A REVIEW OF THE PRESENT KNOWLEDGE OF FOSSIL SCORPIONS WITH THE DESCRIPTION OF A NEW SPECIES FROM THE POTTSVILLE FORMATION OF CLAY COUNTY, INDIANA.[1]

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The following paper is a condensed review of the literature on fossil scorpions with the description of a new species from the Pottsville formation of Clay County, Indiana.

Interest in Fossil Scorpions. Wide interest in fossil scorpions was first aroused by the discovery of a specimen in the Silurian rocks of Sweden which was first made known to the Swedish Academy of Sciences, on November 12, 1884. The fact that this "apparently carried the history of air-breathing or land animals much further back in geological time than had hitherto been known"[2] was enough in itself to attract wide interest. A published statement of the Swedish find first appeared in Comptes Rendu of the French Academy, Dec. 1, 1884. This was closely followed by an announcement of the discovery of a specimen in the Silurian rocks of Scotland, published in the Glasgow Herald, Dec. 19, 1884. Almost a year later (Oct. 10, 1885) a similar find was announced from the Water-Lime beds of New York (Silurian). This almost simultaneous discovery of rare and peculiar fossils caused accounts of them to be published in many scientific and popular journals.

Their Bearing on Geological History. At present fossil remains of scorpions have been described from the Silurian and Carboniferous, and from amber deposits of Oligocene Age. According to Fritsch[3] the order Scorpionida attained its acme during the Carboniferous and subsequently declined.

As stated above the Silurian scorpions constitute the earliest suggestion of land or air-breathing animals, but Whitfield, concludes that they could not have been air-breathers but were wholly aquatic and that their descendants acquired the terrestrial habit in subsequent generations. Pocock has suggested that the supposed mesosomatic "sternites" of Palaeaphonus are really broadly laminate gill-bearing appendages, as they have been shown to be in Eurypterus[4]. Similar appendages occur in the Carboniferous Genus Eobuthus, and it is inferred that respiratory lamellae lay beneath them as they do in Limilus[5]. Many writers have expressed the belief in the origin of the scorpions from the eurypterids and this has been used in the development of a theory for

[1] To Professor Stuart Weller I wish to express my thanks for many valuable suggestions and for his encouragement in attempting the study and description of the specimen. From my brother Prentiss D. Moore I received much assistance in the preparation of the photographs. Greatest thanks are due Arch Addington of Indiana University, who saved the specimen for description.

[2] R. P. Whitfield—On a Fossil Scorpion from the Silurian Rocks of North America. Bull. Amer. Mus. Nat. Hist., Vol. I.

[3] Zittel—Text Book of Palcontology.

[4] Clarke and Ruedeman—New York Geol. Sur.

[5] Zittel—Text Book of Palcontology, p. 788.

the origin of the vertebrates which is discussed at length by Patten[6] and Gaskell[7].

Present State of the Knowledge on Fossil Scorpions. Petrunkevitch[8] also thinks the Water-Lime specimen must have been a marine form, and here it might be well to add a few words on the conclusions reached in his study of the phylogenetic development of the scorpions. He says: "That the different classes of arthropods must have developed not from one ancestor but at different times and from different species of chaetopodous worms;" that the scorpions no farther back than Carboniferous times were not equipped with internal lung books and in the structure of these parts they do not resemble the eurypterids as was suggested by Pocock; that eurypterids have in some respects closer relations with limuloids than with scorpions; that the Bertie water-lime, which contains the eurypterid having the closest resemblance to scorpions, also contains the oldest true American scorpion; and finally, that the Xiphosura, Eurypterida and scorpions developed independently and that the great similarity is due to convergence as Thorell suggested. Some have suggested that the different sub-classes "must have been differentiated even in Pre-Cambric times[9]." The well preserved specimens from the Oligocene indicate that the scorpions then had practically the same habits as they possess today. Schuchert[10], in his discussion of the Silurian forms, after summing up the evidence, concludes that they were semi-aquatic, living along the shore, above the Strandline, feeding on small crustaceans and other small invertebrates.

