

The Scottish Silurian Scorpion.

By

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With Plate 19.

I. INTRODUCTORY REMARKS.

OUR knowledge of the existence of scorpions in marine beds of Upper Silurian age dates from the publication of an announcement to this effect in the 'Comptes rendus de l'Académie des Sciences,' Paris, in December, 1884, wherein Professor Lindström and Dr. Thorell gave an account of the discovery of the well-preserved remains of a fossil scorpion at Gotland in Sweden, proposing for the new form the name *Palæophonus nuncius*. This important find in palæontology attracted wide-spread interest, and was discussed in various journals, scientific and popular. In 1885 it was followed by an exhaustive memoir on the fossil by Lindström and Thorell ('Kongl. Sv. Vet.-Akad. Handl.,' xxi, No. 9, 1885). Prior to the appearance of this memoir an article entitled "Ancient Air Breathers," by Mr. B. N. Peach, was printed in 'Nature' (vol. xxxi, pp. 295—298, 1885). In this a preliminary description was given of a second Upper Silurian scorpion, which had been unearthed in the summer of 1883 at Lesmahago, in Lanarkshire, and formed part of the rich collection of fossils belonging to Dr. Hunter. The value of this second specimen was enhanced by the circumstance that it fortunately lies with its ventral surface exposed, and is thus the complement, as it were, of the Gotland fossil, of which

the dorsal surface, at all events, of the anterior half of the body is uppermost.

For those who hold that the terrestrial Arachnids are descended from marine ancestors allied to *Limulus* and the Eurypterida, and recognise genetic affinity instead of "fortuitous coincidence" and "convergence" in the many deep-seated structural resemblances between the two groups, these archaic scorpions have, since their discovery, been vested with a peculiar interest, largely in view of the possibility of their supplying fresh evidence in support of this relationship. Little in this direction was yielded by the memoir on the Gotland scorpion; and Peach's description of the Scotch specimen, although containing many important anatomical observations, was by no means exhaustive, and the figure that accompanied it not all that could be desired. Hence it has for many years been felt that a complete and properly illustrated account of this unique fossil would make a valuable addition to zoological literature.

In July of last year Prof. Ray Lankester wrote for the loan of the specimen to the authorities of the Kilmarnock Museum, where it has been preserved since the death of Dr. Hunter. The authorities not only kindly and promptly acceded to the request, but most generously permitted the specimen to be kept for three months at the Natural History Museum. I gladly avail myself of this opportunity to express my sincere thanks to Professor Lankester for placing the specimen in my hands for investigation. I am also indebted to Miss G. M. Woodward for the trouble and time she devoted to the lithograph, her skill and experience in interpreting fossils being most helpful in the present instance.

2. DESCRIPTION OF THE SPECIMEN.

So far as the disposition of the various members is concerned, my restoration agrees with that of Mr. Peach in most particulars. I think, however, that the second leg on the right side lies distally across the anterior portion of the

“hand” of the chela, and not across its posterior portion as shown in the figure in ‘Nature.’ One or two other particulars in which I differ from him are referred to in the following pages.

The specimen gives the following measurements in millimetres:—Total length on stone 32·5, actual total length when extended 35·5, trunk 16·5, tail 19.

The Gotland specimen is considerably larger, measuring 62 mm. in total length, the tail being at least 26 mm.

Prosoma.—Owing to the outward displacement of the chelæ the anterior portion of the carapace is visible between the basal segments of these appendages, and in front of those of the first pair of legs. Its surface is thickly granular, its anterior border lightly concave, as is the Gotland specimen, and its antero-lateral angles subquadrate.

Eyes.—In the Gotland specimen no trace of eyes, either median or lateral, is discernible, though the median ocular tubercle of recent scorpions is represented by a relatively large and longitudinally oval elevation, situated in the anterior third of the carapace, and separated from its anterior edge by a space equalling about one half the length of the elevation. Judging from the figure, this tubercle is preserved in its entirety; hence there is no reason to doubt that if eyes had been borne upon it, some trace of them at least would have been preserved.

