

# Article XIX.—THE CRETACEOUS CHIMÆROIDS OF NORTH AMERICA.

BY L. HUSSAKOF.

## PLATES XIX AND XX.

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### INTRODUCTION.

The chimæroids reached their maximum evolution during the Cretaceous period. They were then represented by a larger number of genera, by a greater abundance of individuals, and by huger forms than at any other period. Among them were fishes ten and fifteen feet in length, to judge by their dental plates as compared with those of living forms. Unfortunately these remarkable chimæroids lived under conditions unfavorable to their preservation as fossils, so that they are known to us only from fragmentary remains — dental plates and fin-spines. And upon these elements alone the morphology and evolution of the group in the Cretaceous must, for the present at least, be based.

Two reviews of Cretaceous chimæroids, both dealing chiefly with European forms, have been published. E. T. Newton's classic memoir 'Chimæroid Fishes of the British Cretaceous Rocks,' appeared in 1878 [22], and Dr. A. S. Woodward's revision in his 'Catalogue of the Fossil Fishes in the British Museum,' in 1891 [27]. In the following pages the American forms are reviewed, upon the collection in the American Museum of Natural History as a basis. This collection includes nearly all of Cope's

types, without which, indeed, this review would have been impossible. It may be mentioned that this is the first of several reviews, of groups of fossil fishes extensively represented in the American Museum collections, which the writer has planned. They are intended as contributions toward a revised check list of American fossil fishes. Such a check list, in which every item has been carefully scrutinized, is indispensable as a basis for all studies on the evolution, the migration and the geological range of the American fish faunas.

The determination of species of chimæroid dental plates is very difficult, owing to their wide range of variation due to age, sex and other circumstances. All who have dealt with this group have found the same difficulty. E. T. Newton, for instance, in his discussion of the British forms, says respecting one species: "Examination of a large series of specimens has shown that *Edaphodon sedgwickii* varies very considerably in the form and size of its teeth; so much is this the case that at first I was inclined to regard some of them as distinct species; gradation of intermediate forms, however, compels me to regard them as merely varieties." [22, p. 8.] And Professor Bashford Dean, writing of the dental plates of living forms, says: "Considerable judgment is necessary to determine accurately species of chimæroids when dental plates alone can be studied, *e. g.*, in the case of many fossil forms. Indeed, with so wide a range of variation, it is quite conceivable that *Chimæra colliciei*, if known only by its dental plates, might be described under several species, and possibly two genera." [9, p. 20.]

In judging the validity of species, in the following pages, I have tried to evaluate all the characters — to separate those which may be due to age, sex or individual variation, from those which may be regarded as specific. Each species has been carefully considered; and more satisfactory results are hardly to be expected, except with the accumulation of much new material.

#### HISTORICAL REVIEW.

Dental plates of chimæroids must have been known in Europe, and especially in England where they occur in the Chalk formations, from times immemorial. But their nature was long not understood: they were regarded as the beaks of turtles or the teeth of reptiles [2]. Their true relationship was discovered by William Buckland, in 1835, who compared them with the bones of various fishes and other animals, and at length recognized their resemblance to the dental plates of *Chimæra*. He read a paper on the subject before the Geological Society of London (first published in 1836 [2]); and his view was at once accepted by Louis Agassiz [2, p. 6].

In America, the earliest reference to fossil chimæroids occurs in a paper by Richard Harlan, published in 1835. He figured a dental plate, which had been found with some sharks' teeth and reptilian vertebræ in New Jersey, and believed it to be the tooth of a reptile — this was before the nature of these dental plates had yet been made out. His figure clearly represents the anterior half of an *Edaphodon* mandibular [14].

The first description of an American fossil chimæroid was published by Leidy, in 1856 [18]. He based a new species, *Edaphodon mirificus*, upon eight upper and lower "maxillary plates." That he appreciated the real nature of these elements is evident from the fact that he referred this material to *Edaphodon*.

