

IV.—*On some new Crustaceans from the Lower Carboniferous Rocks of Eskdale and Liddesdale.* By B. N. PEACH, A.R.S.M., F.G.S., of the Geological Survey of Scotland. Communicated by Professor GEIKIE, F.R.S. (Plates VII. to X.)

(Read 19th July 1880.)

By the permission of Professor A. C. RAMSAY, LL.D., F.R.S., Director-General of the Geological Survey of Great Britain and Ireland, and Professor GEIKIE, LL.D., F.R.S., Director of the Geological Survey of Scotland, I have been permitted to describe several new Crustaceans which have come under my notice in my capacity of Acting Palæontologist to the Scotch Survey. They are from the cement-stone group of the Calciferous Sandstone series of the Scottish border, and, with a very few exceptions, were got from one locality on the river Esk, about four miles south of Langholm, in Dumfriesshire, and were almost all collected by A. MACCONOCHIE, Fossil Collector to the Geological Survey of Scotland. They belong to two orders, viz., Phyllopoda and Decapoda.

### I. *Phyllopoda.*

The Phyllopods as yet found in the Calciferous Sandstone series have been confined to the genera *Dithyrocaris*, *Leaia*, and *Estheria*. Some large carapaces, attributable to *Ceratiocaris*, have however been obtained from the Carboniferous Limestone, but as far as I have been able to make out, no body-segments have been described. In the collection above referred to a great many specimens occur, which appear to belong to two different species.

When compared with those found in the Upper Silurian Rocks they differ considerably in having the body relatively much larger than the carapace. The abdomen appears to be out of all proportion to the carapace if we take such well-known forms as *C. papilio* (Salter), or *C. stygius* (Salter), as our ideals. The tests are not ornamented by the same fine striations as these latter.

*Ceratiocaris scorpoides*, spec. nov. (Pl. VII. figs. 1 to 1f). Carapace about one-third the length of the body exclusive of telson, subovate in form, and produced into a blunt snout anteriorly, and posteriorly into a rounded lobe, which extends backwards beyond the median line of the posterior margin. The anterior, ventral, and posterior margins are slightly thickened. The dorsal line is almost straight, with a slight droop anteriorly. Jaws two in number, and placed within the carapace near its anterior ventral margin. They are hollow and denticulated, the toothed portion being much thickened. Body long and

cylindrical, and made up of seven segments which extend beyond the carapace, and at least five which are covered by it. These latter are mere rings, and become shorter and shorter anteriorly. All are articulated and movable. The uncovered segments increase in length posteriorly. The third segment from the end is much the deepest, whence the body tapers each way. The ventral margin of this segment always exhibits a deep notch as if a piece were cut out of it. The seventh segment is almost twice as long as any of the others, and has articulated with it a strong hastate telson which is about equal in length to itself. The telson is broad at the base, tapers rapidly for a short distance, and then, more gradually, to a fine point with a slight upward curve. It is ornamented with at least five serrated flanges, a dorsal, a ventral, and two lateral ones on each side. The lateral flanges on the one side in part of their course are connected with each other at intervals, with buttresses or columns, so that a pattern is produced in the lateral groove. The telson is flanked by two other shorter conical spines, one on each side, which are also articulated to the last body-segment and striated longitudinally. Test, smooth or slightly wrinkled. Total length from 1 to  $2\frac{1}{2}$  inches.

*Observations.*—There is a considerable difference among the several specimens regarding the length and bluntness of the snout, and from none yet seen can the bivalve nature of the carapace be established.

The species is named from a fancied resemblance of the individuals to scorpions, not from any idea of immediate relationship.

*Ceratiocaris elongatus*, spec. nov. (Pl. VII. figs. 2 to 2f). Carapace about one-fourth of the length of the body without the telson, produced into a long snout in front and suddenly deepens where the jaws are seen to show through, whence it is produced backwards into a rounded lobe which extends considerably beyond the medial line of the posterior margin.

Jaws hollow and denticulated, and placed a little less than half-way from the tip of the snout to the posterior margin. They occur nearest the ventral side and sometimes project beyond the margin. Body-segments seven, uncovered and four or five covered by the carapace, all movable, the whole forming a cylindrical body which swells backwards till the third segment from the tail is reached, whence it tapers backwards. This segment too has a similar notch to that observed on *C. scorpioides*, as in that species the segments are each one larger than its immediately preceding neighbour. The telson is nearly twice as long as the last abdominal segment, and is highly ornamented. In addition to five plain flanges it has in the grooves on each side of the dorsal flange a row of minute bosses, which, when magnified, have the appearance of the pine-pattern so common on Indian shawls. Lateral spines not observed. Length, including telson,  $4\frac{1}{2}$  to 8 inches.

*Observations.*—It is only necessary to point out where this species differs from *C. scorpioides*. In the first case its size and proportions are different. The snout of the carapace is much longer and narrower. It is in the tail spine that the greatest difference is found. Both of the above species differ from all others described in the enormously developed abdomen.

Though the side spines of the *C. elongatus* were not observed, yet the articular surface on the segment to which the telson is attached is much broader than there is any apparent need for. It is but natural therefore to infer that such spines may have dropped off in the interval between the death and the interment of the animals.

That those of *C. scorpioides* represent the side spines in the silurian species there can be little doubt though they have dwindled down so as to be out of all proportion to the central one. We had a shadowing of this, however, in *C. inequalis*, Bar.

Fig. 2*b* is interesting, as it shows the course of the intestinal canal, which appears to be a straight cylindrical tube opening on the ventral margin of the last segment near the insertion of the telson. Fortunately the creature is fossilised with the canal distended with food.

A noticeable feature in both species is that the pivots on which the abdominal segments move are placed nearer the ventral margin in the hinder than in the anterior segments, thus allowing of most play in the joints of the former (fig. 1*a*). In both species a row of circular pits is observable on the sides of the abdominal segments. These may represent the place of attachment of the gill feet with which they were probably provided.

## II. *Decapoda macrura*.

Among the specimens are several species which differ in no essential respect from the *Macrura* of the present day. These go to swell the genera *Anthropalæmon* and *Palæocrangon*, Salter. It should be borne in mind, however, that they are not to be considered as being more nearly allied to the genus *Palæmon* than to any other of our recent *Macrura*. As well as these there are several specimens of one species differing from the above in having their thoracic segments free to move on each other, and not covered by the carapace, which only extends over the cephalic region. These agree generally with the American genus *Palæocris*\* of MEEK and WORTHEN, but the species is different from their *P. typus*.†

Genus *Anthropalæmon*, Salter (1861), Quart. Journ. Geol. Soc. Lond., xvii. p. 529.

\* MEEK and WORTHEN, 1865, Proc. Acad. Nat. Sci., Philadelphia, p. 48.

† MEEK and WORTHEN, *Ibid.*, p. 49.