Fossil Carboniferous Scorpions. The Carboniferous scorpions have been extensively treated, by Fritsch in continental Europe, Pocock in England and Petrunkevitch in North America. Petrunkevitch in describing the 16 available specimens from North America placed them in ten species, six genera and four families. The likeness between some of the Carboniferous forms and the recent forms is very striking.

Present State of Classification of the Order. Each one of the workers in this field has arrived at a different conclusion as to the classification of the order; so I will here give a brief summary of the existing state of the classification.

The Classification of Karsch. Karsch[11] divided the order into four genera, *Eoscorpius*, *Microlabis*, *Cyclaphthalmus* and *Mazonia*. In his classification *Eoscorpius* Meek and Worthen contained: *Anglicus*, Woodward and *Carbonarius*, Meek and Worthen. *Microlabis* Corda, contained the species *sternbergii* Corda. *Cyclophthalmus* Corda, contained the species *senior* Corda. *Mazonia* Meek and Worthen, contained the species *woodiana* Meek and Worthen.

Work of Scudder and His Classification. Scudder[12] in his work two years later recognized only three genera placing all of them in the

[6] Patten—The Evolution of the Vertebrates and Their Kin.

[7] Gaskell—The Origin of the Vertebrates.

[8] Petrunkevitch—Trans. of Conn. Acad. of Arts and Sciences, Vol. 18.

[9] Petrunkevitch—Trans. of Conn. Acad. of Arts and Sciences, Vol. 18.

[10] Schuchert—Textbook of Geology, Vol. II.

[11] Karsch, F. E. Zeitschr. deutsch. Geol. Ges. (1882), pp. 556-561.

[12] Scudder, S. H. Proc. Amer. Acad. Arts and Sciences, Vol. XX, 1884, pp. 15-22.

family Eoscorpionidae. He considered the genus *Microlabis* as synonymous with *Cyclophthalmus*. In the genus *Eoscorpius* Meek and Worthen, he placed *carbonarius* Meek and Worthen, *anglicus* Woodward, *euglyptus*, *glaber*, *inflatus* and *tuberculatus* Peach. The genus *Cyclophthalmus* contained *sternbergii* and *senior* Corda.

Hasse's Redivision of the Order. Hasse[13] redivided the order Scorpiones with respect to the true scorpions, into the sub-order Anthracoscorpii, family Eoscorpionidae and sub-families Eoscorpionini and Cyclophthalmi.

Fritsch in Continental Europe. Under the order Scorpiones, Fritsch[14] recognized the sub-order Dionychopades and family Anthracoscorpii, which he divided in seven genera. To the four genera,—*Eoscorpius* Meek and Worthen, *Microlabis* Corda, *Cyclophthalmus* Corda, and *Mazonia* Meek and Worthen, recognized by Karsch, he adds three new genera and two new species from material mainly undescribed. These new genera and species are as follows: *Isobuthus kralupensis* (Thorell and Lindstrom), *Eobuthus rakornicensis* and *Feistmantelia ornata*.

Pocock in England. In his monograph on the English forms, Pocock[15] made some radical revisions of the classification. He first divided the order Scorpiones (other than Silurian) into two divisions, the Lobosterni, and the Orthosterni. The Lobosterni contained those forms having bilobed, posteriorly-laminate sternal plates on the opisthosoma and skeletal plates on each side of the genital operculum. In the division Lobosterni, he placed the genus *Eobuthus* of Fritsch to which he assigns a single species *holti*, a very fragmentary specimen, from the Shipley Clay pits. Pocock also thought *Isobuthus* of Fritsch might be assigned to the same group. The division *Orthosterni* contains the genera *Archaeoctonus*, *Cyclophthalmus* and *Anthracoscorpio*. To *Archaeoctonus* Pocock, he assigned *Eoscorpius glaber* Peach, and *E. tuberculatus* Peach. In the genus *Cyclopthalmus* Corda, he placed the species *Eoscorpius euglyptus* Peach. In the genus *Anthracoscorpio* he placed *Eoscorpius sparthensis* (Baldwin and Sutcliffe) and added two new species, *dunlapi* and *buthiformis*.