Subsequent discoveries in America have resulted in the description of other species of Cretaceous chimæroids — by Cope in 1869 [5, 6, 7]; Marsh, 1870 [21]; and Leidy, 1873 [19]. The number of American forms at present on record is twenty-one, representing nine genera. A list of these is given in the following table.

*Original Names Proposed by Authors for American Cretaceous Chimæroids.*

Original Name	Author	Type	Page
<i>Bryactinus amorphus</i>	Cope, 1875	Small fragmentary dental plate.....	223
<i>Diphrissa latidens</i>	" 1875	Imperfect left mandibular.....	211
" <i>solidulus</i>	" 1869	Left mandibular.....	210
<i>Dipristis meirsii</i>	Marsh, 1869	Large dorsal fin-spine.....	207
<i>Edaphodon mirificus</i>	Leidy, 1856	Eight dental plates.....	204
<i>Eumylodus laqueatus</i>	" 1873	Left vomerine.....	217
<i>Ischyodus divaricatus</i>	Cope, 1869	Right mandibular.....	210
" <i>fecundus</i>	" 1875	Eight mandibulars.....	208
" <i>gaskillii</i>	" 1875	Small left mandibular.....	206
" <i>incrassatus</i>	" 1875	Imperfect right mandibular.....	207
" <i>laterigerus</i>	" 1869	Left mandibular.....	211
" <i>longirostris</i>	" 1875	One mandibular and one palatal.....	208
" <i>monolophus</i>	" 1869	Right and left mandibulars of different fish.....	208
" <i>smockii</i>	" 1869	Several mandibulars.....	213
" <i>stenobryus</i>	" 1875	Pair of mandibulars.....	213
" <i>tripartitus</i>	" 1875	Pair of mandibulars and a left palatal..	215
<i>Isotænia neocæsariensis</i>	" 1875	Left palatal.....	222
<i>Leptomylus cookii</i>	" 1870	Right mandibular.....	219
" <i>densus</i>	" 1869	One mandibular and one palatal.....	218
" <i>forfex</i>	" 1875	Right mandibular.....	221
<i>Sphagepæa aciculata</i>	" 1869	Small spine.....	224

Several writers have shown the necessity for changes in some of these names. A. S. Woodward [27, p. 84] has pointed out, that the species ascribed by Cope to *Ischyodus* belong in *Edaphodon*, Cope having confused the definitions of the two genera. Hay has shown [15, p. 324] that Leidy's *Eumylodus* belongs in *Edaphodon*.

In 1908, the writer published a preliminary review of these forms in his 'Catalogue of Types and Figured Specimens' [16, pp. 37-41], and figured Cope's types which up to then had remained unillustrated. Several of Cope's species, also, were shown to be mere synonyms.

In 1911, Henry W. Fowler, in a review of the Cretaceous and Eocene fishes of New Jersey, republished the original descriptions of the chimæroids of that State, and gave valuable data on the geological horizons of the different species. He also illustrated some of Leidy's types which had remained unfigured.

#### CORRELATION OF THE CRETACEOUS CHIMÆROID HORIZONS OF AMERICA AND WESTERN EUROPE.

There are three localities in America from which Cretaceous chimæroids have been obtained: New Jersey, Mississippi and Wyoming (map, Fig. 1). All are of upper Cretaceous age. The first has yielded the greater number of forms, the others only one each.

The stratigraphy and correlation of the American Cretaceous have been studied by a number of authors, more especially by Charles A. White, 1891, [26], Stuart Weller, 1907, [25], Kümmel, 1911, [17], and Schuchert, 1910, [24]. The exhaustive study of the faunas of the Atlantic and Gulf borders by Stuart Weller, has demonstrated that these formations are divisible into two horizons: a lower, *Ripleyan*, which occurs in the entire Atlantic and Gulf borders; and an upper, *Jerseyan*, which is best developed in New Jersey, and gradually thins out and disappears south of Maryland. The upper, or *Jerseyan* division, is correlated by Weller with the *Danian* of Europe, more especially, with the Maestricht division of the *Danian*. The lower, or *Ripleyan*, he correlates with the *Senonian*. The chimæroids from New Jersey, occurring as they do in the *Jerseyan* formation, are of *Danian* age. In Europe, on the other hand, Cretaceous chimæroids are unknown later than the *Senonian*.

