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ART. VI.—Notice of New Forms of Fossil Crustaceans from the Upper Devonian Rocks of Ohio, with descriptions of New Genera and Species; by R. P. WHITFIELD.*

IN the 16th Report of the State Cabinet of New York, there is described and figured a peculiar bivalve crustacean from the Hamilton formation of New York, under the name *Ceratiocaris punctatus*. It is again repeated on Plate 23, fig. 7, of the Illustrations of Devonian Fossils, Section Crustacea, under the name *Ceratiocaris (Aristozoe) punctatus*. Among the fossils of the Ohio Geological Survey, there are represented three species of similar form, but specifically distinct from the above; and I have seen examples of at least two species from the Hamilton and Chemung groups of New York, which may be distinct from any of these.

These fossils differ from the true type of *Ceratiocaris* in so many particulars, and to so great an extent, that it is quite impossible to include them in that genus. The reference to *Aristozoe* Barrande, is, however, still more erroneous, as the forms to which that name is applied are true *Ostracoides*, having all their parts concealed within the carapace, as in the *Leperditia* and its allies; while the forms under consideration are provided with a bivalve or, at least, a two-sided carapace, which incloses the thoracic portions; while the abdomen and caudal parts are naked, or not inclosed within this covering; and are more properly classed among the *Phyllopods*.

That this latter character, the naked abdomen and caudal plate, pertains to these organisms, is abundantly proven by the Ohio specimens now under consideration. The fossils are found inclosed in small concretions; and there would be but little chance for specimens, or parts of specimens of different species, or, less likely, of parts of individuals of distantly related generic forms, to be inclosed in the same small concretion; so we may safely conclude, that, where parts or fragments of individuals of corresponding size are found in the same concretion, they are parts of one individual or, at least, of the same species. In the concretions in question there are two examples where parts of the naked abdomen and caudal plate with its accompanying spines, are imbedded in the concretion together with the carapace which I have classed as the same species. This I consider as ample proof that the parts belong to the one individual; and that the animal of which they are the remains, was provided with a naked body and spinose caudal appendage as in *Ceratiocaris*. It is also

* These descriptions will be repeated in vol. iii, Paleont. Ohio, with illustrations of the species. All the specimens are from the cabinet of Dr. J. S. Newberry.

stated in the Illustrations of Devonian Fossils that one specimen resembling *C. punctatus* has been found with a body similar to that called *C. armatus* attached to the carapace, showing their individual relations.

The several species above mentioned, while differing greatly from *Ceratiocaris*, possess features in common which at once characterizes them as a natural group, sufficiently marked to be readily distinguished. I therefore propose to recognize them as a distinct genus under the generic name ECHINOCARIS, possessing the following characters:

ECHINOCARIS, new genus.

Carapace bivalve, valves subovate in outline; united on the dorsal margin by a straight hinge; the anterior, basal and posterior margins rounded, and generally more or less produced posteriorly. Surface of the valves marked by a more or less distinctly elevated, curved, longitudinal ridge, centrally or subcentrally situated; also by one or more (usually three) vertical ridges, or ridge-like nodes, extending downward from the hinge-line upon the body of the valve, and usually situated anterior to the middle of the length. Abdomen naked, composed of several segments (four known) and a caudal plate, which is produced into an elongated spine with a lateral, movable spine on each side. Posterior margin of the abdominal segments bearing spines on the now known species. Type *Echinocaris sublevis* Whitf.

Among the genera now known and referred to the *Ceratiocaridæ*, there are several distinct types of structure, indicated by the features of the carapace alone, independent of the changes which take place in the abdominal segments and in the caudal spine and appendages. The following synopsis of some of their characters may serve to illustrate their peculiarities and to show more distinctly the relations which *Echinocaris* bears to other known genera.

1st section: Carapace more or less elongated, with a straight or slightly arched dorsal line; anterior end sharply rounded or pointed (rostrate); posterior end truncate; sides convex, smooth or simply striate, sometimes marked by a simple ocular node near the antero-dorsal margin; no ridges or other nodes. *Ceratiocaris* McCoy, 1849; *Caryocaris* Salter, 1862; *Hymenocaris* Salter, 1852; *Solenocaris* Meek, 1872; (?) *Colpocaris* Meek, 1872. The last somewhat questionable in character.

2d section: Carapace similar in form to that of section 1, with the postero-basal angles produced into spines, and the surface with longitudinal ridges. *Dithyrocaris* Scouler (= *Argas* Scouler).