Late Revision of the American Species by Petrunkevitch. In America Petrunkevitch[16] has revised the entire Class Arachnida. In his work on the scorpions he was able to bring together all the then known specimens for re-examination. He divided the order Scorpiones into two sub-orders, the Apoxypoda containing the Silurian forms and the Dionychopoda containing the Carboniferous forms. In the sub-order Dionychopoda he recognized four families, 12 genera and 23 species, of which six genera with nine species are restricted to Europe, and five genera with six species are restricted to America. The genus *Eoscorpius*, regarded by Pocock as unsound, is accepted by Petrunkevitch. To it he

[13] Hasse, E.—Zeitsch. deutsch. Geol. Ges. 1890, pp. 629-657.

[14] Fritsch, A.—Palaeozoische Arachniden, 1904, Prague pp. 5-80.

[15] Pocock, R. I.—Monograph of the Carboniferous Arachnida of Great Britain, Pal. Soc.

[16] Petrunkevitch, A.—Monograph of the Carboniferous Arachnida of North America, Trans. of Conn. Acad. of Arts and Sciences, Vol. 18.

assigns eight species, four occurring in Europe and four in America. No species are found to be common to both continents. From these facts Petrunkevitch drew the two following conclusions: (1) "that the Carboniferous arachnological fauna of North America is distinct from that of Europe and developed along somewhat different lines," and (2) "that both faunas have more similarity with recent faunas of tropical countries, than with such of the same locality."[17] The following outline brings out Petrunkevitch's classification very clearly:

Order *Scorpiones.*

"Head completely fused with the thorax. Abdomen twelve-jointed, the last five somites forming the so-called cauda or post abdomen, considerably narrower than the anterior seven. Telson with a poison gland and sting. Chelicerae three jointed, chelate. Pedipalpi six-jointed, chelate, powerful. Coxae of first and second pair of legs with maxillary lobes. Abdominal tergites and sternites heavily chitinized connected laterally with each other by means of a soft chitinous cuticle capable of considerable distension. Post abdominal segments without pleural membranes, their sternites and tergites completely fused in each segment. First sternite represented by the genital opercula, second sternite by the basal joint of the comb. Four pairs of stigmata leading to lung-books in third to sixth sternites, one pair to each sternite. Anus without operculum at the end of the twelfth abdominal segment, ventral to the poison gland. Two middle eyes and two to five pairs of side eyes on cephalothorax, some recent species completely blind. All recent scorpions are viviparous."

Sub-order—*Aporydopa* (Silurian).

Tarsi terminating in a sharp point, without claws.

Family *Palaeophonidae* (T. & L. 1884).

Genus *Palaeophonus* (3 species, all European.)

Genus *Proscorpius* (1 species, American.)

Sub-order—*Dionychopoda.*

Scorpions with two claws at the end of each tarsus (includes Pocock's Lobosterni and Opisthosoma). The families of this sub-order are based on the structure of the coxae and not upon the shape of the abdominal sternites.

Family *Isobuthidae.* Coxae of the fourth pair of legs abutting against the genital opercula.

Genus *Isobuthus* (1 species, European).

Genus *Eobuthus* (2 species, European).

Genus *Palaeabuthus* (1 species, American).

Family *Cyclophthalmidae.* Normal arrangement of coxae, sternum pear-shaped.

Genus *Cyclophthalmus* Corda, 1835 (2 species, European).

Genus *Palaeomachus* Pocock, 1911 (2 species, European).

Genus *Archaeoctonus* Pocock, 1911 (1 species, European).

