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Article XIV.— THE LUNGFISH REMAINS OF THE COAL MEASURES OF OHIO, WITH SPECIAL REFERENCE TO THE SUPPOSED AMPHIBIAN *EURYTHORAX* OF COPE.

By L. Hussakof.

Introduction.

In 1871 Cope described a flat plate, three inches in diameter, from the Coal Measures of Ohio, which he regarded as the interclavicle of a new genus of amphibian and named *Eurythorax sublævis*. The description consisted of only two lines, which read: "The pectoral median shield [*i. e.*, interclavicle] is subround and nearly smooth, and belonged to an animal of four feet in length." (Proc. Amer. Philos. Soc., XII, 1871, 177.)

In his extended account of the Ohio Coal Measures amphibia, in 1875, he gave a more detailed description of this plate, and a figure (Rept. Geol. Surv. Ohio, II, pt. ii, Palæon., 401, pl. xl, fig. 4). No further light has since been thrown on this genus nor have any additional specimens ever been obtained.

Some time ago on examining the type, which is preserved in the Newberry collection in the American Museum, it became apparent that it was not an amphibian interclavicle at all, but the operculum of a lungfish. The occurrence of dental plates, scales and various other lungfish remains in the same formation lent support, if any was needed, to this interpretation.

In the following notes the evidence is presented that this plate represents a lungfish, not an amphibian, and the occasion is taken also to discuss the other lungfish remains from the same formation, most of which belong in the genus *Sagenodus*.

A word may here be said, parenthetically, as to the locality from which all these remains are derived. The specimens were collected about 45 years ago from coal mines — notably one known as the "Diamond Mine" — which have been closed now for many years. The locality is generally referred to in books as Linton, Jefferson Co., Ohio. But in 1905 when I visited it I found that the name Linton had been given up decades ago, and was hardly remembered by any one, the locality having been known for a long time as Yellow Creek. None of the coal mines is at present operated, so that it is impossible today to obtain additional specimens.

I. The Supposed Amphibian Genus *Eurythorax* Cope, Based on a Lungfish Operculum.

The type of *Eurythorax sublævis* Cope (No. 8605, Amer. Mus.), is represented in outline, natural size, in Figure 1. It is a thin plate, 72 mm. in height by 78 in width (slightly restored). It is 4 mm. at its thickest part, in the middle, whence it thins gradually, but not uniformly, in all directions toward the margins. The outer face, which is embedded in the matrix, is slightly convex; the inner is flat. The plate is also perhaps a little flattened, due to pressure. The outer face bears minute punctæ, such as may be seen on the outer faces of other ctenodont opercula. The inner, bears a scatter-

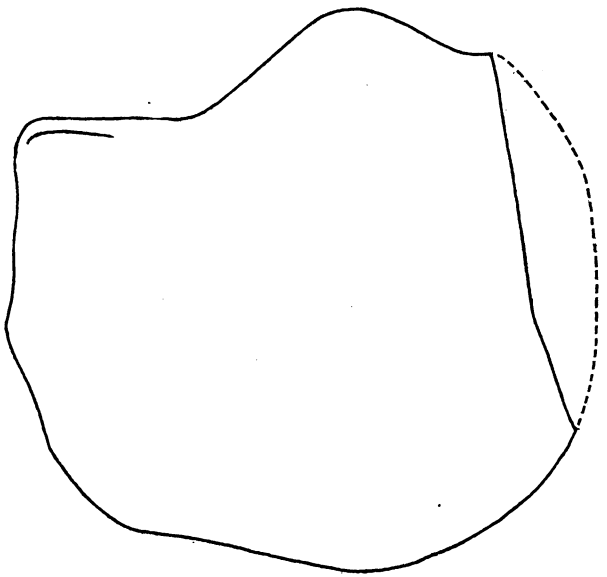


Fig. 1. Operculum of *Sagenodus*. Supposed by Cope to be an amphibian interclavicle, and named *Eurythorax sublævis*. Natural size; No. 8605 Newb. Coll.

ing of incised lines and punctæ radiating from the area below the elevation on its dorsal margin. Cope mistook the inner surface for the outer, saying: "Some delicate radiating grooves are seen on the exposed surface but they are very shallow." These are of course the radiating striæ to be seen on the visceral aspect of most fish plates.