3d section: Carapace rounded at both extremities, elongate-

elliptical or elongate-ovate in form, with a straight dorsal margin; surface concentrically striate, no nodes or ridges. *Lingulocaris* Salter, 1866.

4th section: Carapace triangular, dorsal margin straight; surface punctate or reticulate, and concentrically striated (growth lines?). *Dictyocaris* Salter, 1860.

5th section: Carapace suboval or subovate, with a straight hinge-line: surface marked with longitudinal ridges or representative nodes and ridges; surface of parts smooth, punctate or pustulose. *Echinocaris*, new gen.

6th section: Carapace broadly oval or ovate; no straight cardinal line, consequently no hinge; anterior end rostrated or beaked; surface destitute of nodes or ridges. *Physocaris* Salter, 1860.

7th section: Carapace composed of three pieces, or apparently of three, two of which are semi-circular, with the anterior end of each obliquely truncate, forming, when the two are united, an anterior triangular notch into which the third or rostral plate is inserted; surface concentrically marked by growth lines; no nodes or ridges. *Peltocaris* Salter, 1866; *Discinocaris* Woodward, 1866; *Aptichopsis* Barrande, 1872; *Pterocaris* Barrande, 1872 (not Heller, 1862).

It will be readily seen, from the above synopsis, that *Echinocaris* differs materially in the features of the carapace from all the other genera enumerated. The features of the abdomen and caudal parts are not as reliable as those of the carapace, but are somewhat distinctive, as may be seen by the following table of comparison. (A mark of interrogation indicates that the parts are unknown or only partially known.)

Genus.	Abdominal segments.	Caudal spines.
<i>Ceratiocaris</i>	5 or 6 smooth	3
<i>Dithyrocaris</i>	1 smooth	3
<i>Hymenocaris</i>	8 smooth	6
<i>Dictyocaris</i>	6 smooth	3 ?
<i>Physocaris</i>	5 smooth	3
<i>Echinocaris</i>	4 spiney	3
<i>Discinocaris</i>	4 ?	3 ?
<i>Peltocaris</i>	3 smooth	3
<i>Caryocaris</i>	1 ?	3
<i>Lingulocaris</i>	?	?
<i>Colpocaris</i>	?	3
<i>Solenocaris</i>	?	?
<i>Aptychopsis</i>	?	?

The number of segments here allotted to any given genus indicates the maximum number of naked segments known: some of them contain species having a smaller number, and in some a much greater number exists, some of which are concealed within the carapace. Thus *Ceratiocaris* is known to possess in one species fourteen segments in the abdomen, only six of which are naked.

The genus *Dithyrocaris* McCoy is described as having three longitudinal ridges on the carapace. This feature is seen only when the two valves are pressed open as in McCoy's example, so as to present the appearance of one large plate; in which case the hinge-line forms the middle ridge.

The third or rostral plate in *Peltocaris*, *Caryocaris*, *Discinocaris* and *Aptychopsis*, would appear to be quite analogous to the small rostral plate seen in *Ceratiocaris*, and supposed to exist in *Dithyrocaris*, and perhaps some others, but which is usually absent. It is possible many of the forms may have possessed this rostral plate, at least among those that are deeply notched in front when the valves are spread open. In this case they would as properly be considered as having three plates in the carapace as those grouped under section 7. The forms of this section are usually found with the carapace spread open on the rock, and are then circular and discoid, but when in their natural position would have been more or less roof-shaped.

Colpocaris Meek presents some features which raise a question as to its true affinities. The longitudinal crenulated line and the inflection of the supposed ventral border do not seem to be properly understood; and I am of the opinion it may belong to a different group of Crustaceans.

ECHINOCARIS SUBLEVIS, n. sp.

Carapace obliquely subovate in general outline, the height equal to two-thirds the length, widest and deepest behind the middle, the posterior portion projecting obliquely backward and downward beyond the extremity of the hinge-line; dorsal-line straight, forming a hinge-line two-thirds the length of the valve; outer margin of the valves, except on the dorsum, bordered by a narrow, slightly raised and thickened rim; anterior border nearly vertical from the extremity of the dorsal line, for about one-half the width of the valve, except a very slight rounding backward to the hinge-line above; below it slopes abruptly backward to and along the basal line, and again more abruptly curving around the posterior end of the valve and forward to the extremity of the cardinal line; below which it is distinctly excavated. The portion of the valve which projects beyond the hinge is nearly or quite equal to one-third the length of the valve. Surface of the valves convex, and marked by ridges and tubercles. The principal ridge commences at about the anterior third of the valve, and just above the middle, as an elevated, rounded and nearly vertical ridge; but soon bends somewhat abruptly, and is directed backward in a broad, sweeping curve, at less than one-third of the height of the valve from the lower margin, and gradually decreasing in strength ter-