*Anthrapalaemon Etheridgi*, spec. nov. (Pl. VIII. figs. 3 to 3g; spec. char.). Carapace subovate, narrowest in front, and separated into two unequal areas by the cervical fold. It is strengthened by a marginal thickening, and produced anteriorly into a long serrated rostrum. The posterior angles are rounded, and the posterior margin slightly concave. It is further ornamented with five ridges, a central one which extends back from the apex of the V-shaped cervical fold to the posterior margin. In front of the cervical fold it is continued forward into the rostrum. On each side of this there is another ridge passing back to the cervical groove but not reaching the posterior margin. On the area in front each is continued as two oblong bosses placed upon a low mammiform protuberance. These are the supports of spines with which the three already mentioned ridges were furnished. The remaining two ridges run almost parallel with the lateral margins, but are not found in front of the cervical groove. Unlike the rest, these bear no traces of spines nor crenulations.

The rostrum, which is strong and conical, and about one-third of the length of the carapace, is ornamented with a central toothed crest and two lateral serrated flanges, and ends in a sharp point which is slightly bent upwards.

The eyes are large, reniform, and pedunculated, and placed at the angles made by the rostrum with the carapace which are rounded off into sockets.

The antennules are two, each made up of a propodite of at least three joints, broad, and horizontally flattened at the base and tapering forward. The last joint of each supports a pair of short tapering many-jointed setæ. The antennæ consist of a jointed propodite on each side, which supports a broad denticulated and corrugated basal scale. It also supports a long many-ringed lash, which seems thick at its base compared with the size of the animal.

The walking limbs, which appear to be five on each side, are stout and somewhat flattened laterally and directed forward. From what can be seen, they are made up of precisely the same elements as an ordinary monodactylate limb of a recent macrurous decapod. There is no evidence of any chelate limb.

The abdomen consists of six segments irrespective of the telson. The first two are narrow and highly faceted, allowing of a great deal of play in the joints. Seen from above the unfaceted part is very narrow, but it widens out laterally till past the pivots, when it expands into broad and rounded pleuræ. Those of the second segment overlap those of the adjoining ones both ways. Behind this the pleuræ are pointed, and overlap those of the succeeding segment. The third segment is also highly faceted, but is very much broader than any other of the abdominal rings. It is divided down the centre of the tergum by a depression in which rises a narrow ridge. The fourth and fifth are broad, but not divided medially. The sixth has a central ridge, which is continued into the telson. On each side it has a joint articulated with it, each of which supports a pair of expanded and rounded fin-like appendages,

strengthened by a central or marginal thickening and fimbriated near their lower extremities. The telson is broad at its base, and tapers rapidly for about two-thirds of its length, where it becomes quite narrow. It then expands into a small, oblong, fimbriated flap, with which it terminates. At the points where the tapering ceases, a pair or perhaps two pairs of short spine-like appendages are articulated with it. Length,  $\frac{3}{4}$  inch to 2 inches.

*Observations.*—The above characters have been made out from the study of over forty specimens, all of which were collected by A. MACCONOCHIE from Eskdale. The manner in which the animal is preserved shows that it must have been broader than deep, for out of the large number in the Survey collection, only one is found on its side. All the rest are preserved back upwards. When this is the case the three central ridges on the carapace appear but as if slightly crenulated, and it was only the specimen preserved on its side which showed that these were produced into spines which may be seen to be directed forwards (fig. 3). This taken together with the forward direction of the walking limbs, the overlapping of the pleuræ of the second abdominal segment both ways, and the overlapping of the pleuræ of those behind it only upon those of the next in succession, shows that this animal used the great tail-like apparatus made up of the telson and the flattened appendages of the sixth segment for swimming backwards, which is the mode of progression in the recent *Macrura*.

It is impossible from the manner in which the specimens are crushed to make out the relative position of the antennules and antennæ, and the maxillipedes are never recognisable. The characters on which the classification of the recent *Macrura* so much depend are therefore not reliable in the present case. The general symmetry of the parts best preserved has thus to be depended on for that purpose. This applies equally to the other Crustaceans here described. The thoracic segments in many cases show through the carapace in the manner described by Messrs MEEK and WORTHEN, and R. ETHERIDGE, junior, in the species described by them. Fig. 3*b* exhibits the endophragmal system of the thorax very completely. The segments are all soldered together except the hindermost. It also shows the gill supports; five or six of these are well seen on one side lying in their proper position.

The only species already described with which this might be confounded is the *A. Woodwardi* of R. ETHERIDGE, junior,\* my friend and predecessor in office, after whom I propose to call the present species. It is very much like it in general symmetry, though a much larger creature. It differs from it in the large size of its rostrum, which as well as the three central ridges of the carapace is produced into spines. It is considerably different in the abdominal segments, the third being much the largest, while in *A. Woodwardi* the last is the greatest. In *A. Etheridgii*, the telson broadens out at the tip while the

\* Quart. Journ. Geol. Soc. Lond., 1877, vol. xxxvii. p. 872, t. 27; vol. xxxv. p. 468, t. 23.

other is pointed. They differ also in the nature of the broadened tail-flaps of the sixth segment.

The ornamentation on the carapace and the broad basal scales of the antennæ distinguish it from *A. Gracilis*, Meek and Worthen.\* The tail too is different, being not quite so complicated as in that species.

From *A. Hilliana*, Dawson,† the number of ridges on the carapace show it to be distinct.

*Anthrapalæmon Parki*, nov. spec. (Pl. IX. figs. 4 to 4f). Length from three to four inches, and breadth about one-third of the length, which is continued down to the sixth abdominal segment, where it expands into a remarkably wide tail.

Carapace two-fifths of whole length. When expanded it forms an irregular quadrilateral figure with rounded off corners, and which is a little narrower in front. The anterior margin is concave, and gives off a broad leaf-shaped rostrum. The posterior margin is also concave. The margins are strengthened by a broad thickening band, broadest at the posterior angles. A deep cervical groove, or folding in of the test, proceeds from the anterior angles forming an angle of  $150^\circ$  on the median line of the back and divides the carapace into two unequally sized areas. The posterior and larger is ornamented by seven ridges besides the marginal ones. The middle ridge alone is continued back from the cervical groove to the posterior margin, the next two on each side proceed from the cervical groove, but are lost before reaching it. The two remaining ridges are continued back from the cervical groove, and merge into the lateral thickened band at the posterior angles. The area in front is divided into several raised portions separated by depressions, but none of the ridges are continued on to it. One fold of the test overlaps the base of the rostrum, which is leaf-shaped, being narrow where it joins the carapace, expanding rapidly and then tapering off to a blunt point. The anterior portion is grooved medially and droops downwards. Neither the rostrum nor the ridges on the carapace bear any trace of spines or bosses. The test throughout is smooth or slightly wrinkled.

*The Cephalic Appendages.*—The eyes probably large, and set at the angles made by the rostrum with the carapace which are rounded into sockets. The antennules consist of two pairs of broadened and jointed peduncles, at least three joints are seen which are serrated at their bases, each of which supports two jointed setæ. The antennæ are two broad jointed peduncles which give off long jointed setæ. No broadened basal scale observed. The rest of the cephalic and thoracic appendages not observed. The abdomen consists of six segments without the telson. These are short in front, becoming gradually

\* Illinois Geol. Survey Report, 1866, vol. i. p. 407, pl. xxxii. fig. 4, *a*, *b*, *c*.

