

No. 20.— *A Revision of the American Species of Ceraurus.*

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The genus *Ceraurus* was proposed in 1832 by Green for a new trilobite which he described as *Ceraurus pleurexanthemus*.¹ The genus has been accepted and used by American palaeontologists, with the notable exception of Billings, and by a few European writers, among whom were Roemer and Eichwald. The younger name *Cheirurus*, proposed by Beyrich in 1845,² has, however, been preferred by nearly all European palaeontologists. The description of this genus was accompanied by the diagnoses of four species, *Cheirurus insignis* Beyrich, *Ch. claviger* Beyrich, *Trilobites sternbergi* Boeck, and *Ch. gibbus* Beyrich, and it is evident from the text that Beyrich had other unnamed species in hand at the time. Of the four named species in this article, *Cheirurus claviger* is the type of Corda's genus *Eccoptochile*, and *Ch. sternbergi* and *Ch. gibbus* are species of Salter's *Crotalocephalus*. This leaves only the first species, *Ch. insignis*, to serve as the type of *Cheirurus*, and it is evident from the description that Beyrich based his genus almost entirely on this species. Beyrich was familiar with Green's description of *Ceraurus*, but felt that the description and figure of that genus were so poor as to prevent its recognition. Later, when Green's genus became better known through Hall's figures, Beyrich's genus had become so familiar to European palaeontologists that it retained their preference. The two genera have been considered as essentially synonymous. We, however, believe that this is not the case, and shall attempt to show that *Ceraurus* and *Cheirurus* are distinct, although closely allied, genera.

The genus *Cheirurus*, although originally used so broadly as to include most of the *Cheirurinae*, has been restricted by the erection of genera and subgenera, such as *Eccoptochile* and *Actinopeltis* Corda, *Cyrtometopus* and *Sphaerocoryphe* Angelin. Finally it was restricted by Schmidt³ to those cheirurids in which there are always eleven segments in the thorax, the inner part of each pleuron is cut

¹ Monograph of the trilobites of North America, 1832, p. 83.

² Ueber einige Bohmischen trilobiten. Berlin, 1845, p. 5.

³ Revision der Oestbaltischen Silurischen trilobiten. Mem. Acad. imp. sci. St. Petersburg, 1881, ser. 7, 30, p. 122.

by a diagonal furrow, the glabella expands forward, and the lateral furrows of the glabella are always distinct. Reed ¹ follows Schmidt in this restriction of *Cheirurus*, but goes further and separates Salter's subgenus *Crotalocephalus* from the group which was included in *Cheirurus* by Schmidt. Reed divided *Cheirurus* as restricted by him into two groups, the first with what he designated as the cyrtometopian pygidium (essentially like that of *Ceraurus*), and the second with the *Cheirurus insignis* type of pygidium, that is, with three pairs of subequal pleural spines, and a short median spine. When the characteristics of these two groups are studied, it is found that they differ in the structure of the head as well as of the pygidium. In the second group the posterior pair of glabellar furrows are nearly or quite straight, slope backward at a considerable angle, and open directly into the neck-furrow at or near the middle of the glabella. The basal lobes thus cut off are triangular, and their inner ends almost meet. In this same group the surface of the glabella is smooth, and while the cheeks may be pitted, they are not pustulose. It is further noticeable that the glabella is large in this group, usually occupying one third or more of the width of the cephalon. In the first group, with crytometopian pygidium, the glabella is usually (in the American species always) pustulose, and the glabella is usually less than one third the total width of the cephalon. The posterior glabellar furrows are short, each extending only about one third the distance across the glabella, and instead of connecting with the neck-furrow, their course is approximately parallel to it. There is, however, usually a secondary constriction parallel to the long axis of the glabella, which connects the inner end of the furrow with the neck-furrow. This constriction may be very faint or very deep. In the latter case the posterior glabellar lobes are completely isolated, are nearly square in outline, and are separated from each other by a portion of the glabella whose width is about equal to that of one of the posterior lobes. All of the known species of the first group are found in strata of Ordovician age, while those of the second occur in the upper Ordovician (Bohemia only, so far as known) and Silurian. In geographical distribution, only the first group is found in Russia, and it preponderates in Scandinavia. The home of the second group is in Bohemia, but it is also more prominent than the first group in Great Britain. Both groups are present in North America.

The differences between these two groups are so constant and well

¹ Evolution of *Cheirurus*. Geol. mag., 1896, dec. 4, 3, p. 117.

marked that we believe the groups worthy of generic names. *Cheirurus insignis* Beyrich, has the characteristics of the second group, so that group becomes the *Cheirurus* in our restricted sense, while the first group is typified by *Ceraurus pleurexanthemus*, the type-species of *Ceraurus*. Reed cited *Cheirurus exsul* Beyrich, as the type both of the restricted genus *Cheirurus*, and of his subdivision of the restricted genus in which the pygidium was cyrtometopiform. This species, although described by Beyrich along with Bohemian trilobites, is a northern form, and a *Ceraurus*. It was not described by Beyrich in the paper in which he first described the genus *Cheirurus*, and it cannot be taken as the type of that genus.

The genus *Cheirurus*, as we understand it, comprises those species of Reed's restricted genus *Cheirurus* which have the posterior pair of glabellar furrows nearly straight, sloping more or less rapidly backward, and opening directly into the neck-furrow at or near the axis of the glabella; whose basal glabellar lobes are triangular, and not separated by a portion of the glabella; and the pleural spines of whose pygidia are subequal in length.

