

27. REVISION of the PHYLLOCARIDA from the CHEMUNG and WAVERLY GROUPS of PENNSYLVANIA. By Prof. CHARLES EMERSON BEECHER, Ph.D., F.C.G.S. (Read April 30th, 1902.)

[PLATES XVII-XIX.]

It is now eighteen years since I prepared a memoir for the Second Geological Survey of Pennsylvania, describing the species of Phyllocarida then known from the Chemung (Upper Devonian) and Waverly (Lower Carboniferous) Groups in that State. Subsequent collecting at the original locality has yielded a quantity of material which further elucidates the characters of the original species, and also adds two distinctly new forms to the fauna of the Waverly Group.

The specimens described in the present paper, as well as those on which the original descriptions were based, were all obtained in the vicinity of Warren (Pennsylvania). The chief horizon is in the shale-beds of the Upper Chemung Group, about 50 feet above mean water-level in the Alleghany River. At this level, crustacean remains are fairly abundant, and constitute a conspicuous element of the contained fauna. On this account, the deposits have been called by me 'the Phyllocarid-Beds.' The species thus far secured from the horizon are *Echinocaris socialis*, *Tropidocaris bicarinata*, and *Elymocaris siliqua*. Other forms are much less abundant, and occur in a sporadic manner in the higher strata.

The following notes on the genera and species are to be considered, not as complete descriptions, but as additions and emendations to the original diagnoses.

**ECHINOCARIS SOCIALIS.** (Pl. XVII & Pl. XVIII, figs. 1-7.)

*Echinocaris socialis*, Beecher, 'Ceratiocaridæ from the Chemung & Waverly Groups of Pennsylvania' 2nd Geol. Surv. Penn. vol. PPP (1884) p. 10; Hall & Clarke, 'Palæont. of N. Y.' vol. vii (1888) p. 174.

The new material representing this species, consisting of more than a hundred individuals, presents a greater range in size than was originally observed, and permits of a more exact description of the postabdomen, the ornamentation of the somites, and the number of lobes in the cephalic areas. In addition, the position and character of the mandibles can now be determined.

The telson has the form of an abdominal somite, with a carinated extension behind, forming the spine (Pl. XVIII, fig. 3). The rows of spiniform nodes so characteristic of the other somites are absent. On each side of the base of the telson-spine are the articular faces for the cercopods, the dorsal pivotal points being marked by a node. The cercopods are about one-fourth longer than the telson-spine, and have a groove on their inner side, probably for the insertion of a row of setæ, as in *Mesothyra oceani*, Hall & Clarke.<sup>1</sup>

<sup>1</sup> 'Palæont. of N. Y.' vol. vii (1888) p. 187.

Many of the specimens seem to have suffered little or no compression in the sediments, and therefore the form and ornamentation of the separate somites can be accurately determined. One of the middle somites is represented in Pl. XVIII, figs. 4-6. The dorsal side (fig. 4) shows a transverse row of three nodes across the middle, with two additional ones on the latera. The posterior edge has five nodes occupying a space equal to the three just in front. The ventral side (fig. 5) shows an obsolescence of the transverse row, and a diminution to three in the number of nodes on the posterior edge. An anterior-end view of this somite (fig. 6) is broadly elliptical in outline, and has two nodular elevations at the ends of the long axis, serving as pivots for the flexing of the somite. The large straight abdomen of the individual represented in Pl. XVII has the somites in contact at the latera only, with a slight gaping on the dorsum. During life, these spaces were covered by the inter-articular membrane. The somites are more uniform in length than in *E. punctata*, Hall, the ultimate abdominal segment being of about the same length as the penultimate. There is a gradual shortening forward to the proximal segment, which is also without the central row of nodes.

