

greater relative width, and flat, unfurrowed ribs. There seems to be no other species in the Devonian strata of the central States which closely resembles *D. praenuntia*.

Dalmanites retusus Dunbar, 1918

(Plate 3, figure 21)

D. retusus DUNBAR, Am. Jour. Sci., 4th. ser., vol. 46, p. 743; 1919, Tenn. Geol. Surv., Bull. 21, p. 54, pl. 2, fig. 19 (no descr.); 1920, Trans. Conn. Acad. Arts and Sci., vol. 23, p. 149, pl. 5, fig. 3.

Cephalon and thorax unknown. Pygidium almost twice as wide as long, margin broadly rounded, without terminal spine. Rachis rather broad, depressed convex, tapers rapidly, composed of 11 discernible annulations and a short very low nub with the posterior end merging into the border. There are nine pairs of broad, rather flat, low, unfurrowed ribs, which curve very gently throughout most of their length, more abruptly in the distal quarter. They have long gentle anterior and short steep posterior flanks. Grooves narrow and shallow. Surface smooth.

TYPE: Holotype. A pygidium with test. Peabody Mus. No. 9676.

OCCURRENCE: Devonian. Birdsong shale (Linden formation), Swaynes Mill, Tennessee.

REMARKS: This species differs from most others in the nonspinose nature of the posterior margin. It differs from *D. aspinosus* Weller in the more broadly rounded posterior outline, the broad flat unfurrowed ribs, and narrow shallow grooves. The same differences hold good for *D. stewartae* n. sp. The posterior margin of *D. praenuntia* Stewart shows a very broadly curved re-entrant, and the ribs are all furrowed.

Dalmanites slocomi Stewart, 1923

(Plate 3, figure 33)

D. slocomi STEWART, 1923, Mo. Bur. Geol. and Mines, ser. 2, vol. 17, p. 266, pl. 71, fig. 20.

Cephalon and thorax unknown. Pygidial margins very gently curved, border of moderate width. Rachis low, composed of 14 annulations, the posterior two indistinct, and extends at least five-sixths the total pygidial length.

There are 11 or 12 pairs of broad, gently curved ribs which die out on the lateral border. The anterior eight are furrowed throughout their entire length.

Ornamentation consists of a central pair of distinct tubercles on each annulation and scattered coarse granules. The border is sparsely granulose.

Terminal spine broken flush with margin but apparently was short, acute, and upturned, the base rising as a subangular ridge from inner edge of the border.

TYPE: Holotype. A pygidial cast without terminal spine. U. of C. No. 27535.

OCCURRENCE: Devonian. Little Saline limestone, Little Saline Creek, Ste. Genevieve County, Missouri.

REMARKS: This species differs from other closely related ones in the very long, tuberculated rachis, and the distally furrowed ribs.

Dalmanites stewartae Delo n. sp.

(Plate 3, figures 19, 20)

D. cf. *aspinosus* STEWART, 1923, Mo. Bur. Geol. and Mines, ser. 2, vol. 17, p. 265, pl. 71, figs. 10, 11.

Cephalon and thorax unknown. Pygidium rather broadly rounded posteriorly, its width almost twice the length, with a continuous narrow border. No terminal spine. Rachis narrow, composed of nine to ten annulations, not abrupt terminally.

There are six or seven pairs of simple ribs which are narrower than the grooves, curve gently for most of their length, then abruptly at the border, merging with it.

TYPES: Cotypes. Two fragmentary pygidial casts. U. of C. No. 27541.

OCCURRENCE: Devonian. Little Saline limestone, Little Saline Creek, Ste. Genevieve County, Missouri.

REMARKS: This species is represented by two fragmentary pygidial casts, one of which shows a considerable portion of the rachis and one side of the terminal margin. It was compared previously to *D. aspinosus* Weller, and indeed is very close to the latter species. It differs, however, in the possession of a more rounded terminal outline, a smaller number of rachial annulations, and fewer ribs, which are simple and merge with the border. It differs from *D. retusus* Dunbar in possessing six to seven rather than nine ribs, which are narrow rather than wide and flat. *D. praenuntia* Stewart has a larger number of furrowed ribs and a truncated terminus.

Dalmanites taffi Ulrich and Delo n. sp.

(Plate 3, figure 27)

Cephalon and thorax unknown. Pygidium broadly triangular with uniformly curved lateral margins and a slender, acute, upturned terminal spine. Rachis narrow, of moderate length, composed of 15 annulations and a very short nub, not terminally abrupt, connected to terminal spine by a rather sharp, angular ridge. There are 13 pairs of ribs, the posterior pair incipient, all closely crowded and separated by very narrow grooves, only the anterior ribs showing a well-defined furrow. Surface minutely pebbled.

TYPE: Holotype. A pygidium with test in place, terminal spine broken. U. S. Nat. Mus. No. 79037.

OCCURRENCE: Devonian. About 100 feet below the top of Hunton formation (in Haragan formation), along west side of N. W. ¼, Sec. 21, T. 1 S., R. 8 E., Atoka Quadrangle, Oklahoma.

REMARKS: This species differs from *D. huntonensis* n. sp. in the uniformly curved lateral margins; the wider, shorter rachis which is not terminally abrupt; the more indistinctly furrowed ribs; the longer, higher ridge connecting the upturned spine and rachis; the narrow pleural grooves which make the ribs appear closely crowded. It differs from *D. carlwegi* in the narrower rachis with three more annulations, two more pairs of ribs.

Dalmanites? veiti Clarke, 1907

(Plate 4, figure 22; Plate 6, figure 7)

Dalmanites veiti CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 159, 4 figs.; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 43, 124, 4 figs. and pl. opp. p. 124.

Clarke's description (1908) is in part as follows:

"These pygidia are relatively small, subequally triangular, flattened above and rather abruptly sloping at the margins; apparently without tail spine. There are 11–12 lateral ribs, 6 or 7 of which are grooved medially. The axis bears 13–14 segments. The upper limb of each of the divided lateral ribs carries 2, 3, or 4 pustules so developed as to overhang the sulcus, while each segment of the axis bears a single row of 5, 6, or 7 pustules. The length of these shields will average 23 mm. with an anterior width of 29 mm.

The cephala belonging to these pygidia are not completely preserved but indicate a type of simple glabellar lobation as in *D. micrurus*, with closely pustulose surface. The border is smooth laterally but in front is expanded into a short crenulated snout or shelf as in *D. pleuroptyx* and *D. dolbeli*, though less expanded at the sides than in either of these."

TYPES: Holotype. A complete pygidium. N. Y. State Mus. No. 13399/1. Paratypes. One complete and one incomplete pygidium; a fragmentary cephalic margin. N. Y. State Mus. No. 13399/2, 13399/3.

OCCURRENCE: Devonian. Grande Greve limestone. From a loose block behind Peninsula, Gaspé Basin, Gaspé.

REMARKS: The uniform nature of the ornamentation and absence of a terminal spine differentiate this species. The frontal process also seems to be distinctive. Allocation to *Dalmanites* is tentative in the absence of well-preserved cephala.

Dalmanites verrucosus Hall, 1864

(Plate 4, figures 3-5)

Dalmanites verrucosus HALL, 1864, Trans. Albany Inst., vol. 4, p. 218.
Dalmania verrucosa HALL, 1879, N. Y. State Mus., 28th. Rept., p. 195, pl. 33, figs. 5–17; pl. 34, figs. 13–15.
Dalmanites verrucosus HALL, 1882, Ind. Dept. Geol. Nat. Hist., 11th. Rept., p. 341, pl. 35, figs. 5–17; pl. 36, figs. 13–15.—WELLER, 1907, Bull. Chicago Acad. Sci., Nat. Hist. Surv., vol. 4, pt. 2, p. 280, pl. 25, figs. 6, 7.

Cephalic width and axial length as 2 to 1. Genal spines of moderate length, taper rapidly, extend back to fourth or fifth thoracic segment. Border wide, indented just within the margin of frontal lobe, broadly rounded in front. Eyes of moderate size, extending about half their height above the glabellar surface. Entire surface with exception of border and genal spines, coarsely and thickly tuberculated. A few scattered tubercles on posterior border. Nuchal lobe bears a central posterior tuberculose spine and a row of smaller tubercles.

Each thororachial annulation bears a row of seven prominent tubercles; both branches of the pleura tuberculose.

Pygidium slightly wider than long with gently curved margins and a rounded slender spine equalling almost one-third the total length. Rachis of moderate width, composed of 12 to 13 annulations and continuing into the spine as a rounded, nonannulate ridge. Each annulation bears a row of seven prominent tubercles and occasional small scattered ones. There are nine pairs of prominently furrowed ribs, both branches of which are tuberculose. Border narrow.

TYPES: The location of the types is unknown.

OCCURRENCE: Silurian. Niagaran (Waldron shale, Indiana; Niagaran limestone, Illinois, Wisconsin, northern Indiana; St. Claire limestone, Arkansas).

REMARKS: This species is characterized especially by the conspicuous and widespread ornamentation, the large number of pygorachial annulations and pleural ribs, the slender rounded spine and continuation of the rachis into it. The narrowing of the border on either side of the frontal lobe is also of importance. No other Silurian species possesses this combination of features.

Dalmanites vigilans Hall, 1861

(Plate 3, figures 3-5)

Dalmanites vigilans HALL, 1861, Rept. Progress, Geol. Surv. Wis. for 1860, p. 51.
Dalmania vigilans HALL, 1862, Wis. Geol. Surv., vol. 1, p. 195, figs. a, b; 1867, N. Y. State Cab. Nat. Hist., 20th. Rept., p. 335, figs. 1, 2; p. 375, pl. 21, figs. 16–18.
Dalmanites (Synphoria) vigilans KINDLE, 1904, Ind. Dept. Geol. Nat. Res., 28th. Ann. Rept., p. 485, pl. 23, figs. 4?, 7 (not 5, 6); pl. 24, fig. 20.
D. vigilans WELLER, 1907, Chicago Acad. Sci., Nat. Hist. Surv., vol. 4, pt. 2, p. 276, pl. 24, figs. 1–4.

Cephalon moderately convex with slender genal spines and a smooth border. Frontal process equals about half the width of frontal lobe at base, tapers rapidly for short distance, then very gradually; is upturned, rounded; total length at least

half that of frontal lobe, which is as wide as long and somewhat extended in front. Eyes with basal groove, highly elevated, base of visual area level with glabellar surface; postvisual area negligible. Cheek area steeply sloping. Ornamentation not visible. Thorax unknown.

Pygidium triangular, somewhat convex, border of moderate width; terminal spine triangular, acute, equalling about one-fourth the total length. Rachis terminally abrupt, composed of nine to ten annulations; cross grooves deeper distally. There are seven to eight pairs of prominently furrowed ribs. Ornamentation not visible.

TYPES: Hall's types cannot be found. Type material used by Weller (1907) includes cephalic and pygidial casts. U. of C. No. 9879.

OCCURRENCE: Silurian. Niagaran limestone, Wisconsin, northern Illinois, and northern Indiana. Weller's types from near Lemont, Illinois. Hall's types from Wauwautosa and Waukesha, Wisconsin.

REMARKS: This distinctive species is characterized by the highly elevated eyes and the elongate and upturned frontal process. It differs from *D. halli* in these particulars, in the shorter terminal spine, and straighter pygidial margins.

D. vigilans differs from *D. howelli* n. sp. in the highly elevated eyes and elongate frontal process. Pygidial differences are less distinctive, but the terminal spine of *D. bassleri* n. sp. is relatively longer, the margins more distinctly sigmoid; the rachis in *D. howelli* contains two to three more annulations and two to three more ribs.

Dalmanites werthneri Foerste, 1885

(Plate 4, figures 13, 14)

D. werthneri FOERSTE, 1885, Bull. Sci. Lab. Denison Univ., vol. 1, p. 116, 117; 1887, vol. 2, p. 101, pl. 8, figs. 22–25; 1895, Ohio Geol. Surv., vol. 7, p. 530, pl. 27, figs. 22, 22a, 23–25.

Cephalon normal for the genus, moderately convex, with rather short, slender genal spines. Border very wide, produced anteriorly into a very short rounded process no longer than half the border width and equalling about one-fourth the width of the frontal lobe. Eyes short, rise well above glabellar level. Nuchal lobe elevated, smooth; marginal furrows join at genal angle. Surface of glabella moderately tuberculate, smooth without test; cheeks granulated; border smooth.

Thororachis rather broad; otherwise thorax shows no features of specific value.

Pygidium a rounded triangle with a very broad flat border; terminal spine represented only by a node on the margin. Rachis long, extending to the border, composed of nine or ten annulations and a terminal nonannulated portion. There are six or seven furrowed, asymmetrical ribs which merge distally with the inner edge of the border. Surface irregularly pebbled; casts smooth.

TYPES: Cotypes. Several incomplete cephala and separated pygidia. U. S. Nat. Mus. No. 84799.

OCCURRENCE: Silurian. Brassfield formation, Soldiers Home Quarry, Dayton, Ohio.

REMARKS: This species is notable because of the very wide cephalic border, very short and rather narrow anterior process, and rather short, slender, genal spines. The cephalon of no other species shows this assemblage of features. The pygidium likewise is distinctive because of the very wide border and the incipient terminal spine. The rachis is proportionally larger than normal in the Silurian species of *Dalmanites*.

The original description of this species lists 13 rachial annulations, but after careful examination of several specimens the writer found it necessary to revise this estimate. Likewise there are only six or seven distinct ribs, and the original estimate must therefore be changed.

Genus *Dalmanitina* Reed, 1905

Dalmania (pars) and *Dalmanites* (pars) BARRANDE, 1852; *Dalmanitina* REED, 1905; *Dalmanitina* (pars) MCLEARN, 1918, 1924; *Dalmanitina* R. AND E. RICHTER, 1927.

GENOTYPE: *Dalmania socialis* Barrande, *Dalmanites socialis* Barrande 1852 (p. 552, pl. 26, figs. 1–25). *Dalmanitina socialis* Reed, 1905 (p. 7).

GENERIC DIAGNOSIS: Frontal lobe not strongly detached; frontal border absent; hypostoma short, rounded, or subquadrate; less than 11 pygorachial annulations.

OCCURRENCE: Ordovician, Silurian.

DISTRIBUTION: Europe, North America.

REMARKS: *Dalmanitina* was originally defined by Reed to include a series of rather primitive dalmanitids from older strata in western Europe. Subsequently the genus was discussed incidentally by the Richters, who implied that it is restricted to strata of Ordovician age. This assumption was also supported by the writer in 1935 and appears to be valid for the European species. In North America, however, the genus appears to include at least two species of Silurian age (*D. arkansana* and *D. weaveri*). The hypostoma of neither of these is known, and this important structure must be found before allocation can be quite definite.

Dalmanitina weaveri (Salter, 1865)

(Plate 4, figures 7–10)

Phacops sp. SALTER, 1849, Decades Geol. Surv., 2, art. 1, p. 7, fig. 16.

Phacops weaveri SALTER (part) 1865, Mon. Brit. Tril., Pal. Soc., p. 57, pl. 3, figs. 1–3; pl. 4, figs. 6, 7 (not p. 57, fig. 15; pl. 4, figs. 8, 9).

Dalmanitina weaveri REED, 1909, Geol. Mag. London, dec. 5, vol. 6, p. 69–73.

Dalmanites weaveri MCLEARN, 1924, Geol. Surv. Canada, Mem. 137, p. 169, pl. 27, figs. 7–10.

Cephalic width about twice the axial length; no genal spines, border very narrow. Frontal lobe relatively wide; first lateral lobes much expanded distally; second and third equilateral; lateral furrows straight. Thorax unknown.

Pygidium rather convex, margins uniformly curved, border narrow, terminal spine absent. Rachis of moderate width, composed of 10 broad, distinct annulations, separated by narrow grooves and a nonannulated terminus which extends to the inner edge of the border. There are eight pairs of broad unfurrowed ribs which widen distally, are separated by narrow grooves, and merge with the border. No distinctive ornamentation.

TYPES: Plesiotypes. Casts of pygidia and incomplete cephala. Peabody Mus. No. 473–473c.

OCCURRENCE: Silurian. Ross Brook formation (zones c and d), Arisaig, Nova Scotia.

REMARKS: This species is found only in Nova Scotia and is closely related to similar types in the Silurian of the British Isles. It was first figured by Salter but was imperfectly known until 1909 when Reed examined and described the species in detail. He points out that the pygidial rachis consists of eight distinct annulations and four to seven indistinct ones, but the specimens examined by the writer did not show this feature.

D. arkansana (Van Ingen) has a more convex pygidium with narrower ribs and annulations. The cephalon is relatively narrower, and genal spines are present. No other Silurian species may be readily confused with these.

Dalmanitina arkansana (Van Ingen, 1901)

(Plate 4, figures 1, 2)

Dalmanites (Synphoria) arkansanus VAN INGEN, 1901, School of Mines Quart., vol. 23, p. 69, figs. 20–22; pl. 1, figs. 33–37.

Dalmanites arkansanus WELLER, 1907, Chicago Acad. Sci., Nat. Hist. Surv., vol. 4, pt. 2, p. 278, pl. 24, fig. 5.

Cephalon rather narrowly pointed in front, frontal lobe more or less rhomboidal. Genal spines short, slender. Frontal border absent, lateral border steeply sloping. First glabellar furrows oblique; second straighter, inclined slightly backward distally; third concave anteriorly, curving distally; nuchal furrow gently convex anteriorly. Nuchal lobe elevated. Eyes rise to glabellar level or slightly above. Surface very minutely pebbled. Thorax unknown. Pygidium triangular, convex, with gently curved sides, no terminal spine. Rachis prominent, of moderate width, reaching to terminus, composed of eight or nine annulations and a very short tapering terminus. There are seven or eight furrowed ribs, the branches of equal height, the posterior the broader; they die out against the border. Entire surface minutely pebbled.

TYPES: Cotypes. Two cephala and a pygidium. Princeton Univ. No. 49534–49536. This discussion based in part on exfoliated cephala and pygidia. U. S. Nat. Mus. No. 79149.

OCCURRENCE: Silurian. St. Claire limestone near Batesville, Arkansas.

REMARKS: This species illustrates the general type of structure shown by *Dalmanitina socialis* (Barrande) from the Bohemian Basin, although the latter has a terminal spine. The genus seems to be confined to strata of Ordovician age in Europe and in North America is found only in the Silurian.

Conspecific or very closely related forms appear in Middle Silurian strata in the Lake Michigan area and have been discussed and figured by Weller (1907). Several specimens in the collections of the United States National Museum also appear to be very closely related. These include a glabella and fragmentary pygidium from the Clinton at Armuchee, Georgia (No. 79148), and a fragmentary cephalon from the Osgood shale, Osgood, Indiana.

D. weaveri (Salter) from the Ross Brook formation of Nova Scotia differs in the relatively longer rachis, narrower grooves and wider ribs, absence of genal spines and proportions of the cephalon.

Genus *Odontochile* Hawle and Corda, 1847

Dalmannia EMMRICH, 1844 (pars); *Dalmania* EMMRICH, 1845 (pars); *Dalmania* and *Dalmanites* BARRANDE, 1852 (pars); *Hausmannia* HALL AND CLARKE, 1888 (pars); *Odontochile* HAWLE AND CORDA, 1847, R. AND E. RICHTER, 1931.

GENOTYPE: *Asaphus hausmanni* Brongniart, 1822 (p. 21, pl. 2, figs. 3a, b.). *Odontochile applanata* Hawle and Corda, 1847 (p. 93). *Dalmanites hausmanni* Barrande, 1852 (p. 528, pl. 23, fig. 20; pl. 24, figs. 1–12). *Odontochile hausmanni* R. and E. Richter, 1931 (p. 140).

GENERIC DIAGNOSIS: Dalmanitinae with an elongate, denticulate hypostoma, genal spines, 16 to 22 pygorachial annulations, and broad pygidial doublure.

OCCURRENCE: Devonian.

DISTRIBUTION: Europe, North and South America.

REMARKS: The name *Odontochile*, first proposed by Hawle and Corda (1847, p. 92–93), was later placed in the synonymy of *Dalmanites* by Barrande (1852, p. 536) because he thought it preoccupied by *Odontocheila* Laporte (*Coleoptera*). Reed subsequently followed his example and considered it as congeneric with *Dalmanites*.

Hall and Clarke (1888, p. xxxi) also thought *Odontochile* was preoccupied and substituted the name *Hausmannia* for species which would fall normally within the genus. However the Richters have pointed out that *Odontochile* is not preoccupied by *Odontocheila* Laporte, citing Article 35, International Rules of Zoological Nomenclature to support their contention, with which the present writer is in agreement. Hence *Hausmannia* is invalid.

Although the limits of *Odontochile* are rather distinct in Europe, the dalmanitid species in North America present no clear-cut dichotomy. Whereas in Europe *Dalmanites* does not occur in strata of Devonian age, in North America both genera occur side by side and with such transition that generic differentiation is rather difficult, especially in species which are incompletely known. In allocating species to *Odontochile*, the factors of large size and large number of pygidial segments have been used.

From the evolutionary standpoint, *Odontochile* represents the culmination of development in the conservative dalmanitid sequence *Dalmanitina* (Ordovician-Silurian), *Dalmanites* (Silurian-Lower Devonian), *Odontochile* (Devonian). It occurs in no strata younger than the Onondagan, and the great majority of the North American species are older.

Odontochile acuminatus Ulrich and Delo n. sp.

(Plate 5, figures 9, 10)

Cephalon characteristic for the genus. Anterior margin not seen. Genal spines slender. Ornamentation inconspicuous. Thorax unknown.

Pygidium with gently and uniformly curved lateral margins; width and length, including terminal spine, are equal; border narrow. Rachis narrow, elongate, moderately convex, composed of 18 annulations and a very short terminus, merging backward into the spine. There are 15 angular closely crowded ribs, the pleural grooves (with test in place) in no case as wide as the ribs, but on casts are about the same width. The rather narrow continuous border does not widen at the terminal spine, which is slender, pointed, as wide as the posterior end of the rachis at the base, and equals one-fourth the total pygidial length as measured from the rachial terminus. Surface apparently smooth, but this may be due to weathering.

TYPES: Holotype, a complete pygidium with spine and part of test, on a slab of cherty limestone. On the same slab is a mold of a glabella which obviously belongs to this species. U. S. Nat. Mus. No. 99225. Paratypes, a complete pygidial cast on a limestone slab. Hurd. Mus., Knox College, No. 201. Left half of a pygidium with spine. U. S. Nat. Mus. No. 79048.

OCCURRENCE: Devonian. Helderbergian limestone, Tishomingo County, Mississippi. Paratype (U. S. Nat. Mus. No. 79048), from S. W. corner, Sec. 16, T. 1 S., R. 8 W., Atoka Quadrangle, Oklahoma.

REMARKS: This species is superficially very similar to *D. micrurus*, but the spine is much more slender, there are two more ribs, and the pygidium is proportionally narrower. It is very closely related to *O. lindenensis* from the Birdsong shale of Tennessee but is definitely larger, there is one more rachial annulation and one more rib, the pleural grooves are narrower, and the ribs distinctly straighter.

Odontochile berkleyensis (Swartz, 1913)

(Plate 5, figure 12)

Dalmanites berkleyensis SWARTZ, OHERN, AND MAYNARD, 1913, Md. Geol. Surv., Lower Devonian, p. 512, pl. 94 (all figs.).

Cephalon and thorax unknown.

Pygidium very large, broadly triangular, rounded behind with very broad border.

Rachis very narrow, composed of 16 or 17 annulations and a terminus which reaches the inner edge of the border. There are 14 to 15 broad, unfurrowed ribs, which are rather flat anteriorly, somewhat narrower and more angular posteriorly, and curve very gently. They are at least twice as wide as the grooves and die out on the border. An occasional large node makes it appear that there may have been large tubercles scattered sparingly over the surface, but this cannot be proven because of poor preservation.

TYPE: Holotype. Cast of pygidium in white find sandstone. Maryland Geological Survey collections. Uncatalogued.

OCCURRENCE: Devonian. Ridgely member, Oriskany formation, Berkeley Springs, West Virginia.

REMARKS: This species most nearly resembles *O. ulrichi* n. sp. from the Devonian of Nevada, but in the latter the rachis is relatively wider, and the surface is smooth. There are no other species which resemble these.

Odontochile dunbari Delo n. sp.

(Plate 5, figure 7)

Dalmanites sp. STEWART, 1923, Mo. Bur. Geol. and Mines, 2d ser., vol. 17, pl. 55, fig. 7; pl. 56, fig. 1.

Cephalon and thorax unknown.

Pygidium large, terminus broken, width to length about 7 to 5; rachis of moderate width, long, composed of 18 annulations, the last one indistinct, extending to inner edge of narrow border. Anterior nine or ten cross grooves bend forward mesally. Each annulation bears a mesal cluster of granules and more scattered ones on the posterior edges of the flanks. There are 12 distinct and one incipient pairs of ribs which continue to the border with only a slight distal curve, the posterior ones straight. They are asymmetrical, broad, widen somewhat distally, the anterior eight pairs lightly furrowed. The crest of each rib is granulated for its entire length.

TYPE: Holotype. An incomplete pygidium and counterpart, with terminus and almost the entire border missing but retaining the test. Peabody Mus. No. 15236.

OCCURRENCE: Devonian. Bailey limestone, Little Saline Creek, Ste. Genevieve County, Missouri.

REMARKS: This species is most closely related to *O. purduei* from the Linden formation of Tenessee. But *O. purduei* has 21 annulations and 16 ribs, whereas this species has 18 annulations and no more than 13 ribs. *O. dunbari* is relatively wider, smaller, more of the ribs are furrowed, and the rachis is relatively somewhat broader. There is no other species with which it might be easily confused except *O. micrurus* from the New York region. But the latter species has narrower ribs, only the anterior ones being furrowed, less distinct ornamentation, a shorter rachis with one or two less annulations and more narrowly curved posterior margins.

Odontochile? emarginatus (Hall, 1876)

(Plate 4, figure 23)

Dalmanites emarginatus HALL, 1876, Illust. Dev. Foss., pl. 10, fig. 2.

D. (Coronura?) emarginatus HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 40, pl. 11a, figs. 7–8.

D. emarginatus CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 127, pl. 7, figs. 2, 3.

Only pygidia of this species are known. They are broad, flat, with a moderately broad, regularly tapering rachis composed of 17 annulations, and a short nonannulated terminus. There are 14 furrowed ribs, the posterior branch usually the

larger. Pygidial extremity re-entrant in a smooth curve which reaches the end of the rachis. Ornamentation consists of sharp tubercles on all rachial annulations and both branches of ribs; the larger ones are usually on the posterior branch and are about twice as large as the smaller.

TYPES: Holotype. A fragmental pygidium. N. Y. State Mus. No. 13377/1. Plesiotype. An almost complete pygidium. N. Y. State Mus. No. 13377/4.

OCCURRENCE: Devonian. (Schoharie grit) Schoharie, New York; Grande Greve limestone (cherty beds, division 2) Grande Greve to Little Gaspé, Gaspé, Province of Quebec.

REMARKS: This may be distinguished from other nonspinose species found in strata of Devonian age, by larger size, prominent ornamentation, and the smoothly curved re-entrant terminus. Fragmental pygidia with the terminus missing may be confused with *O. phacoptyx*, but in the latter both rib branches are usually the same size, most of the tubercles are on the anterior branches, and some spines at least five times as large as the small tubercles are present. The same features distinguish it from *O. townsendae*.

O. ? emarginatus was described originally from fragmental pygidia, but complete pygidia were found subsequently by Clarke in the Gaspé region. Both forms are apparently conspecific, although slight differences may appear when more complete material is available for study.

Odontochile keyserensis (Swartz, 1913)

(Plate 4, figures 17–19)

Dalmanites keyserensis SWARTZ, OHERN, AND MAYNARD, 1913, Md. Geol. Surv., Lower Devonian, p. 499, pl. 91, figs. 8, 9.

Cephalic border flat, entire; appears to have been wider in front than laterally, but this may be due to lateral crushing. Eyes very large, highly elevated; cheek area small. Genal spines long, slender, pointed. Surface granulose. Thorax unknown.

The fragmental pygidium shows four annulations and portions of three ribs which apparently were angular, with steeper posterior slope, unfurrowed, and about as wide as the grooves. No ornamentation discernible.

TYPES: Cotypes. Cast of a distorted cephalon and cast of anterior portion of a pygidium, in dark shale. Collections of Maryland Geological Survey. Uncatalogued.

OCCURRENCE: Devonian. Keyser member (Helderbergian), Tonolaway, Maryland.

REMARKS: Although described as a distinct species, no features definitely set this apart from *O. micrurus*. The distortion of both the cephalon and pygidium and poor preservation of both preclude exact description.

Odontochile lindenensis Delo n. sp.

(Plate 4, figure 26)

Cephalon and thorax unknown. Pygidium triangular, convexity moderate, width and length subequal; lateral margins gently curved; border narrow. Rachis low, narrow, gently tapering, with distally deeper cross grooves; composed of 16 to 17 annulations (the posterior two indistinct) and a low terminus which continues as a low rounded ridge into the short, rounded, slightly upturned, acute terminal spine. There are 14 to 15 angular ribs, the anterior nine to ten lightly furrowed, furrows indistinct on casts. Anterior ribs gently curved, median ones somewhat sigmoid, posterior ones straight. They end rather abruptly at the border.

Ornamentation consists of small granules on each of the rachial annulations, the crest of each rib, and the border. This is so fine that it is easily removed by weathering.

TYPE: Holotype. An almost complete pygidium, with end of spine broken. Peabody Mus. No. 15236.

OCCURRENCE: Devonian. Linden formation, (Birdsong shale), Pace, Tennessee.

REMARKS: This species illustrates the generalized type of dalmanitid so characteristic of the Helderbergian. It bears a close resemblance to *O. acuminatus* n. sp. but differs in smaller size, the annulations are about two less in number, the ribs are more distinctly curved and sigmoid. There is no other species which it resembles closely enough to cause confusion.

Odontochile micrurus (Green, 1832)

(Plate 5, figures 1, 2)

Asaphus micrurus GREEN, 1832, Mon. Tril. N. Am., p. 56, cast 19, fig. 3.
Dalmania micrurus, HALL, 1861, Pal. N. Y., vol. 3, p. 359, pl. 74, figs. 13–20.
Dalmania pleuroptyx, HALL, 1861, Pal. N. Y., vol. 3, p. 356, pl. 74, figs. 1–12 5?, 9?).

Cephalon moderately convex, width and length more or less equal, genal spines of moderate length. Border wide, uniformly curved. Entire surface covered by small tubercles.

Thorax shows no features of specific importance. Entire surface lightly pebbled.

Pygidial width and length essentially equal, lateral margins curved only slightly, not sinuous; border rather narrow; terminal spine short, sharply pointed, triangular, length from rachial terminus about one-eighth total length. Rachis depressed convex, rather narrow, long, composed of 17 annulations and a short terminus. There are 13 to 14 pairs of asymmetric, moderately curved ribs, the anterior ones faintly furrowed. Rachis and ribs granulated.

TYPES: Holotype. An incomplete pygidial cast. N. Y. State Mus. No. 13385/1. Other type material, N. Y. State Mus. Nos. 13385/2 to 13385/10; much of it is not conspecific with the holotype.

OCCURRENCE: Devonian. Coeymans limestone, New York region. The type occurrence was given merely as "Helderberg; the Helderbergs, New York." Much of Hall and Clarke's New York material comes from Schoharie, New York.

REMARKS: There has been much confusion in the literature concerning the true identity of this species. As in other instances where a well-known species has a generalized pattern, writers have failed to discriminate sharply between it and similar but distinct forms of the same type. The confusion has been intensified by lack of adequate figures of the holotype, as most workers have had no opportunity to examine Green's casts. James Hall also referred several rather typical examples of the species to *D. pleuroptyx* (Pal. N. Y., vol. 3, pl. 74, figs. 1–4, 6–8, 10–12), and, although he later rectified this error (1888, p. 29), the true nature of the species has not been established adequately. Hence lists of species which cite *D. micrurus* have extended its stratigraphic and geographic distributions to the point where examination of the actual specimens involved becomes a necessity. It is to be emphasized here that *O. micrurus* in all probability is restricted to the area of the Helderbergian seaway which covered western New York and adjacent areas. The forms referred to it from Maine, Gaspé, and other areas are all distinct. Faulty allocation has been caused partially by dependence on cephalic characteristics, whereas these are secondary to those of the pygidium.

In summary, *O. micrurus* is characterized by genal spines of moderate length,

a cephalon ornamented by small tubercles only, a long pygorachis composed of about 17 annulations; 13 or 14 asymmetrical ribs, the anterior ones faintly furrowed; a very short triangular spine.

Both the pygidium and cephalon differ markedly from "*D.*" *pleuroptyx*. That of *micrurus* is relatively narrower and longer, and the frontal border is smoothly rounded rather than crenulated. The pygorachis is relatively much longer, with two or three more annulations, the terminal spine shorter and more triangular, the ribs higher, and much more indistinctly furrowed.

Of the large species of *Odontochile*, *O. micrurus* resembles several superficially but differs from all in important characteristics. It may be differentiated from *O. purduei* by smaller size, two or three fewer rachial annulations, presence of a terminal spine; from *O. ulrichi* n. sp. in smaller size, angular rather than rounded ribs, relatively greater length, and more gently curved margins; from *O. percéensis* in a shorter spine, straighter margins, lack of tubercular ornamentation. It also differs from the "*D. micrurus*" figured by Clarke from Gaspé (1908, pl. 8, figs. 1, 2). The differences will be summarized under the description of these forms.

Odontochile micrurus var. *clarkei*, Delo n. var.

(Plate 5, figure 3),

Dalmanites micrurus CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 120, pl. 9, figs. 1, 3; ? pl. 8, figs. 10, 12.

Cephalon moderately convex, with sharp genal spines of moderate length and a broad, smooth border. Eyes large, extending from the first to the third lateral furrows. Entire cranidial surface tuberculate; cheeks pitted. Thorax unknown.

Pygidia which appear to belong with the cephala described above are distinctly triangular with almost straight margins. Rachis consists of 12 or 13 annulations; ribs are distinctly furrowed, number nine or ten. There is no distinct terminal spine. Surface granulose.

TYPES: Cotypes. Two almost complete cephala. N. Y. State Mus. Nos. 13385/5 and 13385/9. Paratypes. Two pygidia, one with test.

OCCURRENCE: Devonian. Grande Greve limestone (division 2), Lehuquet's Cove, Grande Greve, Gaspé.

REMARKS: This variety was originally referred to *D. micrurus* by Clarke, and a typical cephalon figured with the type cephala to show the resemblance between them (N. Y. State Mus., Mem. 9, pt. 1, pl. 9, fig. 2). There is, however, a visible difference in the curve of the frontal margin, that of the Gaspé specimens describing a broader curve. The principal difference lies in the size of the eyes, those of the Gaspé specimens being about one-third longer than in the typical New York species. This feature is sufficient for varietal differentiation.