TYPE.—*Cheirurus insignis* Beyrich.

The genus *Ceraurus*, on the other hand, comprises those species characterized by short posterior glabellar furrows which slope only gently backward and do not open directly into the neck-furrow but are connected with it by longitudinal constrictions; whose basal lobes are quadrangular, rather than triangular; whose glabella is usually more or less strongly pustulose; and the spines of whose pygidium are very unequal in length, the first pair being strongly developed, and the remainder very short or absent.

TYPE.—*Ceraurus pleurexanthemus* Green.

Key to American Species.

- A. Glabella or neck-segment strongly spinose
 - a. A pair of short horn-like spines on the crest of the frontal lobe
bispinosus, sp. nov.
 - b. A single median spine on the neck-segment . *numitor* Billings
- B. Glabella merely pustulose or with small spines
 - c. Genal angles without spines
Glabella expanding rapidly forward *misneri* Foerste
 - d. Genal angles with spines
 - A. Glabella expanding forward

- I. Eye usually more than half the length of the cephalon from the posterior margin.

A small form, glabellar expansion I in 4.

hudsoni Raymond

A medium sized form, glabellar expansion I in 7.

pleurexanthemus Green

- II. Eye usually about one half of the length of the cephalon from the posterior margin. *milleranus* M. and G.

- III. Eye less than one half the length of the cephalon from the posterior margin. *dentatus*, sp. nov.

- B. Glabella with parallel sides. *granulosus*, sp. nov.

CERAURUS PLEUREXANTHEMUS Green.

Plate 1, fig. 1; Plate 2, fig. 1, 2, 7.

Ceraurus pleurexanthemus Green, Monthly Amer. jour. geol., 1832, p. 560, pl., fig. 10; Monogr. N. A. trilobites, p. 84, pl. 1, fig. 10, cast 33. Hawle & Corda, Prodr. monogr. Bohem. trilobiten, 1847, p. 161, pl. 7, fig. 82. Hall, Pal. N. Y., 1847, 1, p. 242, pl. 65, figs. 1a-c, 1e-g (not 1d, 1h, 1i, 1m, nor pl. 66, figs. 1a-g). Emmons, Amer. geol., 1855, 1, p. 217, pl. 15, fig. 1b-e, 1g (not 1a, 1h, 1i, 1k). Walcott, Ann. Lyc. nat. hist. N. Y., 1875, 11, p. 155, pl. 11; Bull. M. C. Z., 1881, 8, p. 211, pl. 5, fig. 1-6. Clarke, Pal. Minn., 1897, 3, p. 734. Weller, Pal. N. J., 1897, 3, p. 204, pl. 15, fig. 28.

As may be seen from the citations under this species and the next, the literature is full of references to *Ceraurus pleurexanthemus*, but original figures are scarce, most authors seeming to find Hall's imperfect illustrations satisfactory. Barrande, as early as 1852, was led by Hall's figures to believe that two species had been described under one name,¹ but up to the present no one has given the subject any especial attention. There have been two reasons for this neglect of the species. One is, that although it is common at various horizons in the Ordovician, good specimens are exceedingly rare; in the second place, the figures given by Hall are so poor that they do not afford means for fine discrimination, and encourage a quick and loose determination of the specimens.

The Walcott and Dyer collections in the Museum of Comparative Zoölogy afford abundant material for the study of the various forms.

¹ System Silurian de la Boheme, 1852, 1, p. 756.

which have been referred to this species, and the Geological Survey of Canada, through the courtesy of Director Brock, has loaned a considerable number of specimens.

The type of *Ceraurus pleurexanthemus* is well known from the plaster casts distributed by Green, and the original specimen was refigured by Hall. The cast shows a very poorly preserved trilobite, about 25 mm. long, with the greater part of both cephalon and pygidium buried in the matrix. The cephalon shows a pair of narrow flaring genal spines, and small, prominent eyes, which are nearer to the glabella than to the posterior margin of the cephalon. The greater part of the glabella and all of the anterior margin of the cephalon are concealed. On the fixed cheeks, just inside of, and behind the eye, are two small, sharp tubercles which seem to be present in all species of *Ceraurus*. The thorax shows 11 segments; the axial lobe is convex, prominent, a little less than one third the total width. The pleural lobes are flat to the fulcrum, where there is a line of prominent nodes. The part of each pleuron within the fulcrum is divided by a diagonal furrow into two triangular nodes. The pygidium is mostly concealed, but shows one of the long spines which characterize the genus.

A study of the numerous specimens of *Ceraurus* at hand has convinced us that the position of the eye is an important and constant character, and in this respect Green's type agrees with the specimens found at Trenton Falls, N. Y. The other characters, in so far as the cast shows them, are also in accord with the specimens from that locality. Trenton Falls is only about fifteen miles from Newport, which is given as the locality from which the original specimen was derived, but the strata there are somewhat higher in the Trenton than are those at Newport. However, it is not at all impossible that the original specimen may have come from Trenton Falls, as that place had been known as a locality for trilobites long before 1832. In any case, specimens from Trenton Falls may be taken as typical of the species, and the description here given is derived from specimens found there.