The lobation of the cephalic area differs somewhat, according to the size and preservation of the individuals. A large rounded node occupies most of the cephalic area in each valve, and carries the pitted optic node on its posterior side. Between this large node and the dorsal line there are often, in mature examples, three more or less well-developed smaller nodes. One adjacent to the nuchal furrow is always present, and is usually quite prominent. In some specimens, this node has the appearance of being double. Anterior to this, there is generally a smaller node, and a third one occupying the anterior dorsal angle. In an attempt to construe these characters in terms of the appendages, the largest cephalic lobe, as will be shown presently, would correspond to the mandibles. The anterior dorsal node may be taken as representing the first antennal segment; the small one just behind, as the second antennal segment; while the somewhat larger and occasionally double node next to the nuchal furrow may indicate the position of the two maxillæ.

The mandibles in this species (Pl. XVIII, fig. 7) are quadrate in outline, the oblique side forming a masticatory surface without cusps. Several examples show the mandibles protruding in front of the carapace, their inner ends being concealed by the valves (Pl. XVIII, figs. 1 & 2). From the size and position of the mandibles in these and other specimens, it may be inferred that the large cephalic lobes represent hollows on the ventral side, in which the mandibles were situated.

The largest carapace observed has a length of 27 millimetres, and a width of 17 mm. across one valve. The smallest carapace measures 6 millimetres in length.

This ornate and beautiful species is now quite as well known as any *Echinocaris*, and is a very characteristic representative of the genus.

*ECHINOCARIS RANDALLII*, sp. nov. (Pl. XVIII, fig. 8.)

Three right valves represent this species in the present collection. Two are preserved in a fine-grained sandstone, while a third is from an arenaceous and micaceous shale. One of the sandstone-specimens is taken as the type. The valve is broadly ovate, widest in front, moderately convex, width more than half the length. Hinge-line about equal to the width of the valve. The nuchal furrow starts near the middle of the hinge-line, curving outward and forward to the margin. Cephalic area marked by a node (the maxillar?) adjacent to the hinge, with triangular base, a much larger lobe (the mandibular), about four times the size of the smaller one, occupying the remainder of the area. One of the specimens has two minute lobes (the antennal) in front, at the inner extremity of the mandibular lobe.

The thoracic region has two subequal transverse lobes adjacent to the nuchal furrow, between the hinge and the carina. The carina starts near the anterior ventral angle and makes a sigmoid curve, extending along the ventral border; then, following parallel to the posterior margin, it turns forward over the middle of the valve, and becomes obsolete before reaching the lobes.

The surface of the cephalic and thoracic lobes is marked by minute pustules, and the summit of the carina has one or two rows of similar pustules. The border of the valve is somewhat thickened and reflexed, but is apparently without ornamentation.

Abdomen and postabdomen unknown.

The type-specimen, consisting of a right valve, has a length of 13 millimetres and a width of 9 mm.

Distribution.—In the sandstones and shales of the Waverly Group of the Lower Carboniferous, near Warren (Pennsylvania).

This species much resembles the Devonian *E. socialis*, but may be readily distinguished by the form and arrangement of the nodes and carina, and by its less highly ornamented surface. The specific name is given in honour of the veteran geologist of Warren County, Mr. F. A. Randall.

*ECHINOCARIS CLARKII*, sp. nov. (Pl. XVIII, fig. 9.)

The only specimen of this species thus far obtained is a nearly complete individual, with the carapace, abdomen, and postabdomen connected. The valves seem to have been quite tenuous, except along the margin, and have suffered from compression, so that the precise number and form of the nodes cannot be determined.

The valves are nearly elliptical in outline, with the margins considerably thickened, reflexed, and angulated. The outer margin is denticulate around the entire free edges of the valves, and there are also minute nodes along the angulation in the posterior and anterior regions. A nodose carina extends nearly parallel to the ventral border, and a row of granules is present in the mid-thoracic area.

The abdominal segments are not well preserved, but apparently did not differ much in length, and were without conspicuous ornamentation. The telson and cercopods were evidently quite similar to the same structures in *E. socialis* from the Chemung Group (Devonian).