In the Scotch specimen also there is no sign of the lateral eyes. If, however, as is possible, these organs existed, and were placed behind the level of the median eyes, as is the case in the normal Pedipalpi, and, as is alleged, in the Carboniferous Anthracoscorpia, they would be concealed from view beneath the basal segments of the anterior legs, which on each side overlie that portion of the carapace immediately behind the median eyes. The median eyes are very distinctly represented by a pair of elliptical impressions situated close together, one on each side of the middle line, and scarcely more than their own long diameter from the anterior border of the carapace. There is no evidence that these eyes were

elevated upon a tubercle. If, indeed, such a tubercle existed as is exhibited in the Gotland specimen, the eyes must have been situated on its extreme anterior border. The presence of these median eyes, and the probable absence of the tubercle, are two important structural differences to distinguish the Scotch specimen from the Swedish.

Appendages.—The six pairs of prosomatic appendages (i—vi, Pl. 19) are preserved in a state of greater or less completeness, those on the left side being on the whole more clearly defined than those on the right.

The chelicerae or mandibles are, as in the Gotland specimen, very large as compared with those of recent scorpions. The left chelicera, crushed out of shape and position, shows no recognisable feature but a portion of the immoveable digit. The right, on the contrary, is well preserved and occupies its normal position, projecting straight forwards from the fore-part of the prosoma. The immoveable digit is slender, pointed, and nearly straight; the moveable is equally slender and pointed, but is lightly curved and armed in the middle of its lower edge with a single tubercular tooth.

It is noticeable that the digits of the chelicera are thinner, and overlap at the apex to a much greater extent than in the Gotland fossil.

Owing to the distortion and displacement of the left chelicera a portion of the matrix is displayed between the bases of the two appendages just in front of the middle line of the anterior border of the carapace. Presumably it is this portion of matrix which Mr. Peach describes—I think erroneously—as “a fleshy labrum (camerostome) between the bases of the chelicerae.”

Chelæ.—As in the Gotland specimen, these appendages do not appear to differ in any essential respects from those of recent scorpions. Their basal segments are too badly preserved for delineation—a particularly regrettable circumstance in view of the fact that in the Gotland specimen they are concealed from view. Hence it is impossible to surmise whether they took a greater, less, or an equal share in masti-

cation as compared with those of existing forms. The second segments project on each side of the antero-lateral angles of the carapace, and are granularly sculptured. The anterior surface of the third segment is apparently normally crested above and below, and the fourth segment of the left side shows traces of the basal prominence so noticeable in living species. Granules are observable along the anterior side of both these segments. The fifth segment (hand) of the left side differs in shape from that of the right, being more oval in form, with its posterior border in approximately the same straight line as that of the distal segment, the bulge being confined to the anterior surface as in the Gotland specimen and recent species. On the right side the hand is unusually globular, its posterior surface, probably owing to crushing, being abnormally swollen. The fingers are thinner, more taper, and straighter than in the Gotland specimen and recent scorpions. No distinct joint between the finger and hand is discernible, although presumably it is the under side of the hand and of the moveable finger that is exposed to view, both on the right and left sides. It is possible that the shallow median longitudinal groove observable on the finger of the right chela represents the line along which the two fingers meet when closed. The finger of the opposite side is similarly marked with a fine sculptured ridge.

Legs.—So far as can be ascertained the legs resemble those of the Gotland specimen in length, strength, and segmentation. As in other scorpions, and typically in all orders of Arachnida, they increase in length from before backwards, the fourth pair being nearly half as long again as the first. They consist, moreover, of what is doubtless the primitive number of segments—namely, seven. Primitiveness of segmentation is also shown by the subequality in length of the individual segments—a character which, in conjunction with the sharply pointed, practically clawless terminal segment, serves to distinguish the legs of *Palæophonus* from those of all other scorpions, living or fossil. I say

practically clawless because Thorell detected a minute claw-like structure at the tip of the seventh (tarsal) segment in

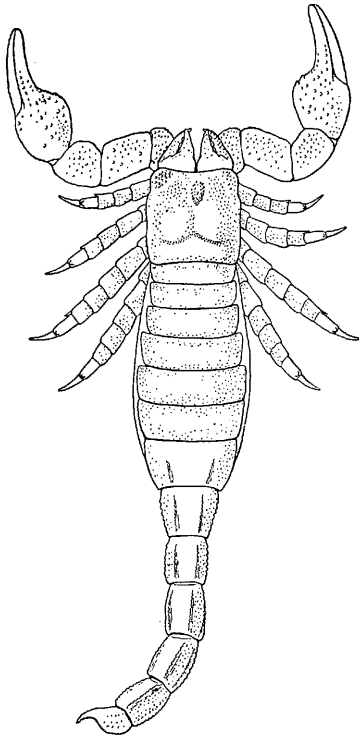


FIG. 1.—Restoration of *Palæophonus nuncius*.
Dorsal view (after Thorell).

the Gotland specimen. Although no trace of such a structure was found in the Scotch fossil, no great value must be

attached to its apparent absence, in view of the chances against the preservation of an organ so delicate.