The following table of Cretaceous horizons in New Jersey shows the stratigraphical range of the American chimæroids, and their time relations to European forms.

Correlation of Upper Cretaceous of America (Atlantic Border) and Western Europe.<sup>1</sup>

America		Europe	Chimæroids	
			America	Europe
JERSEYAN	{ Manasquan marl 20'-30' Vincentown sand 25'-70' Hornerstown marl 30' }	= DANIAN (Mæstricht division)	<i>Edaphodon</i> <i>Leptomylus</i> <i>Isotænia</i>	
RIPLEYAN	{ Tinton bed 10'-20' Red Bank sand 0'-100' Navesink marl 25'-40' Mount Laurel sand 40'-80' Wenonah sands Marshalltown clay 30'-35' Englishtown sand 30'-100' Woodbury clay 50' Merchantville clay 60' Magothy formation 25'-50' (including Cliffe-wood clay) }	= SENONIAN		<i>Ischyodus</i> <i>Edaphodon</i> <i>Elasmodus</i> <i>Elasmodectes</i>
	Raritan formation 150'-250'	= ALBIAN		<i>Ischyodus</i> <i>Edaphodon</i>

In the earlier records the chimæroid horizons of New Jersey are usually given as "Greensand No. 5." In the present classification this is equivalent to subdivision K of the Hornerstown marl [11, p. 112]. One or two chimæroids have been found at Birmingham and at Hurffville, New Jersey. At these localities the Hornerstown marl rests directly upon the Navesink with which it forms a continuous bed. It is possible, therefore, that at these localities the chimæroids are from the Navesink, and not from the Hornerstown; by analogy with the other species, however, this seems improbable, and all the New Jersey chimæroids may, provisionally at least, be referred to the Hornerstown.

The following table gives the geological range of the European and American Cretaceous chimæroids so far as at present known.

<sup>1</sup> The stratigraphic subdivisions are according to Stuart Weller [25]; the thicknesses, according to Kümmel [17].

## Geological Range of Cretaceous Chimæroids on Both Sides of the Atlantic.

	Lower Cretaceous				Upper Cretaceous			
	Neocomian	Barremian	Optian	Albian	Cenomanian	Turonian	Senonian	Danian
<i>Ischyodus incisus</i>				—	—	—		
“ <i>latus</i>				—	—	—		
“ <i>planus</i>				—	—	—		
“ <i>thurmanni</i>	—			—	—	—	—	
<i>Elasmodectes willetti</i>	—					—		
<i>Elasmodus crassus</i>							—	—
“ <i>greenoughi</i>							—	—
<i>Edaphodon crassus</i>				—	—	—		
“ <i>laminosus</i>				—	—	—		
“ <i>mantelli</i>				—	—	—	—	
“ <i>reedi</i>				—	—	—		
“ <i>agassizi</i>				—	—	—		—
“ <i>sedgwicki</i>	—			—	—	—	—	—
“ <i>laqueatus</i>							—	—
“ <i>laterigerus</i>							—	—
“ <i>mirificus</i>							—	—
“ <i>stenobryus</i>							—	—
<i>Isotænia neocæsariensis</i>							—	—
<i>Leptomylus cooki</i>							—	—
“ <i>densus</i>							—	—
“ <i>forfex</i>							—	—

This table brings out the following points:

1. Only two species of chimæroids are common to the Cretaceous of Europe and America — *Edaphodon agassizi* and *E. sedgwicki*.
2. The dominant genera in the European Cretaceous are *Ischyodus* and *Edaphodon*; in the American, *Edaphodon* and *Leptomylus*.
3. In Europe no chimæroids are known from the final stage (Danian) of the Cretaceous, whereas in America they are known almost exclusively from this horizon.<sup>1</sup> From this it appears that condi-

<sup>1</sup> The only American form whose horizon is doubtful is *Edaphodon* (*Eumylodus*) *laqueatus* Ledy, which is probably of Senonian age since at the locality where it was found (near Columbus, Mississippi), the uppermost division of the Cretaceous appears to be absent.

tions especially favorable for chimæroid life developed on the American coast later than on the European; that is, with the gradual subsidence of the coast line and the consequent deepening of the American sea, toward the close of the Cretaceous. The center of chimæroid radiation appears then to have shifted from Europe to America.