The type-specimen has a length of 25 millimetres, of which about 6 mm. pertain to the postabdomen, 9 mm. to the abdomen, and 10 millimetres to the cephalothorax.

Distribution.—In the shales of the Waverly Group, Lower Carboniferous, near Warren (Pennsylvania).

The denticulate border of the valves at once distinguishes this form from any other that belongs to the genus *Echinocaris*. In this character, it is exceeded by the curious *Pephracaris horripilata* of Clarke,<sup>1</sup> which also has a postabdomen of entirely different form, and is without the curved sigmoid carina so characteristic of *Echinocaris*. This species is dedicated to Dr. John M. Clarke, State Palæontologist of New York, who has contributed so much to a knowledge of the American fossil Phyllocarids.

#### TROPIDOCARIS.

Since the present material affords a number of structures hitherto lacking, and necessary for a consideration of the relations and affinities of *Tropidocaris* with other genera, it is now possible to define this genus quite fully.

The valves of the carapace are obliquely truncate behind, marked by one or more longitudinal carinæ, separated by a median lanceolate plate along the thoracic region, and by an elongate rostral plate in the cephalic region. Cephalic area not strongly marked, but generally indicated by indistinct rounded elevations, or by a difference in convexity from the remainder of the valve; ocular node usually at the end of a short carina, and with a minute pit at the summit. Abdomen with two exposed segments, cylindrical in form. Caudal plate short, with telson-spine shorter than the cercopods.

Type, *Tropidocaris bicarinata*, Beecher.

Hall & Clarke<sup>2</sup> first showed the existence of a rostral plate in *Tropidocaris*, and this, together with the recent discovery of the median lanceolate plate, necessitates the removal of the genus from the Echinocaridæ. The same structures are here shown in *Elymocaridæ*; hence this, too, will have to be placed with *Tropidocaris* in another family. In Eastman-Zittel's 'Text-Book of Palæontology' (1900) p. 657, Clarke established the suborder Rhinocarina for Phyllocarida possessed of these distinctive features. The single family of this suborder, the Rhinocaridæ (Clarke), was made to comprise the genera *Rhinocaris*, Clarke, and *Mesothyra*, Hall &

<sup>1</sup> 'Notes on some Crustaceans from the Chemung Group of New York' N.Y. State Mus. 49th Ann. Rep. 1895, vol. ii [1898] pp. 731-33.

<sup>2</sup> 'Palæont. of N. Y.' vol. vii (1888) p. 184.

Clarke, and, as at present constituted, may also include both *Tropidocaris* and *Elymocaris*.

Thus far, each discovery of additional characters for the genera now grouped in the Rhinocaridæ has resulted in strengthening their likenesses and eliminating their differences; and it may be reasonably questioned whether they are all morphologically distinct. The structural elements of the cephalothorax are the same, and the genera seem to differ chiefly in the presence or absence of carinæ, the number of these, the character of the truncation of the posterior ends of the valves, and the number of exposed abdominal segments. It is not within the proper scope of this paper to attempt a revision of the generic and specific synonymy of both American and European forms. A brief review of the literature, in connection with the study of a considerable collection representing a large part of the Hamilton and Chemung species, leads to the conclusion that there are distinct groups of species to which most of the existing generic names may be applied. A number of characters, however, such as the presence of the rostrum and the median lanceolate plate, hitherto serving for generic distinction, must now be considered as of patronymic or subordinal value.

*Dithyrocaris* has been shown by Jones & Woodward<sup>1</sup> to have a median dorsal ridge, consisting of a carinate narrow plate apparently superimposed over the inner edges of the valves. No rostral plate has yet been discovered, though it is quite evident that this genus should be included in any discussion of the members of the family Rhinocaridæ.