Nor was I able to detect a sign of the presence on the fifth segment of any of the legs of that spur so clearly shown on the first, second, and third pairs in the Gotland fossil, and described and figured by Thorell (see cut, p. 296). The interest invested in this spur depends upon the probability of its direct homology with the so-called "tibial spur" found upon the arthrodial membrane at the distal end of the fifth segment in some recent Buthoid scorpions. Certain genera of this family (e. g. *Buthus*, *Lychas*) possess it upon the third and fourth legs, one alone (*Babycurus*) retaining it only on the fourth leg. Assuming that the spurs in the genera just mentioned are homologous to those found in the Swedish *Palæophonus*, their presence upon the third and fourth, or upon the fourth leg in the former, and upon the first, second, and third legs in the latter, suggests that scorpions primitively possessed them upon all four legs. In that case the absence of the spur from the fourth leg in the type of *Palæophonus nuncius* may be a natural characteristic of the species, or may be due to a mere accident of preservation. The same may be said of the apparent total absence of this spur from the legs of the Scotch specimen.

There is, however, a still deeper interest attached to this spur, on account of its apparent presence upon the fourth leg (sixth prosomatic appendage) of *Limulus*. The first and second appendages of this animal agree in structure and in the number of segments with those of scorpions, the former consisting of three and the latter of six segments. But the third, fourth, and fifth appendages of *Limulus* also consist apparently of six segments, resembling in all particulars those of the second pair. In the scorpions, on the contrary, these appendages, as well as the sixth pair, consist of seven segments, the distal being furnished with a pair of moveable claws. Careful examination of these appendages in *Limulus*, however, shows that the fourth segment is encircled in its basal

half with a sutural impression, which represents, I believe, the line of union between two segments, the portion on the proximal side of the line being the fourth, that on the distal side the fifth segment of the appendage. If this interpretation be correct there is the same number of segments in these appendages in both *Limulus* and the scorpions. Now in the fourth leg of *Limulus* (except in *L. rotundicauda*) the fifth segment, according to this new method of enumeration, is furnished beneath distally with a spur like those described above in the scorpions. Again, at the extremity of the sixth segment in *Limulus* there are four moveable lobate sclerites, which spread out like the fingers of a hand when the leg is plunged into the mud. At the extremity of the sixth segment in the scorpion's leg, or rather on the arthrodial membrane between it and the seventh, there are either one or two "pedal" spurs, which represent, I suggest, the lobate sclerites in the same position on the leg of *Limulus*. Lastly, there is attached to the distal extremity of the seventh segment in *Limulus* a pair of short moveable sclerites, forming a small nipper. Similarly there is a pair of moveable sclerites or claws articulated to the distal extremity of the seventh segment in the scorpion's leg. The annexed figure (Fig. 2) will make these suggested homologies clear.

Whether *Palæophonus* possessed any structures comparable to the pedal spurs of recent scorpions and to the lobate sclerites of *Limulus* is doubtful. I can detect nothing comparable to them in the Scottish specimen, but the figure of the Gotland specimen suggests the possibility of the presence of one or more spurs at the distal end of the sixth segment.

It is a matter for regret that the exact structure of the basal segments of the legs, and the relation of these segments to one another, are not with certainty interpretable, owing to the crushing and displacement of the parts composing the ventral area of the prosoma, and of the anterior somites of the mesosoma. Hence too much reliance must not be placed

upon the accuracy of the attempted restoration of these structures.