† Geol. Mag., 1877, vol. iv., new ser., fig. 1, p. 56.

longer, the sixth being the longest. The four posterior segments are ornamented by a broad marginal band anteriorly, which sends back an occasional buttress which is soon lost in the test, except in the case of the median one on the three last segments, which is continued to their posterior margins. Those in a line with the mesial and the two main lateral crests of the carapace are larger and more pronounced than the rest, and are continued down into the telson. As they approach that organ they become ornamented with occasional spines which gradually increase in size backwards. All the abdominal segments have large pleuræ pointed backwards. The appendages on the first five segments have not been observed. Those on the sixth consist of a broad joint articulated with it at the posterior angle on each side, each of which supports a pair of broad swimming flaps. That corresponding to the exopodite is strengthened by a strong, narrow, knife-blade-like rachis on its exterior margin. Its inner margin is supported by a conical spine which is directed towards the point of the knife-blade portion. The inferior and inner margins are broadened out into a flap, which is further strengthened by corrugations of the test. The endopodite is composed of a fin-like lobe with a central slender spine-like thickening, and is corrugated near the margins. The telson, which is broad at the base, tapers rapidly and increasingly for about half its length, whence it is continued into a long sharp spine and looks like the section of a boy's peg-top. At the angles made by what corresponds to the insertion of the peg, two pairs of short conical spines are articulated with it. The convexity of this species is slight, as it is invariably fossilised with its back upwards.

*Observations.*—Besides the above external characters, the specimens in the Survey collection show several points in its anatomy. The eyes as seen, fig. 4*a*, seem to have been large, but they are so much crushed that their original form cannot be made out. Nothing can be said about the maxillæ or maxillipedes, though there is little doubt that the confusion in the carapaces of figs. 4*a* and 4*b* is caused by their being crushed through it. Part of the confusion is, doubtless, owing to the hard parts of the stomach and the endophragmal system. In fig. 4 the thoracic segments are seen shining through the carapace, and on one side the branchial arches are also distinguishable. In the abdominal segments the sternal arches are seen to be pressed up through the tergum, fig. 4. Their epimera are almost as broad as the basis of the pleuræ, but the sternæ are very narrow, which shows that the segments to which these belong had a great deal of play. The tail is enormous compared with the size of the creature, and must have been a most effective organ for swimming backwards. As it is now found, in many cases the strengthening ridges only are preserved, as in figs. 4 and 4*a*, and these give to the creature a very formidable aspect. Fortunately other specimens, as in fig. 4*c*, show the true nature of them. The sharp knife-blade-like portion of the exopodite is ornamented on its

exterior margin by five or six strong conical spines, the broken bases of which are seen in figs. 4 and 4*c*, set in hollows to receive them. Two little reniform bosses are seen on each of the abdominal segments as well as the telson. The tip of the rostrum has not been observed, as it usually buries itself into lower strata than the plane in which the body lies. The test is very thin, and probably contained very little calcium carbonate, as it is apt to be filled with calculi, such as that now found in the common shrimp. Where the test is thin these are mere scales; but in the spines and thickened portions they are semi-globular, the rounded part being mammilated. In every case, however, they have a central nucleus from which radiations proceed. The above remarks are equally applicable to all the Crustacea described in the present paper. Sometimes these calculi are sporadic, at other times they fill the whole tests of the creatures, forming an irregular polygonal net-work, which destroys the character of the test and gives it a granulated appearance. Even in this case the nucleus and radiations are observable. Fig. 4*g* represents a portion of the carapace of fig. 4, magnified about four diameters exhibiting these calculi. Fig. 4*h* is part of the test of the common shrimp *Grangon vulgaris*, affected in a similar manner and magnified about ten diameters. I propose to call this species after my friend WALTER PARK, Esq., Langholm, Dumfriesshire. Though A. MACCONOCHIE was the first discoverer of the species, Mr PARK was the finder of the specimen from which fig. 4*d* is taken, which he not only handed over to the Geological Survey, but generously offered to its collection anything new which might turn up to his hammer. Dr TRAQUAIR was fortunate enough to disinter the magnificent specimen represented by fig. 4. The illustrations are all natural size. Fig. 4*d* is an outline drawing of a portion of the carapace and the abdomen to show to what a size this species sometimes attained. A portion of the right side of a carapace, shown in fig. 4*e*, must have belonged to a still larger individual.

*Anthrapalaemon Traquairii*, nov. spec. (Pl. X. figs. 5 to 5*f*). Carapace short compared to length of body, subovate, posterior margin concave, anterior margin produced into a rostrum as long as the rest of the carapace. The only ornament is a broadened margin slightly crenulated. Cervical fold not distinguishable from the other wrinkles of the test. Test smooth and exceedingly thin. Rostrum broad at the base and gradually tapering to a point, the upper line is slightly hollow and near the point is bent downwards. It is strengthened and deepened by a central keel beneath. A transverse section just in front of the eye would represent a capital T. Though there are several longitudinal grooves near its base, there appear to be no spines.

*Cephalic and Thoracic Appendages*.—Eyes stalked and placed on each side of rostrum, which is hollowed out to form with the margin of the carapace a sort

of socket. Antennules consist of two lengthened, apparently jointed propodites, each supporting a pair of filamentous whips, which are cylindrical near their base, and then become flattened and broadened somewhat before they taper rapidly at the tips. Antennæ made up of jointed propodites with prodigiously large bidenticulated basal scales. Each propodite also supports a long cylindrical many-ringed lash. The remaining cephalic appendages not distinctly observable.

The walking legs, ten in number, are long and thin in their proportions, and somewhat flattened laterally. Their penultimate joints are even more so, and, as well, are strengthened by longitudinal flanges. The dactylopodites are sharp and spinose, and none of the limbs appear to be chelate.

Abdomen long, and tapering backwards, composed of six segments, the last being the longest and much the narrowest. Their only ornament is a slightly thickened band along their anterior margins and a fold of the test along the median line of the sixth segment. They all possess triangular, pointed pleuræ directed backwards. Those of the second segment overlap each way, the next three only overlapping those immediately in their rear. No appendages observable except on the sixth segment, which supports at each posterior angle a broad joint, to each of which are articulated a pair of expanded flaps. The strengthened part of the exopodite is much broader than in *A. Parki*. The telson is similar to that of *A. Parki*, but is narrower and more hastate. It also supports a pair of spine-like appendages on each side.

*Observations.*—This species somewhat resembles *A. Parki*, but is easily distinguished from it by the general shape being much more elongated and tapering backwards, by the absence of the ridges on the carapace, by the long rostrum, by the sudden tapering of the body at the spring of the tail, by the telson, and by its possessing large basal scales to its antennæ.