#### TROPIDOCARIS BICARINATA. (Pl. XIX, figs. 1-5.)

*Tropidocaris bicarinata*, Beecher, 'Ceratiocaridæ from the Chemung & Waverly Groups of Pennsylvania' 2nd Geol. Surv. Penn. vol. PPP (1884) p. 16; Hall & Clarke, 'Palæont. of N. Y.' vol. vii (1888) p. 184.

The new features to be added to this species are of considerable interest and morphological value. First among these may be mentioned a small node or spot in each valve, a little behind the so-called optic node, from which a number of vascular lines extend backward radially over the surface. One line curves inward, meeting the hinge near the posterior end; while the others seem to be confined between the two principal carinæ, and occasionally are branched at their ends. A similar vascular marking has been observed by Clarke<sup>2</sup> in *Rhinocaris columbina*, var. *livonensis*, Clarke, from the salt-shaft at Livonia (N.Y.), and is also present in specimens collected by me from the Cayuga-Lake section. They show the lines originating near the hinge, a little dorsal to the optic node. Obviously, these vascular markings are indicative of some important internal organ. Their position posterior to, and outside of, the cephalic area, with their point of origin at or near the line of attachment of the abdomen with the carapace, is precisely the same

<sup>1</sup> Monogr. Pal. Soc. 'British Palæozoic Phyllopora' pt. iii (1898) p. 131.

<sup>2</sup> 'Devon. Phyllocarida fr. New York' [No. 3 of 'Notes on Palæoz. Crustac.'] N.Y. State Mus. Rep. State Pal. for 1900 (1901) App. iii, p. 100 & pl. iv, fig. 14.

as that of the shell-gland or renal organ of *Apus*. It seems safe to offer this suggested homology, since it invests an external character with some definite physiological meaning, instead of allowing it to stand as a fortuitous feature of little or no significance.

In this connection, an enquiry may be made as to the nature of the so-called optic nodes. It may be stated that they are most strongly developed in members of the family Rhinocaridæ, and are well shown in the species under discussion. Their position is at the posterior end of the short carina lying anteriorly between the two great carinæ. The summit of the node has a minute pit, called the optic pit. No positive information is as yet attainable as to whether or not these nodes are real visual organs. It is the most natural conclusion to reach, but, as the living *Nebalia* (which is analogous in many points of structure with these fossil rostrate forms) possesses independent stalked eyes in front of the first pair of antennæ, it is possible that another interpretation should be given. As a mere postulate, I would suggest that they are infolded points of the test to form muscular fulcra or apodemes for attachment of the muscles moving the mandibles.

Besides the two nodes already discussed, there is still a third and much larger one lying outside the shell-gland, and bisected by the large submedian carina of each valve. I can suggest no obvious homology for this lobe, although it doubtless corresponds with some large organ or ventral appendage.

As already noted, Hall & Clarke<sup>1</sup> proved the existence of the rostrum in this species. It is a narrow lancet-shaped plate, with a strong carina along the middle. The presence of a median lanceolate plate is now determined, as shown in Pl. XIX, fig. 5. It extends from as far forward as the optic nodes to the posterior end of the hinge, and is widest across the anterior fourth. Like the rostrum, it is marked by a strong longitudinal carina, and has a chevroned ornamentation, with the lines pointing backward.

The only specimen yet found that preserves the abdomen in connection with the carapace is represented in Pl. XIX, fig. 3. In this example, only a part of the ultimate abdominal segment is exposed, together with the telson and cercopods. Detached abdominal portions have been found, showing two segments in front of the telson, and this probably represents the number capable of extension beyond the carapace, the others being unprotected by a strong chitinous test. The ultimate segment is about twice as long as the one in front, and is marked by a chevron-pattern, as shown in Pl. XIX, figs. 1 & 2. On the dorsal side, the direction of the lines is forward; while, on the ventral side, they point backward, and are considerably finer and more numerous.

The youngest examples possess valves measuring about 6 millimetres in length. They are proportionately wider than in fully adult individuals, but clearly preserve their specific features. The surface of the valves is covered with fine, wavy, discontinuous, raised lines.