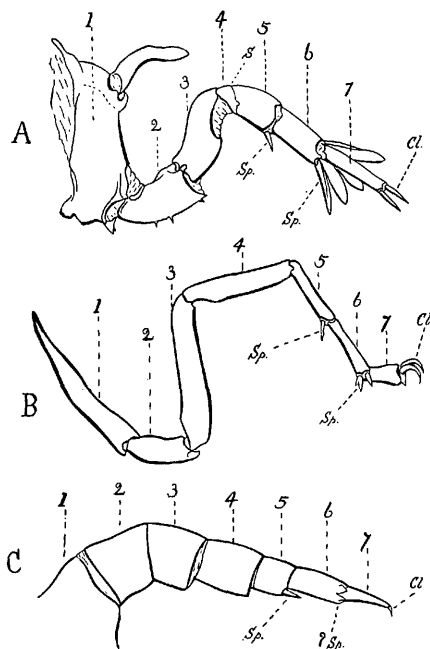


FIG. 2.—A. Fourth leg of *Limulus moluccanus*. B. Fourth leg of a recent scorpion (*Buthus australis*). C. Third leg of Silurian scorpion, *Palæophonus nuncius*, after Thorell.

1—7. Segments. *s*. Suture between fourth and fifth segments of the leg in *Limulus*. *sp*. Spurs and lobate sclerites. ? *sp*. Processes possibly representing the point of attachment of spurs in *Palæophonus*. *cl*. Claws in the scorpion, and pair of sclerites forming a nipper in *Limulus*.

In existing scorpions the basal segments (coxæ) of the legs of the first and second pairs are furnished with a for-

wardly directed sterno-coxal or maxillary process, the coxæ of the second leg meeting each other in the middle line in front of the prosomatic sternum, and sending forwards these processes, which are in contact throughout their length, to

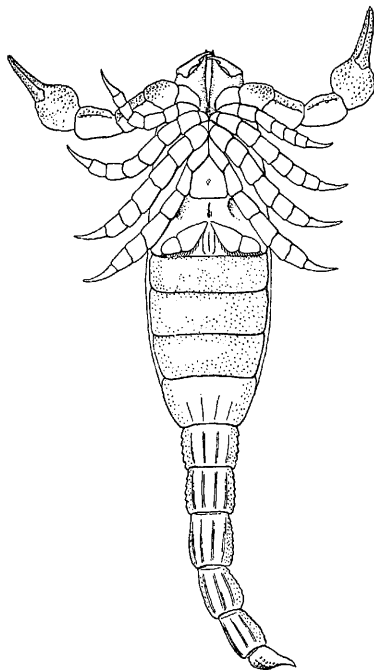


FIG. 3.—Restoration of *Palæophonus Hunteri* (ventral view).

underlie the mouth. The coxæ of the third and fourth legs, on the contrary, are devoid of sterno-coxal processes, and are separated from each other in the middle line by the sternal plate, against the sides of which they abut.

A very different state of things appears to obtain in *Palæophonus*. No trace of a sterno-coxal process is discoverable upon the first leg. On the second, however, a small one seems to be present. This lies transversely, and meets its fellow of the opposite side in the middle line. On the third leg a process similar in its form and relations is also indicated, and the segment that bears it, instead of abutting against the sternum, is mesially in contact with its fellow. The probability of the correctness of this conclusion is enhanced by its tallying with Peach's opinion. I cannot, however, quite agree with this author in believing that the legs of the fourth pair are basally separated by the sternum as in recent scorpions. On the left side of the specimen, where the leg is well preserved, the segments seem to be traceable right up to the middle line, the basal segment being sharply defined. On the right side, however, this is not so clearly indicated, on account of a displacement which has resulted in the overlap of the proximal end of the fourth leg by that of the third.

The sternum (*st.*, Pl. 19) does not stand out as a sharply defined plate with clean-cut edges, but is merely represented by the subpentagonal area that lies between and behind the two proximal segments of the fourth leg of the left side, and those of the third and fourth legs of the right side. It shows a faint central circular depression answering presumably to the similarly shaped sternal depression in *Chærilus*, and to the median groove in other recent scorpions.

