Art. XXVII.—*Structure and Appendages of Trinucleus;* by Charles E. Beecher. (With Plate III.)

Trinucleus departs so widely from the common type of trilobite form, that any contribution of new facts regarding its structure and appendages is a matter of interest. Moreover, this added information will be of assistance in interpreting some peculiar and striking features in the natural group of genera of which *Trinucleus* is evidently a member.

For the present, it is convenient to consider in this group such forms as *Trinucleus*, *Harpes*, *Harpides*, *Dionide*, and *Ampyx*. Most of these have the genal angles extending to or beyond the pygidium, with a broad, finely perforated or punctate margin around the head. They are further characterized by the absence or obsolescence of visual organs, while the facial sutures are either peripheral, as in *Harpes*, or in addition include the genal spines, as in *Trinucleus*, *Dionide*, and *Ampyx*. Several other genera have been recognized as having affinities with those mentioned, but they are imperfectly known, and will be merely noticed here. *Harpina*, Novák, based upon the features of the hypostoma, is probably of only subgeneric value under *Harpes*. *Arraphus*, Angelin, is apparently based upon a specimen of *Harpes* denuded of the punctate border. *Salteria* of W. Thompson, and *Endymionia* of Billings, both generally considered as closely related to *Dionide*, were founded upon too imperfect material to afford decisive data as to their affinities. Angelin's sub-genera of *Ampyx* (*Lonchodomus*, *Raphiophorus*, and *Ampyx*) are based upon the length of the glabellar spine, and the possession of five or six free thoracic segments. Similar characters in *Trinucleus* are not considered as worthy of such marked distinction.

In 1847, Salter* illustrated and described an eye-tubercle on each cheek of *Trinucleus*, from which there was a raised line extending obliquely upward to a punctum or spot on each side of the glabella. He considered this line as a discontinuous facial suture, but the true suture was afterwards correctly determined by Barrande,† and in well-preserved specimens, may easily be observed, extending around the entire frontal and lateral border of the head, and including the genal spines. The "eye-line" was further recognized by McCoy,‡

* On the structure of Trinucleus, with Remarks on the Species, Quar. Jour. Geol. Soc., vol. iii. pp. 251–254.

† Syst. Sil. Bohême. I.. 1852.

‡ Ann. Mag. Nat. Hist., 2d Series, vol. iv., 1849.

and made one of the bases for a division of the genus into two sections or genera—*Trinucleus* proper and *Tetraspis*. These divisions were accepted by Salter, but later were thoroughly discussed, and rejected by Barrande (*l. c.*, p. 617), upon valid grounds. Nicholson and Etheridge,* in 1879, reviewed these facts at some length, and gave original figures illustrating the ocular tubercle and eye-line. They also agree with Barrande in recognizing them as clearly adolescent characters.

The justice of these conclusions is substantiated, and additional results are reached, from the study of a series of *Trinucleus concentricus* Eaton, found associated with *Triarthrus Becki* Green, in the Utica slate, near Rome, New York. The remarkable preservation of the fossils at this locality, has already afforded a means of determining all the principal details of the ventral structure of the trilobite genus *Triarthrus*, and there is now distinct evidence as to the nature of the appendages in another type—*Trinucleus*, as well as to the probable significance of the so-called "eye-tubercle."

As compared with *Triarthrus*, specimens of *Trinucleus* are not very common at this locality, and, although more than fifty individuals of the latter have been obtained from the collections presented to the Yale Museum by Professor Marsh, not more than half a dozen of these are adult specimens, and but three show any appendages. Young specimens of all ages occur, from about 1^{mm} across the cephalon upwards, and in all the eye-line and eye tubercle are present until a width of nearly 5^{mm} is attained, when in the present species these features dwindle and disappear, leaving no discoverable traces in the adult.

Two cephala of young individuals, without the free cheeks, are shown enlarged in figures 1 and 2 of Plate III. Figure 2 represents a specimen before the appearance of the perforate border, and figure 1 gives a later stage, having two rows of perforations around the head. On both specimens the eye-line is clearly shown, extending somewhat obliquely backward from the anterior lobe of the glabella to the central area of the fixed cheeks, enlarging slightly, and terminating in a rounded node or tubercle (*a*, *a*, figure 2).