DESCRIPTION.—Body, disregarding spines, obovate, with flaring spines at the genal angles and on the pygidium. Axial lobe about one third the total width, convex, and tapering but slightly.

Cephalon broad, roughly semicircular in outline, about .4 as long as broad. Glabella very convex, expanding forward, and reaching the frontal margin. The expansion is slight, averaging about 1 mm. in 7. The front of the glabella is nearly square, being but slightly curved. There are three pairs of glabellar furrows; the first two pairs

are short, while the third pair are stronger, and turn abruptly back to join the neck-furrow, thus isolating a pair of small, nearly square lobes at the base of the glabella. The other furrows are deep at their junction with the dorsal furrows, and thus form small, node-like side lobes. There is some variation in the course of the posterior pair of furrows. In the majority of specimens they turn back to the neck-furrow, but in a few they become very faint at the inner ends, so that the posterior lobes do not appear to be isolated. The fixed cheeks are convex, highest at the eye, and bear the genal spines. The free cheeks are small, the sutures reaching the anterior margin at points but little behind the eyes. A facial suture leaves the anterior margin where each dorsal furrow intersects it and runs outward and backward on the arc of a flat ellipse, encircles the top of the eye, then runs almost straight to the margin again, reaching it a little behind the horizon of the eyes. The eyes are small, minutely faceted, high, and prominent, and have eye-lines which originate opposite the first pair of glabellar furrows and extend to the palpebral lobe. The eyes are situated far forward on the cheeks, and a little nearer to the glabella than to the posterior margin of the cephalon. The distance of the back of the eye from the posterior margin was found, by measurement of many specimens, to be from .40 to .58 of the length of the glabella. The curvature of the head makes the cheeks shorter than the glabella, so that the eyes are really very close to the anterior margin. The neck-furrow is narrow and deep on the fixed cheeks, and on the sides of the glabella, but faint on top. The whole cephalon is surrounded by a convex border which is rather wide on the cheeks, but very narrow in front of the glabella.

The surface of the cephalon, barring the genal spines, is covered with pits and tubercles of various sizes. On the glabella, there are, beside the numerous irregularly placed ones, two rows of coarse tubercles which are in a rough alignment. These rows diverge toward the front. The fixed cheeks have many tubercles and pits, and behind, and a little inside the eyes, are two small but prominent tubercles on a line parallel to the axis of the animal, and a little inside the line of nodes marking the fulcrum of the thorax. On many specimens there is a tubercle on the posterior border in line with these. Well preserved specimens show three or four spine-like tubercles on the posterior border of the cephalon. The surface of the genal spines is granulose.

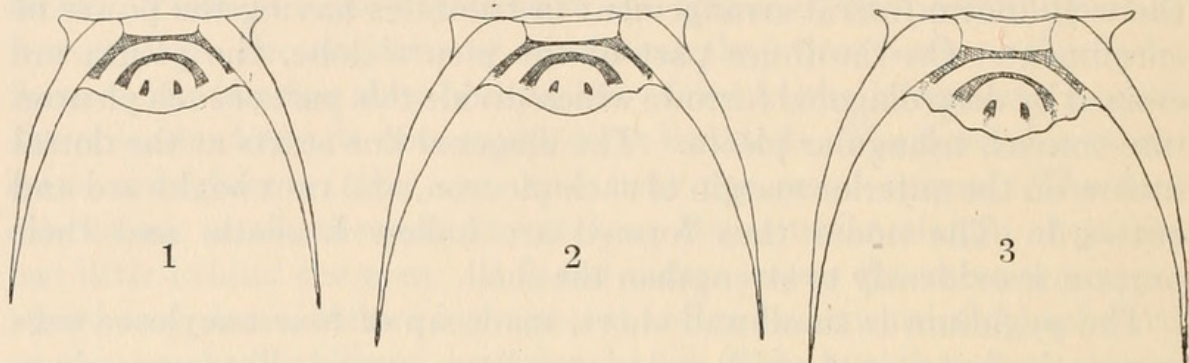
The thorax is composed of eleven segments, the axial lobe convex, and marked by two rows of small nodes. The pleural lobes are divided into two parts, an inner, solid and nodose portion, and an

outer portion consisting of the free ends of the pleura. Along the line dividing these parts, is a series of prominent tubercles, one on each pleuron. In front of each tubercle in this line there is a process which extends under a small fold in the shell of the pleuron in front — the well known fulcral arrangement in trilobites having the power of enrollment. On the inner part of the pleural lobe, the pleura are crossed by deep diagonal furrows which divide this part of each pleuron into convex, triangular pieces. The diagonal line starts at the dorsal furrow on the anterior margin of each pleuron, and runs backward and outward. The nodes thus formed are hollow beneath, and their purpose is evidently to strengthen the shell.

The pygidium is small and short, made up of four ancylosed segments, the first pair of which end in very long, curved, divergent spines. The part of the pygidium within the spines is rounded in outline, and marked by two pairs of ribs which cross the axial portion without a break. The form of the ribs is controlled by the parabolic curve of the great spines, and the third pair make almost a semicircle. The fourth segment is represented by a single ridge running backward on the axial line, within the semicircle formed by the third ribs. Between each pair of ribs are a pair of deep depressions. The ribs extend to, and sometimes cross the narrow convex border. When they cross, they make two pairs of short spines within the great spines, while the central unpaired rib makes a median spine. These spines are never long, and sometimes, when present, they are so short that they merely roughen the outline of the border.