I have carefully compared the plate with two opercula of *Sagenodus* (*Ctenodus*) from the Newsham Coal of England (No. 7800, Amer. Mus.). The latter are both larger, but have about the same proportions of height to

width. The Ohio specimen resembles them in outline, although it differs in details as would be expected in a different species, or, may be, a different genus; but there seems no doubt of its similarity to these elements and of its being the operculum of a lungfish.

The element also agrees with two ctenodont opercula figured by Fritsch (Fauna der Gaskohle, Bd. 2, 1889, pl. 76, figs. 6 and 7). These figures represent two opercula, in inner and outer view, respectively, from the Permian of Bohemia. Fritsch refers them to *Ctenodus obliquus* Hancock and Atthey. Whether this identification be correct or not, the opercula he figures certainly resemble the Ohio one. Like the latter, they show minute punctæ on the outer convex side and radiating lines on the inner.

To sum up — it is obvious on comparison with ctenodont opercula that the plate thought by Cope to be the interclavicle of an amphibian and which he made the type of the genus *Eurythorax,* is really the operculum of a ctenodont fish, probably *Sagenodus.* It differs from the opercula with which it has been compared in minor details, and must be regarded as a distinct species, to be known as *Sagenodus sublævis* (Cope). Should future discovery prove that the other lungfish remains from the Linton beds belong to the same fish, then this name will have to stand for all of them for reasons of priority.

II. Other Lungfish Remains from the Ohio Coal Measures.

Besides the operculum just discussed, a number of other remains of lungfishes — crania, dental plates, scales, etc.— have been described from the Linton beds, by Newberry and by Cope. Several of these have been given specific names. Since they have never been found associated in one fish, and as it is possible that more than one species of lungfish lived in these waters, we must, provisionally at least, retain the several specific names. But it will be useful to bring together in one place a discussion of all these elements and also to put on record several specimens not previously described.

Crania.

Crania are very rare in the Ohio Coal Measures. Only two have been described, and these are perhaps the only ones ever collected.

In 1874, Cope described the larger portion of a cranium under the name *Ctenodus ohiensis* (Proc. Acad. Nat. Sci. Philad., 1874, 91). He further described, and figured it, in 1875 (Rept. Geol. Surv. Ohio, II, pt. ii, Palæon., 410, pl. xlv, fig. 2). A second specimen was briefly described by Newberry,

who gave an outline drawing of the cranial plates (Paleoz. Fishes N. Amer., 1889, 227, fig. 3).

The latter specimen consists of the impression of the right half of a large cranium, preserved in the American Museum (Nos. 8540 and 8541). It has probably suffered some deterioration since Newberry figured it, but not much; and it appears that Newberry's figure, like the one given here (Fig. 2), was made from half of the cranium, the drawing then being folded over and the other half traced from it, thus giving the appearance of having been made from a complete instead of a half specimen.

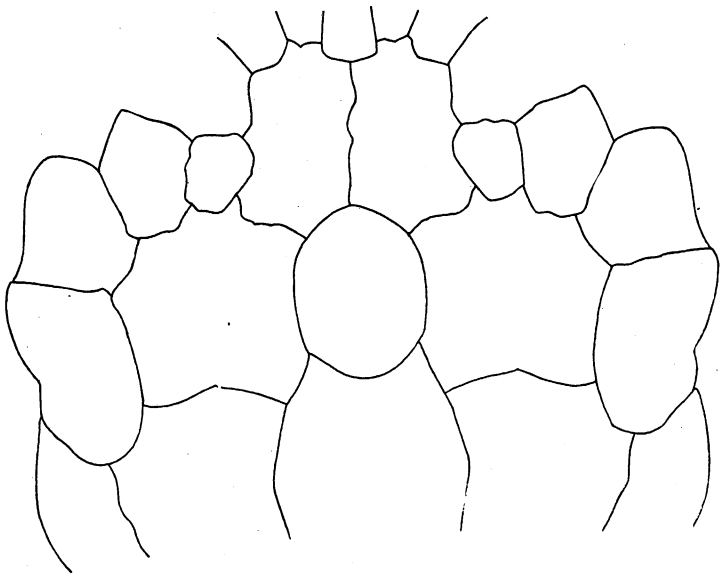


Fig. 2. Cranial plates of *Ctenodus ohiensis* Cope. Drawn from No. 8540 Newb. Coll., which shows only the right half of the cranium. The lateral margins are based on Cope's published figure of another specimen. $\times \frac{1}{2}$.