<sup>1</sup> 'Palæont. of N. Y.' vol. vii (1888) p. 184.

The three characteristic nodes are present, though as yet there are no vascular lines developed from the one homologized with the crustacean shell-gland. The largest carapace measures 35 millimetres in length.

*TROPIDOCARIS ALTERNATA.* (Pl. XIX, fig. 6.)

*Tropidocaris alternata*, Beecher, 'Ceratiocaridæ from the Chemung & Waverly Groups of Pennsylvania' 2nd Geol. Surv. Penn. vol. PPP (1884) p. 19; Hall & Clarke, 'Palæont. of N. Y.' vol. vii (1888) p. 186.

When this species was originally described, but two imperfect valves were known, and the diagnostic features consisted mainly in the considerable number of strong alternating carinæ. A single, though quite perfect, left valve has since been found, which gives the complete outline of the valve, as well as the number of carinæ. The general proportions and outline are not unlike those in *Tr. bicarinata*, but from the ventral half of the posterior margin there are two sharp spiniform extensions, the dorsal one being somewhat the larger. These spines are in line with the fourth and sixth carinæ, as counted from the hinge. There are seven carinæ running nearly the whole length of the valve, the fifth one extending to the anterior apex or prora. Of these seven, three are much stronger than the others, and are marked by a double row of minute pits along their summits. In the cephalic region, there are four or five short interpolated carinæ, and, on the anterior ventral border, there are two more, becoming obsolescent before reaching the posterior end of the valve. The number and arrangement of the nodes in the cephalic area are not easily made out, though, in their main features, they apparently agree with *Tr. bicarinata*.

The specimen here described measures 34 millimetres in length along the dorsum, and 13 mm. in width across the middle. It has thus far proved to be a rare species in the sandstones of the Waverly Group at Warren (Pennsylvania), and has not been noticed elsewhere.

ELYMOCARIS.

In this genus, as in *Tropidocaris*, the cephalothorax is now known to be made up of four parts—the two valves, the median lanceolate plate, and the rostrum. The abdomen has two exposed segments, and three or four others are concealed beneath the carapace.

Type, *Elymocarissiliqua*, Beecher.

*ELYMOCARIS SILIQUA.* (Pl. XIX, figs. 7 & 8.)

*Elymocarissiliqua*, Beecher, 'Ceratiocaridæ from the Chemung & Waverly Groups of Pennsylvania' 2nd Geol. Surv. Penn. vol. PPP (1884) p. 13; Hall & Clarke, 'Palæont. of N. Y.' vol. vii (1888) p. 182.

The new material shows the detailed characters of the rostrum and median lanceolate plate in a very satisfactory manner. The rostrum projects slightly beyond the points of the valves, extends backward as far as the optic nodes, and is widest at about the posterior third of its length; surface with two longitudinal carinæ, one on each side of the middle. The median lanceolate plate is

widest just in front of the mid-length, and has a single carina ornamented with a chevron-pattern of oblique striae directed forward.

The specimen illustrated in Pl. XIX, fig. 7, has the abdomen detached, and lying along the ventral border of the carapace. The distal somites are those which are normally exposed, the others in front being considerably shorter, with a progressively thinner test. Altogether, there are six somites preserved in front of the post-abdomen. The four anterior somites have a single, deep, lateral, longitudinal groove, which is not produced by compression as is a similar appearance shown on the two posterior segments. On the ventral side, there are thickenings and infoldings of the test, probably for the attachment and support of muscles.

The mandibles, or gastric teeth, are short, triangular, and without cusps, closely resembling those in *Echinocaris socialis*.

The valves range in length from 8 to 33 millimetres.

Distribution.—All the known specimens have been obtained from the Phyllocarid-Beds of the Chemung Group (Upper Devonian), at Warren (Pennsylvania).

#### EXPLANATION OF PLATES XVII-XIX.

[The specimens illustrated in these plates are in the collections of the Yale University Museum, New Haven, Conn.]