VARIATIONS.—The amount of variation among specimens from Trenton Falls is surprisingly slight. As has already been noted, the position of the eye is very constant, and other features, such as the proportion of length of cephalon to width, rate of tapering of glabella, and form of nodes on the thorax, are about the same in all specimens. Moreover, young specimens show very little difference from adults. The smallest specimen at hand, 3 mm. long, has the same number of segments as the adult, the same spines on cheeks and pygidium, the same glabellar furrows, and the same nodes on the thorax. In small specimens, the spines on the pygidium, seem, as a rule, to be more curved, and to have their tips nearer together than in the adult. The average length for specimens at Trenton Falls seems to be about 30 to 35 mm., and the majority of the specimens in the collection are shorter than this. The largest specimen is 58 mm. long, and there are few fragments indicating specimens of larger size. It is important to note that the large specimens have the eyes as far forward as the smaller ones.

The only important variations noted have been in the character of the portion of the pygidium inside the great spines. The posterior border of this part of the pygidium may be either aspinose and rounded, or have 2, 4, or 5 short spines or denticles.



FIGS. 1-3 illustrate the three types of pygidium found among the specimens of *Ceraurus pleurexanthemus* at Trenton Falls, N. Y. Some, as in fig. 1, show no traces of spines between the great spines at the sides; others, fig. 2, have one pair of spines; while those like fig. 3 have a suggestion of two pairs of spines between the great spines. A fourth type of pygidium, which is not illustrated, is represented by a few specimens. In this type the middle portion of the pygidium is much like fig. 2, but longer and somewhat shovel-shaped. The figures are drawn from specimens in the Museum of Comparative Zoölogy, (Cat. No. 1, 2, 3) and are $2\frac{1}{2}$ times natural size.

Of sixty-five specimens on which the posterior border of the pygidium could be more or less clearly seen, fifteen had no spines inside the great ones, thirty-seven had only the outer pair, and thirteen had five spines. All but one of the specimens having no spines were small, showing that this was not usually an adult character, but the specimens in the other two groups were of all sizes, showing that the number and size of the spines were not age characteristics.

MEASUREMENTS.—In the following measurements, the length is taken along the axial line, from the front of the glabella to the middle of the posterior border of the pygidium, and does not include the spines. The width is taken at the genal angles, but does not include the spines.

	1.	2.	3.	4.	5.	6.	7.
Length.	3	8	19	31	36	58	25±
Length cephalon.	.9	2.5	5.5	9.5	11	15	7±
Width.	3	6.5	14	24	27	36	22
Width front glabella.		2	4.5	7	8	13	
Width neck-ring.		1.5	4	6	7	10.5	
Length thorax.				19	22	38	
Length pygidium.				2.5	3	5	
Length spines pygid.		2.5	5			14	

Numbers 4 and 5 are adults of typical size, and number 6 is the largest complete specimen from Trenton Falls. Number 7 is one of the plaster of paris casts of Green's type.

In Vodges's Catalogue of trilobites, nineteen species of "*Ceraurus*" are listed, but the name is there used in a very wide sense, and includes species of *Pseudosphaerexochus*, *Nieszkowskia*, *Heliomera*, *Ceraurus*, and *Cheirurus*. The only species with which *Ceraurus pleurexanthemus* need be compared are *C. dentatus*, *C. milleranus*, *C. hudsoni*, *C. misneri*, and *C. pompilius*, and the differences from each are listed under the appropriate headings on later pages.

Note on Ceraurus pleurexanthemus.— Since the above was written, fascicle 1 of series 4 of the *Palaeontologia universalis* (dated July, 1912) has come to hand. Leaves 236 and 236a, written by Dr. Rudolph Ruedemann, are devoted to the figures and description of *Ceraurus pleurexanthemus*. The type, which is in the New York State Museum, is represented by a photographic figure which shows more detail than can be seen on Green's casts, and leaves no doubt that the original specimen is conspecific with the individuals so common at Trenton Falls. As plesiotypes, three individuals are illustrated. The first, lettered P, is a fairly well preserved specimen of *Ceraurus pleurexanthemus* from Trenton Falls, but as it has lost both eyes and the pygidium is buried, it does not show the important characters of the species. Through a typographical error, this figure is labeled as enlarged $\frac{1}{2}$ times, but from its size, it would seem that the meaning should be " $\times 1\frac{1}{2}$." The other two figures, P₁ and P₂, are photographs of casts of two specimens figured by Hall (Pal. N. Y., 1847, 1, pl. 65, fig. 1m and pl. 66, fig. 1a). The originals of these figures are in the American Museum of Natural History in New York. Both are individuals of our *Ceraurus dentatus*.

Ruedemann has accepted Schmidt's diagnosis of *Cheirurus* and is therefore led to state that *Ceraurus pleurexanthemus* has the characteristics of *Cheirurus s. s.* This we have shown in the introduction to this paper is not in accordance with the facts. Schmidt was led by his geographical position to accept the northern *Ceraurus exsul* as the type of *Cheirurus* in place of the proper type, the southern *Cheirurus insignis*.