In seeking for homologous features in other trilobites, the genera *Harpes* and *Harpides* are immediately suggested, since they have similar ocular ridges extending from the sides of the glabella, and ending in a tubercle, which, in *Harpes*, contains from one to three eye-spots, as determined by Barrande. They further agree in having these visual organs on the

* Monograph of the Silurian Fossils of the Girvan District in Ayrshire, Fasc. II., 1879.

fixed cheeks, while in all other trilobites with distinct eyes, the free cheeks carry the visual areas. This type of eye is thus quite different in its relations to the parts of the cephalon from that of *Phacops* or *Asaphus*, and more nearly resembles the eyes of some of the *Merostomata* (*Bellinurus*), as do also the triangular areas in the young *Trinucleus*, so distinctly marked off from the fixed cheeks on each side of the glabella behind the eye-line. Adult *Trinucleus* and *Harpes* have these areas much reduced, and often obsolescent. A spot or node in the median line on the glabella has been noticed by many observers, and although its nature has not been demonstrated, it has generally been called an ocellus. It is more clearly preserved in adult specimens, though it can be detected in young examples, as indicated in figures 1, 2, Plate III.

An eye-line occurs in many early trilobite genera, and is well marked in *Conocoryphe, Olenus, Ptychoparia*, and *Arethusina*. At least four-fifths of the Cambrian forms preserve this feature, which is almost entirely eliminated before Devonian time. It differs in extent, but not necessarily in nature, from the eye-line of *Trinucleus* and *Harpes* in running entirely across the fixed cheeks to the free cheeks, ending in the palpebral lobe in eyed forms. It is evidently a larval character in the trilobites, as shown from its geological history and the ontogeny of *Trinucleus*. From the direction of the optic nerve in *Limulus*, and its relations to the surface features of the cephalothorax, the eye-line probably represents the course of that nerve, and is of much less morphological importance than the different types and arrangement of visual organs.

The pygidium of young *T. concentricus* (Plate III, figure 3) is remarkable for the lack of definition between the axis and pleura. In later and adult stages the number of ridges on the pleura and axis do not correspond, and from figures 4, 5, and 6, it is evident that in this genus the number of pleura is no indication of the number of pygidial segments or pairs of appendages, which, however, may be shown, as in this case, by the annulations of the axis. In this respect, the pygidia in *Encrinurus, Cybele*, and *Dindymene*, are of the same nature. Figure 6 also shows a narrow, striated doublure, a character generally overlooked in descriptions of *Trinucleus*.

Appendages.

Three specimens have thus far been observed which show the nature of the appendages in *Trinucleus*. Two of these are illustrated in figures 4, 5, and 6, of Plate III. Figure 4 represents the thorax and pygidium viewed from the dorsal

side. In this specimen the pyrite which replaced the chitinous remains of the animal has decomposed, and the dorsal crust weathered away, exposing below the stems of the exopodites, with their fringes extending over the entire pleural areas on both sides. A pygidium, with three attached thoracic segments, from another entire specimen (figures 5 and 6), preserves the details of the appendages in the most perfect and satisfactory manner. As both halves showed essentially the same extent and disposition of the fringes on the dorsal side, the specimen was cut in two along the center of the axis, and the left side was then imbedded in paraffine. By careful preparation the appendages were exposed from the ventral side.

The cephala of the three specimens described are considerably compressed, and from them a very imperfect knowledge of the mouth parts could be obtained, so that this information must be left to future discovery.

Endopodites.—The three posterior thoracic endopodites are very similar, and in a general way closely resemble those of *Triarthrus* from the same region of the thorax. They are, however, comparatively shorter and stouter, and could not be extended beyond the ends of the pleura. The two distal joints are cylindrical, with well-marked articular surfaces and ridges. The joints preceding these proximally become much wider, flattened, and produced into transverse extensions which carry large tufts of setæ at the end, as also does the end of the last joint of the limb (dactylopodite).

The endopodites on the pygidium offer no conspicuous differences from those just described, except that a gradual change in form is manifest as the terminal limbs are reached. The separate endites become more and more transversely cylindrical, until the whole limb appears to be made up of cylindrical segments transverse to its length. A similar condition was observed in the young of *Triarthrus.**

Exopodites.—These seem to be composed of slender joints, the distal exites being long and slightly curved outwards. They carry very long, close set, overlapping, lamellose fringes, which evidently had a *branchial* function. Some of the lamellæ are spiniferous. The exopodites become shorter on the pygidium, and apparently are represented near the end of the series of limbs by the oval plates indicated at *c*, figure 6. If this interpretation is correct, the posterior exopodites are simple flabella attached to the limbs, as in *Apus*.

Both Professors A. E. Verrill and S. I. Smith agree that the characters of the appendages in *Trinucleus* indicate an animal of burrowing habit, which probably lived in the soft

* This Journal, vol. xlvii, Pl. VII, fig. 3, April, 1894.

mud of the sea bottom, much after the fashion of the modern *Limulus*. In addition to its limuloid form, the absence of eyes seems to favor this assumption. So does the fact that many specimens have been found preserving the cast of the alimentary canal, showing that the animal gorged itself with mud like many other sea-bottom animals.

Yale Museum, New Haven, Conn., March 15th, 1895.

EXPLANATION OF PLATE III.

Trinucleus concentricus Eaton.