Other points in the anatomy of this species can be made out from some of the specimens. The pedipalps of the maxillipedes were in all probability very long, and extended in front to near the tip of the basal scales of the antennæ. The walking limbs seem all to have been simple, as in fig. 5a, ten limbs are accounted for, and none seems to be much more enlarged than the rest. They agree part for part with the hinder limbs of *Nephrops Norvegicus*, which they greatly resemble. In figs. 5a and 5b the coxopodites of five limbs on one side are observable attached to the thorax. Among the confusion produced by the crushing together of the gills and endophragmal system, exposed by the carapace being lifted in fig. 5a, one small fragment of the gill, apparently belonging to the fifth thoracic segment, is preserved. When magnified it shows a structure like that of the gill of *Palæmon*, fig. 5e.

The convexity of this species must have been considerable, for the individuals are as often found on their sides as with their backs upwards. When

fossilized sideways the limbs are not crushed up into the body, and are more likely to be preserved in a state fit for studying (figs. 5*a*, *b*, and *c*). This also applies to all the other species.

I have named this species after my friend RAMSAY H. TRAQUAIR, M.D., who is describing the fishes got from the same beds with the above, and who has handed over to the Survey such Crustaceans as he has been enabled to collect during his visits to that locality.

*Anthropalæmon Macconochii*, R. Etheridge, Jun; *Anthropalæmon Macconochii*, Quart. Journ. Geolog. Soc., 1879, vol. xxxv. p. 471, pl. 23, fig. 10, Pl. VIII. figs. 6 to 6*d*.

The description of the carapace of this species (all of it then known) by R. ETHERIDGE, JUN., is so complete that it is unnecessary to add to it. Two specimens have recently come to light among those since collected by Mr MACCONOCHIE which exhibit some of the cephalic appendages as well as the body segments and telson in place. The study of these entirely confirms Mr ETHERIDGE'S opinion that the carapace he described belonged to a macrurous decapod.

*Cephalic Appendages*.—The eyes are large and stalked, and placed on each side of the rostrum. The antennules consist of two pairs of short conical many-jointed setæ, each pair supported upon a single peduncle, two joints of which appear beyond the apex of the rostrum. The antennæ are composed of broad peduncles, each of which supports a lash which is many-ringed. These are very thick at the base when the size of the animal is taken into consideration. No basal scale observed.

The abdomen is short compared with the carapace, and made up of six segments, the anterior ones being the narrower. The posterior angles of the carapace project backwards and inwards like horns, and overlap as far as the anterior margin of the fifth segment, so that all those so confined are necessarily narrow. The sixth expands considerably beyond the tips of the horns, and supports a joint on either side, to each of which are articulated a pair of broad, rounded, and flattened swimming flaps.

The telson is broad where articulated with the sixth segment, whence it tapers rapidly for a little over half its length, and then expands once more into a rounded and fimbriated flap. At the narrowest part it has articulated with it on each side a pair of small flaps, so that the tail, made up of all the above elements, is a most effective paddle.

*Observations*.—The tail greatly resembles that of *A. gracilis*, Meek and Worthen,\* but the carapace is sufficient to distinguish it from that species at a glance.

*Locality*.—Tweedon Burn, Newcastleton, Liddesdale.

*Horizon*.—Cement-stone group, Calciferous Sandstone series.

\* Proceedings, Acad. Nat. Science, Philad., May 1865, p. 80.

*Anthrapalæmon ornatissimus*, nov. spec. (Pl. VIII. fig. 7). All that is known of this is obtained from the portions of two carapaces on one slab of grey cement-stone from Larriston Burn, near head of Liddesdale.

Carapace about half an inch long, subovate, and produced anteriorly into a long denticulated rostrum. The posterior angles and margin not observed.

It has a deep cervical groove, and is ornamented by a thickened margin, which bears two or three rows of small tubercles. The medial line of the back bears a slight ridge, which passes back from the apex of the cervical groove, is lost in the carapace before reaching half way to the posterior margin. It bears no tubercles, and does not occur in front of the cervical fold, where its place is represented by a large pyriform elevation. Another line of ridge on each side passes back from the cervical fold and runs almost parallel with the marginal one. This supports two or three rows of tubercles. At the cervical fold it bifurcates, and one branch crosses the fold, and merges into the margin at the anterior angle, the other branch coalesces with the margin behind the fold. The area in front of the cervical fold is further divided into several raised portions by deep sulci. The whole test is studded with minute bosses which are much the smallest on the parts of the carapace that are not ridged. It is from this character that it derives its name.

*Observations.*—This species resembles *A. Macconochii*, R. Etheridge, Jun., but is distinguished from it in having its test covered with minute bosses. The central ridge is not continued back to the posterior margin, does not appear on the area in front of the cervical fold, and does not bear large tubercles. The other ridges have a double or treble row of tubercles, and the rostrum is much larger and denticulated.

*Locality.*—Larriston Burn, Upper Liddesdale.

*Horizon.*—Cement-stone group, Lower Carboniferous.

*Anthrapalæmon formosus*, nov. spec. (Pl. VIII. fig. 8). Carapace quadrilateral, little narrower in front than behind. Anterior margin concave, and produced into a long-toothed rostrum. Posterior margin concave, and posterior angles rounded. Lateral margin bulging, and strengthened by a thickened band, which is broadest in front. There is a deep cervical groove. On the greater area behind this, only two ridges occur, one on each side, close to, and parallel with, the lateral margin. These pass from the cervical groove to the posterior margin; they end in front in a couple of spines, which overlook the groove. With the exception of these, they are quite plain. On a raised mound in front of the cervical groove a line of four or five separate spines passes from the interior angle of the fold into the median line of the rostrum. Two sulci divide this mound from two similar mounds, one on each side, each of which supports two separate spines. Along these latter a single spine is set behind the cervical

groove. As well as the central ridge of spines, the rostrum bears two lateral serrations.

*Observations.*—This small species somewhat resembles *A. Etheridgii* in shape and in being spinose, but the absence of the three central ridges on the carapace possessed by that species distinguishes it. It is not likely to be confounded with any other described species.

*Locality.*—River Esk, 4 miles south of Langholm, Dumfriesshire.

*Horizon.*—Cement-stone group, Lower Carboniferous.

Genus, *Palæocrangon*, Salter, 1861; *Uronectes*, Salter, Trans. Royal Soc. Edinburgh, vol. xxii. p. 394; *Palæocrangon*, Salter, 1861, Quart. Journ. Geol. Soc. vol. xvii. p. 533.