[17] Petrunkevitch, A.—Monograph of the Terrestrial Palaeozoic Arach. of North America, Trans. Conn. Acad. of Arts and Sci., Vol. 18, p. 28.

Family *Cyclophthalmidae*
Genus *Eoctonus Petrunkevitch* (1 species, American).

Family *Eoscorpionidae.*
Normal arrangement of coxae, pentagonal sternum.
Genus *Eoscorpius* Meek and Worthen, 1868, (8 species, 4 American and 4 European).
Genus *Trigonoscorpio* (1 species, American).
Genus *Palaeopisthacanthus* (2 species, American).
Genus *Microlabis* Corda, 1839 (1 species, European).

Family *Mazonidae.*
Middle eyes close to anterior edge of cephalothorax. Structure of pedipalpi and sternum unknown.
Genus *Mazonia* Meek and Worthen, 1868 (1 species, American).

The classification proposed by Petrunkevitch has the advantage that it is based on characters ascertainable even from fossil specimens, although derived from the comparative anatomy of recent forms. This classification will be followed as closely as possible in the description of the specimen in hand.

Comparison of Fossil Scorpions to Modern Forms. In the comparison of most fossil organisms with living forms usually only the broader features can be considered, for the finer generic and specific characters upon which modern forms are differentiated are commonly lacking to a greater or less degree. This condition is met with among the Paleozoic scorpions. The general morphology of scorpions has changed but little since Silurian times, the greatest modifications being in the structrue of the legs and feet and the much debated breathing apparatus. It has been suggested by some authors, after a comparison of the shape of the bodies of some fossil scorpions, that the viviparous habit was acquired before Carboniferous times. These characters may have followed as a result of the change from an aquatic to a terrestrial habitat.

Brief Notes on the Morphology of Modern Forms.—Only the external characters with which this paper is concerned, will be considered here.

Scorpions are animals with a segmented chitinous exterior skeleton, the anterior segments of which are fused to form the cephalothorax. The praeabdomen is composed of seven broad, thick, movable segments which surround the principal viscera. A prolonged extension of the praeabdomen, consisting of five segments, is known as the postabdomen. The last segment of the postabdomen is armed with a stout curved spine which bears at its extremity the opening of two ducts leading from a pair of glands lying in the twelfth abdominal segment and secreting a poisonous fluid.

The first pair of appendages are called the chilicirae and are situated in front of the mouth. These appendages are chelate. The next pair of appendages are the strongest appendages and are provided with chelae. Their chief service is in grasping and bringing food to the mouth. The coxae of the second, third and fourth pairs of appendages are situated about the mouth and serve as jaws. Behind the pedipalps

are four more pairs of appendages, the six-jointed walking legs. The abdomen is also supplied with modified appendages. The first segment of the praeabdomen probably bears the genital opening. The second abdominal segment bears a pair of appendages called the pectines, or so-called combs whose function is not very well understood. The ventral surfaces of the third to sixth abdominal segments, inclusive, bears each a pair of stigmata, the exterior openings to the lung-books which are the respiratory apparatus.

The eyes are situated on the dorsal surface of the cephalothorax and vary from two to six in number. One pair of eyes are larger and are situated near the median line. The others which are smaller are lateral. Some of the modern forms are blind.

Scorpions are viviparous, the genital orifice occupying the same position in both sexes.[16]

The Indiana Specimen. The specimen here under discussion was secured by Arch R. Addington in Clay County, Indiana, while serving in the capacity of assistant to the State Geologist. Mr. Addington recognized the importance of the fossil and later presented it to P. D. Moore, who in turn placed it in my hands for study and description.

Condition of the Specimen. The specimen was collected in a clay pit which had been opened in a shale member of the Pottsville formation. The specimen lying with its dorsal surface exposed is not an impression only in the soft shale, but it preserves the exoskeleton in the form of a thin, brown, chitinous film. The preservation of the specimen is excellent except that most of the terminal segments of the walking legs are missing and the fourth and fifth joints of the postabdomen are badly crushed. The left pedipalp is crushed back on the tip joints of the first left walking leg. The preservation of the remainder of the specimen will be considered as each part is taken up for description.