In connection with the distribution of Cretaceous chimæroids, it is worth noting that no species are at present known from the southern hemisphere, although the group was doubtless represented, since chimæ-

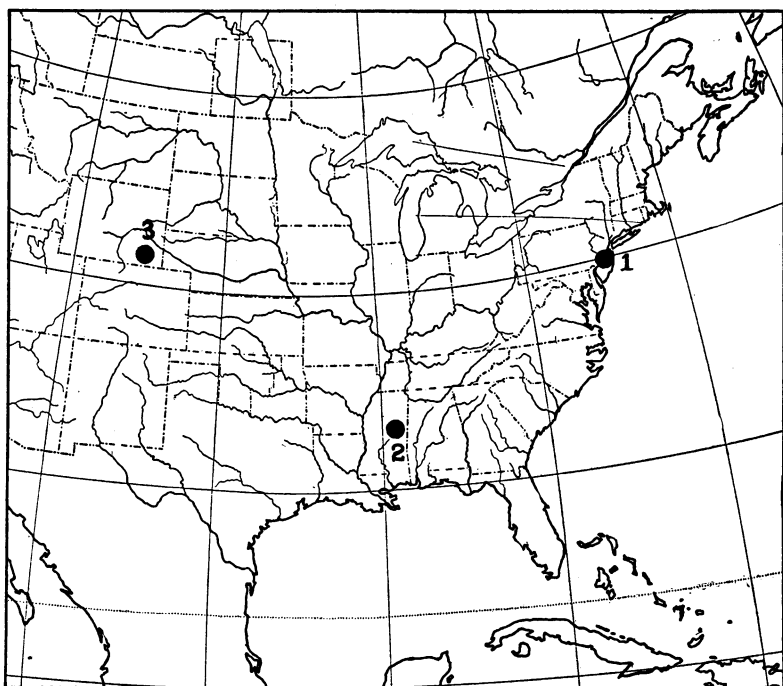


Fig. 1. Map showing American localities from which Cretaceous chimæroids have been obtained.

1. New Jersey: *Edaphodon*, *Leptomylus*, *Isotænia*.
2. Near Columbus, Mississippi: *Edaphodon* (*Eumylodus*).
3. Near Laramie, Wyoming: Egg-case of a chimæroid.

roids occur in the tertiary formations of Australia and New Zealand. A species of *Edaphodon* has been recorded from Amuri Bluff, New Zealand [22, p. 31], and credited to the Cretaceous; but it really belongs in early tertiary times, as has recently been strongly maintained by Chapman and Pritchard. They say: "It is unfortunate that reference to the Amuri

Bluff deposits as Greensand should have been made and perpetuated, considering that the fauna is so distinctly tertiary." [4, p. 64.]

## SYSTEMATIC REVISION.

### Genus *Edaphodon* Buckland.

*Edaphodon* BUCKLAND, Proc. Geol. Soc. London, II, 1838, p. 687.

*Passalodon* BUCKLAND, Proc. Geol. Soc. Lond., II, 1838, p. 687. No description. (Name applied to vomerines only.)

*Psittacodon* AGASSIZ, Poiss. Foss., III, 1843, pp. 340, 348. (Name applied to mandibulars only.)

*Dipristis* MARSH, Proc. Amer. Assoc. Adv. Sci., 1869, p. 230. (Spine only.)

*Diphrissa* COPE, Proc. Amer. Philos. Soc., XI, 1869, p. 244. (Mandibular only.)

*Eumylodus* LEIDY, Rept. U. S. Geol. Surv. Terr., I, 1873, p. 309.