FORMATION AND LOCALITY.— This species occurs in the Black River and Trenton at almost all localities where these formations are exposed. It is less common in the Lowville, and is not positively known from any formation older than the Lowville, or younger than the Trenton.

CERAURUS DENTATUS, sp. nov.

Plate 1, fig. 1; Plate 2, fig. 4, 5.

Ceraurus pleurexanthemus Hall, (*partim*), Pal. N. Y., 1847, 1, pl. 65, figs. 1d, 1h, 1i, 1m; pl. 66, figs. 1a-1g. Emmons, Geology Second Dist. New York, 1842, p. 390, fig. 6; Amer. geol., 1855, 1, pl. 15, figs. 1a, 1f, 1h, 1i, 1k. Billings, Geol. Canada, 1863, p. 188, fig. 188. Cumings, 32d Ann. rept. Indiana state geol. surv., 1908, pl. 54, figs. 9-9b, (after Hall).

The larger specimens figured by Hall differ from the typical form of *Ceraurus pleurexanthemus* in having the eyes much further back and without eye-lines, in the possession of much longer and less divergent genal spines, and in having two pairs of well developed spines on the pygidium, within the great spines.

It might seem that these characters were merely the accompaniments of the greater size attained by the specimens, but that such is not the case is shown by the fact that we have before us specimens of *C. dentatus* from Canada which are smaller than the large specimens from Trenton Falls. And, as has already been stated, series of specimens from Trenton Falls show that there is no backward movement of the eye or increase in the length of the genal spines with increase of size.

It is rather peculiar that the only good figure so far ascribed to *Ceraurus pleurexanthemus* should prove to belong to this new species. The figure referred to is the one given by Billings in the Geology of Canada. The Museum of the Geological Survey of Canada does not contain any specimen as perfect as is indicated by this figure, and it is very probable that it is a composite illustration. The general form, the cephalon, and pygidium would appear to have been drawn from specimen No. 1,775, which is now selected as the holotype of *Ceraurus dentatus*, while the thorax and ornamentation were apparently drawn from specimen No. 1,769. The sharp pustules on the posterior border of the cephalon especially are very like those on that specimen. The figure is less than half the size of No. 1,775, but is almost exactly one half the size of a third specimen, No. 1,769b.

Another well known example of this species is the large specimen figured by Hall on Plate 66 of the Paleontology of New York, 1. This specimen was said by Hall to have come from "near Cincinnati, Ohio," but it is entirely unlike any specimen which has been found in that vicinity since, and very similar to the specimens found in New York and Canada. A recent examination of this specimen in the

American Museum of Natural History in New York shows that the lithology is very unlike the yellow-weathering rock of the Cincinnati region, and, moreover, the specimen is labeled as coming from Middleville, New York.

This species contains the largest specimens of *Ceraurus* now known. The largest specimen so far seen is one in the Museum of the Geological Survey of Canada. It was collected by the late H. C. Vennor at Belleville, Ontario, and must have been, when complete, over 100 mm. long and 85 mm. wide. It was a veritable giant, when compared with the average specimen of *Ceraurus pleurexanthemus* from Trenton Falls, and nearly double the length of the largest specimens found there. The spines on the pygidia of this species grow to great length. The spines on the type, which is 84 mm. long, are 27 mm. long, and we have seen several which had longer ones. The spines on a pygidium collected by the senior author near the base of the Trenton at Heeley Falls, Ontario are 38 mm. long.

MEASUREMENTS.—The holotype is 83 mm. long, 60 mm. wide at the genal angles, the cephalon is 24 mm. long, the glabella 17.5 mm. wide at the front and 15.5 wide at the neck-ring. A somewhat smaller specimen from Cobourg, Ontario, is 74 mm. long, 54 mm. wide at the genal angles, the cephalon is 22.5 mm. long, the glabella is 17.5 mm. wide at the front and 13.5 wide at the neck-ring.

FORMATION AND LOCALITY.—This species is, so far as we now know, confined to the Trenton, but it seems to be found all through that formation, although especially common in the lower part. It is known to occur at the following localities, and it will probably be found at numerous other places, especially in the Central States:—Middleville, New York (exact horizon not known); Roaring Run, East Martinsburg, New York, (in strata corresponding to the crinoid beds of the Ontario section); Belleville, Ontario, (crinoid beds); Cobourg, Ontario, (sponge beds at top of Trenton); Heeley Falls, Ontario, (Dalmanella beds at base of Trenton); Trenton and Peterboro, Ontario, (Prasopora beds); Fenelon Falls and Kirkfield, Ontario, (crinoid beds, very common). The type was collected at Van Kleek Hill, east of Ottawa, Ontario, by Sir William Logan, and the exact horizon is not known.

CERAURUS HUDSONI Raymond.

Ceraurus hudsoni Raymond, Annals Carnegie mus., 1904, 3, p. 367, pl. 14, fig. 15; 7th rept. Vermont state geol., 1911, p. 24, pl. 36, fig. 15.

This species was described as differing from *Ceraurus pleurexanthemus*

mus in having the eyes further forward and the cheeks more convex, but the figures in the Palaeontology of New York with which comparison was made were those which we now refer to *C. dentatus*. *Ceraurus hudsoni* has the flaring spines of *C. pleurexanthemus*, and the eyes agree with that species in being nearer to the glabella than to the posterior margin of the cephalon. The glabella seems to be broader and less convex than in *C. pleurexanthemus*, and the rate of expansion is a little greater (about 1 mm. in 4). There is, however, little difference between the two species, so far as can be seen in the incomplete specimens so far found.