FIGURE 1.—Cephalon of young individual without genal spines; showing ocular ridges and two rows of perforations around anterior and lateral borders. × 40.

FIGURE 2.—Cephalon of younger individual before the growth of the perforate border; showing distinctly the clavate ocular ridges, *a*, *a*. × 40.

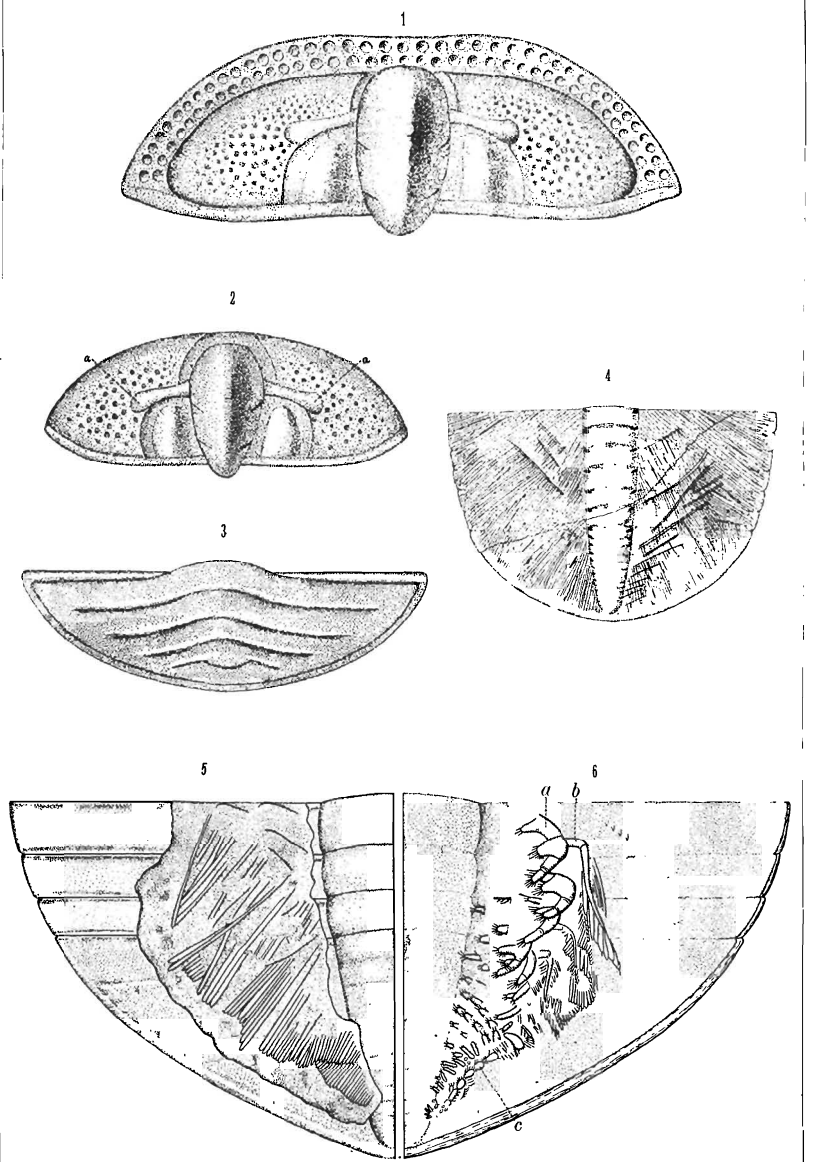
FIGURE 3.—Pygidium of young individual; showing the indistinct limitation of axis and the elevated transverse ridges of the pleura and axis. × 40.

FIGURE 4.—Thorax and pygidium of an entire specimen from which the dorsal test has been removed by weathering, exposing below the fringes of the exopodites, which entirely cover the pleural portions. The stronger lines ascending from the axis are the main stems of the exopodites. The black dots along the axis are the fulcra for the attachment of the limbs. × 4.

FIGURE 5.—One-half the pygidium with three attached thoracic segments, from an entire specimen, with a portion of the test removed; showing the highly developed, lamellose fringes of the exopodites. × 11.

FIGURE 6.—The same; lower side; showing the short, stout, phyllopodiform endopodites, *a*, and the long, slender, exopodites, *b*, bearing the lamellose branchial fringes. In the lower third of the figure the ends of the joints of the separate endopodites are shown by the oblique ascending rows of setiferous nodes. The small ovate organs (*c*) along the side are provisionally correlated with the exopodites. A narrow striated doublure margins the pygidium and the ends of the thoracic pleura. × 11.

Utica slate. Near Rome, N. Y.



TRINUCLEUS CONCENTRICUS Eaton.

1, 2. Cephala of young individuals. ×40.
3. Pygidium of young individual. ×40.
4, 5, 6. Appendages. 4, ×4; 5, 6, ×11.