minates a little within the margin opposite the longest part of the valve. A second and slightly stronger ridge rises from just behind the middle of the length of the hinge, descends with a gentle forward curvature, and terminates near the upper anterior end of the first one. The anterior or principal tubercle is large and distinct, and situated near the antero-dorsal angle of the valve, occupying the greater part of the space between the front margin and the two ridges just described. Between this and the second ridge, the surface is elevated, forming a low tubercle. The surface of the anterior tubercle is occupied by several small but distinct pustules, and the entire surface of the valve is covered by a minutely granulose structure.

Abdomen apparently consisting of four free segments; the first one being short and much thicker than the others on the anterior end, but rapidly narrowed posteriorly; the posterior margin being armed with several small spine-like tubercles. The other three segments are shorter than wide, gradually decreasing in strength and increasing in length backward, the first of the three being apparently less than half as long as wide, their posterior margins all spine-bearing; a long, curved spine on each side, with three short ones between, and all increasing in length backward from the first or anterior segment.

Telson proportionally large, of a general triangular form, but slightly protruding at the origin of the movable spines, and projected behind into a long, slender, and apparently cylindrical spine, making the telson with its spine about as long as the four free segments together. Lateral spines cylindrical, very gently curved, and standing at an angle of about forty-five degrees to the central spine. Surface of the telson highly convex and somewhat angular at the origin of the spine. Surface of the crust of the abdomen smooth.

This species is closely allied in the form of the carapace to *E. punctatus* (*Ceratiocaris punctatus* Hall, 16th Rept. State Cab. N. Y., p. 74, plate 8, fig. 1), but differs in the form of the nodes and ridges, and in the surface structure; also in wanting the projection at the posterior end of the hinge, if this feature is natural on that specimen. It is probable that the abdomen and telson figured on the same plate under the name *Ceratiocaris armatus* belongs to the same species as the carapace of *E. punctatus*, as suggested by Professor Hall in the explanation of plate 23, section Crustacea, Illust. Devon. Fossils; and if so, the distinction between these two parts of the two species is much more marked than between the carapaces.

Formation and locality.—In small calcareous concretions in the Erie shales (Portage and Chemung), at Leroy, Lake County, Ohio.

ECHINOCARIS PUSTULOSA, n. sp.

Carapace ovate, widest anterior to the middle, the greatest height equal to three-fourths of the length; hinge-line straight, rather more than half as long as the valve, while nearly one-third the length of the valve projects behind its extremity; margin of the valve bordered by a narrow, thickened rim; anterior end of the valve slightly excavated below the hinge extremity, and the margin broadly rounded in front; posterior end more pointed, while the basal line is broadly and evenly curved. At the posterior end of the hinge the margin is also slightly constricted as in front. Surface of the valve convex and marked by the characteristic nodes or ridges. The principal ridge commences in an oval node, which is situated just within the anterior third of the length of the valve; is placed vertically, just above the middle of the height, and the horizontal portion, which is sharply elevated and slightly curved, is situated almost in the middle of the width, and terminates a little less than one-fourth of the length from the posterior extremity. The second ridge commences at the hinge-line near the middle of its length, and descends with a slightly forward direction to within a very short distance of the top of the vertical portion of the principal ridge. The anterior ridge, corresponding to the anterior node or tubercle of *E. sublevis*, is narrow and nearly vertical; of a slightly sigmoid form, and originates near the anterior extremity of the hinge-line; the lower end reaching more than one-third the depth of the valve. The surface of the ridges and of the valve in the postero-dorsal field, as also of the space below the principal horizontal ridge, is marked by correspondingly large and distinct pustules. Abdomen and telson unknown.

This species differs from *E. sublevis* in its slightly broader form, and in the want of the obliquity of the axis of the valve with the hinge; in the narrower posterior extremity, pustulose surface, and in the form of the surface ridges; most notably in the anterior one being ridge-like and vertically sigmoid instead of round. The individual used in description is half an inch in length and three-eighths of an inch in its greatest height.

Formation and locality.—In calcareous concretions in the Erie shales, at Leroy, Lake County, Ohio.

ECHINOCARIS MULTINODOSA, n. sp.