*Palæocrangon Eskdalensis*, nov. spec. (Pl. VIII. figs. 9 to 9*i*). A shrimp-like creature, about  $1\frac{1}{2}$  to 2 inches in length. Carapace one-third of the length of the body without the appendages. Seen sideways, it is subquadrate, narrow, and blunt in front, and produced into rounded lobes posteriorly, which extend beyond the posterior margin on the middle line of the back, and overlap the pleuræ of the first abdominal segment. The only ornament is a slight marginal ridge, and the anterior margin is slightly serrated or denticulated. A fold of the test which runs almost parallel with and very near to the anterior margin, and which supports two or three denticles, may represent the cervical groove. The rostrum is not much larger than one of the denticles on the anterior margin. Eyes elongated and pedunculated. The antennules are made up of long three or four jointed propodites, upon each of which are placed two equally long jointed setæ. The antennæ are made up of long many-jointed flagellæ and broad basal scales, the tips of the latter not extending beyond the propodites of the antennules. Of the other appendages belonging to the cephalothorax only a doubtful appearance of a maxillipede has been observed, and represented in fig. 9*c*, but its component parts are not traceable.

The abdomen is cylindrical, and tapers each way from the third segment. It is made up of six segments, each slightly modified to suit the region where it is placed. The first is a mere narrow ring articulated with the last thoracic segment, and has small pleuræ. The pleuræ of the second expand into rounded saddle-flap like lobes, which overlap those of the segments both in front of it as well as behind. At the pivot where this one moves upon the first segment, the anterior margins of the pleuræ are bent forwards at almost a right angle till they touch and overlap the posterior lobe of the carapace, so that the pleuræ of the first segment are entirely hidden. The third, fourth, and fifth segments have pointed pleuræ directed backwards and overlapping their succeeding neighbours. The sixth segment is much longer than any of the rest, and forms a conspicuous feature.

*Abdominal Appendages*.—The appendages on the first abdominal segments seem to be modified for sexual purposes. Figs. 9*b* and 9*c* show articulated with this a stout longish limb-like appendage, made up of five joints, which reminds one somewhat of the corresponding modified limb of the male cray fish, *Astacus fluvialitis*, only it is much larger in proportion. The best preserved case of this is shown magnified in fig. 9*f*. Analogy would incline one to look at those other individuals exhibiting the above character as males. The appendages on the next four segments appear as short and flattened, the segmentation not being traceable in the present state of preservation. The appendages of the sixth segment are made up of the broad propodites articulated with it at its posterior angles, each of which gives rise to a pair of swimming flaps with strengthened ridges; those of the exopodite are blade-shaped and slightly curved outwards. The telson is long and hastate, and supports a couple of spines on each side. Test smooth, or only slightly pitted in appearance very like that of a shrimp.

*Observations*.—It will be at once observed, from the enlarged lobes of the second abdominal segment and their overlapping each way, that it was here the animal doubled itself while swimming, just as in our recent shrimps. Like *P. socialis*, Salter, it often occurs in great numbers. It differs from that species in the shape of the carapace and in the pleuræ of the first and second abdominal segments as well as in the more elongated telson.

*Locality*.—River Esk, 4 miles south of Langholm, Dumfriesshire.

*Horizon*.—Cement-stone group, Lower Carboniferous.

*Note*.—Since the above was written, the Rev. THOMAS BROWN, F.R.S.E., in whose possession the specimens of *P. socialis* are from which Mr SALTER made the genus, has kindly allowed me to see them. There is no doubt that our *P. Eskdalensis* belongs to the same genus, but there is sufficient difference to warrant its being ranked as a separate species.

Genus *Palæocaris*, Meek and Worthen, 1865, Proc. Acad. Nat. Sci., Philadelphia, 1865, p. 48.

*Palæocaris Scoticus*, nov. spec. (Pl. X. figs. 10 to 10*h*). Body long and narrow, and tapering backwards. Length from  $\frac{1}{4}$  of an inch to 1 inch. The carapace only extends over the cephalic segments, and measures about two-sevenths of the body irrespective of telson and appendages. It is rounded in front, and its posterior margin somewhat concave. It is divided into several areas by deep sulci. One of these of a V-shape extends slightly back from the anterior margin, and has its apex directed backwards. Other two proceed from the anterior portion of the lateral margins, and reach the posterior margin after having performed crescent-like curves, the convex sides of which are directed inwards; from these latter short grooves inwards proceed, but do not meet on the median line.

*Cephalic Appendages.*—No eyes have with certainty been observed. Antennules two, each made up of a long propodite of three or four cylindrical joints supporting two many-jointed whips, the tips of which have not been preserved, so that nothing can be said as to whether the outer or inner be the longer. The antennæ consist of a shorter and thicker propodite, which supports a rounded basal scale and a many-jointed flagellum, which is much stouter than those of the antennules, and probably extended much beyond them, though only the bases are now preserved. The other cephalic appendages have not been observed.

Thorax and abdomen are composed of similar segments, which are twelve in number; those of the thorax not having the terga and pleura soldered together nor confluent with the carapace. All are free to move on each other, and are composed exactly like a typical abdominal segment of a decapod. Each ring exhibits a tergum flanked by pleuræ, which are marked off from it by a folding in of the test. These grooves are continued backwards from those already mentioned as occurring on the carapace to the anterior lateral margins of the telson. The pleuræ are pointed, and directed backwards. The body tapers gradually from the second thoracic segment. The three last abdominal segments are ornamented on the terga with two ridges, situated just within the grooves, and these are continued on the telson. No appendages have been with any certainty seen on any of the above segments, except on the last abdominal one, which supports a joint at each posterior angle. To each of these are attached a pair of broadened swimming flaps, the strengthening portions of which are usually alone preserved as flattened spines; those of the exopodite being the longer and more pronounced. The telson is shield-shaped, broad at the base and tapering almost to a point, and then suddenly broadening out spoon-fashion at the tip. At least one pair of small spines are attached to it immediately above its narrowest part. The tail is in character quite that of a macrurous decapod. The test is ornamented all over with slight corrugations, which, along with a metallic lustre the fossil usually presents, makes the slightest fragment recognisable.

*Observations.*—This species was found by A. MACCONOCHIE at the locality on the Esk where the other fossils were procured, and from which about thirty specimens have been obtained. From the nature of the matrix, which is a sandy and calcareous shale, and the fact that the test of even these tiny creatures are infested with innumerable calculi of the character already described, they cannot be studied as narrowly as might be wished. For instance, although in most of the specimens there occur small oblong bosses just in the place where their eyes should be, were they decapods, figs. 10-10*d*, yet the facets of the cornea have been looked for in vain. This is unfortunate, as it prevents one from saying with certainty that these are the eyes, though there is a strong presumption in favour

of their being so. No sessile eyes have been observed on the carapace, neither has a trace of anything been observed that could be construed into such. The nature of the other cephalic appendages preserved is quite that of the decapods, and the same is the case with the tail (see figs. 10-10*e*). The general appearance of the thorax and abdomen much resembles the Isopods, but this is only seeming. Nothing can be said of the walking feet or those of the first five abdominal appendages, as in no specimen yet obtained have these been preserved in a state to be studied, though in some cases there is a faint appearance as if of something of the kind.