The above-described arrangement of the skeletal pieces, forming the ventral surface of the prosoma, offers many points of morphological importance in view of the differences that obtain in this particular between the recent scorpions and *Limulus* or one of the Eurypterida. The relations of the sternum to the coxæ and the coxæ to each other in the scorpions have already been described. Those of *Limulus* and the Eurypterida may be stated in a very few words. In the latter the basal segments of all the appendages, ex-

cepting those of the first pair, acted as jaws, and were frequently armed with teeth, the greatest share in crushing and masticating food falling to the coxæ of the fourth pair, which were especially enlarged for the purpose. Behind, and partially concealing them from the ventral side, lay a large plate, the so-called "metastoma," the homologue of the scorpion's sternum. To all intents and purposes the same arrangement is found in *Limulus*, except that the coxæ of the fourth are less masticatory in function, and the "metastoma" is represented by a pair of moveable sclerites, the "chilaria," set immediately behind and between the bases of the legs of the fourth pair.

In *Palæophonus* the sternal plate of the prosoma lies apparently behind the basal segments of the fourth legs as in *Limulus*, and, as in the latter and in the *Eurypterida*, the basal segments of all the appendages were in contact or capable of meeting in the middle line. On the other hand, the coxæ of the fourth were small and functionless so far as the mouth was concerned, and food was probably crushed by those of the chelæ as in recent scorpions, the sterno-coxal sclerites of the second and third pairs assisting in this process, and preventing the escape of nutritive juices. Thus, so far as the parts now under discussion are concerned, this archaic scorpion presents a condition of things intermediate in many particulars between that of the typical scorpions and of *Limulus* or *Eurypterus*.

Mesosoma.—The ventral portion of the first somite of the mesosoma is represented by a relatively short but wide area lying behind the sternal region of the prosoma. This area is marked in the middle line with a short longitudinal groove (*gen.*, Pl. 19), representing in all probability the divisional line between the right and left halves of the genital operculum. On each side this area is impressed with a shallow but conspicuous indentation, which from its position seems hollowed out for the reception of the third segment of the fourth leg, perhaps in order that this portion of the appendage might be insunk to the level of the generative

orifice, so that its prominence should offer no obstacle to the act of copulation.

A short distance behind the genital cleft a similar but larger and more conspicuous median cleft is visible. This is flanked on each side by a narrow longitudinally elongate plate or lobe (*end.*, Pl. 19), somewhat resembling one half of the genital operculum of recent scorpions. On the outer side of the right-hand lobe lies a bisegmented appendage (*pect.*, Pl. 19), which may be regarded as the homologue of a recent scorpion's pecten or comb. Along the posterior border of this appendage are traceable a number of fine striæ occupying the position of the pectinal teeth. Similar striæ are traceable upon the left-hand side, although the pecten itself is obliterated.

Peach regarded the cleft between the two above-described lobes as the generative aperture, a conclusion it is impossible to accept in view of the improbability of the backward movement of this aperture on to the somite that bears the pectines. The opinion, which I here put forward, that the generative aperture is represented by the slit which, although not mentioned by Peach, appears on his published figure immediately behind the pentagonal prosomatic sternite, seems on morphological grounds far more likely to be correct. Thorell, moreover, suggested that the pair of lobes lying between the pectines correspond to the small, sometimes longitudinally grooved pectinal sternite of recent scorpions. This may be the true interpretation; but the shape of the lobes, the length and depth of the groove that separates them, and their relations to the pecten, suggest that they have another significance, and are probably to be regarded as the inner branches of an appendage of which the pecten is the outer branch. From this standpoint the appendage may be compared with the mesosomatic appendages of *Limulus*, and of the archaic spider *Liphistius*. In the former the appendages (except in the case of the genital operculum of the Eastern species) consist of a broad foliaceous trisegmented external branch, and of a slender trisegmented internal

branch. In *Liphistius* also there are two branches, the inner slender and unsegmented, the outer stout and composed of two principal segments. Although in general form the inner lobes (*end.*, Pl. 19) of *Palæophonus* resemble those of *Limulus*, they differ from the latter, and approach those of *Liphistius* in being unsegmented. The outer branch is broad and flattened, and is somewhat like that of *Limulus*, except that it is relatively smaller, and lies with its axial line directed, not longitudinally, but obliquely outwards and backwards like the comb of a typical scorpion. It shows, however, no signs of segmentation into so-called "fulcra" and "intermediate lamellæ," such as are found in the combs in the majority of species. Structurally, in short, it is intermediate between a typical comb and the outer branch of one of the mesosomatic appendages of *Limulus*. Furthermore, the fine striæ which fringe its posterior edge are, in my opinion, too delicate to be the remains of teeth comparable in shape and size to those of recent scorpions. Rather would I suggest that they are portions of the edges of branchial lamellæ which were affixed like those of *Limulus* to the posterior side of the appendage, with their lines of attachment lying at right angles to its longitudinal axis.