Carapace elongate-subovate, about twice as long as high, rounded in front and somewhat pointed behind; the basal line straightened along the middle portion and parallel to the hinge-line; cardinal line straight and nearly half as long as the length of the valve, and a little nearer the anterior than to the posterior end of the carapace. Margin of the valves

bordered by a narrow, elevated, thickened rim, which is expanded considerably in width around the anterior end of the valve, and terminates in a rounded, elongated ridge at the posterior extremity of the hinge; from which point the ridge is directed obliquely forward and slightly downward from the cardinal line. The surface of each valve is divided into three slightly elevated areas, with depressed sulci between; an anterior, a central and a posterior one. The first is situated in the middle of the anterior end of the shell; the central one unites with the anterior one below, and extends along the basal margin behind, in a narrow curved point below the posterior one, and projects upward near the center of the valve in a triangular form, terminating in an elevated point just above the median line; the posterior and largest area is ovate in form, and occupies a little less than one-half the length of the shell, is narrowed in front and pointed behind, taking the form of the extremity of the shell. The center of the anterior area is slightly tumid. Along the hinge-line and just below its margin there are three subangular tubercles or nodes, at nearly equal distances and of nearly equal strength, except that the posterior one is prolonged at its base into a low, rounded and slightly curved elevation, which extends to near the point of the central raised area before mentioned. These three nodes, together with the oblique, ridge-like one terminating the marginal rim, border the hinge-line on each valve. General surface of the valve finely punctate, but most distinctly so on the posterior field.

The elongated form of the carapace readily distinguishes this from any of the other species described, while the number of node-like ridges is a very marked feature. The abdomen and telson of this species have not been observed, although several imperfect carapaces, mostly showing parts of both valves, have been obtained.

Formation and locality.—In calcareous concretions in the Erie shales, at Leroy, Lake County, Ohio.

Associated with the Entomostraca, above described as from the concretions of the Erie shales of Ohio, are the remains of a *Macrouran Decapod*, which appears to differ so much from any described genus as to make it undesirable to refer it to any of them. One of its peculiarities consists in the possession of a pair of very strong antennal appendages which project from beneath the anterior end of the thoracic carapace, of such size and strength as to raise considerable doubt as to their true nature. The existence of five thoracic limbs, exclusive of these, projecting from beneath the carapace on one side would seem to place their pedal nature out of the question; while their great development as seen on the specimen would indicate that they had served some purpose other than simple antennæ, and to raise the

question as to the possibility of their having been chelate at their extremities. As only the basal portions of these organs are represented, however, this question cannot be satisfactorily determined. Having had an opportunity of consulting Dr. A. S. Packard, Jr., in regard to them, he gave as his opinion, that from their position and the representation of the other five pairs of thoracic members without them, they could not be other than antennal in their functions, notwithstanding their great size and anomalous character. Taking this view of their nature, the specimen would conform strictly to the type of Macrouran Decapods.

In its generic relations, as well as in its general expression, the specimen resembles most nearly the genus *Pygocephalus* of Professor Huxley, first given in the Quart. Jour. Geol. Soc. London, vol. xiii, p. 363, 1857, with figures and descriptions of three specimens, under the name *P. Cooperi*. Neither the genus nor species were well characterized at that time. It is, however, again referred to in vol. xviii, p. 420, of the same Journal, and a figure given of a specimen supposed to be of the same species, much better preserved, from the Coal shales at Paisley. There are, however, too many limbs represented as originating from the thorax for a Decapod; and the antennæ, although represented as of large size, are not like those of the Ohio specimen, while there is a second pair shown. In other parts the figure is indistinct, and in the description the parts are not defined sufficiently for close comparison. The differences, however, are so great that I shall propose for this form the new generic name *PALÆOPALÆMON*, with the following diagnosis.

PALÆOPALÆMON, new genus.

A Macrouran Decapod crustacean, having a shrimp-like body, with a thoracic carapace narrowed but not rostrate in front, and keeled on the back and sides. Abdomen of six segments terminated by an elongated, triangular and pointed telson; segments arched; pleura smooth, not expanded nor lobed; their extremities rounded. Sixth segment bearing caudal flaps, one on each side, composed of five visible elements, the outer four apparently anchylosed to form a single large triangular plate on each side of the telson. Thoracic ambulatory appendages elongated, smooth and filiform, except the upper (second) joint, which is laterally compressed. Abdominal appendages short, the upper joints flattened or convex anteriorly, as if for the attachment of plates or fimbria. Antennæ with the basal joints strong and well developed, of large size, much exceeding in strength any of the thoracic limbs. Eye-peduncles short. Type *P. Newberryi* Whitf.