Geological Position. The specimen was found in a shale member of the Pottsville formation, in the basal portion of the Carboniferous series, of Clay County, Indiana. The Pottsville formation in Indiana consists of a series of sandstones and shales interspersed with coal seams. One thin lime-stone is present overlying the lower Minshall coal located in the upper or Brazil portion of the series. The Pottsville outcrop in Indiana has a northwest southeast trend upon the western side of the Kankakee branch of the Cincinnati arch, extending from Benton County on the northwest to Perry County on the Ohio River, Clay County being near the middle of the area. The general dip of the strata is to the southwest passing beneath the younger Pennsylvanian formations.

Zoölogical Relations of the Species. The preliminary examination of the specimen and the comparison with the descriptions and illustrations of the other American forms showed that it was a member of a genus previously unknown in America. Its characters at once suggested its affinity was with the European genus *Eobuthus* and continued study

[16] For further discussion on the morphology consult J. Playfair McMurrich Textbook of Invertebrate Morphology.

has confirmed its reference to this genus, which becomes the second genus of the Paleozoic scorpions to have representatives on the two continents.

Eobuthus pottsvillensis n. sp. (Plate II. figs. 1, 2, 3, and 4.)

This species is represented by a single specimen, the ventral surface of which is exposed. Since all the other known examples of this genus also preserve the ventral side, satisfactory comparisons can be made.

The measurements of the specimen are as follows:

Total length—37.6 mm.
Length of tail—16.7 mm.
Length of first joint of tail—3.1 mm.
Length of second joint of tail—3.8 mm.
Width of next to last segment of abdomen—8.8 mm.
Length of chela—9.4 mm.

The structure of the cephalothorax is indeterminable due to the condition of fossilization.

The shape of the praeabdomen is an elongate oval. The sternum is clearly oval or sub-oval in outline. In shape it is closely similar to the British and Bohemian specimens except that the sternum of the latter specimens seems larger in proportion. The bilobed shape of the third, fourth and fifth sternal plates is very striking, and they seem to overlap in shingle fashion. No traces of stigmata can be observed even when examined under the high power binocular. The sixth praeabdominal segment curves in a convex line and joins the postabdomen, whose first segment is about one-half the width of this last segment.

The first two segments of the postabdomen are well preserved and show the keel structure in a remarkable degree. The third joint of this division of the body is partly destroyed, but the general size and shape of the first three segments are about the same. The fourth and fifth joints are badly crushed and lost and their outlines can barely be determined. The telson or poison sting is well preserved and lies deeper in the matrix and to the left of the main trend of the tail, this being the first specimen of the genus which has this part of the body preserved.

The appendages are as follows:

The outline only of the chelicerae is determinable. The right one stands out in advance much farther than the left. Their chelate structure can only be inferred.

The right pedipalp is fairly well preserved, the left one being crushed back on the tips of the first left walking legs. In comparison with other specimens these appendages are moderate in size only. The chela of the right pedipalp is preserved in an edgewise condition which gives it a very slender appearance. The position and length of the movable finger cannot be determined.

Only the coxae of the first pair of walking legs are preserved and the position of these seems to be normal. More of the second pair of walking legs is preserved than of any of the others. The right second walking leg is only preserved to the third joint which is