FORMATION AND LOCALITY.—This species has been found only in the Middle Chazy on Valcour Island, New York.

CERAURUS GRANULOSUS, sp. nov.

Ceraurus pompilius Raymond (non Billings), Annals Carnegie mus., 1904, 3, p. 365–6 (not fig. 6), pl. 14, fig. 14; 7th rept. Vermont state geol., 1911, p. 240, pl. 36, fig. 14.

This species was originally identified by Raymond with Billings's species, *Cheirurus pompilius*. Billings's figure shows the glabella of *Ch. pompilius* to be smooth and his description states that the cheeks are punctured. The specimens from Sloop Bay, identified by Raymond as *Ch. pompilius*, have the whole surface papillose, the pustules being small and thickly scattered over the glabella and cheeks, but rather sparingly on the margins and spines. It therefore seems best to refer these specimens from Sloop Island to a new species.

From *Cheirurus pompilius* Billings, *Ceraurus granulatus* is distinguished by the granulate condition of the cephalon and from the other species of *Ceraurus*, by the parallel-sided glabella, and by the faint granulation.

FORMATION AND LOCALITY.—Trilobite Layers, Chazy, Sloop Bay, Valcour Island, N. Y.

CERAURUS BISPINOSUS, sp. nov.

Plate 1, fig. 3, 4.

This species is known only from a fragmentary specimen of a cephalon showing the glabella and one fixed cheek. The fragment shows *C. bispinosus* to have been a ceraurid of medium to large size. The

cephalon is roughly semicircular, and about 0.45 as long as broad. The glabella is very convex, expanding forward and reaching the frontal margin. The expansion is about 1 mm. in 4. The frontal lobe and the first pair of glabellar lobes are much more convex than the posterior ones and compose about two thirds of the glabella. There are three pairs of glabellar furrows; of these, only the posterior pair are deeply incised. There is further a slight constriction running backward from the inner end of each of these two furrows to the neck-furrow. The fixed cheeks are very convex, highest at the eye, and are separated from the glabella by deep dorsal furrows. The free cheeks are apparently small. The eyes are situated far forward on the cheeks and are nearer the glabella than the posterior margin of the cephalon. The distance of the eye from the posterior margin of the cephalon is about 0.5 the length of the glabella. A faint eye-line is present. The neck-furrow is narrow and moderately deep. The whole cephalon is surrounded by a convex border which is rather wide on the cheeks, but very narrow in front of the glabella. The cephalon is covered with scattering pustules and the cheeks are in addition thickly indented with small pits. On the glabella, three pairs of pustules, two on the frontal lobe and one on the first segment are more strongly developed than the rest of the pustules. Of these, the second pair are the largest and resemble a pair of short, heavy, horn-like spines.

REMARKS.— In the general appearance of the cephalon, barring the glabellar spines, *C. bispinosus* is similar to *C. dentatus* and to *C. pleurexanthemus*. In size, however, it is nearer the former than the latter, while the reverse is true with regard to the position of the eye and the eye-lines. The eyes are, however, slightly farther out and forward than in *C. pleurexanthemus*. *C. bispinosus* is most readily distinguished from the other species by the presence of the thick short horn-like spines on the crest of the frontal lobe and by the rapid expansion of the glabella. This species is known only from a single specimen, collected near Ottawa, by Mr. J. E. Narraway, in whose collection the holotype now is.

There was also found the larger part of a free cheek, which may possibly belong to this species. The cheek is roughly triangular, with a curving edge, and is separated from the border by a deep narrow groove. The cheek is slightly convex and is covered with deep pits and small spinules. The facial suture runs backward from the anterior in a gentle curve, curves about the eye, and again gently curving, runs outward to the border. The border is broad, convex, and covered with coarse granules. The animal to which this cheek

belonged was large, apparently two or three times the size of the one to which the type belonged.

FORMATION AND LOCALITY.—*Ceraurus bispinosus* is known only from the Black River limestone, Tetreauville, P. Q.

CERAURUS MILLERANUS Miller and Gurley.

Plate 1, fig. 6–8; Plate 2, fig. 6.

? *Calymene bucklandi* Anthony, Amer. journ. sci., 1839, 36, p. 106, fig. 1, 2.

Ceraurus milleranus Miller and Gurley, Bull. Illinois state mus. nat. hist., 1893, p. 80, pl. 8, fig. 10.

Ceraurus does not seem to be particularly plentiful in the vicinity of Cincinnati, and the vertical range would appear to be very limited. According to Nickles, (Journ. Cinc. soc. nat. hist., 1902, 20, no. 2), *Ceraurus milleranus* is found only in the Corryville division of the Lorraine.

In the Dyer collection in the M. C. Z. there are a number of specimens of *Ceraurus* collected at Cincinnati, none of them absolutely complete, but several of them nearly entire, and well preserved. These specimens differ from specimens of *Ceraurus pleurexanthemus* at Trenton Falls in having shorter and less flaring spines at the genal angles, and in having the eyes less elevated, and further back.