##### PLATE XVII.

###### *Echinocaris socialis*, Beecher.

A large and nearly entire individual: showing the form and ornamentation of the carapace, the six abdominal somites, with the telson and right cercopod. Enlarged 2 diameters. Chemung Group, Upper Devonian. Warren (Pennsylvania).

##### PLATE XVIII.

###### *Echinocaris socialis*, Beecher.

- Fig. 1. A specimen preserving the carapace and abdomen entire: showing the mandibles projecting in front. Enlarged 2 diameters.
2. A similar example, with the mandibles also exposed. Enlarged 2 diameters.
3. The postabdomen, with one abdominal somite: showing the form and length of the telson and cercopods. Enlarged 2 diameters.
4. The dorsal side of a single somite. Enlarged 4 diameters.
5. The ventral side of the same.
6. Anterior-end view of the same.
7. The mandibles, as found on the underside of a carapace. Enlarged 4 diameters.
- Chemung Group, Upper Devonian. Warren (Pennsylvania).

###### *Echinocaris Randallii*, sp. nov.

- Fig. 8. The right valve: showing the form and disposition of the nodes and carina. Enlarged 2 diameters.
- Waverly Group, Lower Carboniferous. Warren (Pennsylvania).

###### *Echinocaris Clarkii*, sp. nov.

- Fig. 9. The type-specimen: showing the general form and proportions. Enlarged a little more than 2 diameters.
- Waverly Group, Lower Carboniferous. Warren (Pennsylvania).



## PLATE XIX.

*Tropidocaris bicarinata*, Beecher.

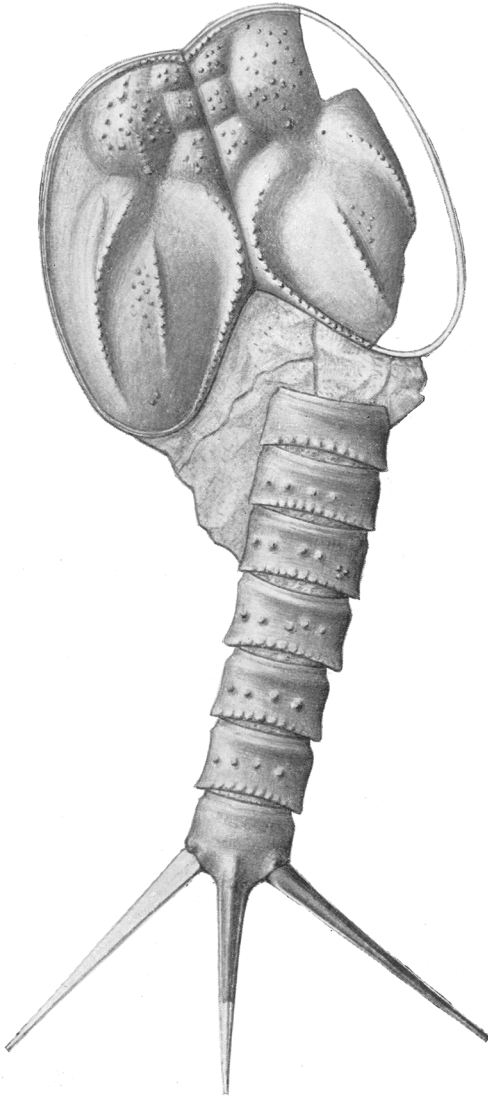
- Fig. 1. The dorsal side of the ultimate abdominal segment: showing the chevron-arrangement of the lines. Enlarged 4 diameters.
2. The ventral side of the same.
3. An individual with the abdomen and postabdomen in position: showing the carinæ on the carapace, the optic node, and the vascular lines radiating from the supposed shell-gland. Enlarged 2 diameters.
4. The right valve of a young individual. Enlarged 4 diameters.
5. The cephalothorax: showing the same features on the valves as the preceding, and, in addition, the rostrum and the median lanceolate plate. Enlarged 2 diameters.
- Chemung Group, Upper Devonian. Warren (Pennsylvania).