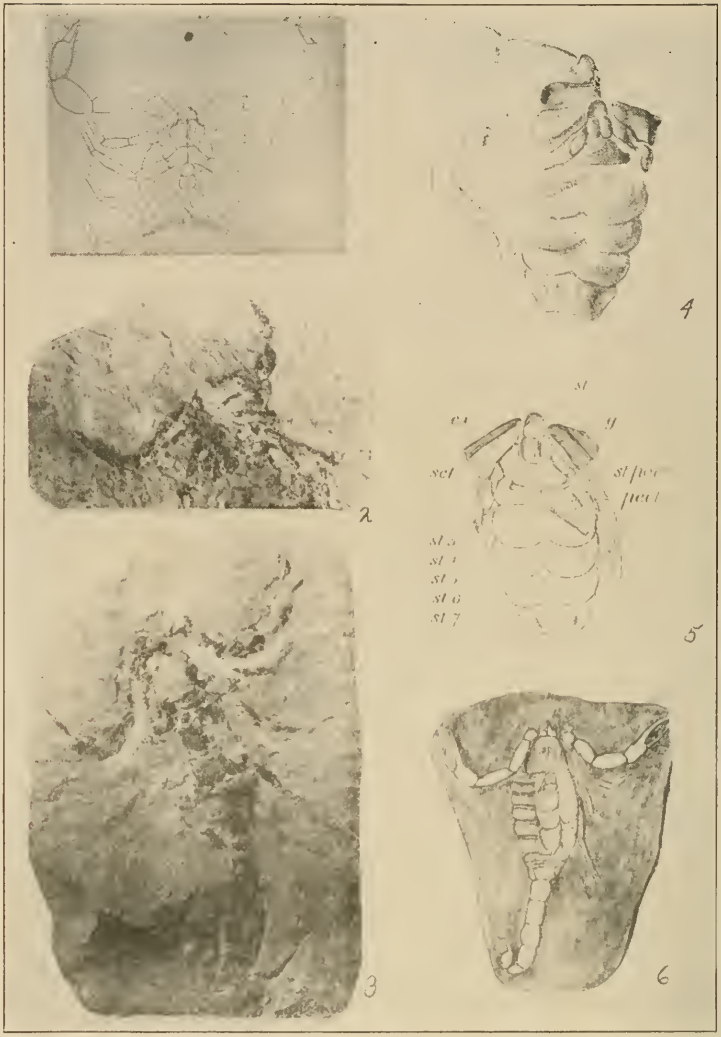
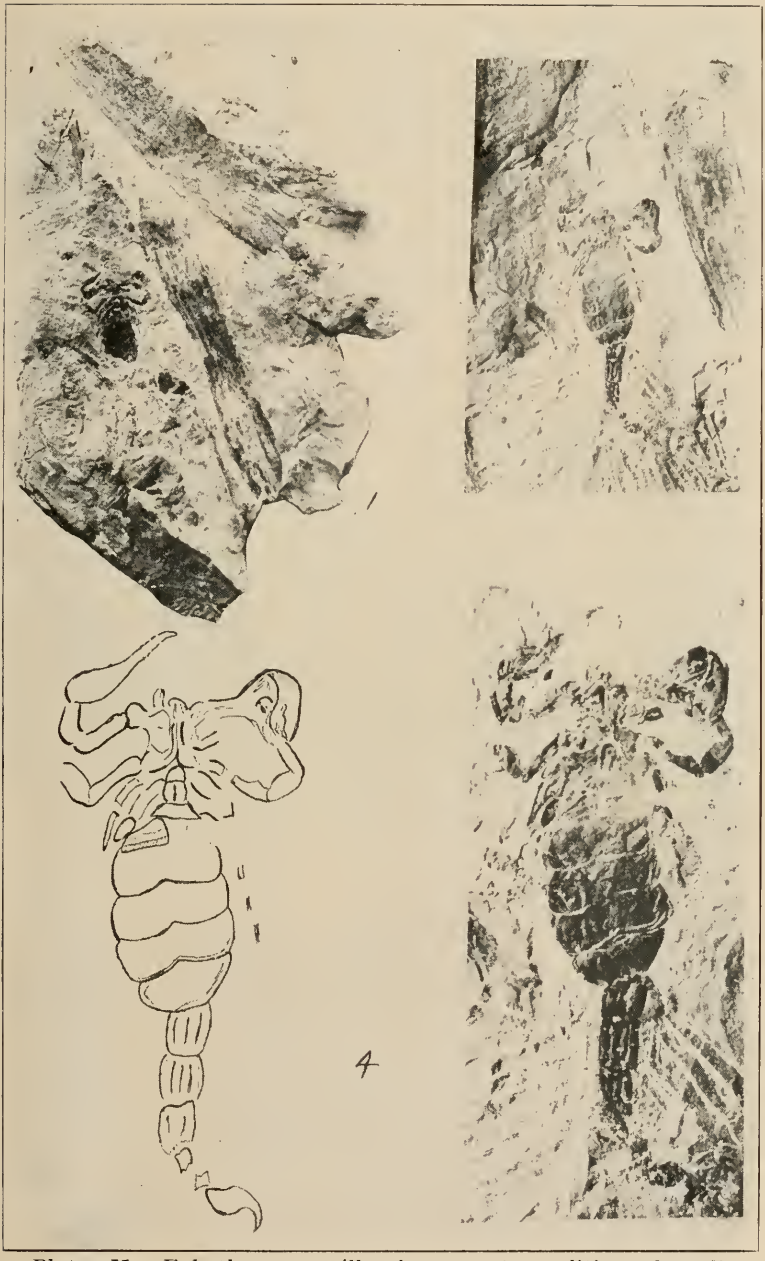