Two names have been applied to the Cerauri at Cincinnati. The *Calymene bucklandi* of Anthony is evidently, from the figure, a *Ceraurus*, but the revival of his name is objectionable, because the type is not now accessible, the figure and description are poor, and the original specimen is not complete enough to show the important characters, should it ever be found. The other name, *Ceraurus milleranus*, is open to many of the same objections, but fortunately we have, through the kindness of Professor Weller, been able to study the type, which is No. 6,062 in the collection at the Walker Museum of the University of Chicago. This specimen agrees with the other specimens from Cincinnati in the length of the genal spines and the position of the eyes, but the pygidium is peculiar, in having the tips of the great spines very close together. We have before us twenty good pygidia from Cincinnati, and none of them show this feature, although there is some approximation toward it in one or two specimens. We believe that this feature, which Miller and Gurley considered the most

important of their specific characters, is really due to a deformation of the specimen. Measurements have failed to confirm the statements of Miller and Gurley that this *Ceraurus* has a shorter cephalon, wider frontal lobe on the glabella, or a wider and less convex thoracic axis than *C. pleurexanthemus*. Their other points, the shorter and thicker spines on the cheeks, and the thicker and straighter spines on the pygidium, we believe to be well taken, and we would add to them the less convex glabella and the lower eyes, whose position is further back than in *C. pleurexanthemus*. In the matter of the position of the eyes, *C. milleranus* is intermediate in position between *C. pleurexanthemus* and *C. dentatus*. In *C. pleurexanthemus* the eye is further from the posterior margin of the head than from the glabella. In *C. milleranus* it is equidistant from the posterior margin and the glabella, while in *C. dentatus* it is nearer the posterior margin than the glabella.

The part of the pygidium of *C. milleranus* which is between the great spines has a rather undulate marginal outline. The second segment sends off short spines which extend beyond the margin, but they are so short and blunt that they merely make an undulation on the margin. All the specimens seem to be of this same type. The pygidia are, in this respect, very unlike those of *C. dentatus*, but similar to a part of the specimens of *C. pleurexanthemus*.

MEASUREMENTS.—*Ceraurus milleranus* is of about the same size as *C. pleurexanthemus* and about the same general proportions. The type is 39 mm. long without the pygidial spines, or 45.5 mm. long with them. The width at the genal angles is 22 mm., the cephalon is 9 mm. long, the glabella 7 mm. wide at the front and 6 mm. wide at the neck-ring. A larger cephalon is 13 mm. long and 31 mm. wide.

FORMATION AND LOCALITY.—This species has been reported only from the Lorraine in the vicinity of Cincinnati. Cumings (32d Ann. rept. Indiana state geol. surv., 1908, p. 1059) records a pygidium of *Ceraurus* from the Lorraine at Manchester, Indiana, which may possibly be this species.

CERAURUS MISNERI Foerste.

Ceraurus misneri Foerste, Bull. Denison univ., 1909, 14, p. 228, pl. 4, figs. 7A, 7B.

The holotype of this species was found in the Whitewater bed of the Richmond at Richmond, Indiana. It appears, from the photographic illustrations given by Dr. Foerste, to be closely allied to *Ceraurus milleranus*, but differs in having a longer cephalon, a more rapidly

expanding glabella, and in lacking spines at the genal angles. Foerste states that the glabella is 5.5 mm. wide at the back, and 9 mm. wide at the front. As the glabella is 11 mm. long, the rate of expansion is much greater than in *Ceraurus milleranus*, *C. dentatus*, or *C. pleurexanthemus*. The eyes are about equally distant from both glabella and the posterior margin of the cephalon, as in *C. milleranus*. The species shows an approach to *Cheirurus*, in that the glabella occupies a large portion of the cephalon. The pygidium was not described by Foerste, and probably is not preserved on the type.

FORMATION AND LOCALITY.—A rare species in the Whitewater bed at the top of the Richmond, at Richmond, Indiana, and Dayton, Ohio.

CERAURUS NUMITOR (Billings).

Plate 1, fig. 5.

Cheirurus numitor Billings, Catal. Silurian fossils of Anticosti. Geol. surv. Canada, 1860, p. 27, fig. 11.

This trilobite is rare and not at all well known, but is remarkable for the possession of a long and stout spine which projects upward and backward from the neck-ring. No other *Ceraurus* is known with such a spine, and in the whole family of the Cheiruridae this feature is paralleled only in the rare genus *Youngia*. *Nieszkowskia*, it is true, has a central spine on the cephalon, but it springs from the glabella and not from the neck-ring. Somewhat over-rating the importance of this unusual spine, we were at first inclined to refer the species to *Youngia*, but it seems to be a true *Ceraurus*. Billings described the glabella as subcircular, which would make it in agreement with that of *Youngia*.¹ Billings's type is lost, but a specimen in the M. C. Z. collected in Anticosti by the Shaler Expedition, although poor, shows that the glabella expands forward and is covered with pustules as in *Ceraurus*. Moreover, the posterior glabellar furrows are deep, rather wide, and are nearly perpendicular to the axis of the glabella, instead of being faintly impressed and curving backward as in *Youngia*. This specimen also shows that the eye is far forward, as in *C. bispinosus*. The neck-spine, is, unfortunately, broken off. The pustulose character

¹ See Lindstroem, Foerteckning pa Gotlands Siluriska Crustaceer. Kongl. vet.-Akad., Foerhandlingar, 1885, no. 6, p. 49, pl. 18, fig. 11; also Reed, the Lower Paleozoic trilobites of Girvan. Palaeontogr. soc., 1906, p. 148, pl. 19, fig. 8-12, *Cheirurus trispinosus* Young, is the type.

of the glabella and the direction of the posterior glabellar furrows exclude this species from *Cheirurus*.