*Bryactinus* COPE, Vert. Cret. Formations West, 1875, p. 282. (Fragment of a vomerine.)

A genus known only from dental plates and dorsal fin-spines. Type species, *Edaphodon bucklandi* Agassiz.

Dental plates, large, massive, in natural association suggestive of a bird's beak; composed of a pair of mandibular, a pair of vomerine, and a pair of palatal elements.

*Mandibular*, beak-like and more or less laterally compressed anteriorly; posteriorly, expanded upward and outward. No definite thickening on outer face. Symphyseal facet broad, extending  $\frac{1}{3}$  to  $\frac{2}{3}$  the length of the mandibular and varying from  $\frac{1}{5}$  to the entire depth of the inner aspect of the beak. Tritors usually four in number: a small one (sometimes two) at tip of beak; one very large tritor (the "median") occupying the inner posterior half of the tooth; and two smaller tritors, along the outer margin, one situated near middle of tooth, the other a short distance posterior to it.

*Palatal*, subtriangular when viewed from oral face. Upper surface with a deep, broad, longitudinal furrow, which extends almost to the anterior margin of the tooth. Symphyseal face smooth and almost vertical; lateral face sloping outward and downward. Tritors large, three in number: two along the symphyseal margin one behind the other; and one situated in the postero-external angle of the tooth.

*Vomerine*, triangular in side view. A row of tritors along the biting edge, on the inner side of the element, extending to the upper surface of the tooth.

*Fin-spines*, large, gently arcuate, and laterally compressed. Anterior margin with a sharp keel; posterior, with a double row of small, sharp, downward-pointing denticles. Lateral faces with faint longitudinal striations.

Fifteen species of *Edaphodon* have been described from the Upper Cretaceous of North America, but only six are valid, the others being referable to them (Fig. 2). These six species are:



1. *Edaphodon mirificus* Leidy.
2.   "   *laterigerus* (Cope).
3.   "   *stenobryus*       "
4.   "   *agassizi* (Buckland).
5.   "   *sedgwicki* (Agassiz).
6.   "   *laqueatus* (Leidy).