If the pygidia which occur with the cephala are parts of the same individuals, differences between the Gaspé and New York forms are further accentuated. The lack of a terminal spine, smaller size, distinctly furrowed ribs, which number two less, and three or four fewer rachial annulations, are distinctive. There is no other species in this region with which this variety may easily be confused.

Odontochile percéensis (Clarke, 1905)

(Plate 5, figures 5, 6; Plate 6, figure 7)

D. (*Probolium*) *percéensis* CLARKE, 1905, N. Y. State Mus., 57th Rept. (for 1903), p. 143, 149.

D. percéensis CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 157, 2 figures; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 69, 126, pl. 4, figs. 1–3; pl. 5, fig. 2.

Glabella without conspicuous features, except size, which may differentiate it specifically. Surface covered with small tubercles; scattered larger ones on the frontal lobes. Thorax unknown.

Pygidium somewhat broader than long, with curving lateral margins and a rather narrow border. Rachis of moderate width, tapers gradually, reaches almost to base of terminal spine, and is composed of 18 to 19 annulations. Terminal spine short, triangular; the distance from its terminus to the posterior end of the rachis equals one-fourth the total length. There are 15 pairs of furrowed, rounded ribs which curve backward abruptly near the margin.

Fine granulation covers the entire pygidial surface. Occasional large nodes occupy the entire surface of the ribs; other smaller ones are restricted to the posterior branch. Some of the rachial annulations bear a central pair of large, low nodes, but weathering has so damaged them on the types that the writer is unable to state definitely which annulations are without them.

TYPES: Cotypes. An exfoliated glabella. N. Y. State Mus. No. 13388e/1. A fragmentary, exfoliated glabella with part of right palpebral lobe. N. Y. State Mus. No. 13388e/2. An incomplete, exfoliated pygidium, N. Y. State Mus. No. 13388e/3.

OCCURRENCE: Devonian. Grande Greve limestone, Percé Rock, Gaspé.

REMARKS: The very large size of *O. percéensis* distinguishes it from most other species of the genus. It may be compared only with *O. berkleyensis* which has unfurrowed ribs and is relatively much wider; with *O. purduei* which lacks nodal ornamentation and a terminal spine; and with *O. ulrichi* n. sp. which is proportionately wider and also lacks nodal ornamentation.

It is worthy of mention that Clarke's figures are somewhat restored. For example, the specimen figured in Plate 5, figure 2 (1908) shows 20 annulations, but actually the end of the rachis is so weathered that only 17 are distinct. No specimen seen showed more than 19 distinct annulations plus a short nub.

Odontochile phacoptyx (Hall and Clarke, 1888)

(Plate 4, figure 21)

Dalmanites (Hausmannia) phacoptyx HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 31, pl. 11a, figs. 23–26.

Dalmanites phacoptyx CLARKE, 1900, N. Y. State Mus., Mem. 3, p. 19, pl. 2, fig. 10.

Cephalon and thorax unknown. Pygidium triangular, lateral margin gently curved. Rachis narrow, with 16 annulations. There are 13 prominently furrowed ribs. Terminal spine rounded, rather slender, equalling about one-fourth the entire pygidial length. Surface covered with spinose tubercles, more closely spaced on the rachis, tubercles of two sizes on the ribs, the smaller more abundant, the larger entirely obstructing the furrows. They are more numerous on the anterior branches. Remainder of the surface pebbled.

TYPES: Cotypes. Wax cast of a fragmental pygidium with terminal spine. N. Y. State Mus. No. 13389/1. Cast of left side of pygidium. N. Y. State Mus. No. 13389/2.

OCCURRENCE: Devonian. Lower Onondagan (Decewville), North Cayuga, Ontario (types). Oriskany, Becraft Mountain, New York.

REMARKS: This species may not be confused easily with others in the New York region. Fragmental pygidia may be differentiated from *O.* ? *emarginatus* by the much greater variation in size of the tubercles and the coarser ribs. *S. multiannulatus* is much larger and lacks a terminal spine. *O. townsendae* from the Grande Greve limestone of Gaspé has the large tubercles systematically arranged on both rachis and ribs and bears no tubercles on the posterior rib branches.

O. phacoptyx differs from the var. *gaspensis* n. var. in two to four fewer annulations, one to two fewer ribs, smaller size, and less regular ornamentation.

Odontochile phacoptyx var. *gaspensis* Delo, n. var.

(Plate 5, figure 11)

Dalmanites phacoptyx CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 123–124, pl. 7, figs. 5–7, 10 (8?, 9?); text plate opp. p. 124, text fig. p. 123.

Fragmentary cephala of this variety are heavily tuberculate throughout with a pair of spinose tubercles symmetrically located on the frontal lobe and a single central one on the nuchal lobe. Border smooth, uniform; eyes large, with basal furrow; sutures in grooves. Genal spines broad, flat, with spinose tubercles along their inner edge, length unknown. Thorax unknown.

Pygidium triangular, margins gently curved; rachis narrow, long, depressed convex, consisting of 18 or 19 annulations. There are 14 to 15 ribs, all but the posterior four or five pairs deeply furrowed. They curve only slightly. Terminal spine rather slender, equalling about one-fourth the total pygidial length.

Ornamentation consists of an alternating double row of small tubercles on each annulation, scattered large tubercles covering the entire surface of the ribs, and abundant small tubercles which are more numerous on the anterior branches.

TYPES: Cotypes. Several pygidial and fragmentary cephalic casts on a slab of limestone. N. Y. State Mus. No. 13389/8.

OCCURRENCE: Devonian. Grande Greve limestone, Grande Greve, Lehuquet's Cove, Gaspé.

REMARKS: This large and profusely ornamented variety has been referred previously to *O. phacoptyx* of the New York region. It is very close to this species and superficially resembles *S. multiannulatus* from the Oriskany of Maryland.

It differs from *O. phacoptyx s. s.* in the larger number of rachial annulations (18 or 19 instead of 16), larger number of ribs (14 or 15 instead of 12 or 13), which are narrow, more regular ornamentation of the rachis, and much larger size. As the cephalon of *O. phacoptyx* is unknown, cephalic comparisons cannot be given.

It differs from *S. multiannulatus* in the smoothly curved frontal border, less sharply tapering genal spines, straight posterior ribs, and presence of a terminal spine. The ornamentation is very similar.

O. townsendae is much smaller, the spine more slender, has fewer ribs and annulations, and the ornamentation is regular.

Odontochile ploratus (Clarke, 1907)

(Plate 5, figure 8)

D. ploratus CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 162, 1 fig.; 1909, N. Y. State Mus., Mem. 9, pt. 2, p. 66, pl. 12, fig. 5.

The species is based on a single fragmentary pygidium. It is about as wide as long with gently curved lateral margins. The rachis is narrow, composed of 22 annulations, and extends almost to the terminus which is so poorly preserved that the former presence or absence of a terminal spine cannot be proven. Each annulation bears a central pair of widely spaced, rather prominent tubercles and a single smaller tubercle on either flank.

There are 15 pairs of furrowed slender ribs with scattered small tubercles on both branches.

TYPE: Holotype. Pygidial impression. Description based on this and its plastotype. N. Y. State Mus. No. 13390e/1.

OCCURRENCE: Devonian. Moose River sandstone, Cunningham's Camp, 4 miles below Matagamon Lake, Maine.

REMARKS: This species differs from *D. bisignatus* and its near relatives in the much greater number of rachial annulations and ribs, and nature of the ornamentation; from *O. phacoptyx* in the greater number of annulations and regular arrangement of the ornamentation; from *O. emarginatus* in the pointed terminus.

Odontochile pratteni (Roy, 1933)

(Plate 6, figures 2–4)

Dalmanites pratteni ROY, 1933, Field Mus. Nat. Hist., Geol. Ser., vol. 6, p. 67–82, 4 text figs.

Cephalon convex with a very narrow border; genal angles broken, but it appears that short spines may have been present. Frontal lobe rhomboidal, rather pointed in front; nuchal lobe broken. Eyes subconical, very high, with a deep basal groove, about two-thirds their height extending above the glabellar surface. Cheeks rather narrow with a very steep, convex slope.

Thorax coarsely tuberculated.

Pygidium distinctly triangular, with very gently curving lateral margins and a narrow border. Rachis very narrow, consists of 23 annulations, and is separated from the base of the erect terminal spine by a narrow sulcus. There are 19 to 20 rather narrow, high, furrowed ribs which average slightly wider than the grooves.

Entire individual covered with rather coarse tuberculation. The pygorachis also bears scattered small spinules, and both branches of each rib bear a row of tubercles.

TYPE: Holotype. An enrolled cast in chert. Field Mus. No. P16704.

OCCURRENCE: Devonian. (Middle Devonian?). Devil's Backbone near Grande Tower, Jackson County, Illinois.

REMARKS: This species is unique in the possession of a rhomb-shaped frontal lobe, the very large eyes, great number of pygidial annulations and ribs, and erect terminal spine. In the original description (Roy, 1933, p. 730) it is noted that each eye consists of not less than 770 lenses, the largest number known to occur among the Dalmanitidae.

There is no other North American species with which the species may be confused. Pygidia without the characteristic terminus would be distinguished by the abnormally narrow rachis, the great number of annulations, and the closely crowded ribs. For detailed comparison, consult the original reference cited above.

There has been some doubt as to the proper generic allocation of this species. It is not typical of *Odontochile* as represented by *O. percéensis* or *O. purduei*, yet the glabellar lobation is more characteristic of *Odontochile* than of any other genus. *O. pratteni* may be considered as a somewhat aberrant member of the genus.

Odontochile purduei (Dunbar, 1919)

(Plate 6, figure 1)

Dalmanites purduei DUNBAR, 1919, Tenn. State Geol. Surv. Bull. 21, p. 54; 1920, Trans. Conn. Acad. Arts and Sci., vol. 23, p. 148, pl. 5, figs. 1, 2.

The species is based on a very large pygidial cast with almost the entire border broken back to the inner edge of the doublure. No apparent trace of a terminal spine. Outline distinctly triangular with gently curved lateral margins, the width only slightly greater than the length. Rachis very long, extending to border, narrow, tapering slightly, composed of 21 annulations. There are 16 pairs of ribs, the anterior ones showing traces of fine furrows; anterior eight to nine ribs gently curved,

with steep posterior slope, sharp crested and almost straight. All about equal to grooves in width. No ornamentation apparent.

TYPE: Holotype. A pygidial cast. Peabody Mus. No. 9710.

OCCURRENCE: Devonian. Ross limestone, 3 miles east of Cerro Gordo, Tennessee.

REMARKS: A fragmentary cephalic cast from the Ross limestone at Olive Hill, Tennessee (Peabody Mus. No. 9711) is probably conspecific with the pygidium described above. The glabella is smooth, the eyes of moderate height, the sutures in grooves. There are genal spines of moderate length and a broad frontal extension of the border, half the width of the frontal lobe, is present.

O. purduei differs from *O. micrurus* in the possession of three to four more rachial annulations and three more ribs, absence of a terminal spine, and much larger size. If the cephalon described above may be considered as conspecific, the frontal process and smooth glabellar surface constitute additional differences.

It differs from *O. berkleyensis* in lesser relative width, wider rachis with four to five more annulations and narrower ribs.

Odontochile ulrichi Delo n. sp.

(Plate 6, figures 5, 6)

Cephalon fragmentary; frontal lobe alate, almost twice as wide as long; border smooth, wide, uniformly curved. Hypostoma denticulate.

A fragmentary pleuron shows a blunt terminus and smooth surface; thorax otherwise unknown.

Pygidium very large, broadly triangular, width to length as 4 to 3, lateral margins broadly curved, border broad, terminal spine very short, broadly triangular, flat, and acute. Rachis of moderate width and height, composed of 16 to 17 annulations, height greatly reduced at the posterior end so that it merges into the base of the spine. There are 15 rounded, prominent ribs which are twice as wide as the grooves; the anterior ones are indistinctly furrowed, describing a very uniform curve to the border; the posterior five or six are straight. Surface thickly punctate, but this feature may be due to the removal of an outer layer of the test by weathering as in *Odontocephalus*.

TYPES: Cotypes, an almost complete weathered pygidium with test, and the anterior portion of the glabella with frontal border. U. S. Nat. Mus. No. 13996. Paratypes. A fragment of pygidium, portion of a thoracic pleuron, and a hypostoma. U. S. Nat. Mus. No. 13993.

OCCURRENCE: Devonian. Eureka district, Nevada.

REMARKS: This species differs from *D. meeki* in much greater size, greater relative width of the pygidium, shorter terminal spine, and a greater number of rachial annulations and ribs. It is relatively wider than *O. micrurus* with two more rounded ribs. It most nearly resembles *O. berkleyensis*, but the rachis is wider, and there are no nodes present. The lack of nodes also distinguishes it readily from *O. percêensis*. *O. purduei* is relatively much narrower, the ribs are much narrower and more angular, and there is a greater number of annulations.

Odontochile townsendae (Raymond, 1931)

(Plate 4, figure 20)

Dalmanites townsendae RAYMOND, 1931, Bull. Mus. Comp. Zool. Harvard, vol. 55, no. 6 (Geol. Ser., vol. 9, no. 6) p. 210, pl. 5, fig. 1.

Cephalon and thorax unknown.

Pygidium of medium size, with moderately curving lateral margins and a rather

long terminal spine. Rachis narrow, composed of 17 annulations, the posterior two indistinct, and continues into the terminal spine, the distance from the rachial terminus to the end of the spine equalling one-third the total length of the pygidium. There are 14 pairs of ribs, the posterior pair very short and indistinct, the anterior 10 or 11 pairs conspicuously furrowed, the remaining angular; anterior seven or eight pairs gently curved, the posterior six sigmoid. Interpleural grooves narrow and deep; furrows prominent.

Ornamentation appears to be distinctive for the species. It consists of three sizes of tubercles on the rachis and pleural areas and fine granulation on the terminal spine. The second, sixth, tenth, and fourteenth rachial annulations each bear a median pair of large tubercles occupying the entire width of the ring, and a pair of intermediate size on the annular flank. All other annulations bear, in addition to a small rounded median tubercle, five irregularly arranged oval low tubercles on each flank. Scattered granules are also present.

The large tubercles on the pleural areas are regularly arranged; near the proximal end of the first rib, distal end of the third, about one-third the distance from the proximal end of the fourth, at the distal end of the seventh. They occupy the entire width of the ribs. All smaller tubercles are confined to the anterior ribs and number from four to six, are of two sizes, the larger somewhat wider than the width of the rib branch. The posterior branch of each rib is granulated.

The terminal spine has a deep dorsal furrow.

TYPE: Holotype. A pygidial impression in weathered limestone. Mus. Comp. Zool. No. 1812.

OCCURRENCE: Devonian. Grande Greve limestone (division 2?), Grande Greve, Gaspé County, Province of Quebec. Found with surface float.

REMARKS: This species may be compared with several others of "Oriskanian" age. It differs from *D. percéensis* in smaller size, more deeply furrowed ribs, longer and more slender terminal spine, and fewer ribs and annulations.

D. veiti has deeply furrowed ribs, but the annulations and ribs are fewer in number, ornamentation is finer, and it has no terminal spine.

S. multiannulatus from the Oriskanian of Maryland is much larger and has no terminal spine. It also lacks the pairs of large tubercles on the rachial annulations, and the number of annulations and ribs is greater.

O. townsendae most nearly resembles *O. phacoptyx* from the Oriskany of New York. It differs from the latter in smaller size, a longer spine, absence of tubercles from the posterior rib branches, and systematic arrangement of the large tubercles on both rachis and pleural areas.

Subfamily SYNPHORIINAE Delo, 1935

Dalmanitidae with more or less complete distal fusion and elevation of first two pairs of glabellar lobes, and reduction of the second and third lateral furrows to submesal pits; cephalon and pygidium may be modified by spines, denticles, or crenulations.

OCCURRENCE: Devonian.

DISTRIBUTION: North and South America, Europe, ?South Africa.

REMARKS: The development of glabellar lobal coalescence in the dalmanitid Phacopidacea shows several lines of evolution. Thus in the Silurian *D. vigilans* Hall there is a slight tendency toward a distal confluence of the first and second pairs of lobes. In *Odontochile hausmanni* the second and third lateral furrows do not completely join the dorsal furrows. In *Synphoria stemmatus* the second pair of furrows are reduced to elongate pits. *A. anchiops* appears to represent the

climax of furrow obsolescence, the second and third furrows being reduced to shallow indistinct pits.

However, these different stages among the Devonian species do not represent a genetic sequence. The Lower Devonian dalmanitids appear to have diverged widely and more or less independently from the ancestral Silurian stock. Many of these species show a pronounced acceleration of cephalic evolution (*Odontocephalus, Corycephalus*) while retaining, in some instances at least (*Corycephalus, Synphoria*), the conservative pygidial characteristics. Contemporaneous with these are species showing no divergence from the conservative stock (*Odontochile*). The synphorinid glabellar pattern and accompanying diverse ornamentation may illustrate a radiate, divergent evolution from a hypothetical ancestor, or ancestors, of conservative dalmanitid plan.

Genus *Synphoria* Clarke, 1900

Asaphus GREEN, 1832; *Dalmanites* of many early authors; *Dalmanites* (*Hausmannia*) HALL AND CLARKE, 1888.

GENOTYPE: *Dalmanites* (*Synphoria*) *stemmatus* CLARKE, 1900 (p. 15–19, pl. 1, figs. 6–16; pl. 2, figs. 1, 2).

GENERIC DIAGNOSIS: Synphoriinae in which the cephalic margin may be smooth, crenulated, or with a simple median protrusion; pygorachial annulations usually about 15 in number.

OCCURRENCE: Lower Devonian; North and South America.

REMARKS: Clarke first suggested the name *Synphoria* (1894, p. 733) but did not designate a genotype. At that time he used it as a group term to include the Devonian dalmanitid species which showed a tendency toward distal confluence and elevation of the lateral lobes. He later described *D.* (*Synphoria*) *stemmatus* from the Oriskany at Becraft Mountain, New York. Although he did not specifically designate the species as the genotype, it is the first species described and figured as belonging definitely to the subgenus *Synphoria*, and the present writer designates it as the genotype for this reason. In the discussion of the subgeneric features, and referring to the coalescence of the lateral lobes, Clarke writes:

"It seems therefore very probable that the term *Synphoria* . . . in its application to . . . species having coalescent glabellar lobes, may prove of subgeneric importance."

(1900, p. 18).

The writer is assigning to *Synphoria* the rather orthodox stock of divergent dalmanitids with moderately coalescent glabellar lobes but without other conspicuously aberrant features.

Allocation of species represented by the pygidium alone can at best be only tentative. In the absence of the characteristic glabellar features, pygidia with fewer than 15 rachial annulations, blunt terminus, and unfurrowed ribs are commonly referred to it. These species obviously do not belong to either *Dalmanites* or *Odontochile*, especially if Oriskanian or younger, nor can they be referred to any of the aberrant genera such as *Odontocephalus*. This circumstance has a tendency to make *Synphoria* a "catch all" for incompletely known species but at least aids in defining the remainder of the Devonian genera.

Synphoria? concinnus (Hall, 1876)

(Plate 7, figures 7, 8)

Dalmanites concinnus HALL, 1876, Pal. N. Y., Illus. Dev. Foss., pl. 10, figs. 3-5.
D. (*Hausmannia*) *concinnus* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 30, pl. 11A, figs. 9–11.

Cephalon and thorax unknown. Pygidium bluntly triangular, very convex, with gently curved margins and steep flanks. Border obscure laterally, widening posteriorly into a short, blunt triangular terminus. Rachis broad, blunt, with rounded, indistinct central ridge; composed of seven or eight flat annulations and a short nonannulated terminus. There are seven or eight pairs of wide, flat ribs, the anterior ones very indistinctly furrowed; grooves very narrow, one-third to half as wide as ribs. Surface smooth.

TYPES: Cotypes. Two complete pygidia of unequal size; the smaller, N. Y. State Mus. No. 13372/1; the larger, N. Y. State Mus. No. 13372/2.

OCCURRENCE: Devonian. Schoharie grit, Schoharie, New York.

REMARKS: Allocation of this species to *Synphoria* is tentative. The sparse annulations and nature of the ribs differentiate it from *Dalmanites*, *Odontochile*, and *Probolium*, but many species of *Synphoria* do illustrate this general type of structure.

It may be distinguished from all other Devonian species except *S. whiteavesi* by the small number of rachial annulations, and the latter has an extended, slender spine. The very broad ribs, smooth surface, and blunt terminus separate it distinctly from all other species.

Synphoria dolbeli (Clarke, 1907)

(Plate 7, figures 14–17)

Dalmanites dolbeli CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 155, 2 figs.; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 43, 121, pl. 8, figs. 1–7.

Cephalon wider than long, as 2 to 1, convex, with short, stout genal spines. Lateral border of moderate width, frontal border narrower, consisting of a series of crenulations. Frontal and lateral lobes ornamented with scattered rounded tubercles of various sizes.

Thororachis wide; annulations and pleura covered with fine granulation.

Pygidium wider than long; lateral margins gently sinuous; terminus blunt. Rachis broad, blunt, composed of 11 annulations. There are eight or nine broad, rounded ribs, the anterior ones faintly furrowed.

TYPES: No type designated previously. Type material includes N. Y. State Mus. No. 13375e/1 to No. 13375e/6. Specimens best showing characteristics of the species include No. 13375e/3, crushed thorax and pygidium; No. 13375e/6, plastotype of a cranidium showing exterior. These are herein designated as the cotypes.

OCCURRENCE: Devonian. Grande Greve limestone (division 2), Gaspé.

REMARKS: Originally referred to *Dalmanites* by Clarke, this species is herein placed in *Synphoria* because of the elevated and fused anterior glabellar lobes and greatly reduced third lobe. The pygidium with a small number of annulations, broad ribs, and blunt terminus, is also characteristic.

S. dolbeli differs from *S. biardi* in the absence of the frontal process, tubercular ornamentation of the glabella, relatively shorter and wider cephalon, and shorter genal spines. The pleural ribs and rachis are broader, and the terminus more bluntly rounded.

The cephalon also has a superficial resemblance to *Synphoroides dolphi* (Clarke) from the Helderberg of New York, but the latter has relatively larger cephalon, a frontal process, and indistinctly coalesced lateral lobes.

The same resemblance is apparent in *S. pleuroptyx*, but the relative proportions of the cephalon are very different, genal spines much longer, and the pygidium bears a terminal spine.

Synphoria? lowi (Clarke, 1907)

(Plate 7, figures 12, 13)

Dalmanites lowi CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 156, 1 fig.; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 43, 122, pl. 9, figs. 6–8.

Cephalon and thorax unknown. Pygidium broadly triangular, width to length as 3 to 2, margins gently sigmoid, terminus bluntly rounded. Rachis broad anteriorly, tapers very rapidly, composed of 11 or 12 annulations bearing obscure, unequally distributed tubercles. There are nine pairs of very deeply furrowed ribs, the posterior furrows less prominent; ribs bend abruptly backward distally and terminate against the narrow border.

TYPES: No type designated. Cotypes herein designated, include an incomplete pygidial cast, N. Y. State Mus. No. 13381e/1; a complete pygidium, N. Y. State Mus. No. 13381e/2; a pygidial plastotype, N. Y. State Mus. No. 13381e/3.

OCCURRENCE: Devonian. Grande Greve limestone (division 2), Grende Greve and vicinity, Gaspé.

REMARKS: In the absence of the cephalon, this species is referred tentatively to *Synphoria* because of the small number of annulations and ribs, and blunt terminus. The deeply furrowed ribs are not characteristic of the genus.

It differs from *S. ? whiteavesi* in the deeply furrowed ribs, lack of a terminal spine, and larger number of annulations; from *D. ? veiti* in the lesser number of annulations, more tapering rachis, possession of fewer, more prominent and deeply furrowed ribs, and absence of tubercular ornamentation.

Synphoria? meeki (Walcott, 1884)

(Plate 7, figures 18–20)

Dalmanites (sp. undet.) MEEK, 1877, Geol. Expl. Fortieth Par., vol. 4, p. 48, pl. 1, figs. 11, 11a.

Dalmanites meeki WALCOTT, 1884, U. S. Geol. Surv., Mon. 8, p. 207–209, pl. 17, figs. 5a–c.

Dalmanites (*Hausmannia*) *meeki*, HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 32, pl. 11 A, figs. 28–30.

Cephalic convexity moderate, genal angles broken, anterior margin smoothly rounded, axial portion of glabella not depressed. Nuchal lobe wide. Characteristic ornamentation lacking. Hypostoma denticulate. Thorax unknown.

Pygidium triangular, length and width subequal, borders narrow, margins sigmoid, curving out posteriorly into a moderately tapering acute spine which equals one-third the total pygidial length and is slightly upturned. Rachis of moderate width and convexity, gradually merging with border, composed of 12 annulations and a short low nonannulated portion. There are 10 to 11 rather flat, asymmetric, unfurrowed ribs, twice as wide as the grooves. They curve backward very suddenly near the margin and die out on the narrow border. Surface very finely pebbled

TYPES: Cotypes. An essentially complete pygidium with test; a fragmentary cephalon; a detached hypostoma. U. S. Nat. Mus. No. 13993.

OCCURRENCE: Devonian.

"Lower horizon of the Devonian limestone, Coomb's Peak, and on the divide at the head of the Reese and Berry Canyon, Eureka District, Nevada."

REMARKS: This species apparently shares the characteristics of more than one Devonian genus, and its allocation to *Synphoria* must remain tentative until more material is available for study. The low convexity of the glabellar lobes suggests *Odontochile*; the small number of pygidial annulations, *Synphoria*; the general pygidial outline, *Anchiopsis*.

There is no other species in the Eureka district which resembles *S. ? meeki*. In the strata of eastern North America, only *A. anchiops* has a similar pygidial structure, but the broad, rather uniformly rounded and gently curved ribs differentiate it.

Synphoria stemmatus Clarke, 1900

(Plate 7, figures 1–3)

Dalmanites n. sp. A CLARKE, 1892, Am. Jour. Sci., ser. 3, vol. 44, p. 412.
D. (Synphoria) stemmatus CLARKE, 1900, N. Y. State Mus., Mem. 3, vol. 3, p. 15, pl. 1, figs. 6–16; pl. 2, figs. 1, 2.

Cephalon large, very convex, anterior and lateral slopes steep; genal angles produced, nonspinose. Frontal border marked by a series of 12 to 15 rounded crenulations, largest in front, which die out opposite the eyes. Nuchal furrow deep, nuchal lobe highly arched, long, smooth. Postmarginal furrow widens distally, terminates abruptly, does not meet lateral furrow. Glabella tuberculate, especially on frontal lobe; cheeks pitted. Thorax unknown.

Pygidium wider than long as 3 to 2, with broadly curved margins. Terminus broadly rounded, produced only slightly, nonspinose. Rachis broad, bluntly terminated, composed of 10 to 11 annulations and a short nonannulated terminus. There are nine or ten rounded, unfurrowed ribs, wider than the grooves. No tuberculate ornamentation apparent.

TYPES: No holotype designated previously. Type material includes N. Y. State Mus. No. 13394/1 to No. 13394/10. Specimens which appear most characteristic are No. 13394/3, complete cephalic cast; No. 13394/8 and No. 13394/9, pygidial casts. These are herein designated as cotypes.

OCCURRENCE: Devonian. Oriskany formation, Becraft Mountain, New York; Oriskany (Ridgley member), Cumberland, Maryland?

REMARKS: This species was described originally by Clarke as illustrating the typical expression of the subgenus *Synphoria*, which was subsequently raised to generic rank by the writer (1935, p. 412).

The large size, high convexity, cephalic proportions, and absence of genal spines, differentiate the species from all others of Devonian age. The pygidium is characterized by the unfurrowed ribs, rounded terminus, and small number of rachial annulations. It differs from *S. dolbeli* in larger size, greater relative length of the cephalon, lack of genal spines, and more rounded pygidial terminus.

Synphoria stemmatus var. *convergens* Clarke, 1900

(Plate 7, figures 4–6)

Dalmanites n. sp. A var. CLARKE, 1892, Am. Jour. Sci., 3d. ser, vol. 44, p. 412.
D. (Synphoria) stemmatus var. *convergens* CLARKE, 1900, N. Y. State Mus., Mem. 3, vol. 3, p. 19, pl. 2, figs. 3–5.

Only a cast of the glabellar portion of the cephalon is known. The frontal margin shows a few poorly defined crenulations, and the surface is tuberculate. The thorax is unknown.

The pygidium is nonspinose, much like that of *S. stemmatus* in number of annulations and ribs and nature of the latter, but differs in the width and length being equal and the terminus rather sharp.

TYPES: Cotypes. A glabellar cast; N. Y. State Mus. No. 13395/1. Plastotypes and impressions of pygidia; N. Y. State Mus. Nos. 13395/2 and 13395/3.

OCCURRENCE: Devonian. Oriskany formation, Becraft Mountain, New York.

REMARKS: This variety is very small, and this feature constitutes the principal difference between it and *S. stemmatus*. The equal length and width and sharper terminus of the pygidium are also characteristic.

The specimen figured by Stewart from the Little Saline formation of Ste. Genevieve County, Missouri (1923, p. 267, pl. 71, fig. 17) is probably not conspecific with the type. More abundant and better preserved material is needed to determine exact comparisons.

Synphoria? whiteavesi (Clarke, 1907)

(Plate 7, figures 10, 11)

Dalmanites whiteavesi CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 160, 1 fig.; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 125, pl. 8, figs. 11, 13.

Cephalon and thorax unknown. Pygidium triangular with uniformly curved margins and a sharp, tapering spine equalling about one-third the total length. Rachis of moderate width, composed of eight annulations. There are seven or eight ribs (eight on the paratype, but the last one is very faint), which are unfurrowed, curve gently, meet the narrow border almost at right angles. Surface smooth.

TYPES: Holotype. A pygidial cast, N. Y. State Mus., No. 13400/1; paratype, a plastotype of a similar pygidium, N. Y. State Mus. No. 13400/2.

OCCURRENCE: Devonian. Grande Greve limestone (division 2), Gaspé.

REMARKS: The long slender terminal spine and small number of rachial annulations suggest that this species may be a close relative of *A. anchiops*. In the absence of the cephalon, which determines the generic affiliation of most of these species, the writer is tentatively assigning it to *Synphoria*. *S. ? whiteavesi* is characterized by the smallest number of rachial annulations illustrated by any of the Devonian species except *S. ? concinnus*, which has no terminal spine. Otherwise it is easily distinguished from all other Devonian species.

Clarke remarks in his original description (1908, p. 125) that the ribs bear fine furrows, but the writer was unable to observe these on the types.

Genus *Coronura* Hall and Clarke, 1888

Asaphus CONRAD, 1841; *Dalmanites* HALL, 1862, 1876; MEEK, 1871, 1873; *Dalmanites* (*Coronura*) HALL AND CLARKE, 1888; *Coronura* DELO, 1935.

GENOTYPE: *Asaphus aspectans* Conrad, 1841 (p. 49, fig. 9). *Asaphus? denticulatus* Conrad, 1841 (p. 48); Hall, 1876 (pl. 10, fig. 1). *Dalmanites* (*Coronura*) *aspectans* Hall and Clarke, 1888 (p. 33, pl. 12, figs. 1–11, 13).

GENERIC DIAGNOSIS: Synphoriinae with smooth uninterrupted cephalic margin. Pygidium with numerous rounded lateral spines and a crescent-shaped spinose terminus.

OCCURRENCE: Lower Middle Devonian.

DISTRIBUTION: North America.

REMARKS: This peculiar genus is widely distributed in the eastern and central States. Although only two common species are now referred to it, others are undoubtedly present, especially in strata of Onondagan age. Specific differentiation is based on ornamentation, nature of lateral spines and terminus, and size. The genus is also unique in containing the largest phacopid species found in North America.

Coronura marylandicus (Prosser and Kindle, 1913)

(Plate 8, figures 3, 4)

Dalmanites marylandicus PROSSER AND KINDLE 1913, Md. Geol. Surv., Middle Devonian, p. 334, pl. 44, fig. 5.

Cephalon and thorax unknown. Pygidial rachis long and narrow, composed of 21 annulations extending to posterior border. Each annulation bears a pair of

central tubercles or granules. There are 16 to 17 furrowed ribs, wider than the grooves, furrows better marked and ribs wider distally. They curve backward rather abruptly at outer end; posterior branch the larger. Each branch decorated with an irregular row of low tubercles, largest distally, rather irregular in size and distribution.

Although broken in the holotype, the terminus is crescent shaped, with two broad, upturned spines, the right one bearing scattered small tubercles and two or three short rounded spines on its inner margin. The original figure is much generalized as to the terminus, otherwise essentially correct.

TYPE: Holotype. Cast of a pygidium somewhat distorted, on slab of dark shale. Maryland Geological Survey, uncatalogued.

OCCURRENCE: Devonian. Romney shale, Hamilton member, Ernstville, Maryland. Its presence suggests Onondagan age.

REMARKS: This species is represented only by the holotype. Although the marginal spines, so characteristic of the genus, cannot be seen, the nature of the ornamentation and the crescentic spiniform terminus are characteristic and form the basis for its allocation to *Coronura*.

It differs from *C. aspectans* in its smaller size, larger number of rachial annulations, and broad, triangular terminal spines. The absence of marginal spines may be an accident of preservation. *D. myrmecophorus* is very much larger and irregularly ornamented.

Coronura aspectans (Conrad, 1841)

(Plate 8, figure 1)

Asaphus aspectans CONRAD, 1841, 5th Pal. Rept. N. Y. Surv., p. 48, fig. 9.
Dalmanites aspectans HALL, 1876, Pal. N. Y., Illust. Dev. Foss., pl. 13, figs. 11–14.
Dalmanites (*Coronura*) *aspectans* HALL AND CLARKE, 1888, Pal. N. Y. vol. 7, p. 33, pl. 12, figs. 1–11, 13.
Coronura diurus CLARKE, 1892, 44th Rept. N. Y. State Mus., p. 105, pl. 4.

Anterior cephalic margin smoothly rounded, border of moderate width, frontal lobe sloping gently anteriorly. Entire surface tuberculate, including border. Genal spines reaching about third thoracic segment. Eyes very high, almost cylindrical.

Thorax tuberculate throughout; otherwise illustrates no specific features.

Pygidium with regularly rounded margins. Rachis narrow, sloping gently into posterior border, composed of 16 to 19 annulations and a very short terminal nub. There are 15 to 18 gently curved pleural ribs which are broad, flattened, faintly furrowed, and become obsolete against the lateral border.

Ornamentation consists of a row of small tubercles on each rachial annulation; a double row on each rib; tubercles scattered on the border. A marginal spine is present at the terminus of each rib excepting the posterior two or three. They are sharp, round, slender, recurved, vary in length in different individuals, are offset just posterior to the rib. There are also two terminal spines separated by about a maximum width of the rachis, with broadly crescentiform interspace.