The entire cranium measured about 16 cm. in length. On the assumption that the ratio of the head to the rest of the body was about as in *Neoceratodus, Sagenodus ohiensis* must have been a fish over 4 feet in length, or as large as the largest specimens of *Neoceratodus*.

Dental Plates.

The lungfish teeth found at Linton, Ohio, were named by Newberry *Ctenodus serratus*. They clearly belong in the genus *Sagenodus* as now understood. The type, a tooth on a piece of coal, in counterpart, is in the

Newberry collection — No. 481 (Fig. 5). Two other dental plates (Nos. 7463 and 7464) and the impression of a third (No. 1887), all smaller than the type, are also in the collection. The three specimens bring out the fact, seen also in other species of *Sagenodus* dental plates, that the smaller teeth are relatively broader than fully grown ones. (*Cf.* Fritsch's Faune der Gaskohle, Bd. 2, 1889, pl. 73).

The type has considerable resemblance to some other species of *Sagenodus* teeth, for instance, to those described by Fritsch, from the Permian of Bohemia and referred by him to *Ctenodus obliquus* Hancock & Atthey (*loc. cit.* pl. 73). It differs from these in the ridges being sharper, and the denticulations fewer, more elongated, and to some extent obliterated.

The species also resembles *Sagenodus fossatus* (Cope), from the Permian of Illinois (Hussakof, Permian Fishes N. America, 1911, pl. 26, figs. 10, 10a, 11), from which it differs chiefly in the ridges being less developed and the denticulation not so plainly marked. It is probable that *Sagenodus serratus* is a direct forerunner of the Illinois Permian species.

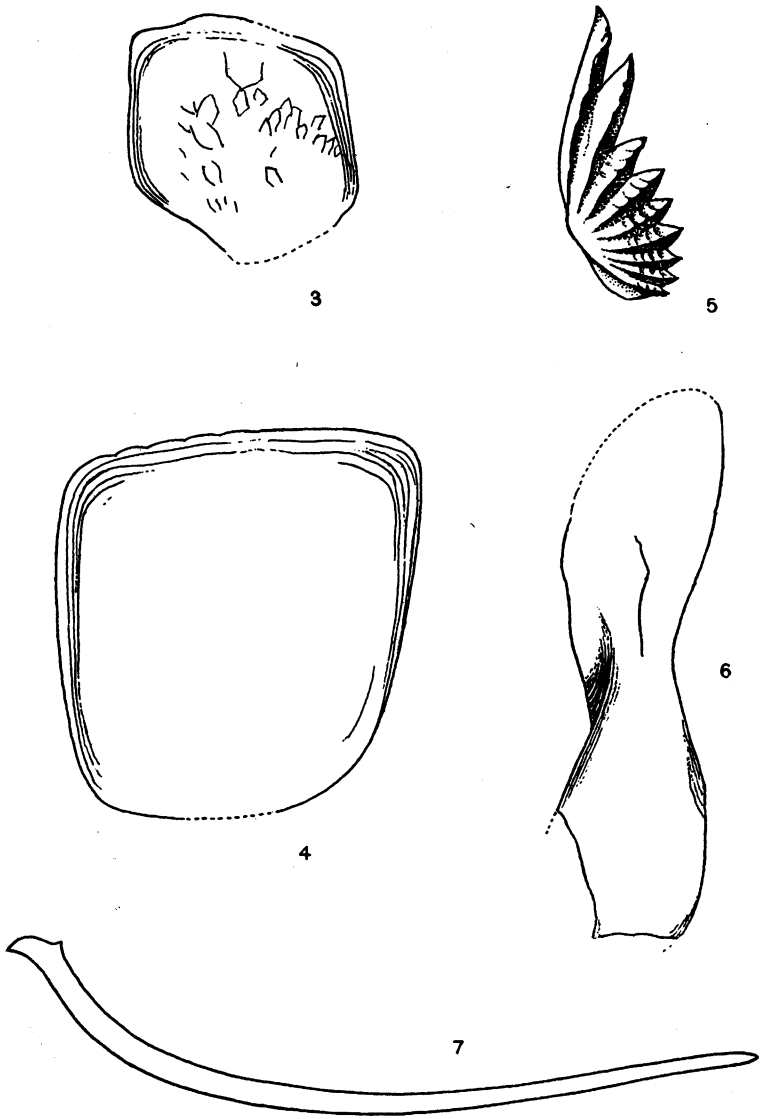
There is also in the Newberry collection a specimen (No. 7461) from the Linton Coal, labeled in Newberry's hand *Ctenodus reticulatus*. He had apparently intended to describe it, perhaps when a more complete specimen turned up, under this name. The specimen is in counterpart. It is very incomplete, shows three very low, rounded ridges radiating from a center, each ridge capped by a wavy, vermiculating line. The specimen is perhaps not a dental plate at all but a fragment of an amphibian scute; the ridges are altogether too low and irregular for a dental plate. This specimen, accordingly, may be ruled out, and we need not modify our view that only a single species of lungfish dental plate is represented in the Linton Coal Measures.