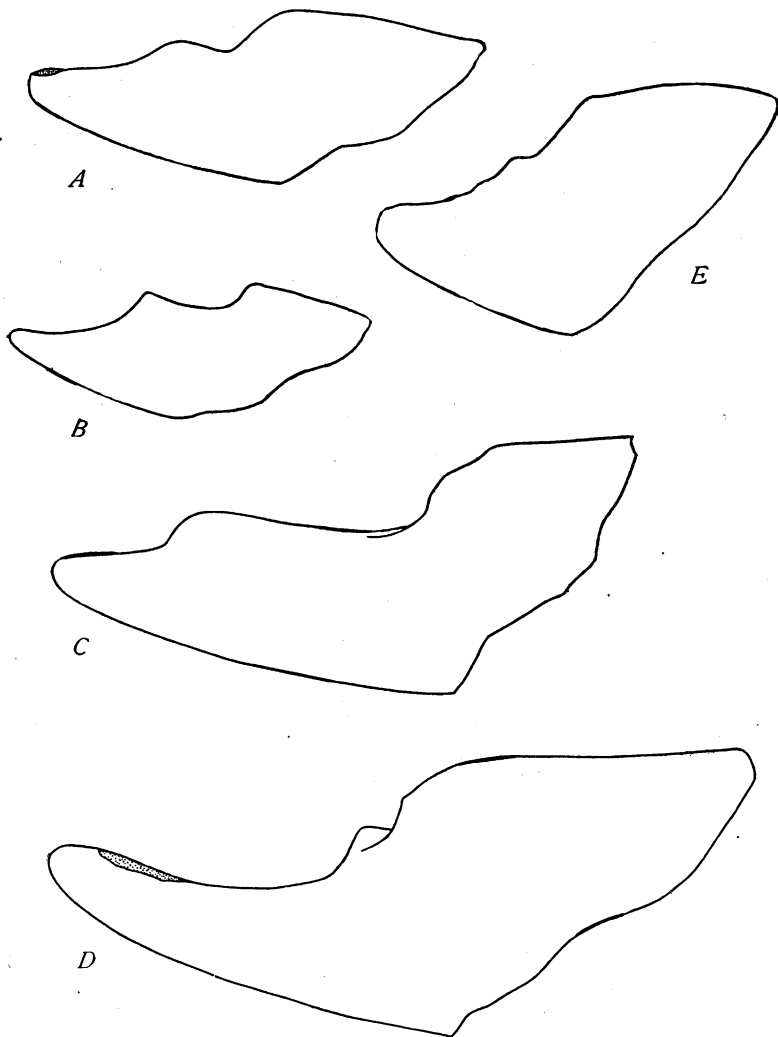


Fig. 2. Diagram-key to the American species of *Edaphodon* of which the mandibular is known. Left mandibulars in outer view.  $\times \frac{1}{2}$ .

A, *Edaphodon mirificus* Leidy; B, *E. agassizi* (Buckland); C, *E. laterigerus* (Cope); D, *E. sedgwicki* (Agassiz); E, *E. stenobryus* (Cope).

**Edaphodon mirificus Leidy.**

1856. *Edaphodon mirificus* LEIDY, Proc. Acad. Nat. Sci. Phila., VIII, p. 221.  
 1869. *Ischyodus mirificus* Leidy, COPE, Proc. Bost. Soc. Nat. Hist., XII, p. 314.  
 1869. *Ischyodus monolophus* COPE, *Ibid.*, p. 314.  
 1869. *Diphrissa solidulus* COPE, Proc. Amer. Philos. Soc., XI, p. 244.  
 1869. *Dipristis meirsii* MARSH, Proc. Amer. Assoc. Adv. Sci., 18th meeting,  
 p. 230. (Fin-spine only.)  
 1873. *Edaphodon mirificus* LEIDY, Rep. U. S. Geol. Surv. Terr., I, p. 306;  
 pl. xxxvii, figs. 6-12.  
 1875. *Ischyodus mirificus* COPE, Vert. Cret. Format. West, p. 291.  
 1875. *Diphrissa latidens* COPE, *Ibid.*, p. 283.  
 1875. *Ischyodus longirostris* COPE, *Ibid.*, p. 287.  
 1875. *Ischyodus incrassatus* COPE, *Ibid.*, p. 289.  
 1875. *Ischyodus gaskillii* COPE, *Ibid.*, p. 290. (Juvenile mandibular.)  
 1875. *Ischyodus secundus* COPE, *Ibid.*, p. 290.  
 1875. *Ischyodus miersii* (Marsh) COPE, *Ibid.* p. 292. (Fragmentary spine and  
 mandibular.)  
 1878. *Edaphodon mirificus* Leidy, NEWTON, Chim. Fishes Brit. Cret. Rocks,  
 p. 24.  
 1908. *Edaphodon mirificus* Leidy, HUSSAKOF, Bull. Amer. Mus. Nat. Hist.,  
 XXV, p. 38, pl. ii, fig. 3.  
 1911. *Edaphodon mirificus* Leidy, FOWLER, Geol. Surv. N. J., Bull. 4, p. 121,  
 figs. 72-75. (Figures of the type specimens.)  
*Type*.—Eight mandibular and palatal teeth. In the collections of the Academy  
 of Natural Sciences, Philadelphia.  
*Horizon and locality*.—Jerseyan, probably "Hornerstown K." (The Jerseyan =  
 Danian of Europe). Hornerstown, New Jersey.

This species is known from the dentition and from fragments of dorsal fin-spines, and may be defined as follows:

*Mandibular* (Fig. 3), over twice as long as deep; its anterior half, in outer view, gradually tapering anteriorward; tritoral prominence at middle of oral margin either present or absent. Middle portion of outer surface concave in the longitudinal axis of tooth. Symphyseal facet, which is usually a smooth, flat area  $\frac{1}{2}$  to 1 centimeter wide, and rarely only a line, extends over half the length of the tooth. Tritors four: a small one, sometimes elongated into a narrow band, at tip of tooth; one very large inner tritor and two smaller outer tritors.