TYPES: Holotype. Left free cheek with eye attached; location unknown. An entire individual described subsequently by Clarke (N. Y. State Mus. No. 13375/5) illustrates all the specific features and was the basis for the description given above. Other type material in the New York State Museum includes several pygidia figured by Hall and Clarke. Type material in the American Museum of Natural History bears catalogue No. 4250/1. This includes two lots; one, a pygidium, the original of *Paleontology of New York*, volume 7, plate 13, figure 11; another tray containing casts of two pygidia bears the same catalogue number and is labelled as containing the original of *Paleontology of New York*, volume 7, plate 13, figure 7.

OCCURRENCE: Devonian. Onondaga limestone. New York, Ohio, and adjacent States. Very similar forms are found in rocks of correlative age in Indiana and Illinois.

REMARKS: Much confusion has arisen concerning the identity of this species because the holotype showed no features of specific value, and the illustrative material figured subsequently has been derived from different regions. Hence it is believed that the entire specimen described by Clarke from Leroy, New York (44th Report, New York State Museum, p. 105) should be designated herewith as the holotype, and the concept of the species fixed upon it. It is probable that as now regarded the species includes several distinct varieties or new species, but study of large collections will be necessary to differentiate them fully.

In general, this species may be distinguished readily from *C. myrmecophorus* by the much smaller size, furrowed ribs, and regular, rather fine ornamentation. The posterior margin is also smooth or moderately tuberculate, rather than spinose. There is no other species with which it easily may be confused.

Coronura myrmecophorus (Green, 1835)

(Plate 8, figure 2)

Asaphus myrmecophorus GREEN, 1835, Mon. Tril. N. Am., Suppl., p. 16.
Dalmanites myrmecophorus HALL, 1876, Pal. N. Y., Illust. Dev. Foss., pl. 13, figs. 15, 16.
D. (Coronura) myrmecophorus HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 37, pl. 11A., fig. 13; pl. 13, fig. 12; pl. 14, figs. 1–6; pl. 15, figs. 1–4.
Asaphus acantholeurus CONRAD, 1841, 5th Ann. Rept., Pal. N. Y., p. 48.

Cephalon unknown except from fragments which indicate that it is covered with spinose tubercles. Thorax unknown.

Pygidial margins rounded; rachis narrow, regularly tapering to posterior border, composed of 17 to 19 annulations and a low nonannulated terminus which tapers into the border. There are 16 rounded ribs, the posterior pair indistinct; all are unfurrowed, much wider than intervening grooves; posterior pairs almost parallel to rachis.

Ornamentation consists of spinose tubercles of various sizes scattered on rachis, ribs, and border. Many of these occupy the entire crest of a rib. Each rib continues distally as a rounded, sharp, slender, recurved spine, offset a little posteriorly. Border very narrow.

Terminus a crescent, bordered by two large erect compound spines with several smaller ones arranged in a semicircle between them.

TYPES: The holotype has been lost. This description based on N. Y. State Mus. No. 13386/2, a rather complete pygidium from Kingston, Ulster County, New York. Other plesiotype material includes several pygidia, most of which are fragmental.

OCCURRENCE: Devonian. Onondaga limestone. Apparently widely distributed in the New York region and central States. Has been reported from Columbus limestone, Ohio; Jeffersonville limestone, Indiana and Kentucky; Camden chert, Tennessee.

REMARKS: This unusual species is noteworthy not only because of the unique ornamentation but also because of its very large size. Hall and Clarke estimated that one specimen restored from an incomplete pygidium had a length of 16 inches. The large size, unfurrowed ribs, scattered tuberculose ornamentation, and erect terminal spines differentiate it from all other species of the genus.

A cast of a glabella in the collections of the American Museum of Natural History (No. 4070) may be allocated doubtfully to the species. It is thickly tuberculate but otherwise shows no features which might ally it definitely with the pygidia described above.

Genus *Corycephalus* Hall and Clarke, 1888

Dalmanites HALL, 1876; BARRETT, 1876; WELLER, 1903; GOLDRING, 1931; *Dalmanites* (*Corycephalus*) HALL AND CLARKE, 1888; OHERN AND MAYNARD, 1913.

GENOTYPE: *Dalmanites regalis* Hall, 1876 (pl. 11). *Dalmanites* (*Corycephalus*) *regalis* Hall and Clarke, 1888 (p. 55, pl. 11, figs. 1–4).

GENERIC DIAGNOSIS: Synphoriinae in which the entire cephalic margin bears a row of separate denticles or short spines; genal spines present.

OCCURRENCE: Lower and Lower Middle Devonian.

DISTRIBUTION: North America.

REMARKS: This unique genus was first defined by Hall and Clarke (1888, p. xxxiv), who called attention to the denticulated cephalic margin. At that time no genotype was designated, but the first species described was *D.* (*C.*) *regalis* and it is therefore designated as the genotype.

Representatives of the genus are rare and for the most part incompletely known.

Corycephalus dentatus (Barrett, 1876)

(Plate 8, figures 8, 9)

Dalmanites dentata BARRETT, 1876, Am. Jour. Sci., 3d. ser., vol. 11, p. 200, pl. 7.
D. (*Corycephalus*) *dentatus* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 58, pl. 11A, figs. 4–6.

Cephalon wider than long as 3 to 2; genal spines slender, posterior cephalic margin curving backward into the spines, the postmarginal furrow very deep, paralleling the margin. Eyes highly elevated. Entire glabellar surface coarsely tuberculate; small tubercles also on palpebral lobes and along posterior margin of genal spines and cranidium.

Nuchal ring broken (restored in figure). Entire lateral and frontal margin denticulate, with uniformly spaced triangular short spines, largest in front and becoming obsolete on the genal spines.

Thoracic pleura produced, acuminate, recurved. Otherwise thorax shows no specific features.

Pygidium triangular, as wide as long, with gently sigmoid margins. Rachis narrow, with 14 annulations, each decorated with a row of tubercles; the central pair larger. Terminus of rachis at base of terminal spine which is triangular, tapers gently, acute; measured from rachial terminus equals one-third total length. There are eight or nine furrowed ribs, the posterior four pairs apparently unfurrowed; They curve backward conspicuously near the margins and merge with the narrow border which widens into the terminal spine. Ribs about as wide as grooves on cast. Each branch bears a scattered row of small tubercles.

TYPES: The holotype has been lost. Plesiotype material described by Hall and Clarke is in the New York State Museum. This description based on No. 13374/1, an exfoliated cephalon; No. 13374/2, an exfoliated pygidium.

OCCURRENCE: Devonian. Helderberg (New Scotland beds). Types described above from Port Jervis, New York. General distribution of the species confined to New York and adjacent area.

REMARKS: This species differs from all others in the possession of the numerous triangular marginal denticles. Other species referred to *Corycephalus* possess spatulate denticles.

The pygidium differs from that of superficially similar species in relatively much greater number of annulations as compared to the number of ribs, the regular ornamentation of the annulations, the possession of a terminal spine in combination with these features. The produced, acute thoracic pleura are characteristic.

Corycephalus regalis (Hall, 1876)

(Plate 8, figure 5)

Dalmanites regalis HALL, 1876, Pal. N. Y., Illus. Dev. Foss., pl. 11, figs. 1–4.
D. (*Corycephalus*) *regalis*, HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 55, 56, pl. 11, figs. 1–4.

Cephalon large, highly convex with vertical anterior and lateral slopes; genal spines as long as remainder of cephalon, slender, curved inward; entire margin composed of spatulate denticles, which extend to end of genal spines. Border very narrow anteriorly, wider laterally. Eyes apparently large, with deep basal groove. Facial suture in deep groove on cheek.

Frontal lobe coarsely tuberculate; upper half of fixed cheeks covered with spinose tubercles, lower half smooth; a row of tubercles along the border and postmarginal ridge; a single large tubercle at juncture of marginal furrows.

TYPES: Holotype, an imperfect cephalon and counterpart. Eyes, ends of genal spines and posterior end of glabella broken. Am. Mus. Nat. Hist., No. 2894. Paratype, a fragmentary cephalon.

OCCURRENCE: Devonian. Schoharie grit, Knox, Albany County, New York.

REMARKS: This rare species possesses so many distinctive features that comparison with others seems unnecessary. It is distinguished from *C. dentatus* by the high convexity, larger size, longer genal spines, spatulate marginal denticles, and coarser tuberculation.

It is difficult, in the absence of abundant material, to differentiate between features of specific and generic value.

Corycephalus? pygmaeus Hall and Clarke, 1888

(Plate 8, figures 6, 7)

Dalmanites (*C.*) *pygmaeus* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 56, pl. 11, figs. 5–8.

This minute species is based on two fragmentary cephala. The glabella is elongate, the axial portion a rounded ridge. Furrows deep, lateral lobes not swollen, and axial portion not depressed. Eyes large, elevated. The narrow margin shows two or three denticles preserved, and the figure given by Clarke is at least partially restored. The nuchal lobe is prominent and bears a central tubercle.

TYPES: Cotypes. Fragmentary cephalic casts. N. Y. State Mus. Nos. 13391/1 and 13391/2.

OCCURRENCE: Devonian. Onondaga limestone, Canandaigua, New York.

REMARKS: Only the types of this unusual species are known. In the absence of more complete material, generic allocation must be tentative. The very small size, peculiar elongate glabella, and marginal denticles are characteristic. There is no other species with which it may easily be confused.

Genus *Odontocephalus* Conrad, 1840

Asaphus EATON, 1832; *Calymene?* GREEN, 1832; *Dalmania* HALL, 1859 et seq.; *Dalmanites* (*Odontocephalus*) MEEK AND WORTHEN, 1868; HALL AND CLARKE, 1888; GOLDRING, 1931; *Odontocephalus* CONRAD, 1840.

GENOTYPE: *Asaphus selenourus* Eaton, 1832 (p. 31, pl. 1, fig. 1). *Calymene? odontocephala* Green, 1832 (p. 9, cast No. 36). *Odontocephalus selenurus* Conrad, 1840 (p. 204). *Dalmanites* (*Odontocephalus*) *selenurus* Hall and Clarke, 1888 (p. 49, pl. 11 B, figs. 15–21; pl. 12, figs. 1–13).

GENERIC DIAGNOSIS: Synphoriinae in which the anterior cephalic border bears a

series of denticles, wider and coalesced distally, narrower and separated proximally; pygidium with a crescent-shaped terminus of two spines.

OCCURRENCE: Lower Middle Devonian.

DISTRIBUTION: North America.

REMARKS: The genotype was described and figured by Amos Eaton (1832, p. 31, pl. 1, fig. 1) as *Asaphus selenourus*. His figure shows a portion of the thorax and the pygidium but does not give a very distinct concept of the structural details of the specimen. The cephalon of this species was first described by Green (1832, p. 9) as *Calymene? odontocephala*. A drawing of Green's cast No. 36 was later reproduced by Hall and Clarke (1888, pl. 12, fig. 1). Identity of Eaton's and Green's specimens as the same species was demonstrated by Conrad who described a complete individual as *Odontocephalus selenurus*.

Other undoubtedly valid species are known from the eastern United States, but representatives of the genus from the Mississippi valley region are as yet incompletely known.

Odontocephalus aegeria Hall, 1861

(Plate 8, figures 10–12)

Dalmania aegeria HALL, 1861, N. Y. State Cab. Nat. Hist., 14th Rept., p. 57.
Dalmanites (Odontocephalus) aegeria HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 53, pl. 11B, figs. 1–11.

Cephalon rather convex, somewhat more narrowly rounded in front than *O. selenurus*; border of moderate width; genal spines sharp, slender, extend back to fourth thoracic segment. Frontal margin consists of 11 spatulate processes, which become progressively longer anteriorly, the center one more than twice as long as the posterior. Remainder of cephalon essentially as in *O. selenurus*. Thorax unknown.

Pygidial margins gently rounded, width to length about equal. Rachis of moderate width, uniformly tapering, posteriorly abrupt, blunt, composed of nine annulations and a short terminus, and extending to within a short distance of the margin. There are nine or ten broad, flat ribs, the last pair indistinct. They widen distally, are more than twice as wide as the grooves, make a moderately abrupt backward bend distally, and merge with the narrow border. Terminus crescentic, about as wide as anterior end of rachis; the border wider than laterally, spines very short, flat, acutely triangular. Surface finely granulose when unweathered; weathered specimens show minute pits.

TYPES: No type designated. Type material includes N. Y. State Mus. Nos. 13361/1 to 13361/3; Am. Mus. Nat. Hist. No. 4967/2 (two specimens from different localities).

The most typical specimens appear to be N. Y. State Mus. Nos. 13361/2 and 13361/3 and are therefore designated as cotypes.

OCCURRENCE: Devonian. Onondaga limestone, New York State; Grand Tower formation, Illinois and Missouri; Jeffersonville formation, Falls of Ohio.

REMARKS: The number of frontal denticles (11) distinguishes the cephalon of this species from that of *O. selenurus* (9), and the genal spines are also characteristic.

The pygidium differs from *O. coronatus* in the presence of terminal spines; from *O. selenurus* in that the spines are short instead of long and rounded; from *O. bifidus* in the more widely spaced and shorter spines, relatively shorter rachis, and much broader posterior border.

Odontocephalus selenurus (Eaton, 1832)

(Plate 8, figures 13–17)

Asaphus selenourus EATON, 1832, Geol. Textbook, p. 31, pl. 1, fig. 1.
Calymene odontocephala GREEN, 1832, Mon. Tril. N. Am., Suppl., p. 9, cast. No. 36.

Odontocephalus selenurus CONRAD, 1840, Pal. Dept., N. Y. Survey, 3rd Ann. Rept., p. 204—HALL, 1843, Geol. N. Y., pt. 4, p. 175, 1 figure.
? *D. (Odontocephalus) arenarius* MEEK AND WORTHEN, 1868, Ill. Geol. Survey, vol. 3, Pal., p. 417, pl. 9, fig. 10.
Dalmanites (Odontocephalus) selenurus HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 49, pl. 11B, figs. 15–21; pl. 12, figs. 1–13.

Cephalon rather narrowly rounded in front, the anterior border composed of nine flat, spatulate, closely crowded, denticles, longer mesally. Lateral border very narrow; genal spines absent. Eyes large with basal groove; nuchal lobe broad, convex anteriorly; nuchal furrow narrow. Surface covered with very fine pitting and fine granulation.

Thororachis very broad, tapering regularly into pygidium. Surface smooth.

Pygidium about as wide as long with very gently curved margins and a crescentic terminus which is about as wide as the anterior end of the rachis and consists of two slender, rounded, acute, subparallel spines. These equal about one-third the pygidial length, may diverge somewhat, or curve inward slightly. Rachis depressed-convex, composed of eight or nine annulations and a short terminus which ends abruptly and bluntly near the margin. There are seven or eight pairs of broad, flat ribs, the last pair indistinct and continuing into the terminal spines. They are about twice as wide as the grooves, widen distally, the anterior ones indistinctly furrowed toward margin. Entire surface thickly covered with small pits.

TYPES: No holotype has been designated, and Eaton's specimen has been lost. Green's cast of the cephalon is extant and therefore must be considered as the type. Other type material. N. Y. State Mus. No. 13392/1, Schoharie County, New York. Am. Mus. Nat. Hist. No. 4069/7, Auburn, New York; No. 4069/4, western N. Y.; No. 4069/8, Ovid, New York.

OCCURRENCE: Devonian. Onondaga limestone. New York region and central States.

REMARKS: The species was first proposed by Amos Eaton and based on a pygidium. Green later described a cephalon, and subsequently Conrad described an entire individual. Both Eaton's and Green's specimens have been lost, but Green's plastotype is yet extant and must now be considered as the type of the species.

Odontocephalus bifidus Hall, 1861

(Plate 8, figures 18, 19)

Dalmania bifida HALL, 1861, N. Y. State Cab. Nat. Hist., 14th Rept., p. 63.
Dalmanites (Odontocephalus) bifidus HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 53, pl. 11B, figs. 22–25.

Cephalon and thorax unknown. Pygidium about as wide as long, with a narrow, rather indistinct border and crescentic terminus consisting of two stout, sharp spines. These are set closer together than the anterior width of the rachis; their length equals distance from rachis to posterior margin. Rachis short, blunt, terminally abrupt, consisting of eight annulations and a short terminus; width of posterior margin equals almost one-half rachial length. There are seven pairs of broad, rounded, unfurrowed ribs; grooves very narrow. Surface pebbled and pitted.

TYPES: No holotype designated. Cotype material herein designated, N. Y. State Mus. No. 13366/1, a partially exfoliated pygidium; No. 13366/2, a well-preserved pygidium, exfoliated in part. The figures (1888, pl. 11B, figs. 24, 25) have been restored.

OCCURRENCE: Devonian. Onondaga limestone. Types from Lime Rock, near Leroy, New York. General distribution throughout New York region.

REMARKS: No cephala or thoraces of this rare species have been figured or described in the literature. It may be differentiated from all other species of the genus

by the very broad posterior margin; from *O. selenurus* specifically by the stout, rapidly tapering spines set closely together, whereas those of the latter are more widely separated, slender, taper only slightly; from *O. aegeria* in which the spines are more widely separated, short, triangular, somewhat flattened. *O. coronatus* has no terminal spines, and the posterior margin is narrower.

Odontocephalus coronatus (Hall, 1861)

(Plate 8, figure 20)

Dalmania coronata HALL, 1861, Descr. new sp. Dev. Foss., p. 58.
Dalmanites (*Odontocephalus*) *coronatus* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 54, pl. 11B, figs. 12–14.

Cephalon unknown, and thorax shows no features of specific importance.

Pygidium about twice as wide as long. Rachis of moderate width, gently tapering, consists of seven free and one very indistinct annulations and a nonannulated terminus equalling about one-fourth the total rachial length. There are eight broad, flat ribs separated by very narrow grooves. The ribs die out against the border and curve backward only very slightly. Terminus very broadly re-entrant with a moderately broad, flat border; terminal spines absent. Entire surface covered with granules which when weathered take on the appearance of pits.

TYPE: Holotype. Pygidium and almost complete thorax with test. Am. Mus. Nat. Hist. No. 4064.

OCCURRENCE: Devonian. Onondaga limestone, near Auburn, New York.

REMARKS: This rare species is differentiated easily from other members of the genus by the nonspinose pygidial terminus and relatively greater width. The ribs meet the border much more nearly at right angles than in *O. selenurus*.

It may be differentiated from other nonspinose phacopid species with re-entrant termini by the very broad, flat ribs, narrow grooves, and almost smooth surface.

Genus *Probolium* Oehlert, 1889

Asaphus CONRAD, 1841; *Dalmania* HALL, 1861; *Dalmanites* KAYSER, 1879; *Dalmanites* (*Probolium*) OEHLERT, 1889; CLARKE, 1907.

GENOTYPE: *Asaphus nasutus* Conrad, 1841 (p. 49). *Dalmania nasutus* Hall, 1861 (vol. 3, p. 362, pl. 75, fig. 2; pl. 76, figs. 1–8). *Dalmanites* (*Probolium*) *nasutus* Oehlert, 1889 (p. 759).

GENERIC DIAGNOSIS: Synphoriinae with glabellar coalescence less pronounced than in *Synphoria*; carapace usually tuberculate; a rostral spine which may be bifid or trifid, and a caudal spine, may be present.

OCCURRENCE: Lower Devonian.

DISTRIBUTION: Europe, North America.

REMARKS: Oehlert (1889, p. 759) proposed to unite under the name *Probolium* all species ornamented with

"un prolongement médian en général très développé et ordinairement terminé par une expansion bifide; type: *Dalmanites nasutus* Conrad."

In the same article (p. 764), concerning the frontal process, he writes,

"ce dernier caractère, commun à tout un groupe, peut servir à caractériser une section à laquelle nous donnons le nom de *Probolium*, et que nous avons rattachée ci-dessus au genre *Dalmanites*."

From the above it appears that Oehlert regarded *Probolium* as a subgenus of *Dalmanites*, and it was so used by Clarke. Oehlert gave no more complete description of the subgenus than that quoted above.

A number of species in the Devonian strata of North America illustrate a glabellar pattern intermediate between *Odontochile* and *Synphoria* and possess, in every case, some type of frontal marginal ornamentation. As strictly defined, however, *Probolium* cannot include all of these but rather only a few species of the distinct type of *P. nasutus* (Conrad).

Probolium nasutus (Conrad, 1841)

(Plate 8, figures 21, 22; Plate 9, figure 1)

Asaphus nasutus CONRAD, 1841, Pal. N. Y. Survey, 5th. Ann. Rept., p. 49.
Dalmania nasutus HALL, 1861, Pal. N. Y., vol. 3, p. 362, pl. 75, fig. 2; pl. 76, figs. 1–9.
Dalmanites (Probolium) nasutus CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 129, 133, fig. 7.

Cephalon wide in proportion to length, with long, slender genal spines. The anterior median process is almost as long as the glabella and consists of a rounded tapering branch about half as wide as the glabella; the margins curve uniformly from the lateral cephalic margin, and it forks terminally into two divergent, slender, rounded spines. In some specimens the process is upturned, but this may be the result of deformation. Entire surface of the cephalon covered with tuberculose granules, largest on the frontal lobe. The thorax is unknown.

Pygidium triangular with rounded margins and narrow border. Rachis narrow, composed of 13 to 14 annulations, terminally abrupt. There are 10 or 11 furrowed ribs, posterior branch the larger, bending backward until the posterior ribs are almost parallel with the rachis. Terminal spine as long or longer than the remainder of the pygidium, very slender, tapering gradually to a sharp point, rounded. Surface covered with granules, also present on spine and doublure. There are a few large, low, rounded tubercles which vary somewhat in size; a prominent pair on the fifth annulation.

TYPE: Holotype, N. Y. State Mus. No. 13387/1, pygidium showing ventral surface and part of terminal spine. Plesiotypes, N. Y. State Mus. Nos. 13387/2 to 13387/6, several cephala and pygidia.

OCCURRENCE: Devonian. Helderbergian (New Scotland beds). Types from Schoharie, New York. Species apparently confined to the New York region.

REMARKS: This species is distinguished by the thick tapering frontal process with slender, rounded, divergent termini; very long, curving genal spines; rounded pygidial margins, and very long, slender, pygidial spine.

Probolium palaceus (Savage, 1913)

(Plate 8, figures 23, 24)

Dalmanites palaceus SAVAGE, 1913, Am. Jour. Sci., 4th Ser., vol. 35, p. 149–150, figs. 4, 5; 1920, Am. Jour. Sci., 4th. ser., vol. 49, p. 173.

Cephalon about twice as wide as long, with wide border and slender genal spines as long as the glabella. Frontal lobe narrow, elongate; first lobes not much larger than second; nuchal very short, only slightly elevated. Eyes large, extending from first to postmarginal furrow, not elevated. Frontal margin enlarged into a spatulate, distally wider process about two-thirds the width of frontal lobe, its width half greater than the length. On either side the border narrows in an abrupt narrow re-entrant to about half its normal width. Surface ornamentation not discernible. Thorax unknown.

Pygidium with rounded margins and a narrow spine, which, although broken on the type, probably equalled no more than one-third the length of the remainder of the pygidium. Rachis short, reaching about two-thirds the distance to base of spine, composed of no more than 10 annulations, which are narrow and separated by narrow

grooves, and a short terminus. There are seven or eight pairs of very narrow, distally curved ribs separated by very wide shallow grooves; they die out on the border. Surface smooth.

TYPES: Holotype, a badly weathered cephalon, retaining the frontal process and an impression of one genal spine. Paratypes, a very fragmentary cephalic cast showing only an impression of the border and frontal process; an incomplete pygidium with test. Univ. of Illinois No. X-913.

OCCURRENCE: Devonian. Bailey and Clear Creek formations, Illinois and Missouri.

REMARKS: The nature of the glabellar lobation, long genal spines, and frontal process, definitely ally this species with *Probolium*. The rounded pygidial outline, short rachis, and slender spine are also characteristic. The unique frontal process, with re-entrant margin on either side, and position of eyes near the posterior border differentiate it easily from all other species allocated to the genus.

Probolium tridens (Hall, 1861)

(Plate 8, figure 25; Plate 9, figures 2, 3)

Dalmania tridens HALL, 1861, Pal. N. Y., vol. 3, p. 361, pl. 75, figs. 3–6.
Dalmanites (*Probolium*) *tridens* CLARKE, 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 129, pl. 5, fig. 1.

Only the anterior process and a small portion of the cephalon are represented in the types. The process is similar to that of *P. nasutus*, but ends in two rounded, divergent spines separated by a short, blunt, triangular process parallel to the cephalic axis. A portion of the test adhering to the frontal lobe of the holotype is ornamented with tuberculose granules similar to those of *P. nasutus*. The eye is also typical.

TYPES: No holotype designated. The first specimen figured by Hall (1861, pl. 75, fig. 3) is also the most complete and is therefore designated as the holotype. It is an impression of a fragmentary cephalon showing one eye, portions of the lateral margin and frontal lobe, and frontal process; N. Y. State Mus. No. 13396/1. Paratypes include other specimens figured by Hall (1861, pl. 75, figs. 5, 6). These are portions of the frontal border and frontal process; N. Y. State Mus. Nos. 13396/2, 13396/3.

OCCURRENCE: Devonian. Helderberg (New Scotland beds). Types from Schoharie, New York.

REMARKS: The fragmental nature of the types does not permit of close comparison with *P. nasutus* except in the nature of the frontal process. In the absence of more complete material, this must be accepted at present as the diagnostic specific character.

Clarke (1908, pl. 5, fig. 1) figured a complete cephalon of this species, but the trifid frontal terminus is not well developed. In other details, the cephala are similar.

There is no species other than *P. nasutus* with which this species may be confused.

Genus *Synphoroides* Delo n. gen.

Dalmanites (*Probolium*) CLARKE, 1907; 1908.

GENOTYPE: *Dalmanites* (*Probolium*) *biardi* Clarke, 1907 (p. 162, 2 figs.); 1908 (p. 129, pl. 6, figs. 1–12).

GENERIC DIAGNOSIS: Glabellar lobes swollen; lateral furrows deeper proximally but complete. Frontal lobe rounded or elliptical in plan. Frontal margin crenulated or may bear a short, flat process which may branch distally. Short genal spines

may also be present. Pygidium with short triangular terminus; about 15 rachial annulations.

DISCUSSION: This genus appears to represent an intermediate stage between the conservative *Odontochile* type of glabellar lobation and the fused and elevated lobation characteristic of *Synphoria*. The crenulated anterolateral margins suggest *Synphoria*, but the frontal process and genal spines are distinctive. It differs from *Probolium* in the crenulations, flattened frontal process which is an outgrowth of the border and does not merge with the frontal lobe, rounded or elliptical rather than rhomboidal frontal lobe, and the essentially nonspinose pygidium. Species herein allocated to *Synphoroides* include *D.* (*P.*) *biardi* Clarke, *D.* (*P.*) *esnoufi* Clarke, *D. dolphi* Clarke, *D. multiannulatus* Ohern and Maynard, *D. pleuroptyx* (Green), and ? *D. griffoni* Clarke.

OCCURRENCE: Lower Devonian.

DISTRIBUTION: North America.

Synphoroides biardi (Clarke, 1907)

(Plate 9, figures 4-7)

D. (*Probolium*) *biardi* CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 162, 2 figures; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 129, pl. 6, figs. 1–12.

Cephalon wide and short, width to length as 3 to 2. Genal spines of moderate length. Cephalic margin smooth except anteriorly, where it bears a flat, rather broad process, about one-third the axial length of the cephalon. Terminus of the process consists of a short axial and two obliquely divergent lateral branches; on either side the margin bears three or four small rounded crenulations, largest near the process. Surface finely pustulose. The thorax illustrates no specific features.

Pygidium triangular, the terminus a blunt, triangular, slightly upturned spine. Rachis relatively narrow, extends to base of spine, composed of 12 annulations and a short nub, separated by mesally shallow grooves. There are nine pairs of rather flat ribs, about as wide as the grooves, the last pair almost parallel to the rachis; anterior six lightly furrowed, posterior branch the larger. Surface minutely pebbled.

TYPES: No holotype has been designated previously. Type material includes N. Y. State Mus. Nos. 13365e/1 to 13365e/8. The most characteristic specimens appear to be Nos. 13365e/8, a relatively entire cephalon, herein designated as the holotype, and 13365e/6, a complete exfoliated pygidium, herein designated as a paratype.

OCCURRENCE: Devonian. Grande Greve limestone, Percé Rock and Blowhole Cliffs, Gaspé.

REMARKS: Clarke originally referred this species to *Probolium*, basing his allocation primarily on the presence of the frontal process and the nature of the glabellar lobation. Comparison of the types with those of *P. nasutus* and *P. tridens* indicates that fusion and elevation of the lateral lobes are by no means as advanced in the latter as in *S. biardi*. The frontal process is an outgrowth of the border rather than a continuation of the frontal lobe as in true *Probolium*.

The very wide, short cephalon with the flat, trifid process and lateral marginal crenulation is possessed by no other species. The pygidium superficially resembles *D. micrurus* but differs in fewer annulations and ribs and blunter terminus.

Synphoroides dolphi (Clarke, 1893)

(Plate 9, figure 10)

Dalmanites dolphi CLARKE, 1893, N. Y. State Mus., 46th. Ann. Rept., p. 195, 1 figure; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 134, fig. 17.

Cephalic width to length as 3 to 2, genal spines of moderate length. Frontal lobe rhomboidal, protruding, as long as wide; eyes moderately elevated. Anterior margin bears two pairs of very short, angular points, and a short, flat median process which is broken at the end. No surficial ornamentation is apparent. The thorax and pygidium are unknown.

TYPE: Holotype. N. Y. State Mus. No. 13376/1, an exfoliated cephalon.

OCCURRENCE: Devonian. Helderberg formation, Port Jervis, New York.

REMARKS: Allocation of this species to *Synphoroides* is based on the nature of the glabellar lobes. Although the first and second pairs are somewhat swollen, they by no means reach the *Synphoria* condition, and the marginal processes appear to be characteristic of the former genus. As in the case of *S. esnoufi*, in which the cephalon alone is known, the diagnostic specific feature is the nature of the anterior process. In his original figure Clarke (1893, p. 49, fig. 1) has drawn the flattened median branch with two short, sharp points, but careful examination of the broken process shows no basis for this restoration, and Clarke makes no explanation of his conclusion in his text. Hence the true nature of the terminus must remain unknown until the discovery of additional material.

The absence of lateral ornamentation along the margin, and the single median process, distinguish this species from *S. esnoufi*.

Synphoroides esnoufi (Clarke, 1907)

(Plate 9, figure 8)

Dalmanites (Probolium) esnoufi CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 164, 1 figure; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 43, 130, pl. 9, fig. 5.

Cephalon wider than long, with a broadly curved, flat border of moderate width, and short pointed genal spines. A short, flat, bifid frontal process is present, the broad pointed branches diverging at right angles from a base almost half as broad as the frontal lobe. Entire surface tuberculate. Thorax and pygidium unknown.

TYPE: Holotype. N. Y. State Mus. No. 13378e/1, an incomplete cephalic cast.

OCCURRENCE: Devonian. Grande Greve limestone (division 2), Grande Greve, Gaspé.

REMARKS: Without the frontal process, this cephalon is much like *O. micrurus*, except that the lobation is more marked, and the genal spines relatively shorter. With only the holotype known, the diagnostic specific character is the unique frontal process.

Synphoroides? griffoni (Clarke, 1907)

(Plate 9, figure 9)

Dalmanites griffoni CLARKE, 1907, N. Y. State Mus., Bull. 107, p. 153, 1 figure; 1908, N. Y. State Mus., Mem. 9, pt. 1, p. 103, pl. 7, fig. 4; pl. 9, fig. 4.

Cephalic width to glabellar length about 2 to 1; cephalon widest at genal angles, narrowly rounded in front with a simple rounded, flat, subtriangular frontal process; margins diverge evenly back toward genal angles. Genal spines short, acute. Frontal lobe elliptical. Surface smooth. Thorax unknown.

Accompanying the cephalon is a pygidium assigned to the same species by Clarke but not described. It is triangular, with sinuous margins and a triangular, bluntly spinose terminus. Border is of moderate width. Rachis narrow, composed of 16 or 17 annulations, the posterior three or four rather indistinct. There are 12 pairs of unfurrowed ribs which widen distally, the anterior ones wider than the intervening grooves, dying out by obsolescence of the grooves against the border. Surface finely pebbled.

TYPES: Holotype. An almost complete cephalon, N. Y. State Mus. No. 13380e/1. Paratype. A complete pygidium, N. Y. State Mus. No. 13380e/2.

OCCURRENCE: Devonian. St. Albans beds, Grand Cavée of the Griffon Cove River, Gaspé.

REMARKS: This interesting species is incompletely known, and Clarke made no mention of either thorax or pygidium in the original description. He described it as having complete glabellar lobation as in *Odontochile* (1908, p. 103), but the writer's observations suggest that the lateral furrows are not so complete as those of *Odontochile*, and the proportions of the cephalon and glabella differ sufficiently to warrant allocation to *Synphoroides*.

There is no direct evidence that the pygidium actually belongs with the cephalon, and the relationship must remain in doubt until a complete individual is found.

The simple frontal process, short, acute genal spines, and smooth surface differentiate this species from all others assigned to the genus.

Synphoroides multiannulatus (Ohern, 1913)

(Plate 9, figures 11–14)

Dalmanites multiannulatus OHERN *in* SWARTZ, OHERN, AND MAYNARD, 1913, Md. Geol. Surv., Lower Devonian, p. 500–502, pl. xcl, figs. 12–15; pl. xcll, fig. 1.

? *Dalmanites multiannulatus* MORSE, 1930, Miss. State Geol. Surv., Bull. 23, p. 31.

Cephalon moderately convex, with long slender genal spines; anterior margin bears sharp angular denticles and a central pair of long, sharp, curved processes diverging at an angle of 90 degrees. Entire surface thickly and rather coarsely tuberculate; tubercles cover glabella, fixed cheeks, free cheeks, become spinose along the postmarginal ridge and the inner edge of the genal spines; border smooth. Thorax unknown.

Pygidium broadly triangular, width to length as 4 to 3. Lateral margins moderately and uniformly curved; no trace of a terminal spine. Rachis long and rather narrow, extends to inner edge of the narrow posterior doublure, and consists of 18 annulations. Several of these bear a central pair of subspinose tubercles with a smaller tubercle on the crest, and all bear two offset rows of two or three tubercles each on either flank. There are 16 pairs of prominent, rather narrow ribs; the anterior 10 pairs are conspicuously furrowed and very gently curved, the posterior ribs unfurrowed, sigmoid, the last pairs curving inward toward the rachis. Each rib bears scattered tubercles of two sizes, the smaller confined almost exclusively to the anterior branch, the larger ones, of which there are four to six on each lobe, occupying the entire width of the rib. Occasional small tubercles are present also on the posterior branches, but seldom more than one on each rib.

TYPES: There are a number of specimens in the collections of the Maryland Geological Survey, on which the original description of the species was based. Only one of these, a complete pygidial cast, is labelled "Type." All are uncatalogued.

OCCURRENCE: Devonian. Oriskany (Ridgley member), Knobley Mountain, Cumberland, Maryland.