In the specimen represented by fig. 10*b*, which is among the few that has been fossilised on its side, the appearance of several segments shows through the carapace. The lobe of the carapace is wrinkled with lenticular sigmoid markings which may possibly represent the gill arches showing through. It also overlaps the pleura of the first thoracic segment so as to entirely hide it, which lends additional strength to this supposition, as it indicates how free it is. As far as the present specimens go to show the affinities of these small crustaceans, I am inclined to the belief that they are lowly decapods, somewhat like the opossum shrimp (Schizopods), though not necessarily identical with them. For comparison, I have reproduced the figures which Messrs MEEK and WORTHEN give of their *P. typus* in the Memoirs of the Geological Survey of Illinois, vol. ii. pl. xxxii. Fig. 10 is fossilised back up, as most of ours are. In it thirteen segments are shown in the combined thorax and abdomen, but the depressions which appear to form the first do not meet in the middle, I am inclined to look upon it as belonging to the head, and the sulci as analogous to those seen in the head of our specimens. The same may be said of fig. 10*g*. If that be the case, the number of segments in each is the same. The American specimens seem to be preserved more in the round than the present ones, hence their generally narrower appearance and their not exhibiting the lobes of the carapace. Fig. 10*h* is the restored tail of *P. typus*, alongside which, fig. 10*e*, a restoration of that of *P. Scoticus*, from the study of more than twenty specimens, is put for comparison.

As far as I am aware, this is the first species referable to the genus *Palæocaris* that has been procured from British strata.

*Note 1.*—The study of the tails of the macrurous decapods, described in the present paper, tends to confirm the opinion of those who hold that the telson in the Macrura is only a modified body segment, for all the telsons that are sufficiently well preserved to retain them have two small swimming flaps or spines articulated with them on each side. These appear to be modified appendages and probably represent the exopodites and endopodites of those of the other segments. Even the lowly *Palæocaris* exhibits these articulations.

In the interval between the reading the present paper and its printing, I have been enabled to study several more Carboniferous Macrura. Some new species of *Palæocragon*, each showing the swimming flaps flanking the telson and articulated with it; also a large suite of fossils of macrurous decapods intermediate between *Palæocaris* and *Anthrapalæmon*, in having only two or three of the thoracic segments covered by the carapace, and the sterna of these not soldered together, and they all exhibit the spines or flaps on the telson. The small spines articulated at the posterior angles of the telsons of our recent shrimps and prawns are evidently a survival of what has once been a useful character of their more ancient progenitors. It seems a pity to disturb the seemingly satisfactory and complete number twenty for the segments of the typical crustacean by adding another to make it twenty-one, but the present evidence favours the latter number.

*Note 2.*—Since the above was written, a paper read by M. P. BROCCHI before the Geological Society of France, in Nov. 1879, and published in the Bulletin of that Society in March 1880, on a “Fossil Crustacean, from the Schistes d’Autun” (Upper Carboniferous or Lower Permian), has come before my notice. After a careful perusal of his paper, I have not been able to satisfy myself with the conclusions M. BROCCHI arrives at regarding the systematic position he assigns to the genus *Palæocaris*, Meek and Worthen, which he includes in his new division of the Amphipoda, the *Nectotelsonides*. His reasoning, based upon the first thoracic limbs not being modified into prehensile organs, disappears in the light of such forms as *Anthrapalæmon Traquairii* and *A. Etheridgii* described in the above paper, or the recent *Palinurus vulgaris*, whose limbs are not so modified, but in which the decapod characters are undoubted. Such evidence as the specimens of *P. Scoticus* afford are in favour of decapod affinities, and I therefore retain the classification latterly adopted by Messrs MEEK and WORTHEN, which M. BROCCHI has apparently overlooked.\*

\* Memoirs of the Geological Survey of Illinois, vol. iii. p. 552, 1868.

## EXPLANATION OF PLATES.

## PLATE VII.

- Fig. 1.—*Ceratiocaris scorpioides*, showing the general form. The carapace is slightly displaced, and exposes some of the segments which during life were covered by it. Jaws seen near anterior margin of carapace. Nat. size. Locality—River Esk, 4 miles south of Langholm, Dumfriesshire.
- Fig. 1a.—*Ceratiocaris scorpioides*, showing carapace slightly displaced, jaws, &c. Nat. size. Same locality.
- Fig. 1b.—Cast of jaws of fig. 1, magnified.
- Fig. 1c.—Crushed jaw of fig. 1a, magnified.
- Fig. 1d.—Tail spines of fig. 1a, magnified.
- Fig. 1e.—Magnified tail spines of another specimen of *Ceratiocaris scorpioides*, from the same locality.
- Fig. 1f.—Magnified tail spines of another specimen of *Ceratiocaris scorpioides*, from the same locality.
- Fig. 2.—*Ceratiocaris elongatus*, showing all but last joint and tail spines. Carapace displaced so as to show some of the segments which it should cover. Jaws seen *in situ*. Nat. size. Same locality.
- Fig. 2a.—Anterior portion of *Ceratiocaris elongatus*, showing lobe of carapace wrinkled, and notch in ventral surface of third segment frontal. Nat. size. Same locality.
- Fig. 2b.—*Ceratiocaris elongatus*, showing intestinal canal. Nat. size. Same locality.
- Fig. 2c.—Showing natural size of last body segment and tail spines of *Ceratiocaris elongatus*.
- Fig. 2d.—Portion of tail spine of fig. 2c, magnified, to show ornamentation.
- Fig. 2e.—Tail of new species of *Ceratiocaris* from the Upper Silurian (Wenlock) Rocks of Roxburghshire, for comparison of ornament with fig. 2d.
- Fig. 2f.—Ornament of 2e magnified.

## PLATE VIII.

- Fig. 3.—*Anthrapalæmon Etheridgii*, magnified 2 diameters. Locality—River Esk, 4 miles south of Langholm, Dumfriesshire.
- Fig. 3a.—*Anthrapalæmon Etheridgii*. Nat. size. Same locality.
- Fig. 3b.—*Anthrapalæmon Etheridgii*, to show endophragmal system and gill supports. Magnified 2 diameters. Same locality.
- Fig. 3c.—Portion of carapace of *Anthrapalæmon Etheridgii*, to show the number and nature of its ridges. Nat. size. Same locality.
- Fig. 3d.—*Anthrapalæmon Etheridgii*, anterior portion of carapace, to show the antennæ and their basal scales. Magnified about 3 diameters. Same locality.
- Fig. 3e.—Magnified portion of specimen of *Anthrapalæmon Etheridgii*, to show eyes. Magnified about 3 diameters. Same locality.