FORMATION AND LOCALITY.—This species is very rare in the English Head formation, (Richmondian), at English Head, Anticosti.

SPECIES INCORRECTLY REFERRED TO CERAURUS.

ENCINURUS RARUS (Walcott).

Plate 2, fig. 3.

Ceraurus rarus Walcott, 31st rept. N. Y. state mus. nat. hist., 1877, p. 15 (advance sheets); 31st rept. N. Y. state mus. nat. hist., 1879, p. 68.

Through the kindness of Professor Weller we have been able to see the type of this species. The specimen now belongs to the Walker Museum at the University of Chicago, and bears the number 12,322. It retains only the glabella and a part of one fixed cheek, and is 3 mm. long. The glabella is very narrow in front of the neck-ring, but expands rapidly toward the front. The glabella differs from that of any known species of *Ceraurus* in that it contracts in front of the neck-ring, so that the sides are not straight, but concave toward the fixed cheeks. The posterior pair of lobes are also extremely small, and not isolated, the last furrows being straight. All of the glabellar furrows are straight, or turn a little forward at their inner ends, none of them turning back as in nearly all species of *Ceraurus*. These features excite suspicion as the generic identification of the specimen.

The specimen was collected at Beloit, Wisconsin, and Dr. Clarke has described, from that same locality, a species which he called *Encrinurus vannulus*. Although the figure given by Clarke¹ is poor, his description fits the present specimen exactly. He says, in part:—"Lateral furrows obscure, but still more distinctly developed than is usual in this genus. The first pair lies a short distance from the anterior extremities of the dorsal furrows, is short, and directed somewhat anteriorly, the second and third furrows are but slightly longer, somewhat more transverse. . . . Occipital ring broader than the lateral slopes, and expanding considerably beyond the base of the glabella."

As there can be no doubt that Dr. Clarke's specimens belong to the genus *Encrinurus*, and as *Ceraurus rarus* is from the same locality,

¹ Paleontology Minnesota, 1897, 3, pt. 2, p. 739, fig. 56.

and seems to be almost identical with Clarke's specimens, it will be necessary to remove *Ceraurus rarus* to the genus *Encrinurus*. The type of *Encrinurus rarus* (Walcott), is so small and fragmentary that it may be impossible to decide whether or not it is the same as *Encrinurus vannulus* Clarke, so that, at least until new material is obtained, it will be better not to unite the two species.

Walcott's specimen is 3.5 mm. long, and the glabella is 3 mm. wide at the anterior end, and 1.5 mm. wide at the posterior lobes.

FORMATION AND LOCALITY.—Lower Trenton, Beloit, Wisconsin.

EOHARPES PUSTULOSUS (Hall).

Ceraurus? *pustulosa* Hall, Pal. N. Y., 1847, 1, p. 246, pl. 61, fig. 2a-h.

Harpes pustulosa Whitfield and Hovey, Bull. Amer. mus. nat. hist., 1898, 11, p. 68.

The senior author has seen the type of this species in the American Museum of Natural History and agrees with Whitfield and Hovey that it belongs to the Harpedidae. Whether it is to be identified with the widespread, though rare, *Eoharpes ottawaënsis* cannot be determined until a more careful revision of our American Harpedidae is undertaken.

FORMATION AND LOCALITY.—Hall reports the specimen as having come from the upper part of the Black River limestone at Watertown, New York.

OTHER SPECIES COMMONLY LISTED AS CERAURUS.

Beside the above species, wrongly listed as *Ceraurus*, Vogdes's Catalogue contains a number of other species which obviously do not belong to the genus as now restricted.

Cheirurus apollo Billings, may be an *Anacheirurus*, (not *Pseudosphaerexochus* as has been supposed by Raymond). *Cheirurus glaucus* Billings, *Ch. satyrus* Billings, and *Ch. perforator* Billings, belong to *Nieszkowskia*. *Cheirurus vulcanus* Billings, *Ch. prolificus* Billings, and *Ch. mercurius* Billings, seem to belong to *Pseudosphaerexochus*. *Ceraurus niagarensis* Hall, *Ch. tarquinius* Billings, *Ch. nuperus* Billings, and *Ceraurus hydei* Weller, are species of *Cheirurus*, though the last two show a curious parallel development in that they have a *Ceraurus*-like pygidium. *Cheirurus sol*, though very imperfectly known, was made the type of the genus *Heliomera* by Raymond. And lastly,

Cheirurus icarus Billings, *Ch. polydorus* Billings, and *Ch. pompilius* Billings, form a group to which the junior author of this paper is giving a new name.

The European genera *Eccoptychile*, *Actinopeltis*, *Areia*, *Youngia*, *Cyrtometopus*, and *Crotalocephalus* do not appear to have been recognized as yet on the North American continent.



Raymond, Percy E. and Barton, Donald C. 1913. "A revision of the American species of *Ceraurus*." *Bulletin of the Museum of Comparative Zoology at Harvard College* 54, 525–543.

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