REMARKS: This species differs from all others in the possession of the peculiar anterior process, the very coarse and widespread cephalic ornamentation, lack of a terminal pygidial spine, prominently furrowed ribs, and nature of pygidial ornamentation.

Only two species bear a superficial resemblance to it. *O. phacoptyx* is profusely tuberculated but lacks the frontal process, possesses a long terminal spine and larger and less regular pygidial ornamentation. *O. townsendae* also has a long terminal spine, less regular ornamentation, and is much smaller.

Synphoroides pleuroptyx (Green, 1832)

(Plate 9, figures 15–17)

Asaphus pleuroptyx GREEN, 1832, Mon. Tril. N. Am., p. 55, cast No. 18.
Not *Dalmania p.* HALL, 1861, Pal. N. Y., vol. 3, p. 356, pl. 74, figs. 1–12 (5?, 9?).
D. (Hausmannia) pleuroptyx HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 28–30, pl. 11A, figs. 1–3.

Cephalon relatively rather wide, with genal spines two-thirds the glabellar length. Eyes of moderate size, extending from first to third furrows; cheeks narrow. Border rather narrow, re-entrant at the corners of the frontal lobe, then broadly produced mesally to about twice its lateral width; margin marked by a prominent central pair and four or five low lateral pairs of crenulations which become obsolete at the corners of the frontal lobe. Axial portion of glabella offset by parallel depressions. Surface of all lobes ornamented by small tubercles; cheeks pitted. The thorax illustrates no features of specific importance.

Pygidial width and length about equal; lateral margins almost straight; terminus triangular, rather sharply pointed; border narrow. Rachis narrow, low, rather short, gently tapering, composed of about 15 annulations. There are 10 or 11 gently and uniformly curved ribs, the two posterior pairs indistinct. The anterior eight pairs are distinctly furrowed, the posterior branch the larger. Anterior eight annulations ornamented by a central pair of nodes. Each rib branch bears a row of granules.

TYPES: Holotype. N. Y. State Mus. No. 13390/1, a flattened, weathered pygidium with part of test missing. This is the original of Green's cast No. 18. Other type material, N. Y. State Mus. Nos. 13390/2 to 13390/7, pygidia and cephala.

OCCURRENCE: Devonian. Helderberg formation (New Scotland beds), New York region. The holotype is cited as "from the Lower Helderberg of the Helderberg Mts."

REMARKS: This species is characterized by the broad, crenulated frontal expansion, genal spines, axially offset glabella; the pygidium by the triangular outline, rachial nodes, and furrowed ribs. The number of annulations (15) and ribs (10 to 11) appears to be constant in all specimens seen by the writer.

There has been much confusion concerning the actual identity of this species. Hall (1861, p. 356, pls. 74, 75), confused it with *O. micrurus*, and, although the mistake was corrected later (1888, p. 28, 29), Hall and Clarke did not republish figures of *O. micrurus* to emphasize the differences between the two species.

In summary, the differences between the pygidia are: *O. micrurus* is much larger, the ribs are distinctly asymmetrical and not distinctly furrowed, the rachis is longer, there are at least two more annulations and two or three more ribs, and the rachis lacks the paired nodes on the anterior annulations. The cephalon of *micrurus* has no frontal crenulation or process, is relatively longer, the cheeks are tuberculated, and the glabellar lobation is characteristic of *Odontochile*.

There is no other species with which *S. pleuroptyx* readily may be confused.

Hall and Clarke also expanded the range of *pleuroptyx* to the Onondagan, but no specimens have been seen from either the Oriskany or Onondagan which are closely related to it. It is to be emphasized that the "*D. pleuroptyx*" reported by many authors from areas outside the Appalachian region are in all probability entirely different species. This has been true of all cases in which there has been an opportunity to examine the specimens in question.

Allocation of *pleuroptyx* to *Synphoroides* is based primarily on the nature of the glabellar lobation and the marginal crenulation. The species cannot be referred to *Synphoria* because the glabellar lobes are not coalesced nor to *Odontochile* because

of the offset and depressed axial portion of the glabella, the somewhat elevated lobes, and insufficient number of rachial annulations.

Genus *Anchiopsis* Delo, 1935

Calymene GREEN, 1832, and early authors; *Phacops* BURMEISTER, 1843; *Dalmania* HALL, 1861; *Dalmanites* (*Chasmops*) HALL AND CLARKE, 1888; OHERN AND MAYNARD, 1913; *Dalmanites* GOLDRING, 1933.

GENOTYPE: *Calymene anchiops* Green, 1832 (p. 35, cast No. 7). *Dalmanites* (*Chasmops*) *anchiops* Hall and Clarke, 1888 (p. 59, pl. 9, figs. 1–6, 10, 12, 13; pl. 10, figs. 1–13).

GENERIC DIAGNOSIS: Synphoriinae with cephalon short and wide; glabellar lobes confluent and highly elevated distally; second and third pairs of lateral furrows represented by rounded pits separated by rounded depressed median ridge; dorsal furrows continuous but less deeply impressed than first lateral pair, which tend to join the submesal pits and divide posterior portion of glabella into three linear ridges; nuchal and genal spines may be present. Pygidium triangular, with short, triangular upturned spine; pygorachis short, bluntly terminated, consisting of less than 15 annulations; pleural ribs show only faint distal furrowing, absent on casts.

OCCURRENCE: Lower and Middle Devonian.

DISTRIBUTION: North America.

REMARKS: *Anchiopsis* marks the climax of lobal coalescence and elevation in the Synphoriinae. This condition is so well developed that Hall and Clarke erroneously assigned the genotype and related species to *Chasmops*. But *Chasmops*, by definition, applies only to species in which the first pair of glabellar lobes are greatly enlarged and the second pair greatly reduced (type: *Calymene odini* Eichwald). This is not the case in *D. anchiops*.

Synphoria shows a somewhat similar coalescence of the glabellar lobes, but the cephalon is much less convex, the lobes less swollen, the first pair of lateral lobes less prominent, and the second and third pairs of furrows deeper.

Anchiopsis anchiops (Green, 1832)

(Plate 10, figures 1–5)

Calymene anchiops GREEN, 1832, Mon. Tril. N. Am., p. 35, cast No. 7.
Dalmanites (*Chasmops*) *anchiops* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 59, pl. 9, figs. 1–6, 12, 13; pl. 10, figs. 1–13.

Cephalon highly convex with slender genal spines equalling half the cephalic length. Frontal lobe wider than long, frontal margin produced in narrow arc, inflected by a series of five or six very obscure crenulations which are indiscernible on casts. Glabella sparsely covered with rounded tubercles of two sizes, the larger on the frontal lobe. Nuchal furrow narrow, nuchal ring produced into a steeply inclined, acute, rounded, spine of moderate length. Eyes large. Cheeks covered with rounded confluent tubercles. Lateral border very sparsely granulated; posterior border smooth. Thorax shows no features of specific importance.

Pygidium triangular, margins sigmoid, terminal spine sharp, upturned, equal to one-third the total length. Rachis of moderate width, blunt behind, composed of eight or nine annulations. There are seven or eight pairs of rounded, unfurrowed ribs, as wide as the grooves. Surface smooth.

TYPE: Holotype. New York State Mus. No. 13362/4, an almost complete individual.

OCCURRENCE: Devonian. Oriskany, Walpole, Ontario. Schoharie grit, Ulster County, New York. Onondaga, New York, Ontario, Falls of the Ohio.

REMARKS: This species was first described by Green as *Calymene a.*, (1832, p. 35) and was subsequently referred to *D.* (*Chasmops*) by Hall and Clarke (1888, p. 59) because of the highly elevated and coalescent lateral lobes. But *Chasmops* is a genus in the subfamily Pterygometopinae, and both the morphological pattern and the manner of lobal coalescence differ in the two genera.

It differs from the *A. anchiops* var. *sobrinus* in presence of a nuchal and genal spines; from var. *armatus* in much smaller nuchal spine and presence of genal spines. In convexity and crenulation of the anterior border it is much like *S. stemmatus*, but the latter has no genal spines, the cephalon is relatively larger, crenulations more numerous and much more prominent, has no nuchal spine, and the pygidium is nonspinose. *S. pleuroptyx* has a much less convex cephalon, a short, crenulated frontal process, no nuchal spine, more numerous pygorachial annulations, and a much shorter terminal spine.

Although apparently rather widely distributed, *A. anchiops* is common only in the Schoharie formation in New York State.

Anchiopsis anchiops var. *sobrinus* (Hall and Clarke, 1888)

(Plate 10, figure 8)

Dalmanites (*Chasmops*) *anchiops* var. *sobrinus* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 62, pl. 9, fig. 11.

Cephalon with broadly rounded anterior and rather straight posterior margins. Frontal lobe very convex, anterior slope vertical. Genal angles and nuchal lobe nonspinose. Ornamentation indistinct, consisting of minute glabellar tubercles. Thorax and pygidium unknown.

TYPE: Holotype. N. Y. State Mus. No. 13364/1, a cast of an almost complete cephalon.

OCCURRENCE: Devonian. Schoharie formation, Schoharie, New York.

REMARKS: The nonspinose nuchal lobe and genal angles in combination are characteristic. Only the holotype is known.

Anchiopsis anchiops var. *armatus* (Hall, 1861)

(Plate 10, figures 6, 7)

Dalmania anchiops var. *armata* HALL, 1861, N. Y. State Cab. Nat. Hist., 14th Rept., p. 56.

Dalmanites anchiops var. *armatus* HALL, 1876, Pal. N. Y., Illus. Dev. Foss., pl. 9, figs. 2, 7, 8.

D. (*Chasmops*) *anchiops* var. *armatus* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 62, pl. 9, figs. 7–9.

Cephalon very large, very wide in proportion to length, posterior margin rather straight, genal angles nonspinose. Eyes relatively small. Nuchal spine very large, its base occupying the entire nuchal lobe, its length about two-thirds that of the glabella. Surface apparently smooth. Thorax and pygidium unknown.

TYPES: Cotypes. N. Y. State Mus. No. 13363/1, cast of a cranidium with spine; No. 13363/2, cast of a complete cephalon.

OCCURRENCE: Devonian. Type from Schoharie formation, Albany and Schoharie Counties, New York. Hall also reports it from the Onondaga formation, Mackinac, Michigan.

REMARKS: The very large size, nonspinose genal angles, cephalic proportions, and long, stout nuchal spine differentiate this variety from *A. anchiops*. It differs from var. *sobrinus* in larger size, greater width, presence of nuchal spine. It is not a common form.

Genus *Trypaulites* Delo, 1935

Dalmania and *Dalmanites* HALL, 1861 et. seq.; *Dalmanites* (*Chasmops*) HALL AND CLARKE, 1888; *Dalmanites* (*Odontochile*) GOLDRING, 1931.

GENOTYPE: *Dalmania calypso* Hall, 1861 (p. 61). *Dalmanites* (*Chasmops*) *calypso* Hall and Clarke, 1888 (p. 64, pl. 11A, figs. 19–22). *Dalmanites* (*Odontochile*) *calypso* Goldring, 1931 (p. 386).

GENERIC DIAGNOSIS: Synphoriinae with coalescence of all three pairs of glabellar lobes advanced; frontal lobe small, transversely elliptical; median portion of glabella between first and second lobes depressed; second and third glabellar furrows reduced to shallow pits; dorsal furrows much reduced and elevated opposite eyes; eyes large, with elevated palpebral lobes; short genal spines; broad uninterrupted cephalic border.

Pygidium rounded behind, moderately convex, with well-defined border; pygorachis of less than 15 annulations, continuing to posterior margin; pleural ribs flat, broad, indistinctly furrowed.

OCCURRENCE: Lower Middle Devonian.

DISTRIBUTION: North America.

REMARKS: Although the degree of fusion of the lateral lobes reaches about the same stage in *Trypaulites* as in *Anchiopsis*, there is no possibility of confusing members of the two genera. The frontal lobe in *Anchiopsis* is more or less rhomboidal, that of *Trypaulites* more nearly circular. The fused lateral lobes of the former are much more highly elevated, the cephalon increases in elevation posteriorly and is much more convex.

The pygidial features of *Trypaulites* are found in no other genus of the Dalmanitidae.

Trypaulites calypso (Hall, 1861)

(Plate 10, figure 9)

Dalmania calypso HALL, 1861, Descr. new sp. of Fossils, p. 61.
Dalmanites (*Chasmops*) *calypso* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 64–66, pl. 11A, figs. 19–22.

Cephalon moderately convex, with very broad, flat, continuous border, short genal spines, and large eyes. Nuchal furrow narrow; nuchal lobe long, elevated. Glabella moderately tuberculate. Thorax shows no features of specific value.

Pygidium convex, rounded behind with a continuous border of moderate width. Rachis rather narrow, tapering rapidly to posterior margin, composed of 11 angular annulations each of which bears a central spinose tubercle. The posterior nonannulated portion extends to the margin as an angular ridge. There are 10 or 11 broad, flat furrowed ribs, which are about twice as wide as the grooves and die out against the border. Surface smooth.

TYPES: Holotype, as designated by Hall and Clarke (1888, desc. of pl. 11A, fig. 22), a cast of an incomplete pygidium, Am. Mus. Nat. Hist. No. 4249. Paratype, a plastotype of a complete individual, N. Y. State Mus. No. 13370/1.

OCCURRENCE: Devonian. Onondaga limestone. Holotype, Falls of Ohio; Paratype, Sandusky, Ohio. Widely distributed at this horizon.

REMARKS: Hall and Clarke (1888, pl. 11A, fig. 21) also figure a hypostoma from Sandusky, Ohio, but there is nothing in their discussion to show that it was found attached to the paratype.

This species differs from *T. erinus* in the narrow curve of the posterior pygidial margin, the angular rachis, and spinose annular tubercles. The eyes appear to be smaller than the one shown by *T. macrops*, but no valid specific difference is apparent. Specific characteristics appear to be confined to the pygidium.

Trypaulites erinus (Hall, 1861)

(Plate 10, figures 10, 11)

Dalmania erina HALL, 1861, Descr. new sp. of fossils, p. 62.
Dalmanites (Chasmops?) erina HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 67, pl. 11A, figs. 16–18.

Cephalon and thorax unknown. Pygidial margins rather evenly rounded, width greater than length. Rachis rather narrow, with abrupt flanks and narrowly rounded crest, composed of 11 or 12 annulations. It descends gently in height to posterior margin, posterior portion nonannulated. There are 11 pleural ribs, the anterior ones very faintly grooved, flat, twice the width of the grooves, curving only very gently distally, and becoming obsolete against the broad border.

Ornamentation consists of very fine granulation along the crests of the annulations and ribs.

TYPES: Cotypes. Two pygidia, N. Y. State Mus. Nos. 13378/1 and 2.

OCCURRENCE: Devonian. No. 13378/1, Onondaga limestone, Clarence, Erie County, New York; No. 13378/2, drift boulder of Onondaga limestone, Naples, Ontario County, New York.

REMARKS: This rare species differs from *T. calypso* in the rounded rather than angular rachis and the absence of annular spinose tubercles. There is no other species with which it may be easily confused.

Trypaulites macrops (Hall, 1861)

(Plate 10, figure 12)

Dalmania macrops HALL, 1861, Descr. new sp. of Fossils, p. 59.
Dalmanites (Chasmops) macrops, HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 68, pl. 11A, figs. 14, 15.

This species is based on an incomplete cephalic cast which retains one very large eye containing about 500 lenses. The cephalon is strongly convex, the glabella tuberculate. No other features of specific importance are shown. Pygidium and thorax unknown.

TYPE: Cast of a cephalon lacking the left eye, genal angles, and anterior margin. N. Y. State Mus. No. 13382/1.

OCCURRENCE: Devonian. Onondaga limestone, Schoharie, New York.

REMARKS: Insofar as known, no specimens referable to this species have been found since description of the holotype. It is undoubtedly congeneric with *T. calypso*, but there are no distinctive specific features other than the large size of the eye.

Subfamily ASTEROPYGINAE Delo, 1935

Dalmanitidae with relatively unmodified glabellar lobation and genal spines; pleural extremities progressively produced or spinose posteriorly. Pygidium with five pairs of marginal spines or lappets, which are continuations of the anterior branch of the pleural ribs; terminal spine or process may be present.

OCCURRENCE: Devonian.

DISTRIBUTION: Europe, Asia Minor, North America, South America and Falkland Islands, South Africa.

DISCUSSION: The group of dalmanitid forms comprising the subfamily have long been referred to the genus *Cryphaeus* Green, 1837, despite its preoccupation by *Cryphaeus* Klug, 1833 (Coleoptera). They all possess in common a multispinose or lappeted pygidium, a feature so conspicuous that other more fundamental taxonomic features have been ignored, and much systematic confusion has been introduced.

R. Richter (1909) has adequately elucidated the importance of glabellar features within the group and has assigned pygidial features to a secondary role in classification.

In addition to the North American genus *Greenops*, the subfamily includes *Asteropyge* Hawle and Corda, 1847; *Metacanthus* Hawle and Corda, 1847; *Comura* R. and E. Richter, 1926; *Cryphina* Oehlert, 1889; *Kayserops* Delo, 1935; *Hadrorachus* Delo, 1935; and *Cryphaeoides* Delo, 1935.

Genus *Greenops* Delo, 1935

Cryphaeus GREEN, 1837, and many other authors (preoccupied by *Cryphaeus* KLUG, 1833). *Dalmanites* (*Cryphaeus*) HALL AND CLARKE, 1888.

GENOTYPE: *Cryphaeus boothi* Green, 1837 (p. 217, 2 woodcuts). *Dalmanites* (*Cryphaeus*) *boothi* Hall and Clarke, 1888 (p. 42, pl. 16, figs. 1–4; pl. 16A, figs. 3–8.)

GENERIC DIAGNOSIS: Asteropyginae with moderately convex cephalon, widely diverging dorsal furrows; glabella gently arched both transversely and longitudinally; frontal lobe transverse; first and second lateral lobes coalesced distally but not swollen; second lateral furrows reduced to rounded pits (elongate transversely on casts); third lateral lobes much reduced; third furrow short, deep, not entering dorsal furrows at their level (much deeper on casts); eyes of moderate size, visual area low, elevated to or slightly above glabellar surface; genal spines large, compressed. Pygidium much like that of *Metacanthus* in outline and convexity; pleural ribs wide, flat, with narrow but distinct interpleural grooves.

OCCURRENCE: Middle and Lower Upper Devonian.

DISTRIBUTION: North America.

REMARKS: In the allocation of North American species formerly referred to *Cryphaeus*, it became evident that they differed from those of other regions in the nature of the glabellar lobation. This is a fundamental feature, and, despite the superficial similarity to *Metacanthus* in pygidial features, must separate these species from it.

The North American forms show very little variation, and specific differentiation is based largely on pygidial features.

Greenops barrisi (Hall and Clarke, 1888)

(Plate 10, figure 18)

Dalmanites (*Cryphaeus*) *barrisi* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 48, pl. 16a, fig. 18.

Cephalon and thorax unknown. Pygorachis broad, with six to eight annulations. Ribs strongly furrowed, the anterior branches about twice the width of the posterior. Lateral spines rounded, slender, acute, separated at the base. Terminal spine triangular, about two-thirds as long as the adjacent lateral spines. Annulations and ribs moderately granulose; spines smooth.

TYPE: The holotype has been lost. No other type material is known

OCCURRENCE: Devonian. Cedar Valley limestone, Iowa City, Searstown, and near Buffalo, Iowa.

REMARKS: The description given above is based on the original description and figure. This species is very incompletely known, as the holotype cannot be located, and no other type material is available. It appears to differ from *G. boothi* in the slender spines; from *G. boothi* var. *calliteles* in the smaller number of rachial annulations (6 to 8 instead of 10 to 11), the much longer posterior lateral spines, and the longer terminal process.

G. fitzpatricki (Walter) from strata of the same age appears to differ in the possession of flattened, spatulate lateral spines.

Greenops boothi (Green, 1837)

(Plate 10, figures 14, 15, 17)

Cryphaeus boothi GREEN, 1837, Am. Jour. Sci., 1st ser., vol. 32, p. 343, 1 text figure.
Dalmanites (Cryphaeus) boothi HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 42–45, pl. 16, figs. 1–4; pl. 16A, figs. 3–8.

Genal spines very wide, smooth, extending back to about the fourth thoracic segment. Nuchal ring with central spinose tubercle and small granules. Posterior marginal furrow ends abruptly at juncture of cheek and spine. Axial portion of glabella and frontal lobe marked by small tubercles. Remainder of cephalon and genal spines finely and uniformly granulose.

Thoracic pleura produced laterally into wide, subacute extensions. Rachial annulations granulated mesally, the posterior ones with indistinct central node.

Pygorachis with eight or nine annulations, rachis tapering backward abruptly. There are five pairs of bifurcate ribs. Marginal processes crowded, leaflike, flat, rounded, terminal one short. All rachial annulations granulose. Pleural ribs covered with indistinct, finely scattered granules; marginal and terminal processes all distinctly and thickly granulose.

TYPES: The holotype is not known. Type material used by Hall and Clarke (1888) in redescribing the species is well preserved. This description is based on N. Y. State Mus. No. 13368/2, a complete indvidual with test, but somewhat crushed about the head (Hall and Clarke, 1888, pl. 16, figs. 1, 2).

OCCURRENCE: Devonian. Hamilton beds, New York region.

REMARKS: *Calymene microps* (Green, 1832, p. 34, cast No. 6) is generally supposed to be conspecific with this species, but the cast was apparently made from a weathered specimen and shows no features of specific value. The original is unknown.

The holotype, which Green described as occurring at Huntingdon, Pennsylvania, has been lost (1837, p. 343, text figure). Green's text figure is of little value, but his description makes it appear certain that the specimens figured by Hall and Clarke are conspecific with it.

G. boothi differs from the var. *calliteles* in the flat genal spines, less prominent nuchal lobe, absence of spinose tubercles on the rachial annulations, broad pygidial processes, and two or three fewer rachial annulations.

It differs from *G. kindlei* n. sp. in the short terminal spine, less elongate cephalon, and narrow anterior border. *G. pleione* has long, slender, pygidial processes; *G. comis* shorter, rounded processes and nodose rachial annulations.

Most specimens from outside the New York region which have been referred to this species are specifically or varietally distinct.

Greenops boothi var. *calliteles* (Green, 1837)

(Plate 10, figures 13, 16, and 19)

Cryphaeus collitelus GREEN, 1837, Am. Jour. Sci., 1st ser., vol. 32, p. 346.
Dalmanites (Cryphaeus) boothi var. *calliteles* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 45–48, pl. 16, figs. 5–22; pl. 16A, figs. 9–17.

Genal spines impressed by a continuation of the posterior marginal furrow which curves abruptly backward through the center of the spine; the portion above, a continuation of the posterior margin, is convex; that below is flattened. Spines extend almost to end of thorax, more slender than in *G. boothi*, but this is purely relative and varies in different individuals. Nuchal spine much more prominent than in *G. boothi*. Ornamentation of cephalon much as in *G. boothi*, although in some specimens the glabella is smooth, and granules are confined to border and spines, coarsest on genal spines.

Thororachial annulations granulose, all, beginning with second or third, bearing a central node. Posterior branch of pleura sparsely granulose, higher and narrower than in *G. boothi*. All pleura produced distally into subacute processes, somewhat more slender than in *G. boothi*, thickly granulated.

Pygidial rachis composed of 10 or 11 annulations, all granulose. Pleural ribs prominent, the anterior branch much larger and higher than the posterior, sparsely granulose. Marginal processes relatively slender, sharply pointed, separated, the line of greatest convexity narrow, posterior; terminal spine very short.

TYPES: Holotype unknown. This description based on type material described by Hall and Clarke, especially N. Y. State Mus. No. 13369/1, a complete individual retaining test (Hall and Clarke, 1888, pl. 16A, figs. 9, 14–15).

OCCURRENCE: Devonian. Hamilton beds. Hall and Clarke's type from Canandaigua Lake; Green's type described as from Huntingdon, Pennsylvania. General distribution throughout New York and adjacent States.

REMARKS: As in the case of *G. boothi*, the holotype of this variety has been lost, and the original description is incomplete. The abundant and well-preserved material described and figured by Hall and Clarke appears to be identical with the form described by Green.

The original spelling, *collitelus*, was thought by Hall and Clarke to be a typographical error, and their spelling is followed herein.

This variety differs from *Greenops boothi* in possessing two or three more pygorachial annulations; slender, separated pygidial spines, spinose tubercles on the rachis, more prominent nuchal lobe, and furrowed genal spines.

Greenops comis (Hall and Clarke, 1888)

(Plate 10, figure 21)

Dalmanites (*Cryphaeus*) *comis* HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 41, pl. 14A, fig. 1.

The cephalon and thorax are unknown. Pygidial rachis rather broad, extends to posterior margin, composed of six annulations, the last two indistinct, and a nonannulated part which slopes uniformly to the broken posterior margin. Both lateral margins incomplete. Cross grooves of rachis deeper laterally. Each annulation bears a low central node. Anterior branches of ribs much the larger, becoming higher distally. Lateral spines round, pointed, short, stout; terminal spine missing.

TYPE: Holotype. Cast of an incomplete pygidium. N. Y. State Mus. No. 13371/1.

OCCURRENCE: Devonian. Onondaga limestone, Walpole, Cayuga County, Ontario.

REMARKS: This unusual species is chiefly noteworthy because of the very short lateral spines which easily differentiate it from all others of the genus. Only the holotype is known.

Greenops kindlei Delo n. sp.

(Plate 10, figures 22, 23)

Cephalon relatively elongate, narrowly rounded in front, with a flat border of uniform width. Nuchal lobe nodose. Genal spines show the typical furrowed condition characteristic of *G. boothi* var. *calliteles* but are more slender, pointed. No ornamentation distinguishable. Thorax unknown.

Pygidial rachis narrow, composed of five distinct and five to seven indistinct annulations. Ornamentation, if present, indistinguishable. Spines broad, but well separated. Terminal spine broad, about three-fourths as long as the nearest lateral ones.

TYPES: Cotypes. A cephalic cast complete except for one genal spine; one complete pygidial cast; one incomplete pygidial cast. U. S. Nat. Mus. No. 62218.

OCCURRENCE: Devonian. Jeffersonville limestone, Little Rock Creek, Cass County, Indiana.

REMARKS: The cephalon of this species resembles that of *G. boothi* var. *calliteles* because of the furrowed slender genal spines but differs in being more elongate, more narrowly rounded in front, and in the possession of a border of moderate width. The broad, separated pygidial spines and elongate terminal spine are distinctive.

Greenops pleione (Hall and Clarke, 1888)

(Plate 10, figure 20)

Dalmanites (Cryphaeus) pleione HALL AND CLARKE, 1888, Pal. N. Y., vol. 7, p. 41, pl. 16A, fig. 2.

Cephalon and thorax unknown. Pygidial spines slender, very long (as long or longer than the corresponding rib), and rounded, curved backward, widely separated. Terminal spine triangular, about half as long as the adjacent ones, not acute. Spines not granulose as in *G. boothi* and var. *calliteles*. There are seven visible rachial annulations; end of rachis broken, but, judging by the proportions, there were only a few terminal ones. Bifurcation of ribs not pronounced as in *calliteles*.

TYPE: Holotype. A fragmentary pygidium. Am. Mus. Nat. Hist. No. 4248.

OCCURRENCE: Devonian. Hamilton, Silver Creek formation (Hydraulic limestone), Falls of Ohio.

REMARKS: This species superficially resembles *G. boothi* var. *calliteles*, but the spines are more slender near the base, do not taper as rapidly, and bear no granulose ornamentation, and the ribs are less prominently furrowed. It differs markedly from *G. boothi* and *G. kindlei* n. sp. in the slender rounded spines. Only the holotype is known.

Subfamily PTERYGOMETOPINAE Reed, 1905

Small Dalmanitinae with a tendency toward hypertrophy of the first glabellar lobes, or hypertrophy and fusion of the first and second lobes and reduction of the third. Pygidium of moderate size, nonmucronate, in most species rather convex.

OCCURRENCE: Ordovician. Western Europe, ? Burma, Siberia, North America.

REMARKS: Reed (1905, p. 1–11 of separate) established the subfamily and referred to it the species included in his "Branch C" of the Phacopidae. He also believed that the alteration of the glabellar segmentation within the subfamily took place by increase in size of the first lateral lobes and reduction of the second and third. This is true in *Chasmops* but not entirely so in other genera.

The North American representatives of the group include numerous species ranging in age from Chazy to English Head. Although rather well-marked relationships may be indicated, no definite sequence of appearance of the related genera can be traced, and several seem to have no direct relationship to previous North American forms. *Calliops*, with a complete second lateral furrow, appears to be the most primitive North American genus and is very similar to the European *Pterygometopus* which is not represented in North America. Closely related to it is *Eomonorachus* in which the second furrow is distally reduced in size; then *Calyptaulax* with the second furrow reduced to a fine line and both the first and second lobes enlarged. The culmination of this evolutionary series seems to be *Monorachus*, in which the second furrow is reduced to a proximal pit, and the anterior lobes are further enlarged. *Ligometopus*, with glabellar lobation similar to *Calliops* and a large frontal protrusion, is a minor departure from the main line of development. *Chasmops*

represents a more marked departure, as in this genus the first lobes are greatly enlarged, and the second almost obsolete. *Chasmops* is found in strata as old as Lower Middle Ordovician in the Baltic region and appeared in North America as a migrant in the Upper Ordovician. *Eomonorachus* does not occur outside North America, but *Calyptaulax* is found on both continents. *Calliops* appears suddenly in the Chazyan in North America and is there contemporaneous with *Calyptaulax;* hence it appears that both developed elsewhere.

Achatella may be a second major offshoot from the orthodox group, for, despite the rather generalized pterygometopid glabellar pattern, the flattened form, styliform eyes, and long genal spines suggest that it is specialized.

The relationship of the pterygometopids to the remainder of the phacopids has never been satisfactorily clarified. Clarke was misled by the superficial form of *Achatella achates* and *A. carleyi* and thought that they marked a transition between *Pterygometopus* and *Dalmanites* (1894, p. 732-733). This cannot be true, however, as these species possess specialized features which were not continued in the Silurian *Dalmanites*. He also thought that the lobal coalescence of *Chasmops* and other similar forms was evidence for phylectic immaturity. This view was based evidently on the reappearance of partial lobal coalescence in the Devonian dalmanitids (Synphoriinae), and he held that the latter marked a recurrent condition concomitant with racial senility.

If it is recognized that the genera with unmodified glabella lobation are generalized, then those with fused lobes should mark later stages in the development of the group. Unfortunately, specimens representing all stages in pterygometopid evolution have not been found in the same region, and their stratigraphic relationships are not entirely clear. This difficulty is enhanced by the finding of species indicating lobal specialization in the Lower Ordovician with those which are essentially unspecialized. As these mark the first appearance of the group, the nature of previous forms can be determined by conjecture only.

In summary, it seems clear that the Upper Ordovician forms are specialized and were derived from a common ancestor. The absence of pterygometopid structures in the Silurian phacopids make it seem very probable that the group disappeared at the close of the Ordovician without giving rise to any other branch of the Phacopidacea.

Genus *Calliops* Delo, 1935

GENOTYPE: *Phacops callicephalus* Hall, 1847 (p. 247, pl. 65, figs. 3a–i). *Dalmania callicephala* Hall, 1859 (p. 73). *Pterygometopus callicephalus* Clarke, 1894 (p. 731, figs. 51, 52) and later authors.

GENERIC DIAGNOSIS: Pterygometopinae with frontal lobe not conspicuously alate, sharply bounded, only slightly wider than large first glabellar lobes, which are distinctly triangular; second glabellar furrows narrower, shallower than first and third; eyes large, with conspicuously swollen palpebral lobes reaching backward to posterior marginal furrow; nuchal lobe prominent. Pygidium convex never mucronate, much as in *Pterygometopus, s. s.*

REMARKS: The genus differs primarily from *Pterygometopus s. s.* as typified by *P. sclerops* (Dalman) in the less alate frontal lobe which slopes abruptly to the cephalic border. In *P. sclerops* the lateral lobes are more or less elliptical, grading downward in size backward, the first lobe much narrower than the frontal. In *Calliops*, by contrast, the first lateral lobes are very large, definitely triangular, and only slightly shorter than the frontal lobe. The first lateral furrows are directed obliquely backward, the second obliquely forward, and the third almost parallel to

the second. The abrupt reduction in the size of the second and third lateral lobes gives the glabella a distinctly club-shaped appearance.

Calliops differs from *Eomonorachus* in the much smaller size of the second lateral lobes and the mesally arched glabella. It differs from *Calyptaulax* in the smaller size of the second lateral lobes and the complete second lateral furrows which reach the dorsal furrows.

OCCURRENCE: Ordovician.

DISTRIBUTION: North America.

Calliops annulatus (Raymond, 1905)

(Plate 11, figures 5-8)

Pterygometopus annulatus RAYMOND, 1905, Ann. Carnegie Mus., vol. 3, p. 376, pl. 14, figs. 24, 25; 1910, Vt. State Geol., 7th Ann. Rept., p. 247, pl. 36, figs. 24, 25.

? *Pterygometopus annulatus* RAYMOND, 1925, Bull. Mus. Comp. Zool., vol. 67, no. 1, p. 160, pl. 10, figs. 16, 17.

Frontal margin produced in narrow curve; frontal lobe width to length as 2 to 1; first lobes narrower than frontal. Nuchal lobe long, convex behind, not highly elevated; nuchal furrow shallow, narrow. Genal angles not prominently produced. Surface of glabella and palpebral lobes thickly tuberculate; cheek areas pebbled.

Thorax unknown. Pygidial width to length as 4 to 3, terminus prow-shaped, lateral flanks very steep. Zone of flexure at anterior end about one-third distance from dorsal furrow to margin, extending to rachial terminus. Rachis of moderate width, gently tapering in height and width, prominent, composed of nine annulations and a short nonannulated nub; cross-grooves sinuous. There are six pairs of furrowed ribs, the last indistinct. Furrows of the anterior two pairs about is long as grooves; remainder distinctly smaller; all originate near the dorsal furrow. Anterior branches of anterior ribs very long, extending almost to margin. Border narrow anteriorly, widening backward. Surface smooth.

TYPES: The holotype has been lost. Topotype material identified by Raymond in the Carnegie Museum from the type locality includes: No. 1384, a complete cephalic cast, eyes broken; No. 1385, an incomplete cephalon with test; No. 1386, an incomplete pygidial cast; No. 1387, a complete pygidial cast. Other uncatalogued topotype material is in the Museum of Comparative Zoology.

OCCURRENCE: Ordovician. Chazy formation, Valcour Island, New York. Type locality, Sloop Bay.

REMARKS: This species is very similar to *C. callicephalus* but differs in the expanded rather than elliptical glabellar plan, less produced genal angles, absence of cheek tuberculation, greater difference in length of rib branches, more sinuous rachial grooves, and one or two fewer annulations.

The material described by Raymond from the Lower Holston limestone, Liberty Hall, Ottosee, and Athens formations of Virginia, (1925, p. 160, pl. 10, figs. 16, 17) may be varietally distinct.