- Fig. 3f.—Magnified portion of another specimen of *Anthrapalæmon Etheridgii*, showing antennæ, with their basal scales. Magnified 4 diameters. Same locality.
- Fig. 3g.—*Anthrapalæmon Etheridgii*. Magnified dorsal portion of second abdominal segment, to show nature of ornament of test. Same locality.
- Fig. 6.—*Anthrapalæmon Macconochii*, R. Etheridge, Jun., showing body segments and cephalic appendages. Nat. size. Locality—Tweedden Burn, Newcastleton, Liddesdale.
- Fig. 6a.—*Anthrapalæmon Macconochii*. Nat. size. Same locality as preceding.
- Fig. 6b.—Carapace of *Anthrapalæmon Macconochii*, to show nature of ornament. Nat. size. Same locality.
- Fig. 6c.—*Anthrapalæmon Macconochii*. Magnified anterior portion of fig. 6, showing eyes, antennules, and antennæ.
- Fig. 6d.—Tail of *Anthrapalæmon Macconochii*, magnified from fig. 6.
- Fig. 7.—*Anthrapalæmon ornatissimus*. Nat. size. Locality—Larriston Burn, Upper Liddesdale.
- Fig. 8.—*Anthrapalæmon formosus*. Nat. size. Locality—River Esk, 4 miles south of Langholm, Dumfriesshire.
- Fig. 9.—*Polæocrangon Eskdalensis*. Nat. size. Same locality.
- Fig. 9a.—*Polæocrangon Eskdalensis*, showing eye, antennules and antennæ. Nat. size. Same locality.
- Fig. 9b.—*Polæocrangon Eskdalensis*, showing antennules and basal scale of antenna, appendages, &c. Nat. size. Same locality.
- Fig. 9c.—*Polæocrangon Eskdalensis*, exhibiting same as above. Nat. size. Same locality.
- Fig. 9d.—*Polæocrangon Eskdalensis*. Nat. size. Same locality.
- Fig. 9e.—Carapace and basal scales of antennæ of *Polæocrangon Eskdalensis*. Nat. size. Same locality.
- Fig. 9f.—Modified appendage of first abdominal segment of *Polæocrangon Eskdalensis*. Magnified from Fig. 9b.
- Fig. 9g.—Last abdominal segment and tail of *Polæocrangon Eskdalensis*. Nat. size. Same locality.
- Fig. 9h.—*Polæocrangon Eskdalensis*. Last abdominal segment and tail. Nat. size. Same locality.
- Fig. 9i.—Eye of fig. 9a, to show the crushed facets of cornea. Highly magnified.
- Fig. 9k.—Restoration of tail of *Polæocrangon Eskdalensis*, from the study of a great number of specimens from the above locality.

## PLATE IX.

- Fig. 4.—*Anthrapalæmon Parki*, showing antennules, antennæ, rostrum, abdomen, and tail. Nat. size. Locality—River Esk, 4 miles south of Langholm, Dumfriesshire.
- Fig. 4a.—*Anthrapalæmon Parki*, showing carapace, rostrum, eyes, antennæ, three abdominal segments, and tail. Nat. size. Same locality.
- Fig. 4b.—*Anthrapalæmon Parki*, to show nature of ornament on carapace. Nat. size. Same locality.
- Fig. 4c.—Last abdominal segment and tail of *Anthrapalæmon Parki*, showing that the spines in the other specimens are portions of fin-like lobes, shows spinelets on the outer margin of the exopodite and small spines articulated with telson. Nat. size. Same locality.
- Fig. 4d.—Outline of specimen of *Anthrapalæmon Parki*. Natural size, to show to what a size they sometimes attained. Same locality.
- Fig. 4e.—Outline of portion of right margin of carapace of still larger individual. Nat. size. Same locality.
- Fig. 4f.—Restored tail of *Anthrapalæmon Parki*, made out from the study of a large suite of specimens.
- Fig. 4h.—Portion of test of common shrimp (*Crangon vulgaris*), highly magnified as a transparent object, to show nature of calculi which infest it.
- Fig. 4g.—Portion of carapace of fig. 4, *Anthrapalæmon Parki*, showing similar calculi in these ancient crustaceans, magnified 3 diameters, as an opaque object.

## PLATE X.

- Fig. 5.—*Anthropalæmon Traquairii*, showing general proportions. Nat. size. Locality—River Esk, 4 miles south of Langholm, Dumfriesshire.
- Fig. 5a.—*Anthropalæmon Traquairii*, fossilised sideways, shows carapace, rostrum, eyes, antennules, antennæ, with basal scales, coxæ of walking limbs, walking limbs, gills, and portions of six abdominal segments. Nat. size. Same locality.
- Fig. 5b.—*Anthropalæmon Traquairii*, exhibits portions of ten walking limbs. Nat. size. Same locality.
- Fig. 5c.—*Anthropalæmon Traquairii*, showing walking limbs. Nat. size. Same locality.
- Fig. 5d.—Basal scales of antennæ of *Anthropalæmon Traquairii*. Nat. size. Same locality.
- Fig. 5e.—Highly magnified portion of gill of fig. 5a.
- Fig. 5f.—Restored tail of *Anthropalæmon Traquairii*, made out from the study of several specimens which are not figured for comparison with that of *A. Parki*.
- Fig. 10.—*Palæocaris Scoticus*, magnified  $2\frac{1}{2}$  diameters. Same locality.
- Fig. 10a.—*Palæocaris Scoticus*, showing antennules, antennæ, with basal scale. Magnified 3 diameters. Same locality.
- Fig. 10b.—*Palæocaris Scoticus*, fossilised sideways, shows rostrum, eye (?), segments appearing through carapace, and overlapping of lobe of carapace over the pleura of first thoracic segment. Magnified about 2 diameters. Same locality.
- Fig. 10c.—Head and appendages of *Palæocaris Scoticus*, magnified 5 diameters to show rostrum, eyes (?), antennules, antennæ with basal scale, and folds of carapace. Same locality.
- Fig. 10d.—Another specimen, magnified 5 diameters, showing the same cephalic appendages as fig. 10c. Same locality.
- Fig. 10e.—Restoration of tail of *Palæocaris Scoticus*, from the study of over 20 specimens, to compare with fig. 10h.
- Fig. 10f.—Reproduction of figure of *Palæocaris typus*, of Messrs Meek and Worthen, from the Memoirs of the Geological Survey of Illinois, U.S.A., vol. ii. plate 32, for comparison with *P. Scoticus*.
- Fig. 10g.—*Palæocaris typus*. Reproduction of Messrs Meek and Worthen's figure, *ibid.*
- Fig. 10h.—Reproduction of Messrs Meek and Worthen's restoration of their *Palæocaris typus*, *ibid.*, to compare with fig. 10e.





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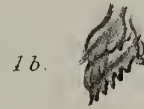
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1a.



1c.



1b.