These appendages overlie and almost completely conceal the sternite of the third mesosomatic somite. The sternites of the fourth, fifth, and sixth somites, however, are fully exposed and well preserved. They are granular, and resemble the corresponding plates in recent scorpions but for the absence of the muscular impressions and, so far as my observations go, of the stigmata. Peach, however, declares most emphatically that "all four sterna exhibit on the right side undoubted slit-like stigmata at the usual places." It is true that the sternites are somewhat wrinkled laterally, and, as shown on Pl. 19, exhibit certain shallow impressions, which, especially in the case of the fourth and fifth sternites, might be mistaken for stigmata; but it is hard to believe that slits as conspicuous as the stigmata of recent scorpions should be so indistinctly preserved on sternites in such an

admirable state of conservation that even their granulation is still apparent. Nevertheless it must be borne in mind that Peach's opinion on this point is in complete agreement with Thorell's regarding the Gotland specimen.

According to Thorell this specimen exhibits on its right side a portion of a displaced sternal plate, upon which a distinct stigma is visible. This sternal plate he assigns to the third somite of the mesosoma; but a glance at his drawing shows that the greater part of it lies at the sides of and beneath the tergite of the second somite, and that at all events a large part of the third sternite is situated on the left-hand side beneath its corresponding tergite. To hold that this third sternite has been fractured and displaced to the extent that Thorell's interpretation demands appears to me to be an opinion based on an improbability. From the position of the fragment that protrudes on the right-hand side, I judge that it belongs to the second mesosomatic somite—a somite which in all known scorpions bears the pectines but is without stigmata,—and that it is part of its pleural membrane. This interpretation, if correct, involves the conclusion that the "spiraculum" described by Thorell is a fortuitous crack in the integument. There is one other point, too, bearing indirectly upon the question of the presence or absence of stigmata, in which, without further evidence, I find it impossible to accept Thorell's decision. The Swedish specimen is broken in two by a transverse fracture, crossing the fourth somite of the mesosoma. The posterior half thus contains the fifth and sixth mesosomatic somites and the metasoma. It is admitted—and there is no reason to doubt—that the ventral surface of the metasoma is exposed. According to Thorell, however, the two mesosomatic somites which go to make up the severed portion of the body lie back uppermost. This supposition implies the belief that the severed portion of the specimen was itself completely divided into two at the junction of the mesosoma and metasoma, that the latter was overturned, and was so accurately fitted into place that perfect continuity between it and the mesosoma was restored. That

the uninterrupted outline presented by the somites in question, which imparts so natural an appearance to this region, is thus the result of pure accident I find hardly credible. In fact, there is, I think, no reason to doubt that the fifth and sixth mesosomatic somites were united to the metasoma, and shared its unmistakable inversion. Hence the plates in question are sternites. The important point attached to this conclusion is the absence of stigmata on these sternites. Perhaps it was this fact which led Thorell to his decision as to their tergal character.

The above-given reasons justify a sceptical attitude towards the alleged existence of stigmata in the Gotland *Palæophonus*, at all events until a further examination of the specimen settles the points now under dispute. And since I found no distinct traces of stigmata in the Scotch specimen, I am inclined to believe that Peach fell into error on this point perhaps influenced in part by the alleged presence of stigmata in the Gotland example, perhaps in part by the assumption that a form so closely resembling recent scorpions in other structural details must also resemble them in the nature of its respiratory organs.

To the belief in the presence of stigmata, implying the existence of organs fitted for aerial respiration, coupled with the knowledge of the terrestrial habits of all living scorpions, is traceable the conviction evinced by most previous writers that these Silurian scorpions lived on the land. This belief is less easy to reconcile with the facts that both the known specimens are relatively in an admirable state of preservation, and were met with in strata of undoubted marine origin, containing abundance of admittedly marine organisms, than the belief, which I hold, that *Palæophonus* lived in the sea, probably in shallow water, its strong, sharply pointed legs being admirably fitted, like those of a crab, for maintaining a secure hold amongst the seaweed or on the jagged surface of rocks, and for resisting the force of the rising and falling waves.