Calliops antecavatus Ulrich and Delo n. sp.

(Plate 11, figures 13, 14)

Cephalic width to length as 3 to 2; frontal margin narrow, flattened, a narrowly curved continuation of lateral margins. Frontal lobe not including border, twice as wide as long. Second lobes large for genus; nuchal lobe elevated above glabellar surface, broadly convex behind. Nuchal furrow with short anterior and long posterior slope. Axial portion of glabella depressed between lobes. Viewed in profile, entire surface of frontal lobe slopes in broad curve; posterior end of eyes elevated to

level of nuchal lobe. Cheek area between eye and genal angle triangular; distance from eye to anterior margin long. Genal angles narrowly curved; posterior border widens rather gradually, beginning about one-third the distance from dorsal furrow; lateral border width increasing gradually to genal angle.

Surface of glabella and nuchal lobe coarsely tuberculate; a group of tubercles on each extremity of frontal lobe outside the sutures; palpebral lobes finely tuberculose. Cheeks and border smooth.

Thorax and pygidium unknown.

TYPES: Holotype, an exfoliated cephalon. U. S. Nat. Mus. No. 78981.

OCCURRENCE: Ordovician. Middle of Kimmswick limestone, Elsberry, Missouri.

REMARKS: This species differs from others in strata of about the same geologic age from the Mississippi valley area, in the narrower rounding of the genal angles, relatively narrower genal border, larger cheek area, and wider curve of lateral margins. Whereas in *C. brevis* n. sp. (Galena) and *C. plattevillensis* n. sp. (Platteville) the margins describe a broadly rounded curve, in this species the radius of the marginal arc is much longer, and the cephalic outline is subtriangular. It differs in this feature from all others known to the writer.

Calliops armatus Ulrich and Delo n. sp.

(Plate 11, figure 12)

Cephalic width to length about 2 to 1. A definite broad lateral border present; it narrows just within the corners of the frontal lobe, then protrudes in a broad curve to about twice the width. Genal spines stout, short, sharp, their lower margin making a continuation of cephalic margin curvature. Second furrows tend to become transverse, concave backward; second lobe depressed; third lobe short, depressed, slightly separated axially from anterior lobes; nuchal furrow shallow, narrow, concave forward; nuchal lobe very long, elevated to level of first lobes. Eyes large, highly elevated with half of posterior end of visual area above glabellar surface; distance from anterior end to cephalic margin very long. Palpebral lobes infringing postmarginal furrow. Posterior border widens outside eyes. Surface of glabella and nuchal lobe covered with prominent tubercles; a group of smaller ones on upper surface of palpebral lobes; a row on frontal border; numerous tubercles on cheek area; a few small ones on posterior border.

Thorax and pygidium unknown.

TYPE: Holotype. A complete cephalon with test. U. S. Nat. Mus. No. 89988.

OCCURRENCE: Ordovician. Bromide formation at Rock Ford, Hickory Creek, Criner Hills, Oklahoma (about 2½ miles west of Overbrooke).

REMARKS: This species is unique because of the possession of a broad border, the relatively more elongate glabella with depressed posterior lobes, highly elevated eyes with low visual area, and genal spines. The latter separate it distinctly from all other members of the genus except *C. schmidti* (Clarke), but in the latter the spines are narrower, more acute, and do not continue the smooth curve of the cephalic margin. The cephalic margin is also much like that of *C. callicephalus*.

Calliops brevis Ulrich and Delo n. sp.

(Plate 11, figures 9–11)

Cephalic width to length as 4 to 3; anterior margin definitely prow-shaped. Frontal lobe convex, appearing rounded laterally, rather sharply offset from border. First lobes distinctly narrower than frontal; second rounded, with furrows slightly concave posteriorly; third lobe long mesally, offset from anterior portion of glabella;

axial part of glabella slightly offset from lobes. Viewed in profile, the glabellar surface is level from posterior portion of frontal lobe backward to nuchal lobe, which rises appreciably above it. Eyes large, posterior end rising just above surface; distance from anterior end to margin rather long. Border wide, genal angles rounded. Ornamentation consists of tubercles covering glabella uniformly; smaller on palpebral lobes; a few smaller ones on postlateral cheek area. Thorax unknown.

Pygidium convex, rounded triangular; width to length as 3 to 2. Angle of articulation planes very close to dorsal furrow. Rachis rather wide anteriorly, tapers rapidly in width and height, composed of eight or nine annulations, the last one indistinct. There are five deeply furrowed ribs and a posterior indistinct single pair. The rib branches are subequal, the anterior in each slightly longer and wider. Furrows begin very close to dorsal furrow at zone of flexure of lobe; surface smooth.

TYPES: Cotypes. Two cephala and a pygidium with test. U. S. Nat. Mus. No. 79002.

OCCURRENCE: Ordovician. Galena limestone (Prosser member: *Clitambonites* bed); Kenyon, Goodhue County, Minnesota. Other conspecific material in the United States National Museum collections includes No. 43104 from Cannon Falls, Minnesota.

REMARKS: This species represents a minor variation of the type of *C. callicephalus* from the Trenton of New York, and differences are chiefly matters of proportion and ornamentation. In *C. callicephalus s. s.* the second furrows are straight, and the second lobes more nearly quadrangular; anterior margin less produced; ornamentation more pronounced. The pygidium of *C. brevis* is relatively shorter, with one or two fewer annulations and ribs, a rounded instead of prow-shaped terminus, and the angle of the articulation planes much nearer the dorsal furrow. The surface is smooth instead of tuberculose.

C. plattevillensis n. sp. from the Platteville limestone of the same area is much larger than *C. brevis*, the cephalon less convex, frontal lobe more alate, border in front of eyes distinctly narrower, genal angles more produced, nuchal lobe lower. The pygidium is proportionally a little longer, more pointed behind with wider border, relatively lower and narrower rachis with one more annulation and one more pair of ribs.

Calliops callicephalus (Hall, 1847)

(Plate 11, figures 1–4)

Phacops callicephalus HALL, 1847, Pal. N. Y., vol. 1, p. 247, pl. 65, figs. 3a-i.
Not *Pterygometopus callicephalus* CLARKE, 1894, Minn. Geol. Nat. Hist. Surv., vol. 3, pt. 2, p. 731, figs. 51, 52.

Cephalon almost twice as wide as long, genal margins curving backward conspicuously. Frontal border protrudes mesally, otherwise essentially obsolete. Lateral border wide; lateral marginal furrow very wide and shallow, meeting straight narrow postmarginal furrow and outlining a triangular cheek area. Posterior border rounded, narrow from dorsal furrows to eye (about one-third its length), then widening abruptly backward until almost three times its proximal width. Eyes large, attain glabellar surface.

Frontal lobe almost twice as wide as long. Third lobe rises mesally to glabellar surface. Nuchal lobe long, very broadly convex backward. First lateral furrows straight; nuchal furrow of moderate depth, anterior slope the steeper and shorter.

Ornamentation consists of thickly distributed tubercles on glabellar and nuchal lobes; smaller ones on palpebral lobes. Cheek field covered with tubercles between eye and genal angle, with row of tubercles continuing forward below base of eye.

A group of tubercles are also present on the frontal lobe extension outside the sutures.

Thororachis prominent, of uniform width, each annulation thickly and coarsely tuberculated. Pleura finely pebbled.

Pygidium prow-shaped posteriorly; width to length as 3 to 2. Rachis prominent, narrow, tapering more rapidly in first half than in posterior, where dorsal furrows are almost parallel; gradually reduced in height but distinct at terminus; composed of 10 or 11 annulations separated by broadly sinuous cross-grooves.

There are six pairs of furrowed ribs and a very short single one parallel to the rachial terminus. Grooves and furrows about same width; anterior rib branches slightly wider and longer; furrows begin close to dorsal furrows. Rachial annulations and ribs tuberculate.

TYPES: The holotype has been lost. The description above based on specimens in the Walcott Collection, Museum of Comparative Zoology. Both are entire individuals from Trenton Falls, Mus. Comp. Zool. Nos. 4477 and 4478.

OCCURRENCE: Ordovician. Trenton formation, New York, Ontario.

REMARKS: Although known for three-quarters of a century, much confusion has arisen in the literature concerning the exact identity of this species. Because of the great similarity between most species of *Calliops*, many distinct species from areas other than the New York region have been assigned to *C. callicephalus*. The original figures and description are not suitable for discriminating differentiation.

An attempt is made herein to outline the major features of this species and to describe other new species by comparison with it.

Calliops declivis Ulrich and Delo n. sp.

(Plate 11, figures 15–19)

Frontal lobe very large, wider than first lobes; second lobes very small for the genus, depressed. Third lobe long; nuchal lobe long, moderately convex behind, elevated only slightly. First furrows straight, short; second very short, shallow, narrow; third deeper and wider than second; nuchal furrow narrow and shallow. Axial portion of glabella very wide; axial surface almost level from center of frontal lobe to nuchal furrow. Eyes rise above nuchal lobe, very long. Genal angles rounded, produced backward prominently. Ornamentation consists of scattered prominent tubercles on glabella and palpebral lobes.

The thorax shows no features of specific importance.

Pygidium convex, rather narrowly rounded behind, wider than long. Rachis narrow, with sinuous cross-grooves, tapers regularly in height and width, indistinct terminally, composed of eight or nine annulations. There are five pairs of very low, broad, flat, indistinctly furrowed ribs. They are distinct for only about two-thirds the distance from dorsal furrow to margin. Border uniformly very wide, dropping very steeply posteriorly. Surface smooth.

TYPES: Cotypes. Two cephala with test, one with part of thorax attached; two pygidia, one with test complete, one partially exfoliated. U. S. Nat. Mus. No. 78979. Paratypes. A cranidial cast and pygidium with thorax attached. U. S. Nat. Mus. No. 78979.

OCCURRENCE: Ordovician. Lenoir limestone, Friendsville and McMullen, Tennessee.

REMARKS: This species is unique because of the short furrows, very wide axial area on glabella, and very small second lobes. The pygidium may be differentiated by the very wide, low, flat ribs and narrow pleural grooves. No other species allocated to the genus has this combination of features.

Calliops fredricki (Slocom, 1913)

(Plate 11, figures 22-25)

Pterygometopus fredricki SLOCOM, 1913, Field Mus. Nat. Hist., Geol. Ser., vol. 4, p. 79, pl. 18, figs. 1-5. WALTER, 1927, Iowa Geol. Survey, vol. 31, p. 256, pl. 20, figs. 1-3.

Cephalon almost twice as wide as long; anterior margin very broadly and evenly rounded; a narrow border of uniform width present. Glabella widens very rapidly anteriorly. Viewed in profile the glabellar surface forms almost a straight line, then bends downward abruptly at the anterior end. First lateral lobes short; second directed steeply backward; third very narrow; nuchal elevated to or slightly above glabellar surface. Eyes low, with five facets in vertical rows, not attaining glabellar surface; long, extending from first almost to postmarginal furrow. Palpebral lobes low, wider than average for genus. Genal cheek area small, border not widened conspicuously. Glabellar and palpebral lobes tuberculose. The thorax shows no features of specific importance.

Pygidium rather broadly curved for the genus; width to length as 4 to 3. Rachis narrow, equals about three-fourths total length, composed of eight to ten annulations separated by sinuous grooves. There are six to eight pairs of furrowed ribs and a smooth border. Surface without ornament.

TYPE: Holotype. A complete individual. Field Mus. No. P 17924.

OCCURRENCE: Upper Ordovician. Maquoketa formation. Mississippi valley region. Holotype from top of Lower Maquoketa beds, Bloomfield, Iowa.

REMARKS: This species differs from *C. larrabeei* (Slocom) which occurs in the same strata, in the relatively wider cephalon with the broadly rounded margin, whereas the latter is subangular in front; in the lower eyes with five facets in a vertical row instead of eight; in the abrupt rather than gentle anterior curve of the frontal lobe when viewed in profile. The pygidium is more gently rounded posteriorly than in *C. larrabeei*.

Calliops gracilens (Raymond, 1925)

(Plate 11, figure 26)

Pterygometopus gracilens RAYMOND, 1925, Bull. Mus. Comp. Zool., vol. 67, no. 1, p. 162, pl. 10, fig. 18.

Cranidium moderately convex, broadly rounded in front, greatest convexity between first lateral lobes, from which the surface slopes in all directions. First furrows straight, third furrow very poorly marked mesally and third lobe quite reduced in height. Nuchal furrow narrow, very shallow, nuchal lobe low, broad, more or less evenly convex both anteriorly and posteriorly. Surface finely pebbled. Thorax unknown.

Pygidium triangular, narrow, pointed behind with very steep flanks, highly convex, with a narrow prominent rachis composed of 10 or 11 annulations and a short rounded nub which is very prominent, with subparallel sides; cross grooves straight. There are seven pairs of very low, flat, rather broad ribs. Grooves very narrow and shallow. Furrows very narrow and faint, only easily discernible on distal half, but appear to begin near the dorsal furrow. They continue nearer the border than the grooves, especially anteriorly, and curve backward. Anterior branch of first two ribs continue prominently to margin. Border narrow laterally, then widening gradually until it occupies entire space behind the rachis. Surface smooth.

TYPES: Holotype. An almost complete pygidium with test. Mus. Comp. Zool. No. 1725. Paratype. Cast of a cranidium. Mus. Comp. Zool., uncatalogued.

OCCURRENCE: Ordovician. Lower Lenoir limestone, 1 mile east of Bluff City, Tennessee.

REMARKS: The pygidium of this species is much more convex and pointed than any other species of *Calliops* known to the writer. The broad nuchal lobe and the shallow nuchal furrow also serve to differentiate it, but the cephalon is too incompletely known for critical comparison with other species. It differs from *P. intermedius* with which the pygidium might be confused in the shorter pygorachis and the furrowed very flat ribs. The very small size is also characteristic.

Calliops larrabeei (Slocom, 1913)

(Plate 11, figures 20, 21)

Pterygometopus larrabeei SLOCOM, 1913, Field Mus. Nat. Hist., Geol. Ser., vol. 4, p. 81, pl. 18, figs. 6-8. WALTER, 1927, Iowa Geol. Survey, vol. 31, p. 259, pl. 20, figs. 8, 9.

Cephalic width to length as 4 to 3; margins doubly curved laterally, frontal margin extended into a pronounced, flattened, narrowly rounded protrusion. Viewed in profile, glabellar surface straight from posterior end of frontal lobe to nuchal furrow. First lateral lobes short, cut off anteriorly by eyes; second narrow and somewhat depressed; third further depressed but not offset mesally from anterior portion of glabella. First furrows straight; second concave backward. Nuchal lobe slightly convex posteriorly, rising to glabellar level; nuchal furrow narrow, shallow. Frontal and first lobes and axial portion of glabella covered with small tubercles. Thorax unknown.

Pygidial width to length as 3 to 2; terminus smooth, prow-shaped; lateral articulation planes the width of the pleural areas. Rachis narrow, low, gently tapering, very low posteriorly; composed of eight or nine sinuous annulations, the last indistinct, and a short terminus. There are six pairs of furrowed ribs, their anterior branches much the longer, those of the anterior two pairs extending to the margin. Furrows very long, extending to dorsal furrows, almost as wide as grooves. Surface smooth.

TYPES: Holotype. An almost complete individual. Field Mus. No. P 11256. Paratypes. A complete enrolled individual; a complete cephalon. Present location unknown. Topotypes used in part as a basis for this discussion include a complete cephalon and pygidium. Walker Mus. No. 28043.

OCCURRENCE: Upper Ordovician. Lower Maquoketa formation. Mississippi valley region. Holotype and topotypes from Clermont, Iowa. Source of paratypes unknown.

REMARKS: Slocom mentions in his original description that *C. larrabeei* differs from *C. fredricki* in possession of a longer pygidium with more rachial annulations. Examination of the topotypes and comparison with the original figures and description fail to show this difference. The pygidium of *C. larrabeei* is more pointed; the cephalon more elongate.

Calliops leithi Delo n. sp.

(Plate 12, figures 1-3)

Cephalic width to length almost 2 to 1; genal angles rounded; frontal border upturned, bluntly pointed. Dorsal furrows make a double curve; glabella tapers gradually. Frontal lobe twice as wide as long, but frontal protrusion makes it appear longer. Greatest glabellar convexity between first lobes, which are of moderate size for the genus, narrower than the frontal, very blunt anteriorly because cut off by anterior end of eye. Second lobes small, rectangular, depressed; second furrows

short, straight, making an angle of about 70 degrees with first furrows. Third lobe depressed, not separated from anterior lobes. Nuchal lobe long, does not reach maximum height of glabella, subequally convex in plan; nuchal furrow rather narrow and shallow.

Posterior margin and furrow very narrow, making it appear that eyes reach posterior margin. Eyes reach glabellar level at posterior end. Palpebral lobes long, swollen, level with crest of eye, palpebral furrow deep. Ornamentation consists of coarse granules on frontal lobe, somewhat finer on lobes.

Thorax unknown. Pygidium convex, triangular, with prow-shaped terminus. Rachis prominent, gently tapering, extending four-fifths total length, composed of eight or nine annulations and short terminus, which on casts shows three to four very faint, narrow rings. Cross grooves wide, V-shaped, not sinuous; annulations well separated, angular on casts.

There are six complete and one incomplete ribs, the furrow in all beginning near the dorsal furrow, and subequal with grooves. Branches subequal, the posterior failing to reach the narrow border. Only four ribs visible on casts. Border increases in width posteriorly, terminally forming a narrow curve. Surface smooth.

TYPES: Cotypes. Two cephala with test; two pygidia, one without test. Peabody Mus., No. 15193.

OCCURRENCE: Ordovician. Long Point series; Three Rocks Point, St. George Peninsula, Newfoundland.

REMARKS: The writer is indebted to the courtesy of Mr. Edward Leith and the Peabody Museum for the opportunity of describing this interesting species. It shows close affiliation with *C. callicephalus* in the outline of the pygidium but is somewhat narrower, the border is narrower, and the surface lacks tubercular ornamentation. The cephalon is likewise much like that of *C. callicephalus*, but the ornamentation is much less pronounced, the axial, unfurrowed portion of the glabella is wider, and the nuchal lobe less elevated. The frontal protrusion is also more pronounced. There is no other species with which it may easily be confused.

Calliops plattevillensis Ulrich and Delo n. sp.

(Plate 12, figures 4, 5)

Pterygometopus callicephalus CLARKE, 1894, Minn. Geol. Nat. Hist. Surv., vol. 3, pt. 2, p. 731, 732, figs. 51, 52.

Cephalon very convex, width to length almost 2 to 1. Frontal lobe rather flattened, very wide; second lobes produced antero-laterally; nuchal lobe of moderate length, not prominently convex behind, rising only to glabellar surface. First furrows slightly sinuous. Viewed in profile, the glabellar surface rises in a smooth curve to second furrows. Eyes very large, separated anteriorly from margin by narrow border, rising to or slightly above glabellar surface posteriorly. Genal angles markedly produced; posterior cheek area elongate transversely, triangular.

Ornamentation consists of tubercles uniformly covering glabella; smaller and much less abundant on palpebral lobes; absent on cheeks and border. Thorax unknown.

Pygidium moderately convex, width to length as 5 to 4; prow-shaped posteriorly. Angle of articulation planes about one-third distance from dorsal furrow to margin. Dorsal furrows shallow. Rachis rather low, of moderate width, tapering gently in height and width, and consisting of 10 to 11 annulations separated by narrow, sinuous grooves. There are six pairs of flat, furrowed ribs, the anterior branches the longer; furrows beginning near the dorsal furrows and of same width as grooves. Border very wide. Surface smooth.

TYPES: Holotype, a cephalon with test, U. S. Nat. Mus. No. 78972. Paratypes, two pygidia with test, U. S. Nat. Mus. No. 78984.

OCCURRENCE: Ordovician. Platteville limestone. Cephalon, Minneapolis, Minnesota. Pygidia, Dixon, Illinois.

REMARKS: This species was erroneously described and figured by Clarke as *P. callicephalus* (1894, p. 731, figs. 51, 52) but careful comparison with typical specimens of the latter from Trenton Falls, New York indicate distinct differences. The cephalon of *C. plattevillensis* is relatively wider with more produced genal angles, frontal lobe relatively wider, first furrows sinuous instead of straight, second lobes more produced antero-laterally. Pygidium more broadly rounded with fewer ribs and annulations, broader flatter ribs, and smooth instead of tuberculate surface.

It differs from *C. brevis* n. sp. in larger size, wider cephalon, flatter cephalic profile, more alate frontal lobe, sinuous first furrows, triangular cheek area, narrower border in front of eyes, and more produced genal angles. The pygidium is less convex, relatively sharper behind, with less distinct ribs and dorsal furrows, and wider border.

Calliops schmidti (Clarke, 1894)

(Plate 12, figures 6, 7)

Pterygometopus schmidti CLARKE, 1894, Minn. Geol. Nat. Hist. Surv., vol. 3, pt. 2, p. 729, fig. 50.

Cephalon very similar to *C. brevis* and *C. callicephalus* but differs primarily in the presence of short, sharp genal spines, which begin abruptly on the genal angles, are narrow at the base, and very acute. The thorax shows no specific features.

Pygidium with gently curved margins and prow-shaped terminus; border wide. Width to length as 4 to 3. Rachis narrow, gently tapering, low posteriorly, equalling about three-fourths total length, composed of eight or nine sinuous annulations. There are five or six pairs of broad ribs separated by narrow grooves, last pair indistinct. Furrows equal about two-thirds total length of ribs, essentially same width and depth as grooves. Anterior rib branches extend indistinctly on border. Surface smooth.

TYPE: Holotype. A complete cephalon. Present location unknown.

OCCURRENCE: Ordovician. Galena formation. Upper Mississippi valley.

REMARKS: In general details of glabellar lobation this species resembles contemporary species of *Calliops*. The frontal lobe is relatively narrower than in *C. plattevillensis*, and the pygidium much more slender. It differs from *C. brevis* in broader ribs and somewhat more slender pygidium, but differences other than the genal spines are matters of proportion only.

Clarke's original figure is not accurate in depicting the nature of the genal spines, which are more slender at the base and do not continue the curve of the lateral cephalic margin.

Calliops strasburgensis Ulrich and Delo n. sp.

(Plate 12, figures 8-10)

Cephalic width to length about 4 to 3. Cephalon highly convex, narrowly rounded, with very narrow lateral border and narrow median liplike frontal protrusion. Genal angles narrowly rounded, genal border narrow. Viewed in profile, frontal lobe slopes abruptly in front. Axial portion of glabella offset from lateral lobes by subparallel depressions. First lateral lobes short; second ovate, very small; third not offset from remainder of glabella; nuchal highly elevated, long, posteriorly arcuate. First lateral furrows straight; second concave backward;

third present only distally; nuchal very shallow and narrow. Eyes of average size for the genus, rising above glabellar surface; palpebral lobes narrow. Glabellar surface, including nuchal lobe, heavily tuberculose; cheeks finely pebbled; border smooth. Thorax unknown.

Pygidium convex, prow-shaped behind; margins gently and evenly curved; border wide, smooth. Rachis prominent for entire length, sharply defined behind, narrow; composed of six distinct and two indistinct sinuous annulations. There are four pairs of short, prominently furrowed ribs. On casts the furrows begin about one-fourth the distance from the dorsal furrows and are about as wide as the grooves. Surface smooth.

TYPES: Holotype. An incomplete cephalon with part of test preserved. Paratypes. Two exfoliated cranidia; two exfoliated pygidia. U. S. Nat. Mus. No. 78982.

OCCURRENCE: Ordovician. Upper Chazyan (Bed 4 of Ulrich's 1905 section; location 333, f 12), Strasburg, Virginia.

REMARKS: This species most nearly resembles *C. declivis* n. sp. but differs in the larger second lateral lobes and much larger nuchal lobe. The pygidia are much alike, but in *C. strasburgensis* the rachis is higher posteriorly, relatively shorter; the ribs relatively narrower, more prominent, much more deeply furrowed.

Calliops tuberculatus Delo n. sp.

(Plate 12, figures 11, 12)

Cephalon and thorax unknown. Pygidium convex, very broadly rounded behind, width to length as 3 to 2. Rachis narrow, prominent, gently tapering, distinct posteriorly, composed of eight angular, nonsinuous annulations and a low terminal nub. There are five double ribs and one single, the fifth and sixth indistinct. Ribs broad, furrows and grooves narrow, subequal, becoming obsolete on the broad border. Furrows appear to begin very close to dorsal furrows. Crests of annulations and ribs bear small tubercles.

TYPES: Cotypes. A complete pygidium with test; one incomplete and one complete pygidial cast. U. S. Nat. Mus. No. 99224.

OCCURRENCE: Ordovician. Fernvale formation, 2 miles north of Providence, Arkansas (Sec. 5, T. 15N., R. 14W.).

REMARKS: This species is particularly characterized by the broadly rounded posterior outline, the broad border, and tubercular ornamentation. It differs from all other species known to the writer in this combination of features.

Genus *Calyptaulax* Cooper, 1930

GENOTYPE: *Calyptaulax glabella* Cooper, 1930 (p. 388–389, pl. 5, figs. 9–11).

GENERIC DIAGNOSIS: Pterygometopinae with first and second lobes coalesced distally; second lateral furrows very shallow, not reaching the dorsal furrows; eyes usually very long.

DISCUSSION: Cooper established *Calyptaulax* for species representing a transition in glabellar evolution between *Pterygometopus s. s.* and *Monorachus* Schmidt. He considered that the presence of the faintly impressed second glabellar furrows was evidence for the coalescence of the first and second glabellar lobes. *Chasmops*, in contrast, has the first glabellar lobe greatly enlarged and the second lobe almost obsolete. Other intermediate stages between *Pterygometopus* and *Monorachus* were subsequently described by the present writer (1935, *Calliops*, p. 417; *Eomonorachus*, p. 417). The acme of lobal fusion seems to have been reached in *Monorachus* in which

the first and second lobes occupy the entire lateral portion of the glabella, and the second furrows are reduced to submesal pits.

OCCURRENCE: Lower Middle and Middle Ordovician.

DISTRIBUTION: North America; ? British Isles.

Calyptaulax compressa Cooper, 1930

(Plate 12, figures 16, 17)

Calyptaulax compressa COOPER, 1930, Am. Jour. Sci., 5th ser., vol. 20, p. 389, pl. 5, figs. 7, 8.

Cephalon broadly rounded, width to length about 3 to 2. Axial portion of glabella wide. Frontal lobe transversely elliptical; first lateral lobes blunt, cut off anteriorly by eyes; second shorter than wide, directed backward; third long, indistinct, depressed. Nuchal lobe rather long, broadly convex behind, moderately elevated. First furrows well defined, relatively short, almost straight; second distinctly oblique; third distinct only distally; nuchal straight, narrow, very shallow. Eyes long, extending to postmarginal furrows; palpebral lobes broadly convex. Genal border of moderate width. Entire glabellar and palpebral surface tuberculose; nuchal lobe with single large tubercle.

Thorax and pygidium unknown.

TYPES: Cotypes. Two incomplete cephala with test. Peabody Mus. Nos. 12904 and 12920.

OCCURRENCE: Upper Ordovician. Zone F8 (No. 12904), South Cove; Zone F1 (No. 12920), Priest's Road; Gaspé.

REMARKS: This species differs from *C. glabella* Cooper in the rounded cephalic outline, relatively shorter first lobes, proportionally broader glabella, less oblique first furrows, more oblique second lobes, narrow genal border, and tuberculose ornamentation.

Calyptaulax confluens (Foerste, 1919)

(Plate 12, figure 21)

Pterygometopus confluens FOERSTE, 1919, Ohio Jour. Sci., vol. 19, no. 7, p. 396, pl. 19, fig. 19.

Glabella typical for the genus; genal angles and cephalic margin not seen. Second lateral lobes rounded distally; nuchal furrow shallow, asymmetrical; nuchal lobe long, broad, highest at posterior edge, without ornament. Highest part of glabella between confluent lobes. Eyes very long, reaching from first to postmarginal furrows. Entire cranidial surface minutely pebbled; glabella covered with scattered tubercles. Thorax unknown.

Pygidium (not figured) accompanying cranidia is fragmental. Rachis consists of five distinct annulations and a terminal indistinctly annulated portion of almost equal length. There appear to be about five broad, flat, unfurrowed ribs separated by sharp, narrow grooves.

TYPES: The types include three cranidia without test, one of which is incomplete; a fragmental pygidium. The cranidium figured by Foerste (1919, pl. 19, fig. 19) which should be designated as the holotype has not been catalogued separately.

OCCURRENCE: Ordovician. Tyrone member, Black River formation. High Bridge, Kentucky. All type material from this locality. Foerste (1919, p. 397) also states that similar cranidia have been collected from the Campnelson member of the Stones River at the same locality, differing only in more prominent ornamentation.

REMARKS: This species appears to be unique in the nature of the pygidial rachis

and the flat, unfurrowed ribs in combination. The cranidium appears to show no features of specific importance.

Calyptaulax eboraceous (Clarke, 1894)

(Plate 13, figures 1, 2)

Pterygometopus eboraceous CLARKE, 1894, Minn. Geol. Nat. Hist. Survey, vol. 3, pt. 2, p. 728, figs. 48, 49.

Cephalon narrowly rounded, widest at genal angles, which bear short stout spines. Lateral and posterior borders swollen, the latter not increasing conspicuously in width laterally. Frontal lobe wider than long, almost rhomboidal. Mesal portion of glabella depressed below lateral lobes. First lobes large, produced anteriorly; second large, fused with first distally; third indistinctly separated mesally, slightly depressed. Nuchal lobe long, elevated, convex and highest posteriorly, bearing a large mesal tubercle and several smaller ones. First furrows at about 45 degrees with body axis, almost straight; second at right angles to axis, deep proximally, very shallow distally; third deep, and posteriorly convex distally, very indistinct and anteriorly convex mesally. Eyes of moderate size, extending from slightly behind anterior end of first lobes to center of second. Genal cheek area large. Frontal lobe and mesal portion of glabella tuberculate.

Thororachis rather narrow, all annulations covered with small tubercles.

Pygidial width to length as 3 to 2; blunt posteriorly. Rachis narrow, not reaching posterior margin, composed of nine annulations. There are eight pairs of broad, prominent, furrowed ribs which extend almost to the margin. Annulations covered with very small tubercles; ribs smooth.

TYPE: Holotype. Cast of an entire individual. N. Y. State Mus. No. 14060/1.

OCCURRENCE: Ordovician. Trenton limestone. New York area. Holotype from Rawlins Mills, New York.

REMARKS: This species differs from most others assigned to the genus in the short eyes, short stout genal spines, and combination of blunt pygidium and furrowed ribs. It resembles *E. intermedius* superficially but differs in the blunt pygidium, incomplete second furrows, smaller eyes, ornamented nuchal lobe, stouter and shorter genal spines. It differs from *C. holstonensis* in the relatively longer frontal lobe, rounded stout genal spines, straight first furrows, and furrowed ribs.

Calyptaulax glabella Cooper, 1930

(Plate 12, figures 13–15)

Calyptaulax glabella COOPER, 1930, Am. Jour. Sci., 5th ser., vol. 20, p. 387, pl. 5, figs. 9–11.

Cephalon narrowly rounded, glabella rather narrow, frontal lobe rhomboidal, obtusely pointed anteriorly. First lateral lobes very long, narrowly produced; second small; third depressed mesally, curved anteriorly. Nuchal lobe long, distinctly curved backward. First furrows shallow, very oblique to body axis, slightly convex anteriorly; second just discernible, slightly oblique to axis; third curved forward mesally; nuchal narrow, shallow, straight. Eyes very long, extending from first to postmarginal furrows; palpebral lobes very broad, not highly swollen. Genal border broad. Surface smooth except for faint medial tubercle on nuchal lobe. Thorax unknown.

Pygidium bluntly angular, lateral margins slightly curved, width to length as 4 to 3. Rachis indistinct behind, less than one-third the total width, consists of eight or nine annulations separated by sinuous grooves, and equals about three-fourths the

total pygidial length. There are five or six pairs of very broad ribs, the last indistinct. The anterior pairs are furrowed for about half their length. Grooves very narrow and shallow; border wide, smooth. Surface minutely pebbled.

TYPES: No holotype previously designated, but original author based the species on cephalic characters, and the incomplete cephalon is herein designated the holotype. Peabody Mus. No. 12918. Paratypes. A complete pygidium, and one with border broken. Peabody Mus. No. 12917.

OCCURRENCE: Upper Ordovician. Zone F8, South Cove, Gaspé.

REMARKS: This species is characterized particularly by the romboidal frontal lobe, very long and narrow first lateral lobes, and smooth surface. The very broad pygidial ribs and narrow shallow grooves are also diagnostic. No other species of the genus possesses this combination of features.

Calyptaulax goodridgi (Schuchert, 1900)

(Plate 12, figures 18–20)

Dalmanites (*Pterygometopus*) *goodridgii* SCHUCHERT, 1900, Proc. U. S. Nat. Mus., vol. 22, p. 174, pl. 12, figs. 4–6.

Anterior cephalic margin with slight central angular inflection and a broad inward curve on either side. Anterior glabellar lobes characteristic for the genus; third reduced to distal nubs; nuchal elevated, long, doubly convex. Eyes very high, on styliform bases, visual surface low. Postmarginal furrow narrow. Genal spines short. Surface smooth. Thorax unknown.

Pygidium rather rounded behind, almost as long as wide. There are three very broad, furrowed ribs discernible on the test; only one on cast. Rachis composed of five annulations and a short terminal portion reaching to posterior border; prominent, tapering.

TYPES: Cotypes. A cephalon with nine thoracic segments attached; a detached pygidium; both with test. U. S. Nat. Mus. No. 28170.

OCCURRENCE: Ordovician. "Trenton." Head of Forbisher Bay, Baffin Land.

REMARKS: This species differs from other members of the genus in the short styliform eyes with low visual areas, the smooth surface, angular inflection of the frontal margin, and small number of pygidial annulations and ribs.

Calyptaulax? holstonensis (Raymond, 1925)

(Plate 13, figures 3, 4)

Pterygometopus holstonensis RAYMOND, 1925, Bull. Mus. Comp. Zool., vol. 67, no. 1, p. 161, pl. 10, figs. 9–11.

Cephalon uniformly convex, with broadly curved frontal border and flat, acute genal spines equalling about one-third the axial cephalic length. Lobate portion of glabella has an almost square appearance, decreasing in width very suddenly at the third lateral lobes. First and second lobes fused distally, second as wide as the frontal lobe. First lateral furrows almost vertical to body axis in proximal half, oblique and slightly convex backward in distal. Second furrows are proximal pits and extend for about five-eighths the lobal width, at right angles to body axis.

Nuchal furrow asymmetrical, with a steep anterior flank; nuchal lobe elevated, convex behind, with long gentle anterior slope. Ornamentation consists of small tubercles thickly distributed over frontal lobe and axial portion of glabella; more sparsely so on lateral lobes; remainder of cephalon smooth. Thorax unknown.