This is, so far as I am aware, the most ancient Decapod crustacean yet recognized, and on that account alone is of great interest. The character of the caudal plates, in having the parts combined to form a solid plate on each side of the telson, is also an interesting feature, if rightly understood. From the impression of the plate as seen on the ventral side, it was at first supposed to be of a single element only, but on obtaining an impression in the fragment of rock, chipped from the top or dorsal surface, the obscure lines of the first and second joints were detected, while the outer three are only traceable from the very slight difference in the surface character of two of them, and the thickened substance of the third or marginal one. Of the thoracic limbs only parts have been seen, and of the abdominal members the three anterior ones on one side; the others being concealed by the rock. The abdominal appendages are inclined backward from their point of origin, while in most of the allied living forms as *Atyoides*, *Regulus*, *Pandalus* and others, they are inclined in the opposite direction; but this is not necessarily of importance. The eye-stalks appear to have been very short, judging from the spherical cavities beneath the anterior extremity of the carapace, which are small, close together and shallow.

The earliest form of Decapod crustacean previously described, so far as I can ascertain, is given by Mr. Salter in the Quart. Jour. Geol. Soc. London, vol. xvii, p. 531, 1861, as *Palæocrangon socialis*, said to be from the Lower Carboniferous limestone of Fiefshire, Scotland. There is another supposed Decapod, *Gitocrangon*, noticed by Richter (Beiträge Paleont. Thuring.), from the Upper Devonian, which is mentioned by Salter, but of which he says he is doubtful if it be a crustacean at all. I have not seen the work in which the original description occurs, and can only judge of its nature from Mr. Salter's remarks.

PALÆOPALÆMON NEWBERRYI, n. sp.

Body slender, the carapace forming a little more than one-third of the entire length, higher than wide, narrowed anteriorly and truncate behind; being longer below than above; median line carinate, with a second carina on each side a little below the crest; anterior end not rostrate but obliquely truncate, and sloping rapidly backward above the truncation, forming, when looked upon in front, a narrow, elongated shield-shaped and slightly depressed area, obtusely pointed above and rapidly widening at the base, the lateral carinæ rising from the lower angles; lower posterior angles rounded; basal margins gently curved throughout and bordered by a narrow, thread-like band with a narrow groove within it. Abdomen moderately robust, highly arched along the dorsal line, the

pleura curving inward below, giving a cylindrical form. Pleura broadly rounded at their extremities on the anterior face, but slightly angular on the posterior corners; posterior margin of the segments strongly arching forward on the back. Telson elongate triangular, a little less than twice as long as wide, somewhat angular above and marked by a central ridge below, and by a backward curving, transverse ridge across the widest part. Caudal flap large, forming a triangular plate on each side, the first and second joints short sub triangular; marginal plate of the flap thickened, narrow and elongate; central plate narrowly triangular, a little longer than wide: third or inner plate of equal length with the second and a little wider than the marginal one; the three combined as one, being apparently ankylosed at their margins to form a solid piece. Antennæ very strong, the first joint half as long as the thorax, slightly swollen in their lower half, and flattened on the under side; the other portions unknown. Thoracic limbs very slender and only of moderate length, the second joint laterally compressed, making the height nearly double the width; other joints apparently cylindrical. Abdominal limbs known only by their second (?) joints, which appear to be triangular in form, widening below, flattened and plate-like in character or slightly convex on the anterior face. (In one case only, a single thread-like appendage can be seen, as if projecting from the outer lower angle.)

Surface of the carapace marked by very fine, tortuous and interrupted, raised lines, strongest anteriorly and running obliquely upward and backward; also by a single slender, distinct, raised ridge, extending more than one-fourth the length of the carapace, originating at the lower anterior angle and passing upward and backward, with a bifurcation at the anterior third of its length. Surface of the abdomen essentially smooth. Caudal flaps marked by impressed lines increasing in number and fineness from above downward.

ART. VII.—*Upon an Optical Method for the Measurement of High Temperatures*; by E. L. NICHOLS, Ph.D. (Göttingen).

IN a previous paper* a series of experiments upon the nature and intensity of the light emitted by glowing platinum were described. It is proposed in this article to discuss more fully the results then obtained, and to develop from them, so far as is at present possible, an optical method for the measurement of

* On the Character and Intensity of the Rays emitted by Glowing Platinum, vol. xviii, Dec., 1879.