*Tropidocaris alternata*, Beecher.

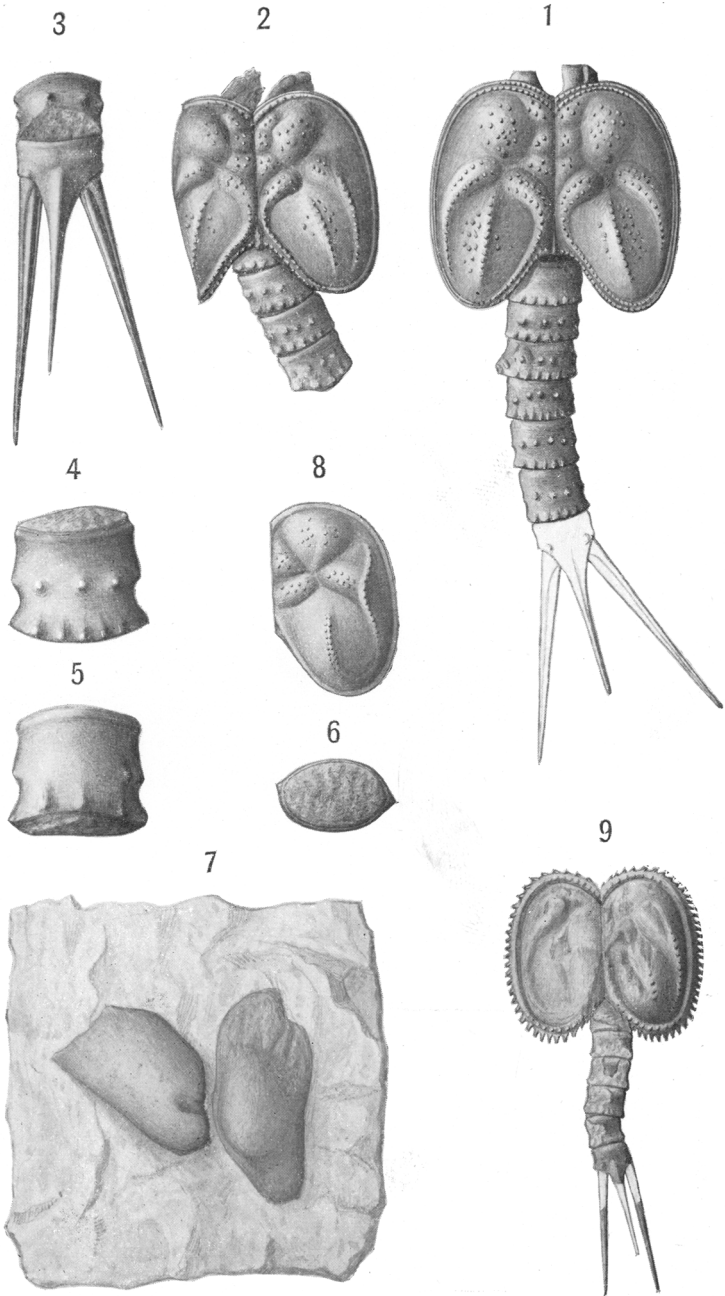
- Fig. 6. An entire left valve: showing the numerous alternating carinæ and posterior spiniform extensions. Enlarged 2 diameters.
- Waverly Group, Lower Carboniferous. Warren (Pennsylvania).

*Elymocaris siliqua*, Beecher.