Scales.

Several well-preserved scales from the Linton Coal Measures are extant. The best one was described and figured by Newberry, in 1873, under the name *Rhizodus quadratus* (Rept. Geol. Surv. Ohio, I, Pt. ii, Palæon., 343, pl. 39, fig. 8). This scale and the others of the same kind are now known to belong to lungfishes, and to be referable to the genus *Sagenodus*.

Three such scales are in the Newberry collection in the American Museum. One, preserved in counterpart (Nos. 467 and 467a), is a fine, large scale shown natural size in figure 4. It is very like the type figured by Newberry, although some slight differences from Newberry's figure make it uncertain that it is the type. It measures 49 mm. in height by 48 in width.

A second scale (No. 8529), is smaller and more polygonal (Fig. 3). It



Figs. 3, 4. Scales of *Sagenodus*, natural size. Nos. 8529 and 467 Newb. Coll. The original of Fig. 3 shows the very fine basal fibrillæ, but these are omitted in the figure.

Fig. 5. *Sagenodus serratus* Newb. Drawn from a squeeze of the counterpart of the type, No. 481 Newb. Coll. Natural size.

Fig. 6. Cleithrum of *Sagenodus?* Natural size. No. 8471 Newb. Coll.

Fig. 7. Rib of *Sagenodus*, natural size. Based on two specimens on a piece of coal, No. 8697 Newb. Coll.

measures 32 mm. in height by 29 in width. A third, consists of half of a fine scale similar in size and form to the first of the above mentioned scales.

These scales, between them, show considerable of the finer structure; one can make out the polygonal reticulations and the fine basal fibrillæ. The fine structure of the *Sagenodus* scale was first made known by Fritsch, who figured all the minute details of the scale in exquisite perfection. He also figured the fine detail of the *Neoceratodus* scale for comparison, and proved that the early fossil lungfishes had scales identical in minute structure with those of the living Australian lungfish (Fritsch, *loc. cit.*, pl. 80).

Recently, Cockerell in the course of his studies on the scales of fishes has investigated those of *Sagenodus* on specimens from the Waverly of Mazon Creek, Illinois.[1] His observations entirely substantiate those of Fritsch. The scale of *Sagenodus*, he says, "in appearance and structure essentially agrees with the scale of the living (Australian) *Neoceratodus*. The reticulations are evident and the very fine basal longitudinal fibrillæ are minutely tuberculated."

Cleithrum.

There is in the Newberry collection, the cleithrum of a fish from the Linton Coal (No. 8471), which probably belongs to *Sagenodus*. It is represented, natural size, in figure 6. It is apparently the cleithrum of the left side, shown in outer view. It resembles fairly well the same element in *Polypterus*.[2]

Ribs.

A piece of coal in the collection, from Linton, bears two incomplete ribs, apparently of *Sagenodus* (No. 8697). One lacks only the distal extremity, but the head is well shown. The other consists of the distal two-thirds of a rib. Figure 7, is based on both specimens. They agree well with the ribs figured by Fritsch from the Permian of Bohemia (*loc. cit.*, pl. 79).

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[1] Additional note on reticulated fish scales, Science, n. s., XXXIV, 1911, 865. See also his paper, The scales of the Dipnoan fishes, Sci., n. s., XXXIII, 1911, 831–832.

[2] *Cf.* figures of shoulder girdle of *Neoceratodus* and *Polypterus* given by W. K. Gregory in his paper, Present status of the problem of the origin of the Tetrapoda, Ann. N. Y. Acad. Sci., XXVI, 1915, figs. 5 and 6.