Respiration, as already suggested, may have been effected

by means of the appendages of the second mesosomatic somite, although it must be admitted they appear too small to have performed this office for the whole organism without help from other organs. It is possible that there were such organs in the form of small appendages bearing branchial lamellæ attached to the mesosomatic sterna. But if so, no definite trace of such has been preserved. Or, indeed, it is possible that the ventral plates, above regarded as mesosomatic sternites, may have been broadly laminate mesosomatic appendages, closely pressed down against the ventral surface of this region, and bearing branchial lamellæ on their posterior surfaces. This suggestion gains some support from the fact that the laminate mesosomatic appendages of the Eurypterida are generally indistinguishable from sternal plates.

Metasoma.—This region of the body in the Scotch specimen closely resembles that of the Swedish specimen, the same surface, namely the ventral, being in each case uppermost. Peach, however, states that the dorsal surface of the posterior caudal segments is in part exposed. According to my interpretation, on the contrary, in all the segments it is the area lying between the inferior lateral keel on the left side (*inf. lat.* and *sup. lat.*, Pl. 19) and the superior lateral keel on the right that is exposed. Both of these keels are granular. As in most recent scorpions, a pair of median keels (*inf. med.*, Pl. 19) lie along the lower surface of the tail, between the inferior lateral keels on the first four segments of the tail. Keels corresponding to these four inferior medians and inferior laterals are traceable upon the first metasomatic sternite, and also, I think, upon the sixth (fifth caudal segment). This last fact, if true, is of some interest, inasmuch as it shows a more primitive arrangement than is found in recent scorpions, where the two median keels have invariably coalesced into one. The inferior median keels on the posterior caudal segments appear to be smooth. In the Swedish specimen they are granular. The lower side of the vesicle is granular in both, but the aculeus in the Scotch example is

apparently less curved, less circular in section, and more triangular than in recent scorpions and the Swedish specimen.

3. DESCRIPTION OF THE SPECIES, WITH NOTES ON THE OTHER KNOWN SILURIAN SCORPIONS.

The preceding description of the Scottish fossil, and the comparisons that have been made between it and the Swedish specimen, have revealed some noticeable structural differences between the two, which leave no other course open than to regard the former as the representative of a distinct and undescribed species. This I propose to dedicate to Dr. Hunter, and to diagnose as follows :

Palæophonus Hunteri, sp. n.

Differing from *P. nunciatus* in its much smaller size, being 35.5 mm. as compared with 62 mm. in total length, in possessing a pair of median eyes set close to the anterior border of the carapace, in having the digits of the chelicerae longer and thinner, and the moveable more curved, and the chelæ very much lighter in build, with the digits nearly straight; in the absence of a spur from the fifth segment of the first, second, and third pairs of legs, and in the smoothness of the inferior median keels on the posterior segments of the tail.

In addition to the specimens discussed in the preceding pages, two other scorpions have been recorded from Silurian strata, namely, *Proscorpius Osborni* and *Palæophonus loudonensis*. The first was described by Whitfield ('Science,' vi, p. 88, 1885; 'Bull. Amer. Mus. Nat. Hist.,' i, No. 6, pp. 181 to 190, 1885), and was based upon a fairly well preserved specimen, with the dorsal surface exposed, from rocks referred to the middle of the Upper Silurian. Like the Swedish and Scotch specimens, it was associated with fossil remains of *Pterygotus*, *Eurypterus*, and other marine organisms.

The specimen was examined by both Whitfield and

Scudder. The latter (Zittel's 'Handbuch der Paläontologie,' ii, p. 739, 1885) classified it with the Carboniferous scorpions on account of the alleged presence of a pair of claws at the extremity of the anterior leg of the left side. This classification was endorsed by Whitfield, who based the genus *Proscorpius* mainly upon these claws, declaring them to be very similar to those of living forms. His figure shows no such similarity. The apical segment of the leg is simply bifid at the tip, a feature which may be due to fracture, or may represent a pair of sclerites like those borne at the tip of the distal segment of the fourth leg of *Limulus*; or may be explained on the supposition that the end segment terminated in a sharp point as in *Palæophonus*, and was furnished near the tip with a moveable spine or spur. Since, however, there is no agreement between Scudder and Whitfield as to whether the segment stated to possess these claws is numerically the third or sixth from the base, it seems idle to discuss the matter further. If Scudder's interpretation of the numbers of the segments is correct, these "claws" are situated at the end of the third or fourth segment, and cannot be compared with the tarsal claws of other scorpions.