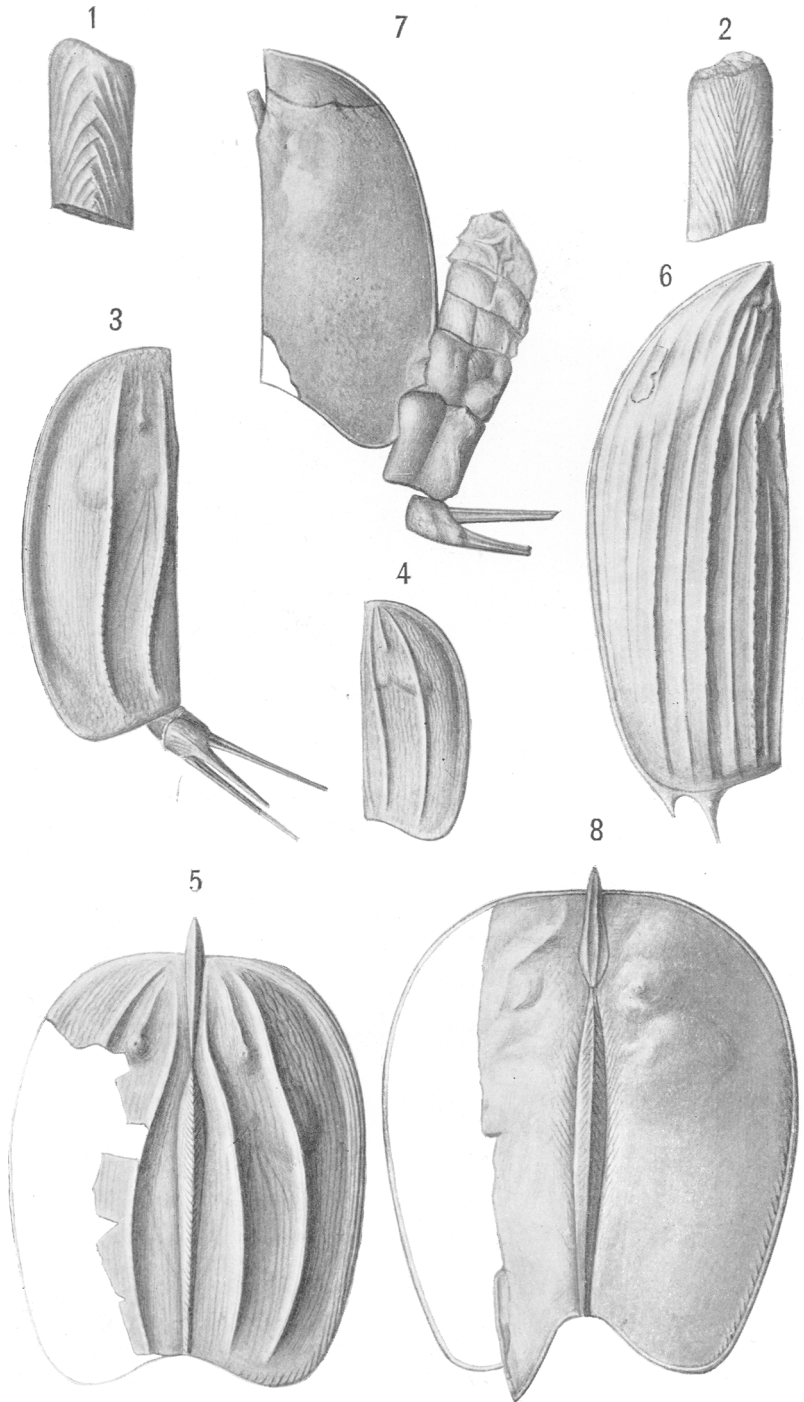
- Fig. 7. A specimen with the valves closed and the abdomen detached. Enlarged 2 diameters.
8. A specimen with the valves open: showing the rostrum and median lanceolate plate in position. Enlarged 2 diameters.
- Chemung Group, Upper Devonian. Warren (Pennsylvania).



**ECHINOCARIS SOCIALIS.**



**ECHINOCARIS SOCIALIS** (figs. 1-7); **E. RANDALLII** (fig. 8);  
**E. CLARKII** (fig. 9).



TROPIDOCARIS AND ELYMOCARIS.