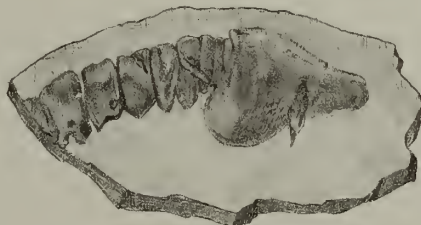
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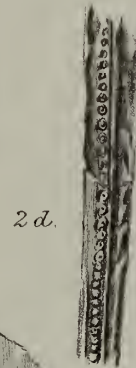
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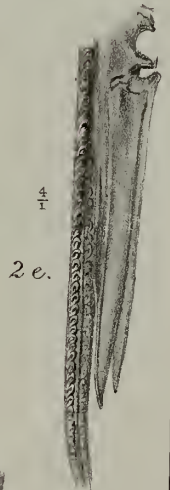
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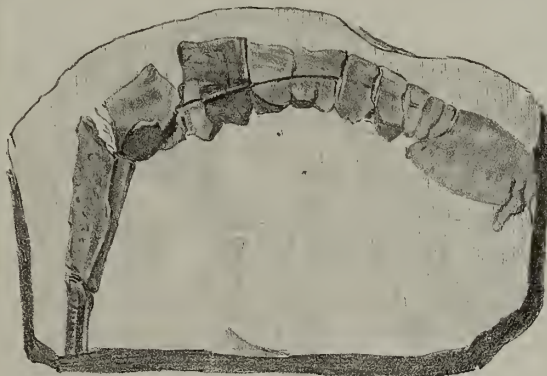
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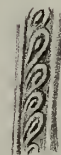
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2c.

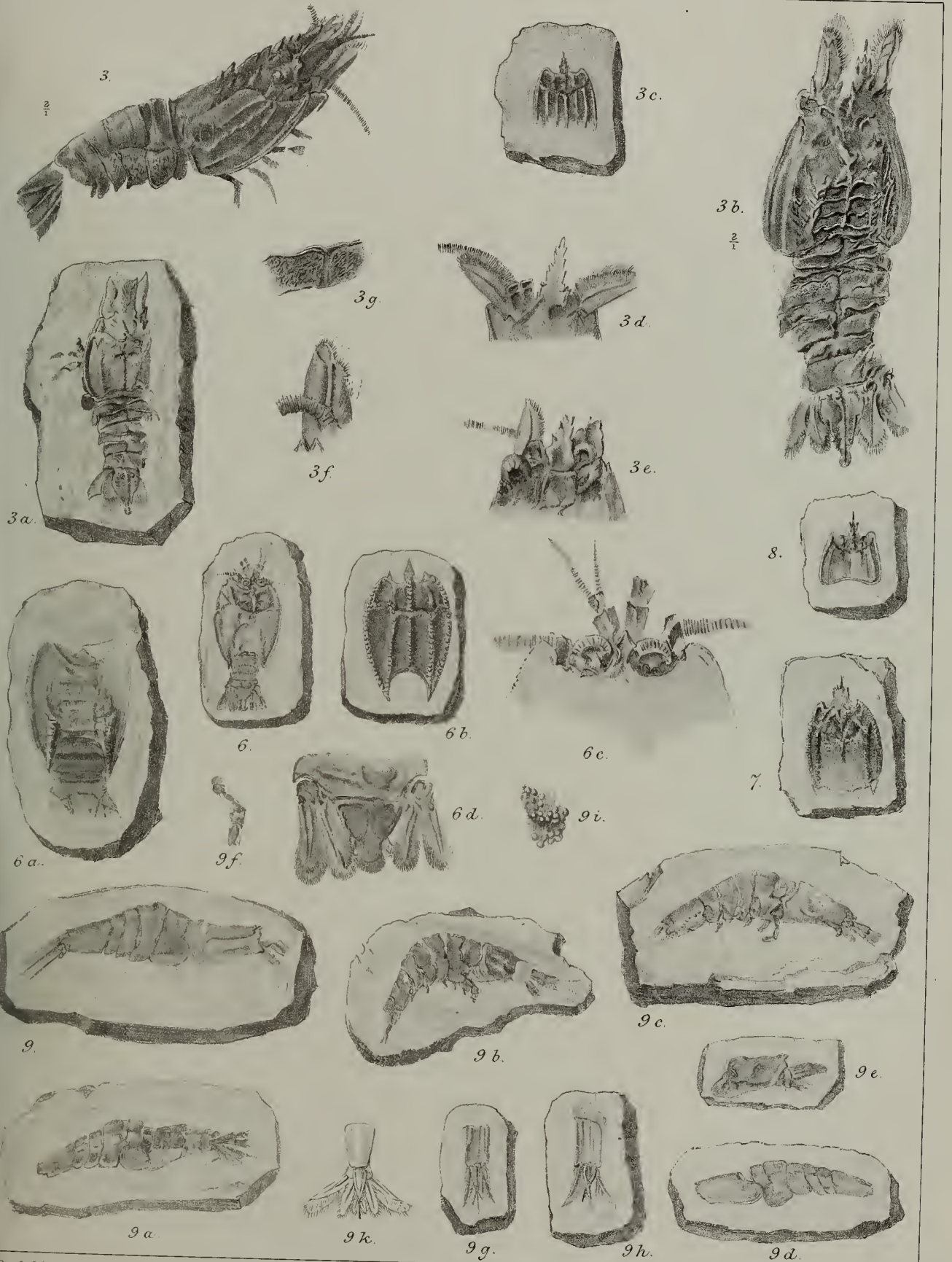


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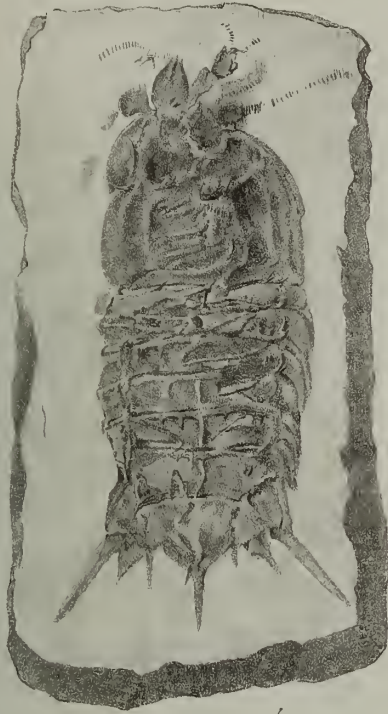


2f.









4.



4 e.



4 a.



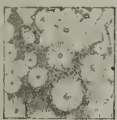
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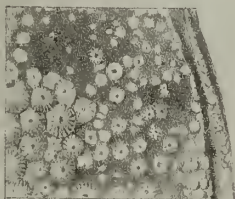
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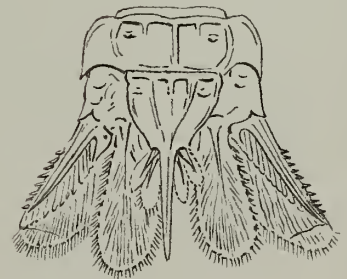
4 c.



4 h.



4 g.



4 f.

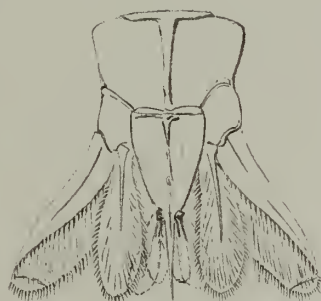




5 e.



5 d.



$\frac{5}{1}$



$\frac{5}{1}$



$\frac{5}{1}$