Pygidium strongly convex, broadly rounded and steeply sloping behind. Rachis prominent, extending almost to posterior margin, the anterior portion tapering distinctly and composed of five prominent annulations; cross-grooves straight.

There are two or three indistinct terminal annulations; six or seven broad ribs with shallow distal furrows. Grooves equal about half the width of anterior ribs. No ornamentation discernible.

TYPES: Holotype. Cranidium with fixed cheek and genal spine. Mus. Comp. Zool. No. 1644. Paratypes. Pygidial cast. Mus. Comp. Zool. No. 1645; cast of glabella. Mus. Comp. Zool. No. 1646.

OCCURRENCE: Ordovician. Holston limestone. Hoge farm, Bland County, Virginia.

REMARKS: This species is unique in the possession of the quadrangular glabella, incomplete second furrows at right angles to body axis, and even transverse convexity.

It differs from *E. convexus* n. sp. in the double curve of the first lateral furrows, absence of axial glabellar depressions, lack of tubercle on nuchal lobe, more thickly distributed and smaller tuberculate ornamentation, and more completely fused lateral lobes.

It differs from *E. intermedius* in the relatively broader cephalon, double curve of the first lateral furrows, more tapering first and shorter second lobes.

There are no other species with which it easily may be confused.

Calyptaulax lincolnensis (Branson, 1909)

(Plate 13, figures 5, 6)

Pterygometopus lincolnensis BRANSON, 1909, Trans. St. Louis Acad. Sci., vol. 18, no. 4, p. 46, pl. 7, figs. 17–19.

Cephalon broadly rounded in front, with very slight broad median angulation. Genal angles rounded. Axial portion of glabella offset by linear depressions. Frontal lobe broader than long as 3 to 2, highest at posterior end, sloping steeply anteriorly. Viewed in profile, posterior portion of glabella appears straight, third lobe slightly elevated, nuchal furrow shallow. Nuchal lobe elevated well above glabellar surface, rather long, highest and broadly arcuate behind. First lobes produced, narrow; first furrows straight; second lobes small, depressed below first, oblique. Eyes long, extending from first to postmarginal furrows. Surface of frontal lobe and axial portion tuberculose, lateral lobes more sparsely so; third and nuchal lobes smooth.

Thororachis gently tapering both anteriorly and posteriorly. Pygidium narrowly triangular, highly convex, terminus and flanks vertical; border very narrow. Rachis tapers uniformly in anterior half, then very gently to terminus, bending downward to the edge of the vertical portion of the terminus which equals from one-third to half the total height. There are about 20 annulations, the anterior 10 or 12 distinct, the posterior eight or ten indistinct, but may be counted easily with a hand lense on casts. Ribs broad, prominent, flat, almost straight, numbering nine or ten pairs, the last on the terminal flanks. Surface smooth.

TYPES: Cotypes. One almost complete individual with crushed glabella and pygidium; a fragmentary cephalon; a crushed cephalon with part of thorax attached; all are casts. Walker Mus. No. 11484, 11554.

OCCURRENCE: Ordovician. Auburn chert, near Auburn, Missouri.

REMARKS: Unfortunately the types of this species have not been available for study. Study has been made, however, of a collection from the type locality, courteously loaned by the original author. In it are two species represented by cranidia and pygidia. One of the former is obviously *C. lincolnensis*; the other appears to be *E. intermedius*. The pygidia which seem to belong with the latter are relatively wider, with sloping rather than vertical flanks, five or six fewer an-

nulations (two to four fewer distinct ones) and two fewer pairs of ribs. The original figures of *C. lincolnensis* fail to show the true nature of the pygidium, but the number of rachial annulations seems to be diagnostic. It may be that the *P.* cf. *lincolnensis* described by Foerste from the top of the Plattin limestone at Buford Cave, Ralls County, Missouri (1920, vol. 19, pl. 21, fig. 19) includes a pygidium of *E. intermedius*, although the cranidium appears to be normal for the species.

The cephalon of *C. lincolnensis* differs from *E. intermedius* in lack of genal spines, relatively broader frontal lobe, straight instead of curved first lateral furrows, more oblique second furrows, smaller second lobes, and larger eyes. It differs from *C. eboraceous* in lack of genal spines, smooth nuchal lobe, elliptical rather than rhomboidal frontal lobe, more tapering pygidium with many more annulations.

C. holstonensis also has genal spines, second lobes are vertical to body axis, first furrows doubly curved, surface thickly tuberculate.

Genus *Chasmops* McCoy, 1849

GENOTYPE: *Calymene odini* Eichwald, 1840 (p. 62) *Chasmops odini* McCoy, 1849 (p. 403, 1 text figure).

GENERIC DIAGNOSIS: Pterygometopinae in which the first lateral lobes are greatly enlarged, triangular; second very small. Eyes small, cone-shaped. Genal spines usually present. Pygidium rounded, strongly convex; ribs prominent; border indistinct.

DISCUSSION: *Chasmops* marks the culmination of enlargement of the first lateral lobes and obsolescence of the second. Although it appears in the Middle Ordovician strata of western Europe, the North American species are confined to the Upper Ordovician, and most of them appear to be migrants from Europe. It also marks the final appearance of the Pterygometopinae.

The genus was assigned to the subfamily by Reed (1905, p. 9, 10), and more recently has been discussed by Cooper (1930, p. 386–388). It appears to represent the climax of a developmental sequence which includes *Calliops* and *Calyptaulax* as earlier stages.

OCCURRENCE: Ordovician.

DISTRIBUTION: Europe, North America.

Chasmops anticostiensis (Billings, 1866)

(Plate 13, figures 14–16)

Chasmops anticostiensis BILLINGS, 1866, Cat. Sil. Foss. Anticosti, p. 61.—TWENHOFEL, 1928, Geol. Survey Canada, Mem. 154, p. 336, pl. 60, figs. 3, 4.

Axial portion of glabella offset from and depressed below fused lateral lobes. Nuchal furrow narrow; nuchal lobe rather long, elevated above glabellar surface, about level with crest of eyes. Eyes fail to reach anterior corner of first lobes; posteriorly reach almost to nuchal furrow; grooved at base. Facial suture in groove. Posterior margin widens laterally, curving backward into broad, elongate, gradually tapering genal spines as long as the glabella. Surface sparsely granulated; minutely pebbled between granules.

The thorax shows no features of specific value. Pygidium highly convex, narrowly rounded behind. Rachis prominent, long, blunt behind, gradually tapering, composed of 10 distinct and two indistinct annulations separated by straight grooves. There are 10 pairs of broad unfurrowed, prominent ribs, twice as wide as the grooves which extend to the indistinct border; ribs terminate by obsolescence of grooves. Surface smooth.

TYPES: Present location of types unknown. Plesiotype material used primarily

for this description, a complete individual and a separate cephalon, private collection of W. H. Twenhofel, No. 751.

OCCURRENCE: Upper Ordovician. English Head formation (zone 4), English Head; Vaureal formation (zones 1, 6), White Cliff and Vaureal Falls; Ellis Bay formation (zones 1, 4, 5, 7, 9), Junction Cliff and vicinity, and Ellis Bay: Island of Anticosti.

REMARKS: This interesting species differs from *C. occidentalis* Twenhofel from the same area, in the larger size, longer lateral lobes, and straight instead of curved rachial grooves.

Chasmops? breviceps (Hall, 1866)

(Plate 13, figure 18)

Dalmania breviceps HALL, 1866, N. Y. State Cab. Nat. Hist., 20th Rept., Adv. Sheets, p. 16; 1872, N. Y. State Mus. Nat. Hist., 24th Ann. Rept., p. 223, pl. 8, figs. 15, 16.

Anterior cephalic margin slightly produced mesally; genal spines pointed, about three-fourths as long as glabella, reaching to sixth thoracic segment. Frontal lobe almost twice as wide as long. Lateral lobes appear to show no specific features. Eyes large, with an average of five facets in a vertical row. Nuchal lobe elevated. Glabella coarsely tuberculate; cheeks smooth. The thorax shows no features of specific importance.

Pygidium very convex, bluntly triangular with almost vertical flanks and terminus. Rachis broad, high, gently tapering, abruptly terminated, composed of six or seven distinct annulations in anterior half and four or five indistinct posterior ones. There are six or seven pairs of broad, flat, unfurrowed ribs, separated by narrow grooves and extending to the narrow border. Surface smooth.

TYPES: The holotype has not been found. This description based in part on U. S. Nat. Mus. No. 78471 (Foerste, 1918, Ottawa Nat., vol. 31, pl. 6, fig. 31b).

OCCURRENCE: Upper Ordovician. Richmond formation. Ohio, Indiana. Holotype from Lebanon, Ohio; plesiotype from Richmond, Indiana.

REMARKS: This species differs from other North American representatives of the genus in the low eyes with an average of five facets in vertical rows, the short genal spines, and three or four fewer pygidial ribs.

Chasmops occidentalis Twenhofel, 1928

(Plate 13, figures 12, 13)

Dalmanites callicephalus BILLINGS, 1866, Cat. Sil. Foss. Anticosti, p. 27.
Chasmops occidentalis TWENHOFEL, 1928, Geol. Survey Canada, Mem. 154, p. 338, pl. 60, fig. 5.

Anterior cephalic margin broadly rounded, slightly pointed and projecting mesally. Cephalic width to length about 5 to 3. Genal spines equal cephalic length. Eyes with a maximum of eight facets in vertical rows. Lateral lobes rounded, not produced anteriorly. Nuchal lobe prominent. Glabella covered with scattered tubercles; remainder of cephalon smooth. The thorax shows no features of specific importance.

Pygidial width to length as 3 to 4, terminus narrowly rounded. There are 14 rachial annulations. All but the anterior annulation curve backward mesally and bear a row of four tubercles. Rachis equals seven-eighths entire pygidial length, tapers rapidly for anterior half, flanks subparallel throughout posterior half. There are nine pairs of ribs, the last indistinct, all furrowed throughout the distal two-thirds; they merge distally with the narrow border.

TYPES: Holotype. An incomplete cephalon with one genal spine. Paratypes. A second smaller incomplete cephalon, a detached pygidium.

OCCURRENCE: Ordovician. English Head formation (zones 3, 4), English Head; Vaureal formation (zone 4), Vaureal River: Island of Anticosti.

REMARKS: This species differs from *C. anticostiensis* Twenhofel from the same area in much smaller size (the holotype cephalon is 14 mm. in width; that of *C. anticostiensis* is 30 mm.). The eyes of the former are much lower with a maximum of eight facets in vertical rows; the average of the latter is 12. The rachial grooves of *C. occidentalis* are curved, and the annulations tuberculate; those of *C. anticostiensis* are straight and smooth.

Genus *Eomonorachus* Delo, 1935

GENOTYPE: *Dalmanites intermedius* Walcott, 1877 (p. 16); 1879, (p. 69). *Pterygometopus intermedius* Clarke, 1894 (p. 727, 728, text-figs. 45–47).

GENERIC DIAGNOSIS: Pterygometopinae with frontal lobe not conspicuously alate; first and second lateral lobes more or less coalesced, offset from median portion of glabella by axial depressions; second lateral furrows complete, narrow, shallow, deeper proximally; third lobes reduced to pair of distal tubercles and low median ridge. Pygidium sharply triangular, strongly convex, indistinctly bordered; narrow rachis extending to its extremity.

DISCUSSION: *Eomonorachus* appears to mark a divergence from the main trend of pterygometopid development. Whereas this main trend is characterized by reduction in the size of the second lateral lobes and reduction of the second furrows, *Eomonorachus* illustrates partial obsolescence of the second furrows, which are complete, deeper proximally, and do not meet the dorsal furrows at their level, but the second lobes, instead of being reduced, are enlarged. The culmination of this tendency seems to have been reached in *Monorachus* Schmidt from the Ordovician of Siberia, in which the second furrows are reduced to proximal pits and both the first and second pairs of lobes are greatly enlarged.

OCCURRENCE: Middle Ordovician.

DISTRIBUTION. North America.

Eomonorachus intermedius (Walcott, 1877)

(Plate 13, figures 7, 8)

Dalmanites intermedius WALCOTT, 1877, N. Y. State Mus., 31st Rept., adv. sheets, p. 69; 1879, N. Y. State Mus., 31st Rept., p. 69.

Pterygometopus intermedius CLARKE, 1894, Minn. Geol. Nat. Hist. Surv., vol. 3, pt. 2, p. 727, figs. 45–47.

Anterior cephalic border produced slightly into a prowlike terminus. Frontal slope of glabella rather steep, anterior furrows almost straight, curving very slightly backward distally. Second furrows narrow, deep for almost half the width of the lobes, then very faint, with a tendency to bend backward very slightly. On casts only the deeper portion is discernible. Third furrows curve forward. First lateral lobes the largest, reach glabellar level; second smaller; third represented distally by low nodes and a low central ridge which is greatly depressed. Axial portion of glabella from posterior end of frontal lobe to third lobe depressed. Nuchal furrow narrow, shallow, asymmetrical; nuchal lobe elevated, long, prominent. Genal spines long, slender. Eyes reach from behind the anterior end of first lobe almost to end of second and extend slightly above glabellar surface. Postmarginal furrow narrow; crest of frontal and lateral lobes sparsely tuberculate. The thorax shows no features of specific importance.

Pygidium very convex with almost vertical flanks, especially at the terminus; it is triangular in plan, with gently curved margins; width and length almost equal. Rachis narrow, extends to terminus, and consists of eight annulations in the first two-thirds of its length; remainder indistinct. There are seven or eight broadly rounded, unfurrowed pleural ribs, the grooves about half the width of the ribs, which die out on the narrow vertical border.

TYPES: No holotype is known. Plesiotype, a complete enrolled individual (Clarke, 1894). U. S. Nat. Mus. No. 41955.

OCCURRENCE: Ordovician. Plesiotype from Decorah shale, Chatfield, Minnesota. Reported from various localities in the Mississippi valley region; also from Middle Ordovician strata in the Appalachian region.

REMARKS: This species was first figured by Clarke (1894, p. 728, figs. 45-47), although described previously by Walcott. Clarke's figure of the pygidium represent it as being relatively narrower than is actually the case, but otherwise it is correct. The species is not an uncommon element of the Decorah fauna, and specimens which seem to be conspecific occur in the Galena limestone at Duck Creek, Wisconsin, and in the Auburn Chert of Missouri. It seems probable that there are several varieties which differ from the type in minor details. In all probability, citations of the species from regions other than the Mississippi valley and from formations other than those mentioned represent distinct varieties.

E. intermedius differs from other species of the genus in the anteriorly narrow cephalon, the very large second lateral lobes, relatively straight lateral cephalic margins, and pointed pygidium.

Eomonorachus convexus Ulrich and Delo n. sp.

(Plate 13, figure 9)

Cephalon highly convex; frontal lobe very steep in front and rather long, width to length as 8 to 5. Axial portion of glabella offset by linear depressions; lateral lobes large, swollen, extending back almost to nuchal lobe. Second furrows almost at right angles with body axis, deeper proximally, but complete. Third furrows curve forward proximally to meet the axial linear depressions. Nuchal furrow narrow, asymmetrical; nuchal lobe very high, elevated much above glabellar surface, very convex posteriorly, overhanging behind with a continuous forward slope from posterior edge; it bears a small central node. Genal spines about half as long as cephalon, slender, joining posterior border with a rather sharp angle. Eyes large, extending from first furrow to third, with a space about as wide as posterior border between end of eye and postmarginal furrow, which is rather narrow, straight, and meets the lateral marginal furrow at a sharp angle. Posterior border increases in width only slightly toward the genal angle.

Ornamentation consists of tubercles covering the entire glabella; sparsely so on lateral lobes; arranged in two irregular rows on axial portion. Palpebral lobes, cheeks, and border, smooth. Thorax and pygidium unknown.

TYPES: Holotype, an exfoliated, incomplete cephalon with one genal spine attached. U. S. Nat. Mus. No. 89987. Paratypes, glabella without test. U. S. Nat. Mus. No. 79015; glabella and top of one eye, exfoliated. U. S. Nat. Mus. No. 79014.

OCCURRENCE: Ordovician. No. 89987, Trenton formation, (*Prasopora* bed), Trenton Falls, New York; No. 79014, Lower Trenton, 4 miles west of Saratoga Springs, New York; No. 79015, Lower Trenton, 2 miles above Poland, New York.

REMARKS: This differs from all similar species in the nature of the genal spines, greater cephalic convexity, shorter eye, very high nuchal lobe, proportions of lateral

lobes, and nature of second furrows. The ornamentation seems fairly characteristic, especially that on the axial portion of the glabella.

It differs from *E. intermedius* in the rounded frontal margin, smaller second lobes, larger eyes, and coarser ornamentation.

Calyptaulax holstonensis differs in the incomplete second furrows, absence of linear axial depressions, much more thickly distributed ornamentation, and lack of a tubercle on the nuchal lobe.

Genus *Ligometopus* Ulrich and Delo n. gen.

GENOTYPE: *Ligometopus typus* Ulrich and Delo n. sp.

GENERIC DIAGNOSIS: Pterygometopinae with frontal lobe not conspicuously alate; first and second lateral lobes partially fused, somewhat offset from axial portion of glabella by shallow axial depressions. First lateral furrows curved forward through the distal half; second directed obliquely backward, consisting of proximal elongate pits and a shorter very shallow distal part; third lobes reduced to semidetached low tubercles and a low median ridge. The anterior cephalic margin bears a broad blunt spatulate process, as long, and almost two-thirds as wide, as the frontal lobe, with the facial sutures continued around its outer edge. Thorax unknown.

Pygidium very convex, broadly rounded behind, with broad furrowed ribs.

DISCUSSION: This genus is unique in the possession of the spatulate frontal process. The glabellar lobation appears to mark an intermediate stage between *Calliops*, in which lobation is complete and the second furrows reach the dorsal furrows at their level, and *Calyptaulax*, in which the second furrows are reduced to a thin line. The pygidium resembles somewhat that of species of both *Calyptaulax* and *Calliops* in the rounded outline and broad prominent ribs.

There is some doubt as to which of the features described are of specific and which of generic value. The finding of specimens other than the genotype should solve this problem. It seems probable that the peculiar frontal process and certainly the unique glabellar lobation are primary generic characteristics.

OCCURRENCE: Ordovician. Base of Liberty Hall limestone, on Reservoir Hill, Lexington, Virginia.

DISTRIBUTION: Probably confined to the southern Appalachian region. Only the genotype is known.

Ligometopus typus Ulrich and Delo n. sp.

(Plate 13, figures 10, 11)

Cephalon represented by an exfoliated glabella. Frontal margin bears a process almost two-thirds as wide and as long as the frontal lobe, with the facial sutures continued around its outer edge. Frontal lobe broader than long, second lobes almost as wide, third distinctly narrower. Viewed in profile, third lobes rise level with glabellar surface which is gently convex axially, highest point at posterior end of frontal lobe. Nuchal furrow wide, with steep anterior slope; nuchal lobe long, convex behind, wtih a long gentle anterior slope, elevated above glabellar surface. Thorax unknown.

Pygidium rounded behind, highly convex anteriorly, rachial crest sloping uniformly backward. Rachis prominent, tapers more gently throughout the posterior half, composed of five prominent and four or five rather indistinct annulations; reaches almost to posterior margin. There are five broad, prominent, furrowed ribs, and two or three narrow, angular, indistinct ones. Furrows strong only on distal

half but appear longer on casts. Distal portion of posterior ribs a continuation of anterior branch; especially apparent on casts. No ornamentation visible.

TYPES: Holotype, an exfoliated glabella with frontal process. Paratypes, two pygidia, one with test. U. S. Nat. Mus. No. 89996.

OCCURRENCE: Ordovician. Base of Liberty Hall limestone, on Reservoir Hill, Lexington, Virginia.

REMARKS: This species is characterized by the smoothness of the glabella, the very broad nuchal lobe, and the spatulate anterior process. Only the finding of more material will determine whether the latter feature is of generic or specific importance. The pygidium differs in the prominent, broad ribs and rounded, rather steep, posterior terminus.

Genus *Achatella* Delo, 1935

GENOTYPE: *Dalmanites achates* Billings, 1860 (p. 63, fig. 9). *Pterygometopus achates* Foerste, 1919 (p. 397, pl. 19, figs. 8, 18a).

GENERIC DIAGNOSIS: Pterygometopinae with broadly rounded cephalic margin, very alate frontal lobe, unreduced third lateral lobes, broad and elevated nuchal lobe, highly elevated, cone-shaped eyes set near the center of the cheeks, and genal spines. Pygidium subtriangular, indistinctly bordered, with wide furrowed pleural ribs and narrow grooves. Convexity of entire animal much less than in *Pterygometopus* and other members of the subfamily.

DISCUSSION: *Achatella* differs from *Dalmanites s. s.* in the alate frontal lobe which is not detached from the remainder of the glabella, expanded nuchal lobe, and indistinctly bordered pygidium. It differs from *Dalmanitina* in the nature of the frontal lobe, presence of a frontal cephalic border, cone-shaped eyes, elevated and broad nuchal lobe, and wide pygidial ribs. All other genera allocated to the Pterygometopinae are highly convex and possess large eyes, a greatly reduced or incomplete third lateral lobe, and less rounded cephalic outline.

OCCURRENCE: Middle and Upper Ordovician.

DISTRIBUTION: North America, British Isles.

Achatella achates (Billings, 1860)

(Plate 13, figures 19–21)

Dalmanites achates BILLINGS, 1860, Canad. Nat., vol. 5, p. 63, fig. 9.—CLARKE, 1894, Minn. Geol. Nat. Hist. Surv., vol. 3, pt. 2, p. 726, fig. 44.—FOERSTE, 1919, Ohio Jour. Sci., vol. 19, no. 7, p. 397, pl. 19, figs. 8, 18a.

Cephalon relatively very large, entire body tapering regularly to pygidial terminus. Frontal margin very broadly and regularly rounded, antero-lateral marginal curve abrupt. Genal spines very long, slender, extending almost to the end of the thorax. Eyes very highly elevated, styliform. Nuchal ring elevated into a short blunt spinose tubercle. Entire cephalic surface covered with low, irregularly confluent tubercles, largest on the glabella.

Entire thoracic rachis covered with granules; rachis prominent; pleura flat.

Pygidium depressed, narrowly triangular, rachis extending to posterior border; without terminal spine. There are nine or ten rachial annulations and eight or nine wide, furrowed ribs separated by narrow grooves. Rachis granulated, remainder of surface smooth.

TYPES: Present location of holotype unknown. Plesiotype used for this description and figured by Clarke (1894) is a complete individual with test. N. Y. State Mus. No. 13360/1.

OCCURRENCE: Ordovician. Trenton limestone, New York, Ontario. Plesiotype from Trenton Falls, New York.

REMARKS: This unique species may be differentiated from others allocated to *Achatella* by minor details only. The genal spines appear to be proportionally longer and the ornamentation less prominent, than in *A. carleyi* var. *rogersensis* (Foerste). *A. carleyi* (Meek) has two or three more rachial annulations and ribs, a less tapering pygidium, shorter genal spines and cephalic ornamentation restricted to the anterior portion of the glabella. *A. katharina* (Bradley) has three to six more rachial annulations, smaller eyes, and more slender curving genal spines.

Achatella carleyi (Meek, 1872)

(Plate 13, figures 22-24)

Dalmanites carleyi MEEK, 1872, Am. Jour. Sci., 3d. ser., vol. 3, p. 424; 1873, Ohio Geol. Surv., vol. 1, pt. 2, p. 170–173, pl. 14, figs. 2, a-d.

Pterygometopus carleyi FOERSTE, 1919, Ohio Jour. Sci., vol. 19, no. 7, pl. 19, fig. 17.

There has been no opportunity to examine either the type or typical representatives of this species. Foerste (1919, pl. 19, fig. 17) figures a typical cephalon and adds some descriptive remarks (p. 398, 399).

The anterior cephalic margin is broadly rounded with slight median angularity. Genal spines about as long as glabella. Eyes styliform, at least half their length from posterior margin; about seven lenses in a vertical row (Meek, 1873, p. 171); in var. *rogersensis* there are 11 or 12 (Foerste, 1919, p. 398). Nuchal lobe of *carleyi* bears a prominent spinose tubercle, and coarse ornamentation is confined essentially to the frontal lobe.

The pygidium (Meek, 1873, p. 171) is about as wide as long, the posterior extremity curved upward a little, with 13 distinct and two or three indistinct annulations, and about 13 unfurrowed ribs. Ornamentation consists of rather fine, irregularly scattered granules.

TYPES: The types figured by Meek (1873, pl. 14, figs. 2, a-d) include a cephalon and a pygidium. Present location unknown. The location of the complete cephalon figured by Foerste (1919, pl. 19, fig. 17) is also unknown.

OCCURRENCE: Ordovician. Fairmount member, Maysville formation. Cincinnati region.

REMARKS: In the absence of the type, there is no certain means of defining the distinguishing features of this species. Its relationship to the variety *rogersensis* is discussed in the description of the variety. It appears to differ from *A. achates* in the more restricted coarse ornamentation of the cephalon, shorter genal spines, two or three more pygidial annulations and ribs, and less tapering pygidium.

Achatella carleyi var. *rogersensis* (Foerste, 1910)

(Plate 13, figure 25)

Dalmanites carleyi-rogersensis FOERSTE, 1910, Bull. Sci. Lab. Denison Univ., vol. 16, p. 85.

Dalmanites achates FOERSTE, 1914, Jour. Cincinnati Soc. Nat. Hist., vol. 21, p. 147, pl. 1, fig. 18.

Pterygometopus carleyi-rogersensis FOERSTE, 1919, Ohio Jour. Sci., vol. 19, no. 7, p. 398, pl. 19, figs. 18A, B.

"So far no difference is known between the variety *rogersensis*, as found in the Rogers Gap division of the Cynthiana formation, and the typical forms of the species *carleyi*, from the Fairmount division of the Maysville formation, except in size, the Rogers Gap specimens usually being larger. . . .In *Dalmanites carleyi* the coarser granules are confined chiefly to the frontal lobe and to the median parts of the glabella; a few occur on the first pair of glabellar lobes, but elsewhere they usually

are rare or absent. In the variety *rogersensis*, these larger granules occur also in moderate numbers on the other glabellar lobes, on the neck ring, and less prominently, even on the fixed cheeks. This may be due to their larger size. The movable cheeks are macroscopically smooth. . . .In *Dalmanites carleyi*, a spinose granule ornaments the middle of the neck ring, close to the posterior margin. The presence of this spinose granule has not been demonstrated in any specimen of the variety *rogersensis*, but this part of the neck ring is defective in all specimens of *rogersensis* found so far. . . .In the Fairmount specimens of the species *Dalmanites carleyi* the ribs on the pleural lobes of the pygidium are curved more or less backward toward their extremities, especially in case of the posterior ribs. In the pygidia of the variety *rogersensis*, so far known, these ribs are nearly straight."

TYPE: Holotype. A cephalic cast. Present location unknown.

OCCURRENCE: Ordovician. Rogers Gap member, Cynthiana formation. Holotype collected along railroad north of Rogers Gap, Kentucky, 54.8 miles south of Ludlow, Kentucky.

REMARKS: There has been no opportunity to compare specimens of *A. carleyi* and the variety *rogersensis*. The description cited above includes the pertinent comparative portions of Foerste's description (1919, p. 398, 399). From examination of the figures, it appears that the two forms are very similar. In summary, the variety *rogersensis* seems to differ in larger size, more widely distributed coarse glabellar ornamentation, and straight instead of distally curved pygidial ribs.

Achatella katharina (Bradley, 1930)

(Plate 13, figures 26–29)

Dalmanites katharina BRADLEY, 1930, Contrib. Walker Mus., vol. 2, no. 6, p. 286–288, pl. 30, figs. 19–28.

Frontal margin very broadly curved, abruptly so laterally, giving cephalon a rectangular appearance in front. Genal spines very long, narrow, sharp, gently tapered, slightly curved, longer than glabella as 5 to 4. Eyes styliform, bases level with glabellar surface, opposite first lateral lobes and second lateral furrows. Nuchal furrow shallow; nuchal lobe elevated, nonspinose. Postmarginal furrow curves backward distally and disappears abruptly near the genal angle. Frontal lobe sparsely tuberculate; first lateral lobes and axial part of glabella bear a few scattered tubercles; cheek surface below and behind eyes sparsely pebbled. Thorax unknown.

Pygidium narrowly triangular, highly convex. Dorsal furrows very shallow. Rachis composed of 11 to 13 (16?) annulations with narrow cross grooves and extends to the short, steep, terminal slope. There are 10 or 11 broad, flat, faintly furrowed ribs, twice as wide as the intervening grooves. They broaden distally and die out on the border because of obsolescence of the grooves.

TYPES: Holotype. Cast of cephalon. Walker Mus. No. 20685. Paratype. Cast of pygidium. Walker Mus. No. 28977. Paratypes. Casts of several cephala and one pygidium. Walker Mus. No. 33780.

OCCURRENCE: Ordovician. Kimmswick formation. Holotype, 1 mile north of Batchtown, Illinois. Paratype, Glenco Lime Quarry, Glen Park, Missouri. Paratypes, 1 mile north of Batchtown, Illinois.

REMARKS: A large pygidial cast from the Kimmswick formation along Little Saline Creek, Ste. Genevieve County, Missouri (Walker Mus. No. 23115) also referred to this species shows 16 annulations and 13 ribs but appears to be identical otherwise.

This species differs from *A. achates* in the shorter, more styliform eyes, longer and more slender genal spines which are more prominently curved, and three to six more rachial annulations.

Achatella transsectus (Raymond, 1925)

(Plate 13, figure 30)

Pterygometopus transsectus RAYMOND, 1925, Bull. Mus. Comp. Zool., vol. 67, no. 1, p. 163, pl. 10, fig. 12.

This species is represented by a portion of a glabella and one fixed cheek. The second and third lateral furrows almost meet at the dorsal furrow, the third being posteriorly convex. First lateral lobe very small for the genus, second pointed distally. Distal nodes of third lobes rather large and separated. Surface without ornamentation. Thorax and pygidium unknown.

TYPE: Holotype. A portion of a glabella and fixed cheek, with test. Mus. Comp. Zool. No. 1641.

OCCURRENCE: Ordovician. Top of Holston limestone, 3 miles northeast of Blacksburg, Virginia. Very rare.

REMARKS: This unusual species, although based on very fragmentary material, is amply differentiated, by the smooth cephalic surface and pointed second lobe, from all others assigned to *Achatella*.