Plate I. Figs. 1 and 2, *Eobuthus rakornicensis*, the figure 1 being a restoration by Fritsch from the genotype. (Fig. 1: 1, chelicerae; 2, coxae of pedipalps; c, coxae of second walking legs; b. basal plate of pectines.) Figs. 3 and 6, *Anthracoscorpio sparthensis*. Fig. 4, *Eobuthus holti*, found in the coal measures at Sparth, near Rochdale, England. Fig. 5, line drawing of figure 4 (after Pocock); *cx.* coxae of third leg, *g.* genital operculum, *pect.* one of the pectines, *scl.* schlerites abutting genital operculum, *st. 5* to *st. 7* third to seventh somites of opisthosoma.



Plates II. *Eobuthus pottsvillensis* n. sp. 1, condition when discovered; 2, as it appeared when the postabdomen had been uncovered (slightly less than natural size); 3, enlargement of 2; 4, line drawing to bring out structure.

club shape in outline, probably due to flattening in fossilization. The tip joints of the left second walking leg seem to be preserved but they are in contact with the crushed left pedipalp and their outlines are difficult to distinguish. Only the first two joints of the third and fourth pairs of walking legs are preserved. The coxae of the third pair seem to be situated a little more anterior than the coxae in *E. holti* although all the coxae resemble *E. holti* more than *E. rakovnicensis*. The basal joints of the fourth pair of legs abut against the genital operculum. These are the skeletal plates referred to by Pocock, about whose function he was in doubt. The Indiana specimen clearly shows that these belong to the fourth walking legs.

One pectine is very well preserved and the other one very faintly. Its structure as well as its plate of attachment is essentially similar to that in *E. holti*. The plate of attachment is roughly pentagonal in outline.

No trace of the stigmata has been detected.

General Observations and Comparisons. This specimen is better preserved than either of the other two specimens assigned to the genus. It exhibits all features except the dorsal surface and the extreme tips of the walking legs. Its closest relation is with *E. holti* (Pl. I, figs. 4 and 5) rather than with the genotype, but it differs from the single known fragmentary specimen *E. holti* in the shape of the praeabdomen and the position of the coxae, with also the probable difference in the ratio of the size of the sternum. It differs from *E. rakovnicencis* (Pl. 1, figs. 1 and 2), the genotype, in the shape and length of the pedipalpi, and in the shape of the coxae and pectine. The absence of stigmata and the structure of the sternites suggests that these forms were not air-breathers but possessed respiratory organs similar to Limulus.