Apart from the leg, the chief points of interest connected with *Proscorpius Osborni* are the presence of a pair of eyes on a median ocular tubercle, and of a row of lateral eyes (not shown in the figures, by the way) on each side of the carapace. The rounded median tubercle projects in the middle line of the fore border of the carapace, the lateral angles of which are also rounded. Hence the trilobate appearance of the anterior border of this plate, which forms such a contrast to the even emargination seen in the Swedish and Scotch *Palæophonus*. It is further to be noticed that the dorsal integument is smooth, and not granular as in *Palæophonus nunciatus*.

Along the right-hand side of the specimen, both Scudder and Whitfield agree that six (five mesosomatic and one metasomatic) abdominal sternites are exposed. The first of these belongs to the second mesosomatic somite, which in

recent scorpions bears the pectines and has no appreciable sternal area.

But there appears to me to be no reason for regarding this so-called sternal area other than as the pleural membrane of the second somite of the mesosoma.

Mr. Whitfield could find no satisfactory evidence for the existence of stigmata, and infers from this fact, and from the nature of the strata in which the specimen was preserved, that the species was "aquatic in habits," and furnishes a "link between the true aquatic forms like *Eurypterus* and *Pterygotus* and the true air-breathing scorpions of recent periods."

Of *Palaeophonus loudonensis*, described by Laurie, from the Upper Silurians of the Pentland Hills ('Tr. Royal Soc. Edinb.,' xxxix, p. 576, pl. i, fig. 1, 1889), little need be said, the specimen being too imperfectly preserved to yield satisfactory data for discussion. That the specimen was specifically distinct both from *P. nuncius* and *P. Hunteri* cannot be doubted if the great length of the carapace and the slenderness of the tail in the fossil are not attributable to imperfection of preservation. As in *P. Hunteri*, there are a pair of median eyes close behind the fore border of the carapace, which is emarginate.

No genuine stigmata were discovered, but on some of the mesosomatic somites a curved ridge running obliquely outwards and backwards on the sides of the segments was traceable. The ridge on the second somite Laurie interprets as the impression of the outline of the pecten, those on the others as the outline of a plate-like gill-bearing appendage.

4. RECAPITULATION.

From a morphological point of view, perhaps the most important results obtained by the examination of this fossil are those connected with the structures of the basal segments of the prosomatic appendages, and their relation to the sternal area of this region, and those connected with the

structure of the appendage of the second somite of the mesosoma.

If the above-given interpretation of the arrangement of the parts constituting the ventral side of the prosoma is correct—and I do not think it is likely to be very far wrong—*Palæophonus* occupies an intermediate position between *Limulus* and the Eurypterida on the one hand, and recent scorpions on the other, standing, if anything, rather nearer to the former than to the latter.

The same may be said of the structure of the second mesosomatic appendage, which with its outer and inner branch is like the corresponding appendage in *Limulus*; while the outer branch itself, although in general form and size resembling the pecten of a scorpion, offers some interesting structural features in which it differs from that organ, and resembles the outer branch of a mesosomatic limb of *Limulus*.

On the whole, it must be admitted that *Palæophonus Hunteri* supplies a few more links to the chain of evidence pointing to the descent of the scorpions from marine *Limuloïd* ancestors.

EXPLANATION OF PLATE 19,

Illustrating Mr. Pocock's paper on "The Scottish Silurian Scorpion" (*Palæophonus Hunteri*).

The figure gives a magnified view of the specimen of *Palæophonus Hunteri*, Pocock, from the Upper Silurian of Lesmahago, Lanarkshire. It was formerly in the collection of Dr. Hunter, and is now in the Kilmarnock Museum. This lithograph was executed from the specimen itself by Miss G. M. Woodward, under the supervision of Mr. R. I. Pocock, in October, 1900.

1—vi. Prosomatic appendages. *st.* Sternal area of prosoma. *gen.* Genital cleft. *pect.* Pecten, or external branch of appendage of second somite of mesosoma. *end.* Internal branch of appendage of second somite of mesosoma. *sup. lat., inf. lat., inf. med.* Superior lateral, inferior lateral, and inferior median crests of fourth somite of metasoma.