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EXPLANATION OF PLATES

PLATE 1. PHACOPINAE

FIGURE

(1, 2) *Phacops rana* (Green). Holotype. × ⅔. Courtesy N. Y. State Mus. (2) Hall and Clarke's figure of a type specimen. × ⅔. (p. 22)

(3) *Phacops rana* var. *milleri* Stewart. Lateral view of a cotype showing large eye, diagnostic feature of variety. × ⅔. (p. 23)

(4, 5) *Phacops cristata* Hall. Typical cephalic cast and a lateral view of a type thorax and pygidium showing rachial spines. × ⅔. From Hall and Clarke. (p. 16)

(6, 7) *Phacops cristata* var. *pipa* Hall and Clarke. Type cephalon and pygidium as figured by Hall and Clarke. × ⅘. (p. 17)

(8, 9) *Phacops logani* Hall. (8) Typical cephalon as figured by Hall and Clarke. × ⅘. (9) Eye, as figured by Hall. × ⅘. (p. 19)

(10–12) *Phacops logani* var. *gaspensis* Clarke. (10) Type cephalic cast, × ⅔. (11) Small pygidium, × ⅘. (12) Large pygidium showing typical ornamentation. × ⅔. All are Clarke's original figures. (p. 20)

(13–15) *Phacops logani* var. *birdsongensis* Delo n. var. (13, 14) Cephalic and pygidial views of holotype. × 2. (15) Lateral view of holotype cephalon, × ⅘. (p. 19)

(16) *Phacops hudsoniscus* Hall. Lateral view of type cephalon showing eye, as figured by Hall. × ⅘. (p. 17)

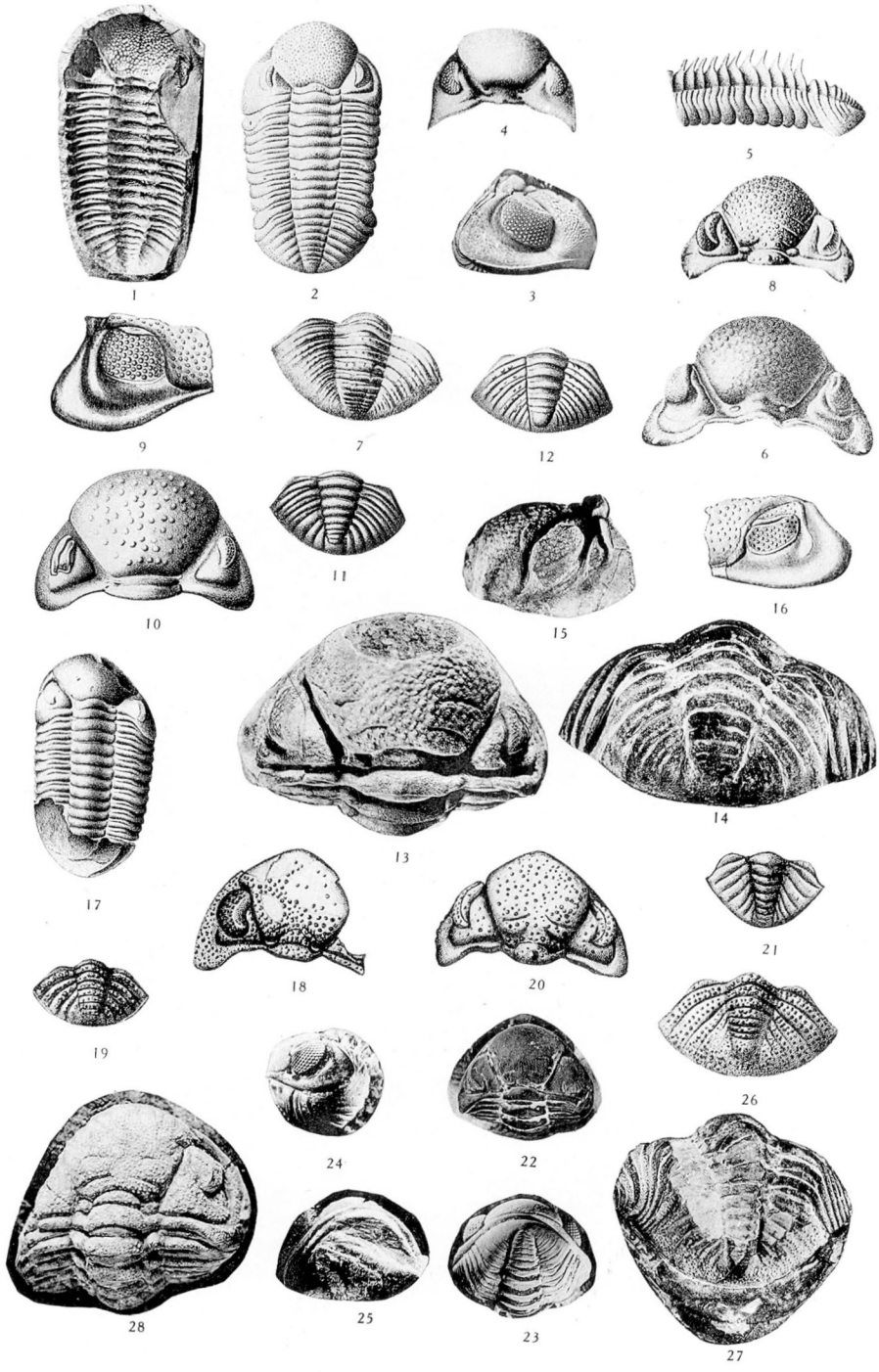
(17) *Phacops nupera* Hall. Hall and Clarke's figure of holotype. × ⅔. (p. 21)

(18, 19) *Phacops iowensis* Delo. Cephalon and pygidium of holotype. × ⅔. (p. 18)

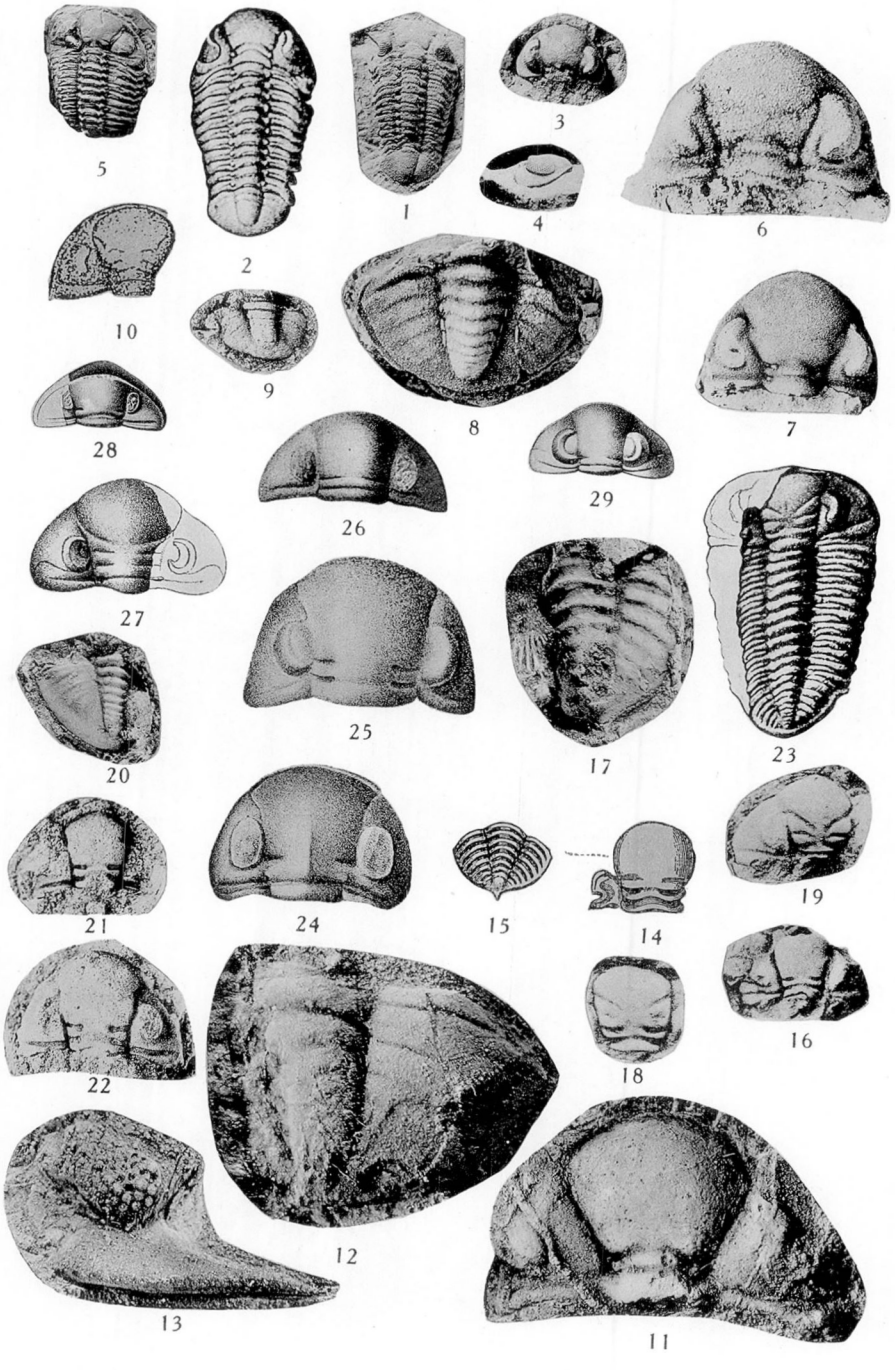
(20, 21) *Phacops raymondi* Delo. Holotype cephalon and a paratype pygidium. × ⅔. (p. 24)

(22–25) *Phacops orestes* Billings. (22–24) Dorsal, pygidial, and lateral views of a typical specimen from Anticosti Island. (25) Subcephalic view of another specimen in same collection showing subcranial furrow. All are × ⅘. Peabody Mus. Coll. (p. 21)

(26–28) *Reedops deckeri* Delo. (26) Holotype pygidium. (27, 28) Typical specimen from Birdsong shale illustrating lack of a subcranial furrow, low eye, and large cheek field. Peabody Mus. Coll. All × ⅔. (p. 25)



PHACOPINAE



PHACOPINAE AND ACASTINAE

Plate 2. Phacopinae and Acastinae

Figure

(1–4) *Eophacops handwerki* (Weller). Holotype, a cast. × 1. (2) Weller's original figure of holotype. × 1½. (3, 4) Dorsal and lateral views of a paratype cephalon. × 1. Courtesy Walker Mus. (p. 26)

(5) *Eophacops marklandensis* (McLearn). One of types, a cast. × 1. Courtesy Royal Victoria Mus. (p. 28)

(6) *Eophacops mancus* (Foerste). Holotype, a cephalic cast. × 1. Courtesy G. A. Cooper. (p. 27)

(7, 8) *Eophacops matheri* Delo n. sp. (7) Holotype, a cephalic cast. × 1. (8) Paratype, a pygidial cast. × 1. Courtesy G. A. Cooper. (p. 27)

(9) *Eophacops cerviculata* Ulrich and Delo n. sp. Holotype, a pygidial cast. × 1. Courtesy G. A. Cooper. (p. 26)

(10) *Eophacops? pulchellus* (Foerste). Copy of original drawing of holotype. × 1. (p. 29)

(11–13) *Eophacops primaevus* (Clarke). Plesiotype cephalon, incomplete pygidium, and eye with free cheek described and figured by Cooper (1930). All × 4. Courtesy Peabody Mus. (p. 28)

(14–17) *Scotiella logani* (Hall). (14, 15) Copies of Hall's original figures of holotype. × 1. (16) Copy of McLearn's figure of a typical cephalon. × 1. (17) Typical pygidial cast. × 2. Courtesy Peabody Mus. (p. 33)

(18–20) *Scotiella logani* var. *conservatrix* (McLearn). (18, 19) Copies of McLearn's figures of a type glabella and incomplete cephalon. × 1. (20) Pygidial cast. × 2. Courtesy Peabody Mus. (p. 34)

(21, 22) *Scotiella obsoleta* Ulrich and Delo n. sp. Cotype cephalic casts. × 1. Courtesy G. A. Cooper. (p. 34)

(23) *Acaste downingiae* (Murchison). Copy of Bastin and William's figure of a complete cast from Eastport, Maine district. × 1. (p. 30)

(24, 25) *Phacopina anceps* Clarke. (24) Copy of Clarke's original figure of holotype, a cephalic cast. (25) Clarke's figure of a paratype cephalic cast. Both much enlarged. (p. 31)

(26) *Phacopina nylanderi* Clarke. Copy of Clarke's original figure of holotype cephalic cast, approximately × 2. (p. 33)

(27–29) *Phacopina? correlator* Clarke. (27) Copy of original figure of holotype. × 3. (28, 29) Copies of figures of two cephalic casts from Gaspé assigned to species by Clarke. × 1½. (p. 32)

PLATE 3. DALMANITINAE

FIGURE

(1) *Dalmanites limulurus* (Green). Holotype of *Asaphus wetherilli* Green. × ⅔. Courtesy N. Y. State Mus. (p. 43)

(2) *Dalmanites limulurus* var. *lunatus* Lambert. Plesiotype from Clinton, New York, cast of an entire individual. × ⅔. Courtesy G. A. Cooper. (p. 44)

(3–5) *Dalmanites vigilans* Hall. (3, 4) Views of Weller's plesiotype cephalic cast from Chicago area. × ⅔. Courtesy Walker Mus. (5) Copy of Weller's drawing of a typical pygidium from same area. × ⅔. (p. 51)

(6–9) *Dalmanites halli* Weller. (6, 8, 9) Copies of Hall's figures of "*D. vigilans*" from Waldron, Indiana. × ⅔. (7) Typical cephalon from Waldron in collections of Museum of Comparative Zoology. × ⅔. (p. 41)

(10, 11) *Dalmanites bassleri* Ulrich and Delo n. sp. (10) Paratype pygidial cast without terminal spine. × ⅔. (11) Holotype pygidium. Courtesy G. A. Cooper. (p. 37)

(12, 13) *Dalmanites howelli* Ulrich and Delo n. sp. (12) Paratype cephalon. × ⅔. (13) Holotype pygidium. × ⅔. Courtesy G. A. Cooper. (p. 47)

(14, 15) *Dalmanites platycaudatus* Weller. Cotypes. (14) Cephalic cast. (15) Pygidial cast. Both × ⅔. Courtesy Walker Mus. (p. 48)

(16) *Dalmanites bicornis* Hall. Copy of Hall's original figure of holotype. × ⅔. (p. 37)

(17) *Dalmanites praenuntia* Stewart. Holotype pygidium. × ⅔. Courtesy Walker Mus. (p. 48)

(18) *Dalmanites aspinosus* Weller. Copy of Weller's original drawing of type. × ⅔. (p. 36)

(19, 20) *Dalmanites stewartae* Delo n. sp. Cotypes: copies of Stewart's original figures of *D.* cf. *aspinosus*. × ⅔. (p. 49)

(21) *Dalmanites retusus* Dunbar. Holotype pygidium. × ⅔. Courtesy Peabody Mus. (p. 49)

(22, 23) *Dalmanites bisignatus* Clarke. Copies of Clarke's original figures of cotype pygidia. × ⅔. (p. 38)

(24, 25) *Dalmanites danae* Meek and Worthen. (24) Paratype cephalic cast. (25) Paratype pygidial cast. Both × ⅔. (p. 40)

(26, 28) *Dalmanites huntonensis* Ulrich and Delo n. sp. (26) Holotype pygidium with spine present and test broken from left side. × ⅔. (28) Paratype pygidium with terminal spine broken but entire test in place. × ⅔. Courtesy G. A. Cooper. (p. 42)

(27) *Dalmanites taffi* Ulrich and Delo n. sp. Holotype, a pygidium with terminal spine broken but entire test present. × ⅔. Courtesy G. A. Cooper. (p. 50)

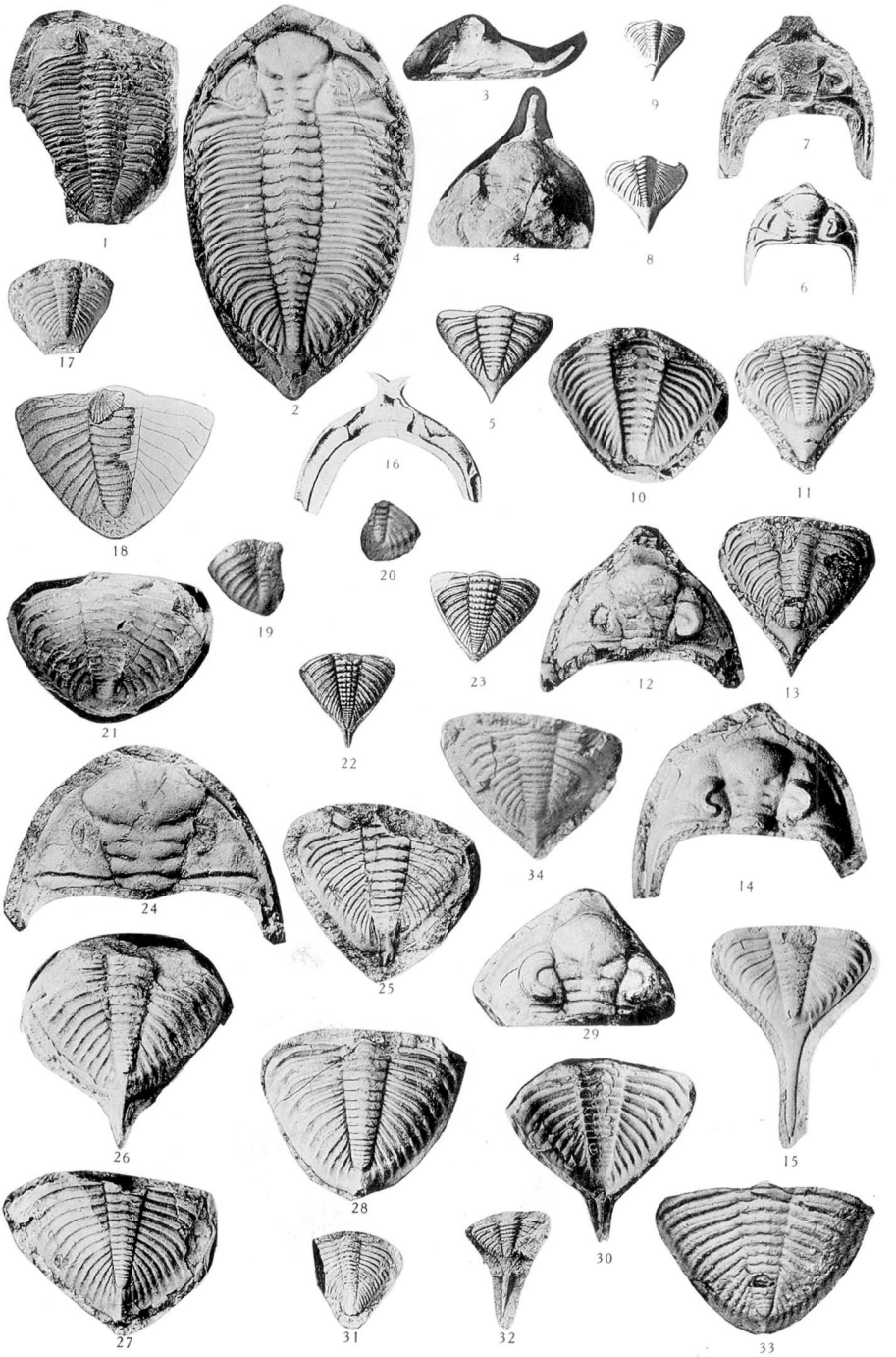
(29, 30) *Dalmanites lingulifer* Ulrich and Delo n. sp. (29) Holotype, an incomplete cephalon. × ⅔. (30) Paratype pygidium. × ⅔. Courtesy G. A. Cooper. (p. 45)

(31) *Dalmanites mississippiensis* Delo n. sp. Holotype, a pygidial cast. × ⅔. (p. 47)

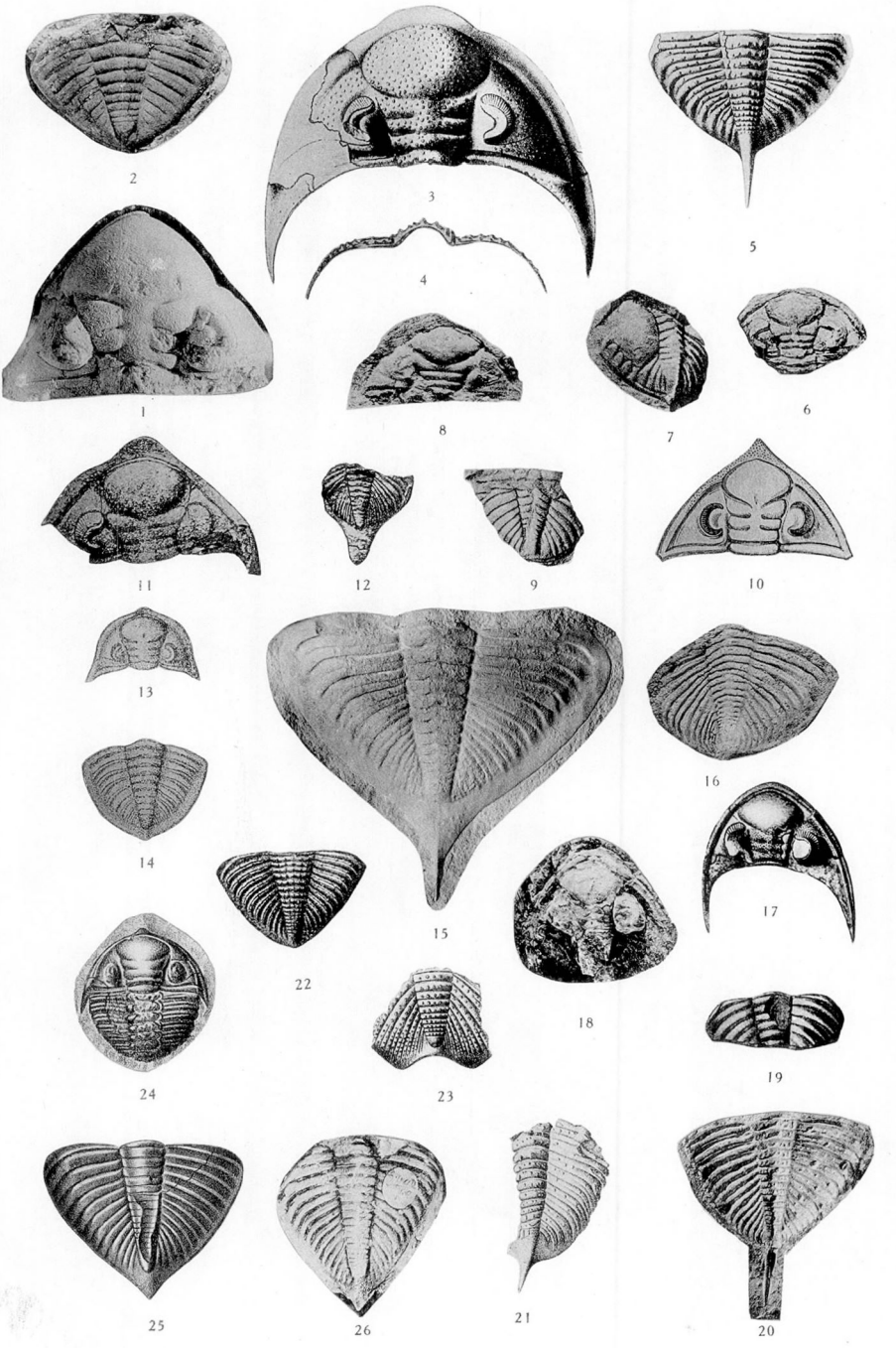
(32) *Dalmanites longispinus* Delo n. sp. Holotype, a pygidial cast. × 3. (p. 46)

(33) *Dalmanites slocomi* Stewart. Copy of Stewart's original figure of holotype pygidium. × ⅔. (p. 49)

(34) *Dalmanites carlwegi* Stewart. Copy of original figure of holotype pygidium. × ⅔. (p. 39)



DALMANITINAE



DALMANITINAE

Plate 4. Dalmanitinae

Figure

(1, 2) *Dalmanitina arkansana* (Van Ingen). Previously unpublished photographs of cotypes made by Van Ingen. Both are casts. Courtesy Princeton Univ. (p. 54)

(3–5) *Dalmanites verrucosus* Hall. Copies of Hall's original figures of types. (3) Typical cephalon. (4) Thoracic segment showing ornamentation. (5) Typical pygidium with conspicuous ornamentation and terminal spine a continuation of rachis. All × ⅔. (p. 51)

(6) *Dalmanites caudatus* var. *jupiterensis* Twenhofel. Copy of Twenhofel's original figure of holotype. × ⅔. (p. 40)

(7–10) *Dalmanitina weaveri* (Salter). (7–9) Specimens referred to the species by McLearn. × ⅔. (10) Copy of Salter's original figure of species. × ⅔. (p. 53)

(11, 12) *Dalmanites brevigladiolus* Foerste. Copies of Foerste's original figures of types. Both are casts. × ⅔. (p. 39)

(13, 14) *Dalmanites werthneri* Foerste. Copies of Foerste's original figures of types. Both are casts. × ⅔. (p. 52)

(15) *Dalmanites illinoisensis* Weller. Holotype pygidial cast. × ⅔. Courtesy Walker Mus. (p. 43)

(16) *Dalmanites? latus* Ohern and Maynard. Holotype, a pygidial cast in sandstone. × ⅔. (p. 43)

(17–19) *Odontochile keyserensis* (Swartz). Copy of original restored figure of holotype cephalon. (18) Unretouched photograph of same. (19) Copy of fragmental paratype pygidial cast. All × ⅔. (p. 57)

(20) *Odontochile townsendae* (Raymond). Holotype, a mold of a complete pygidium. × ⅔. (p. 63)

(21) *Odontochile phacoptyx* (Hall and Clarke). Copy of original figure of holotype, an incomplete pygidium with test. × ½. (p. 60)

(22) *Dalmanites? veiti* Clarke. Copy of Clarke's figure of one of cotype pygidia. × ⅔. (p. 50)

(23) *Odontochile? emarginatus* (Hall and Clarke). Copy of original figure of holotype. × ⅔. (p. 56)

(24) *Dalmanites gaveyi* Clarke. Copy of Clarke's original figure of holotype. × ⅔. (p. 41)

(25) *Dalmanites coxius* Clarke. Copy of original figure of holotype pygidium. × ⅔. (p. 40)

(26) *Odontochile lindenensis* Delo n. sp. Holotype, a pygidium with test. × ⅔. Courtesy Peabody Mus. (p. 57)

Plate 5. Dalmanitinae

Figure

(1, 2) *Odontochile micrurus* (Green). First published photograph of Green's holotype of species, a pygidial cast. × ⅔. Courtesy N. Y. State Mus. (2) Copy of Hall's figure of a complete young specimen. × ⅔. (p. 58)

(3) *Odontochile micrurus* var. *clarkei* Delo n. var. Copy of Clarke's figure (1908, Pl. 9, fig. 3) of an incomplete cephalon referred to *D. micrurus*, herein designated as holotype. × ⅔. (p. 59)

(4) *Dalmanites brevicaudatus* (Foerste). Copy of Foerste's original figure of cotype pygidial casts. × ⅔. (p. 38)

(5, 6) *Odontochile percéensis* (Clarke). (5) Copy of original figure of type pygidium. (6) Copy of original figure of type glabella. Both × ⅔. (p. 59)

(7) *Odontochile dunbari* Delo n. sp. Holotype, a pygidium with test. × ⅔. Courtesy Peabody Mus. (p. 56)

(8) *Odontochile ploratus* (Clarke). Copy of Clarke's original figure of holotype. × ⅔. (p. 61)

(9, 10) *Odontochile acuminatus* Ulrich and Delo n. sp. (9) Paratype from Haragen formation of Oklahoma. Courtesy G. A. Cooper. (10) Holotype, a pygidial cast from Helderbergian limestone of Mississippi. Both × ⅔. (p. 55)

(11) *Odontochile phacoptyx* var. *gaspensis* Delo n. var. Copy of Clarke's original figure of *D. phacoptyx* from Gaspé, herein designated as holotype of variety. × ⅔. (p. 61)

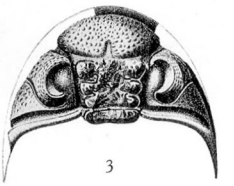
(12) *Odontochile berkleyensis* (Swartz). Holotype, a pygidial cast in sandstone. × ⅔. (p. 55)

(13) *Phacopina chapmani* (Williams and Breger). Holotype, a somewhat distorted cephalic cast. × 3. Courtesy G. A. Cooper. (p. 31)

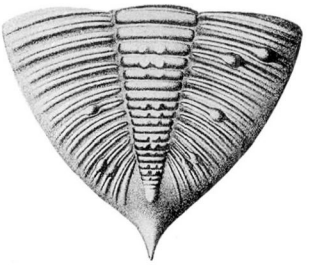
(14) *Dalmanites litchfieldensis* Delo n. sp. Holotype, a pygidium complete except for terminus. × ⅔. Courtesy G. A. Cooper. (p. 46)



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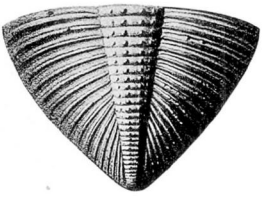
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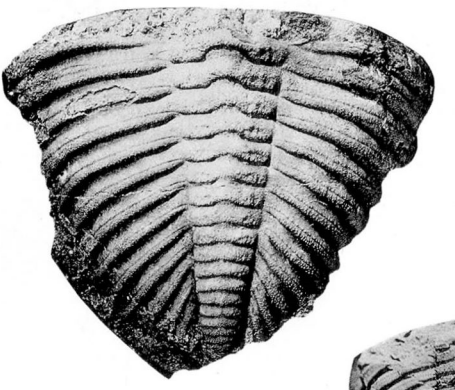


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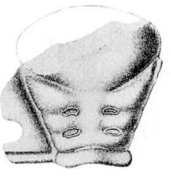
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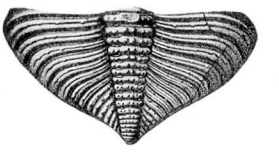
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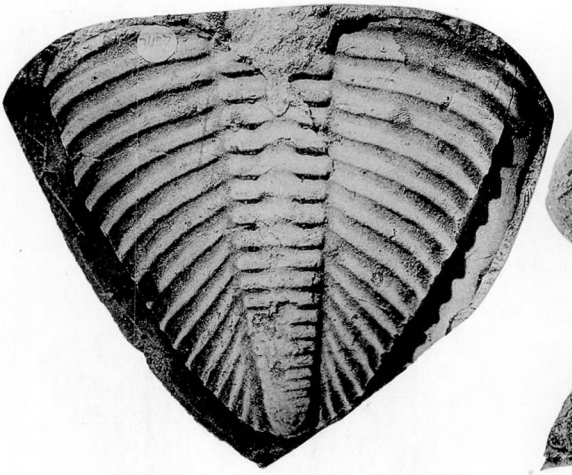


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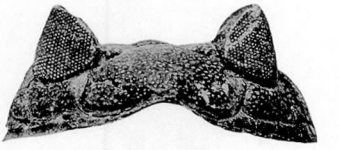
DALMANITINAE



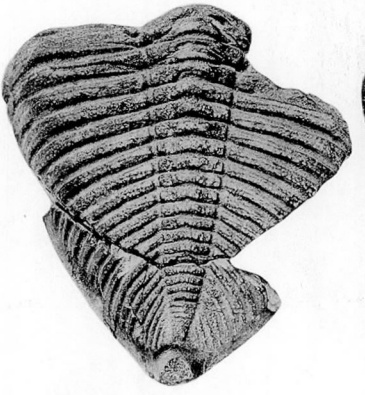
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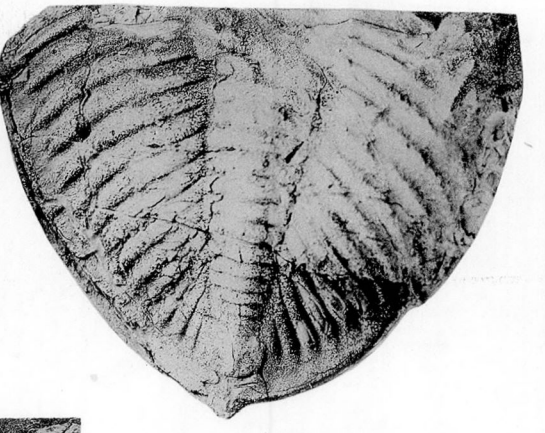
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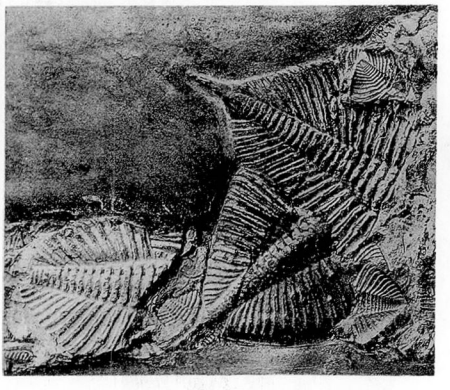
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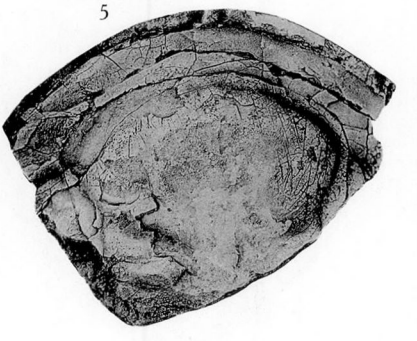
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DALMANITINAE

PLATE 6. DALMANITINAE

FIGURE

(1) *Odontochile purduei* (Dunbar). Holotype, a pygidial cast. × ⅔. Courtesy Peabody Mus. (p. 62)

(2–4) *Odontochile pratteni* (Roy). (2, 3) Views of cephalon of holotype. (4) Pygidium of holotype showing broken base of erect terminal spine. All × ⅔. Courtesy Field Mus. (p. 62)

(5, 6) *Odontochile ulrichi* Delo n. sp. (5) Holotype, a pygidium with test. (6) Paratype, a frontal lobe and margin. Both × ⅔. Courtesy G. A. Cooper. (p. 63)

(7) *Odontochile percéensis* (Clarke) and *Dalmanites? veiti* Clarke. Copy of Clarke's figure of a slab of limestone from Gaspé, now in N. Y. State Museum. Upper large pygidium of *O. percéensis* is restored terminally and probably shows too many annulations. × ⅔. (p. 59)

PLATE 7. SYNPHORIINAE

FIGURE

(1–3) *Synphoria stemmatus* Clarke. (1, 2) Copies of Clarke's original figures of holotype, a cephalic cast. (3) Paratype pygidial cast. All × ½. (p. 68)

(4–6) *Synphoria stemmatus* var. *convergens* Clarke. Copies of Clarke's original figures of types. × ½. (p. 68)

(7, 8) *Synphoria? concinnus* (Hall and Clarke). (7) Copy of original figure of holotype. × 1. (8) Copy of original figure of a paratype. × 1. (p. 65)

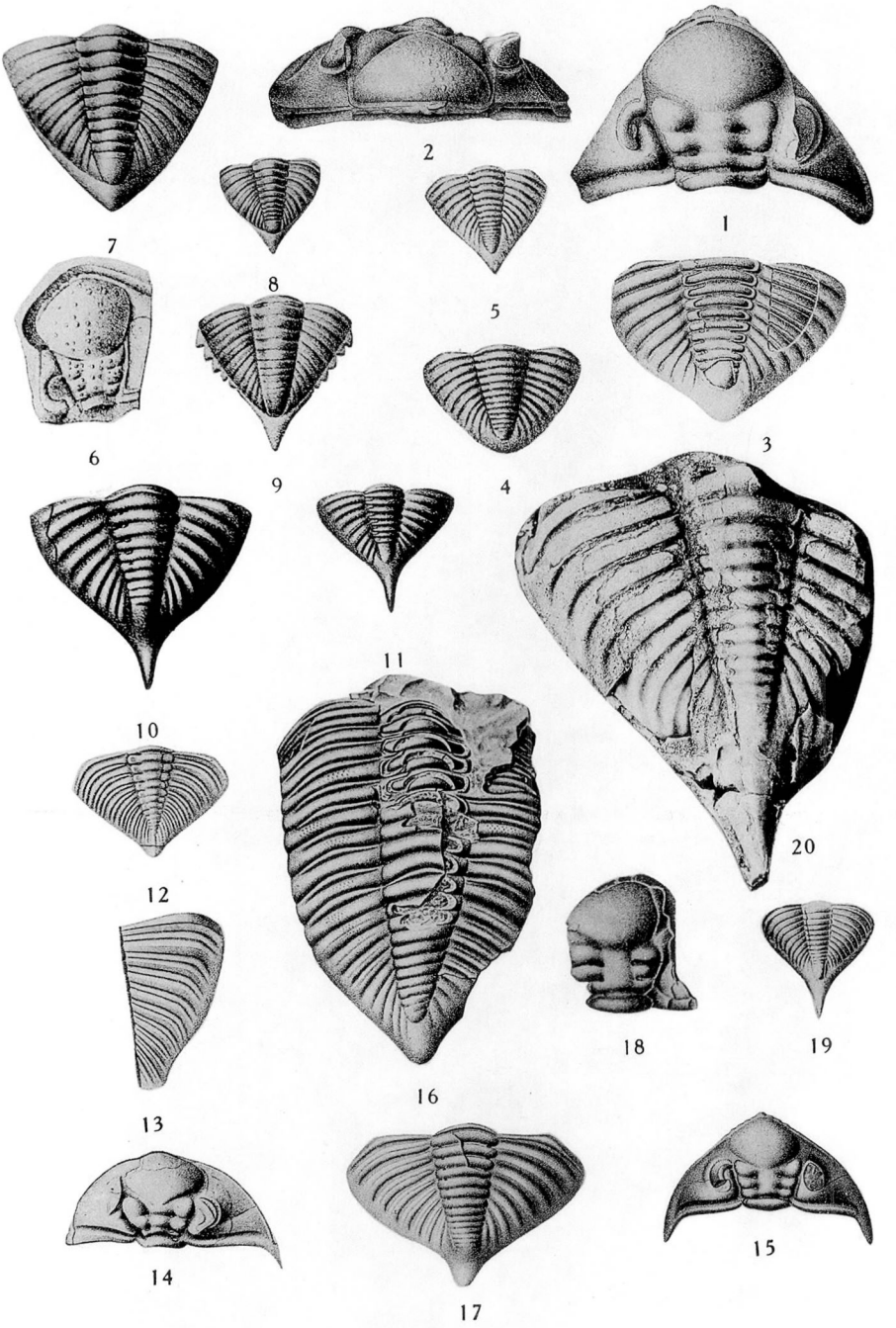
(9) *Synphoria? concinnus* var. *serrula* (Hall and Clarke). Copy of original figure of holotype pygidium. × 1.

(10, 11) *Synphoria? whiteavesi* (Clarke). Copies of original figures of type pygidia. × 1. (p. 69)

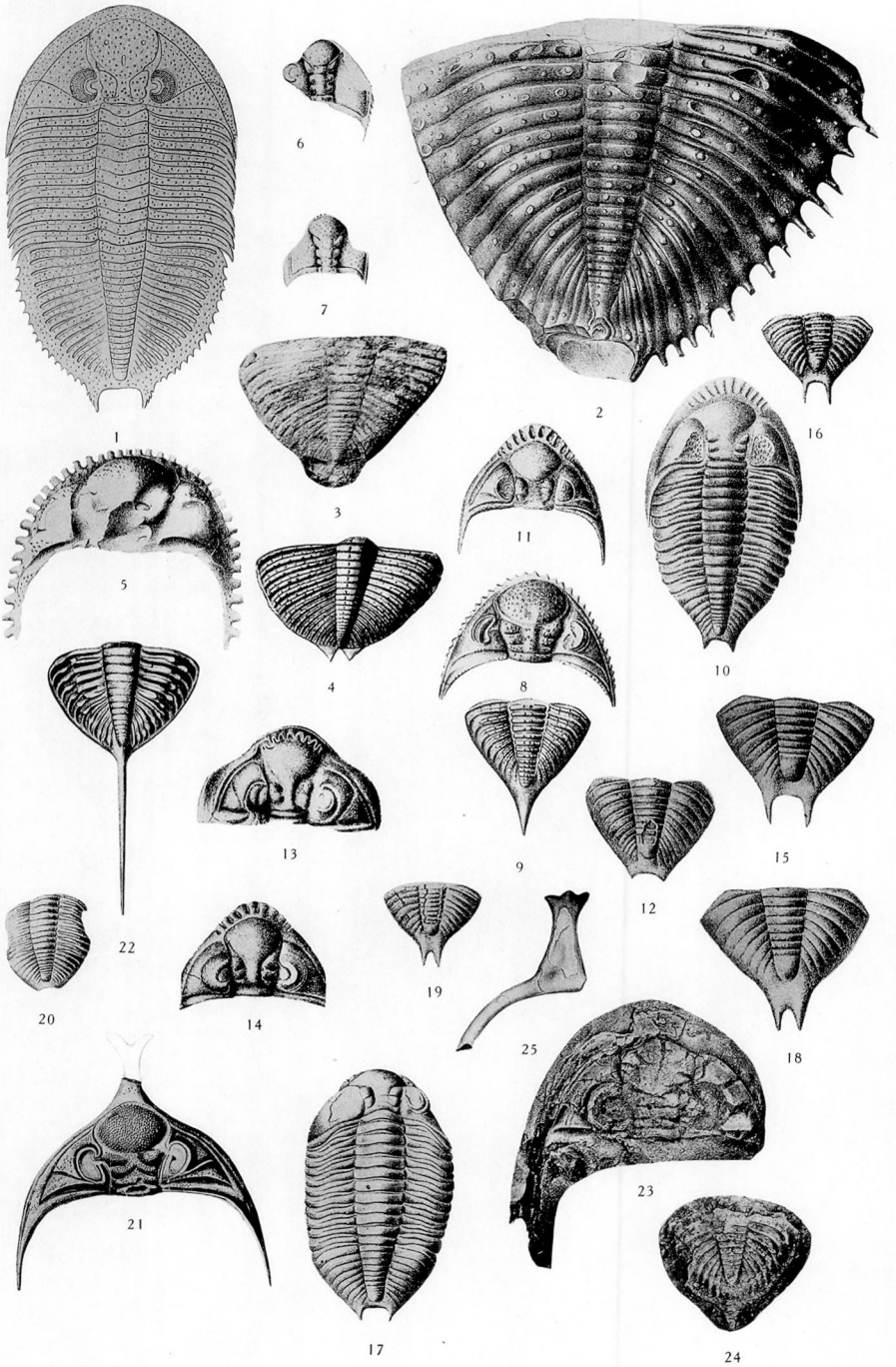
(12, 13) *Synphoria? lowi* (Clarke). Copies of original figures of type pygidia. × ½. (p. 67)

(14–17) *Synphoria dolbeli* (Clarke). Copies of original figures of type specimens. (14, 15) Cephalic casts. (16) Thorax and pygidium with test. (17) Pygidial cast. All × ½. (p. 66)

(18–20) *Synphoria? meeki* (Walcott). (18, 19) Type glabella and pygidium as figured by Hall and Clarke. (20) Photograph of holotype pygidium, which is almost entirely exfoliated. Courtesy G. A. Cooper. (18, 19) much reduced. (20) × 1. (p. 67)



SYNPHORIINAE



SYNPHORIINAE

Plate 8. Synphoriinae

Figure

(1) *Coronura aspectans* (Conrad). An entire individual as figured by Clarke. × ⅔. (p. 70)

(2) *Coronura myrmecophorus* (Green). Type pygidium as figured by Hall and Clarke. × ⅔. (p. 71)

(3, 4) *Coronura marylandicus* (Prosser). (3) Holotype pygidial cast showing nature of terminus. × ⅔. (4) Copy of original figure of holotype as restored. × ⅔. (p. 69)

(5) *Corycephalus regalis* (Hall). Copy of original figure of holotype cephalon. × ⅔. (p. 73)

(6, 7) *Corycephalus? pygmaeus* Hall and Clarke. Copies of original figures of cotypes. × ⅔. Drawings were much enlarged. (p. 73)

(8, 9) *Corycephalus dentatus* (Barrett). Plesiotype cephalon and pygidium as figured by Hall and Clarke. × ⅔. (p. 72)

(10–12) *Odontocephalus aegeria* (Hall). (10) Copy of a figure of a complete individual with test. "The pygidium has been drawn too narrow and constricted near the posterior extremity, and the caudal spines too long." (Hall and Clarke, 1888, Pl. 11B, fig. 3). × 1½. (11) Cephalic cast, from Hall and Clarke. × ⅔. (12) Normal pygidium, from Hall and Clarke. × ⅔. (p. 74)

(13–17) *Odontocephalus selenurus* (Conrad). (13) Green's cast of *Calymene? odontocephala*. × ⅔. (14) Cephalic cast of a normal individual with broken genal angles. × ⅔. (15) Pygidium with test. (16) Pygidial cast. × ⅔. (17) Complete individual of normal proportions. × ⅓. All from Hall and Clarke. (p. 74)

(18, 19) *Odontocephalus bifidus* (Hall). Typical pygidia, as figured by Hall and Clarke. × ⅔. (p. 75)

(20) *Odontocephalus coronatus* Hall and Clarke. Holotype, from Hall and Clarke. × ⅓. (p. 76)

(21, 22) *Probolium nasutus* (Conrad). (21) Copy of Hall's figure of a type cephalon with process restored. × ⅓. (22) Copy of a type pygidium, from Hall. × ⅓. (p. 77)

(23, 24) *Probolium palaceus* (Savage). (23) Holotype cephalic cast with one genal spine broken. × ⅔. (24) Incomplete paratype pygidium. × ⅔. (p. 77)

(25) *Probolium tridens* (Hall). Copy of a paratype figured by Hall. Trifid anterior process is diagnostic feature of species. × ⅔. (p. 78)

PLATE 9. SYNPHORIINAE

FIGURE

(1) *Probolium nasutus* (Conrad). *See* Plate 8. Typical cephalic cast showing nature of glabellar lobation. × ⅔. Courtesy N. Y. State Mus. (p. 77)

(2, 3) *Probolium tridens* (Hall). *See* Plate 8. (2) Copy of Hall's figure of holotype. × ⅔. (3) Restoration of a complete cephalon without process termini, from Clarke. × ⅓. (p. 78)

(4–7) *Synphoroides biardi* (Clarke). (4) Typical exfoliated cephalon with a complete anterior process. × ⅓. (5) Cephalon with terminal branch of process broken. × ⅓. (6) Terminus of a typical process. × ⅔. (7) Cast of doublure and process. × ⅓. All copied from Clarke. (p. 79)

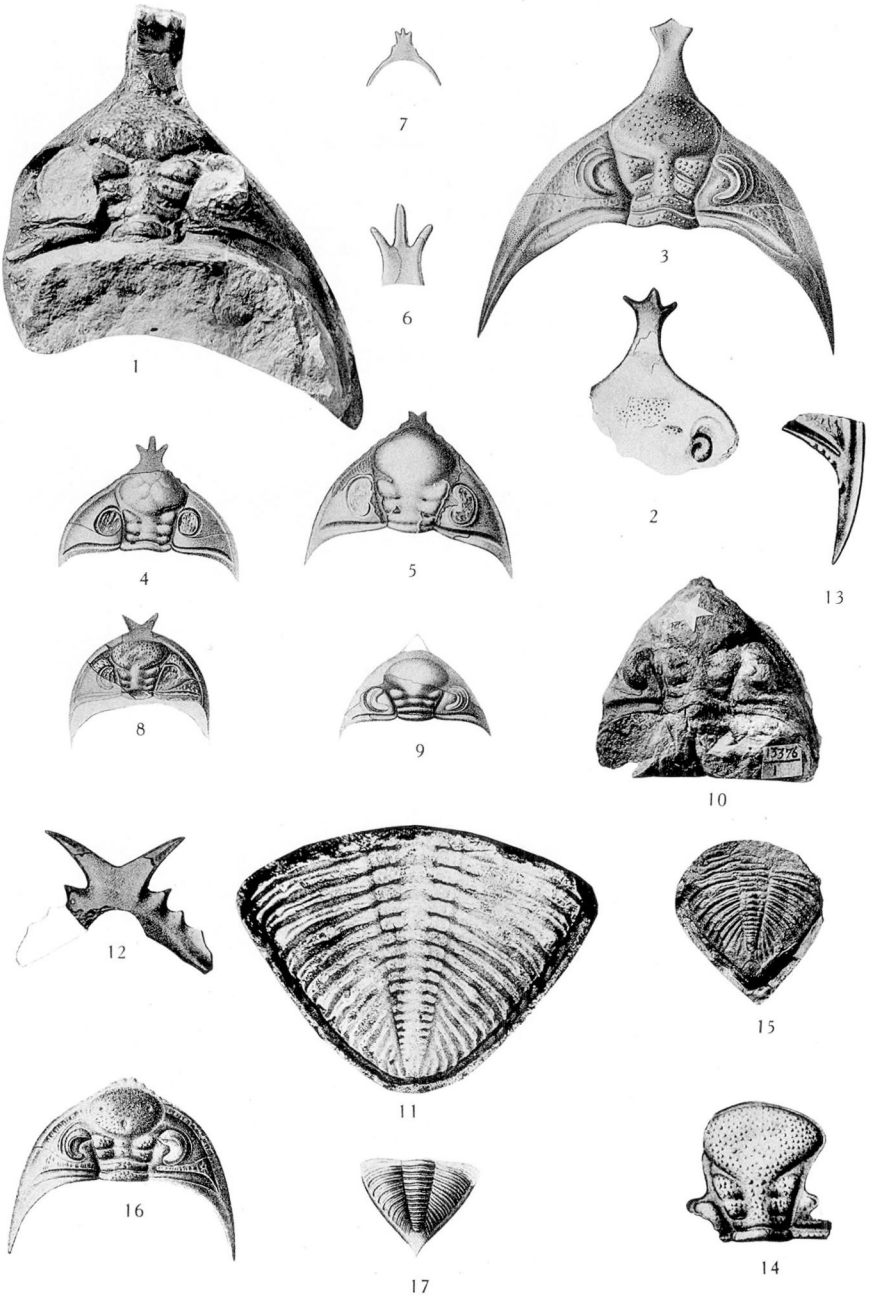
(8) *Synphoroides esnoufi* (Clarke). Holotype cephalon as figured by Clarke. × ⅓. (p. 80)

(9) *Synphoroides? griffoni* (Clarke). Holotype cephalon as restored and figured by Clarke. × ⅓. (p. 80)

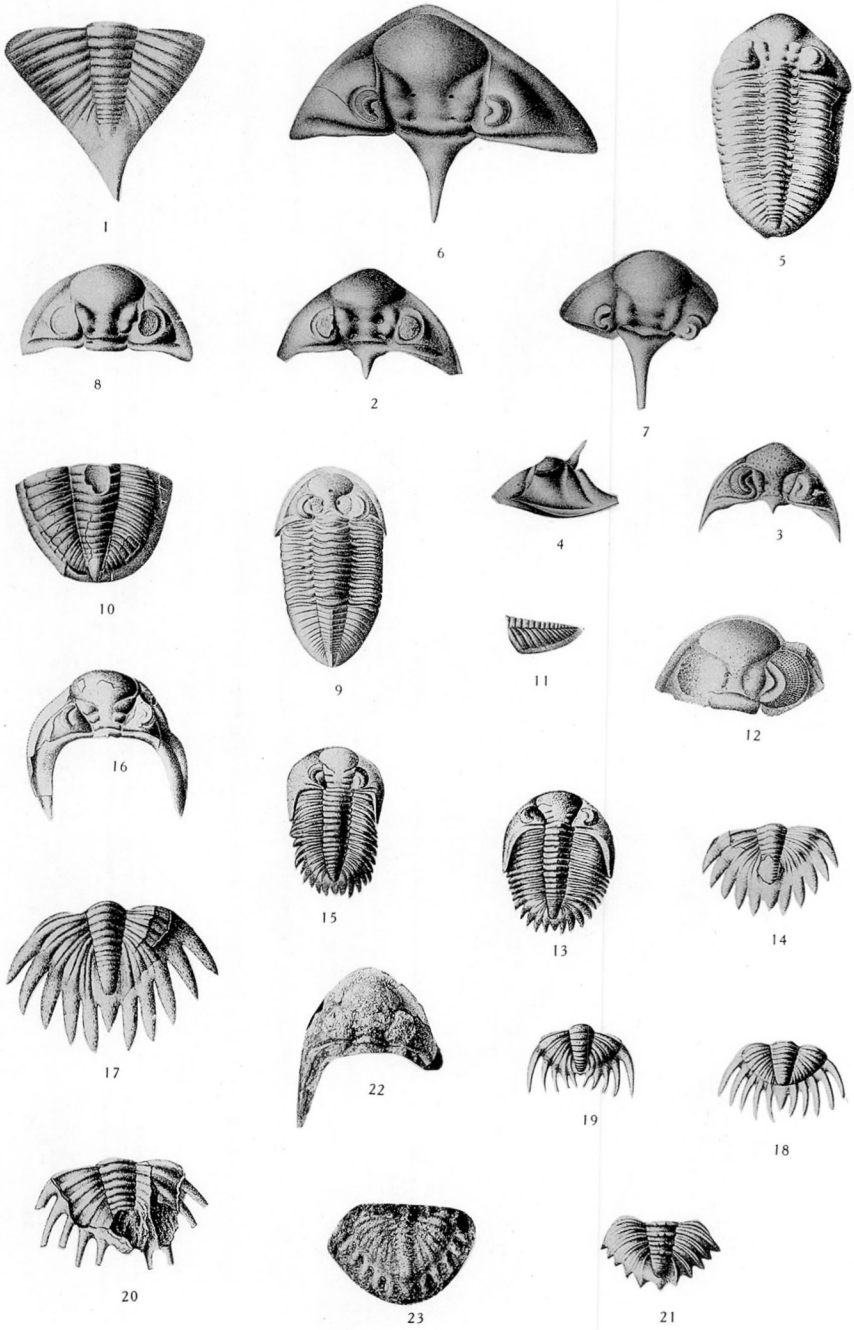
(10) *Synphoroides dolphi* (Clarke). Holotype, an exfoliated cephalon. × ⅔. Courtesy N. Y. State Mus. (p. 79)

(11–14) *Synphoroides multiannulatus* (Ohern and Maynard). (11) Holotype pygidial cast. × ⅔. (12–14) Copies of original figures of anterior process, genal spine, and glabella. × ⅔. (p. 81)

(15–17) *Synphoroides pleuroptyx* (Green). (15) Photograph of Green's holotype of species, a weathered pygidium with test. This is first figuring of this specimen. × ⅔. Courtesy N. Y. State Mus. (16, 17) Copies of Hall and Clarke's figures of a typical cephalon and pygidium. × ½. (p. 82)



SYNPHORIINAE



SYNPHORIINAE AND ASTEROPYGINAE

PLATE 10. SYNPHORIINAE AND ASTEROPYGINAE

FIGURE

(1–5) *Anchiopsis anchiops* (Green). (1) Typical pygidium with right margin missing. × ⅓. (2) Typical cephalic cast showing nuchal spine. × ⅓. (3) Small normal cephalon retaining test. × ⅔. (4) Same viewed laterally to show cephalic convexity. × ⅔. (5) Green's holotype of species. × ⅓. All from Hall and Clarke. (p. 83)

(6, 7) *Anchiopsis anchiops* var. *armatus* (Hall and Clarke). Type cephalic casts as figured by Hall and Clarke. × ⅓. (p. 84)

(8) *Anchiopsis anchiops* var. *sobrinus* (Hall and Clarke). Holotype, a cephalic cast, from Hall and Clarke. × ⅓. (p. 84)

(9) *Trypaulites calypso* (Hall). Copy of Hall and Clarke's figure of a wax cast of a type specimen showing diagnostic features of species. × ⅓. (p. 85)

(10, 11) *Trypaulites erinus* (Hall). (10) Holotype pygidium. (11) Lateral view of a paratype pygidium. Both from Hall and Clarke. × ½. (p. 86)

(12) *Trypaulites macrops* (Hall). Copy of Hall and Clarke's figure of holotype. × ⅔. (p. 86)

(13, 16, 19) *Greenops boothi* var. *calliteles* (Green). (13) Complete individual with pygidial spines somewhat blunter than is usual in this variety. × 1½. (16) Large cephalon. × 1. (19) Pygidium from a young individual, much enlarged. All from Hall and Clarke. (p. 88)

(14, 15, 17) *Greenops boothi* (Green). (14) Large pygidium with normal spines. × ⅔. (15) Entire normal individual, with test. × 1. (17) Large pygidium showing more than normal acuteness of spines. All from Hall and Clarke. (p. 88)

(18) *Greenops barrisi* (Hall). Copy of Hall and Clarke's figure of holotype pygidium. × 2. (p. 87)

(20) *Greenops pleione* (Hall). Holotype, an incomplete pygidium, from Hall and Clarke. × ⅔. (p. 90)

(21) *Greenops comis* (Hall and Clarke). Holotype, a pygidial cast, as restored and figured by Hall and Clarke. × ⅔. (p. 89)

(22, 23) *Greenops kindlei* Ulrich and Delo n. sp. (22) Type cephalon showing anterior profile and slender genal spines. × ⅔. (23) Type pygidium showing nature of marginal spines. × ⅔. (p. 89)

PLATE 11. PTERYGOMETOPINAE

FIGURE

(1–4) *Calliops callicephalus* (Hall). (1) Typical complete individual of species from Trenton Falls. × 1. (2, 3, 4) Copies of Hall's original figures of types. × 1. (p. 94)

(5–8) *Calliops annulatus* (Raymond). (5, 6) Metatype cephala from type locality. × 1. (7) Paratype pygidium. × 1. (8) Metatype pygidial cast. × 2. (p. 92)

(9, 10, 11) *Calliops brevis* Ulrich and Delo n. sp. (9, 10) Views of holotype cephalon. × 2. (11) Paratype pygidium. × 2. (p. 93)

(12) *Calliops armatus* Ulrich and Delo n. sp. Holotype, a cephalon with test. × 2. (p. 93)

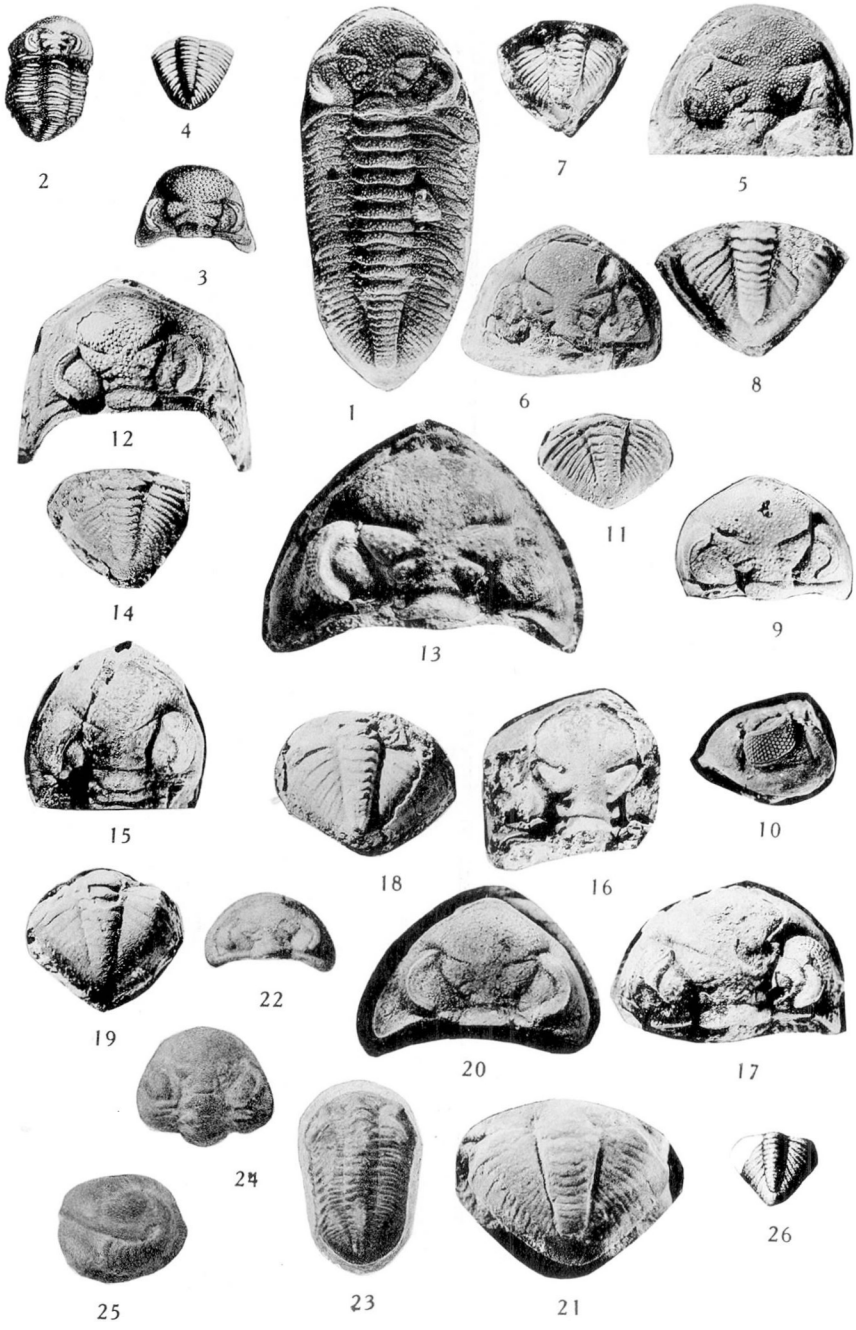
(13, 14) *Calliops antecavatus* Ulrich and Delo n. sp. (13) Holotype, an almost complete cephalon. × 3. (14) Paratype pygidial cast. × 2. (p. 92)

(15–19) *Calliops declivis* Ulrich and Delo n. sp. (15) Holotype cephalon, with test. × 1. (16, 17) Paratype cephala. × 1. (18, 19) Paratype pygidia, one of which has a large portion of test missing. × 2. (p. 95)

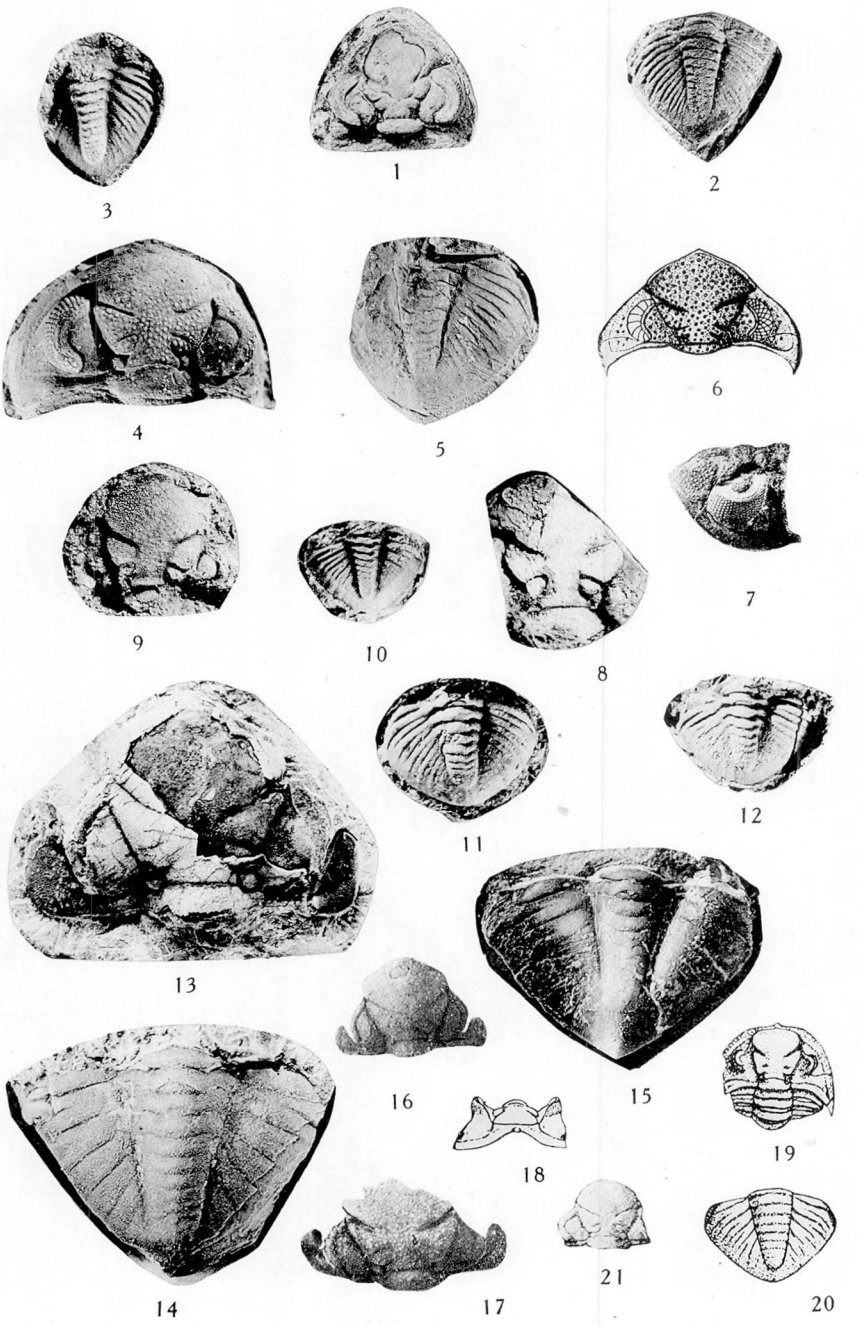
(20, 21) *Calliops larrabeei* (Slocum). (20) Metatype cephalon. × 2. (21) Metatype pygidium. × 2. Walker Mus. No. 28043. (p. 97)

(22–25) *Calliops fredricki* (Slocom). Copies of Slocom's original figures of types. (22) Typical cephalon. × 1. (23) Holotype. × 1. (24, 25) Small but typical enrolled specimen. × $2\frac{1}{2}$. (p. 96)

(26) *Calliops gracilens* (Raymond). Holotype pygidium, as figured by Raymond. × 2. (p. 96)



PTERYGOMETOPINAE



PTERYGOMETOPINAE

PLATE 12. PTERYGOMETOPINAE

FIGURE

(1–3) *Calliops leithi* Delo n. sp. (1) Type cephalon. (2) Type pygidium with test. (3) Exfoliated paratype pygidium. All × 1. (p. 97)

(4, 5) *Calliops plattevillensis* Ulrich and Delo n. sp. (4) Holotype cephalon. (5) Paratype pygidium. Both retain the test. × 2. (p. 98)

(6, 7) *Calliops schmidti* (Clarke). (6) Copy of Clarke's original drawing of the holotype. (7) Specimen from Duck Creek, Wisconsin, illustrating nature of genal spine. × 1. (p. 99)

(8–10) *Calliops strasburgensis* Ulrich and Delo n. sp. Cotype glabellae and an exfoliated paratype pygidium. × 1. (p. 99)

(11, 12) *Calliops tuberculatus* Delo n. sp. (11) Holotype pygidium with test. (12) Paratype exfoliated pygidium. Both × 1. (p. 100)

(13–15) *Calyptaulax glabella* Cooper. (13) Holotype cephalon. (14, 15) Type pygidia. All × 3. Courtesy Peabody Mus. (p. 102)

(16, 17) *Calyptualax compressa* Cooper. Copies of original figures of cotype cranidia. (16) × 2. (17) × 1½. (p. 101)

(18–20) *Calyptaulax goodridgi* (Schuchert). Copies of original drawings of types. × 1. (p. 103)

(21) *Calyptaulax confluens* (Foerste). Copy of original figure of holotype cranidium. × 1. (p. 101)

PLATE 13. PTERYGOMETOPINAE

FIGURE

(1, 2) *Calyptaulax eboraceous* (Clarke). Two views of holotype, an entire exfoliated individual. × ⅔. Courtesy N. Y. State Mus. (p. 102)

(3, 4) *Calyptaulax? holstonensis* (Raymond). (3) Holotype showing glabellar lobation and slender genal spine. × ½. (4) Paratype exfoliated pygidium. × ⅔. (p. 103)

(5, 6) *Calyptaulax lincolnensis* (Branson). Copies of Branson's original figures. × ⅔. (p. 104)

(7, 8) *Eomonorachus intermedius* (Walcott). Cephalic and pygidial views of holotype. × ⅔. Courtesy G. A. Cooper. (p. 107)

(9) *Eomonorachus convexus* Ulrich and Delo n. sp. Holotype, an exfoliated cephalon showing one genal spine. × 2½. (p. 108)

(10, 11) *Ligometopus typus* Ulrich and Delo n. sp. (10) Holotype, a partially exfoliated cranidium showing large second lobes and broad frontal process. × ⅔. (11) Paratype exfoliated pygidium. × ⅔. Courtesy G. A. Cooper. (p. 109)

(12, 13) *Chasmops occidentalis* Twenhofel. (12) Copy of original figure of type cephalon. × ⅔. (13) Photograph of type pygidium. × ⅔. Courtesy Peabody Mus. (p. 106)

(14–16) *Chasmops anticostiensis* Twenhofel. (14) Copy of original figure of types. × ⅔. (15, 16) Cephalic and pygidial views of a typical specimen from W. H. Twenhofel's personal collection. × ⅔. (p. 105)

(17) *Chasmops bebryx* (Billings). Copy of original figure of type. × ⅔.

(18) *Chasmops? breviceps* (Hall). Copy of Hall's original figure of type. × ⅔. (p. 106)

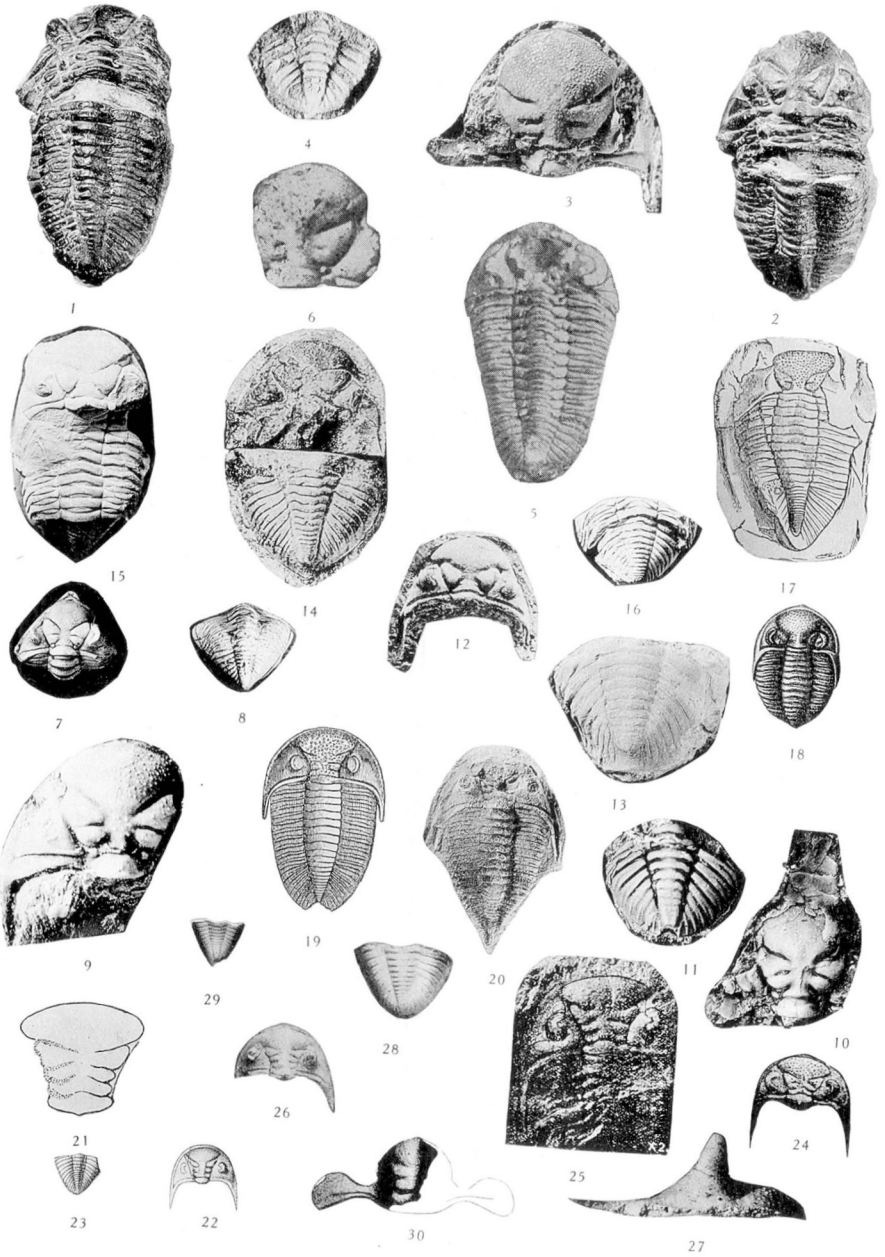
(19–21) *Achatella achates* (Billings). (19) Copy of Billing's original drawing of species. × ⅔. (20) Typical, somewhat weathered specimen from the Trenton at Trenton Falls, New York. × ⅔. (21) Drawing of glabellar pattern of a type specimen, from Foerste. × ⅔. (p. 110)

(22–24) *Achatella carleyi* (Meek). (22, 23) Copies of Meek's original figures of types of species. × ⅔. (24) Typical cephalon as figured by Foerste. × ⅔. (p. 111)

(25) *Achatella carleyi* var. *rogersensis* (Foerste). Copy of Foerste's original figure of holotype. × 1½. (p. 111)

(26–29) *Achatella katharina* (Bradley). Copies of Bradley's original figures of types. × ⅔. (p. 112)

(30) *Achatella transsectus* (Raymond). Copy of Raymond's original figure of holotype. × ⅔. (p. 113)



PTERYGOMETOPINAE