*Palatal*, relatively massive, and more or less triangular when viewed from oral face. A broad furrow, which deepens anteriorward, extends from the posterior margin of tooth to within a short distance of its anterior edge. Externo-lateral face of tooth sloping downward from the outer edge of the furrow. Tritors three: two inner and one outer. Anteriormost tritor begins back of anterior edge of tooth, a distance equal to  $\frac{1}{3}$  or  $\frac{1}{4}$  the length of the tooth. Posterior inner tritor the largest.

*Vomerines*, similar to those of other species, differing only in trivial characters. Eight tritors along oral edge; the four nearest the symphysis long and slender, the next three somewhat shorter, the eighth and last, relatively large and oval. These tritors extend up through the element to its dorsal margin.

This is the most common American Cretaceous chimæroid. Over half the dental plates in collections belong to it; and to it, also, should be referred at least eight of the forms which have been described as distinct

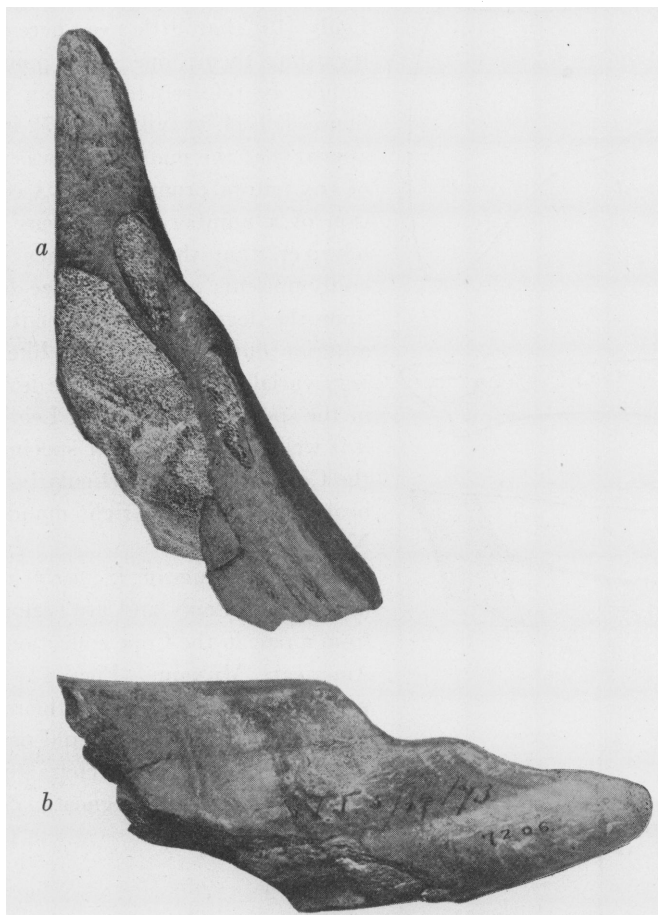


Fig. 3. *Edaphodon mirificus* Leidy. Right mandibular, in oral (a), and outer (b), views. No. 7206 Amer. Mus.  $\times 1$ .

species. Most of these were based on single elements, some on even fragmentary or juvenile ones, and one (*meirsi*) on a fin-spine. All these "species" intergrade nicely, forming an unbroken series from the small form, "divaricatus," to the large, senile form, "incrassatus." The range of variation in this series is not greater than in the materials of *Edaphodon sedgwicki* in the British Museum, which I had the opportunity of examin-

ing, in 1909. A detailed discussion of the forms referred to *E. mirificus* is given below.

The mandibular and palatal elements of *Edaphodon mirificus* have been so carefully described and figured by Leidy [19] that little need here be said regarding them; one small point only should be referred to. From Leidy's figures [19, pl. xxxvii, figs. 6, 7], it might appear that the mandibular was devoid of any tritoral prominence. A comparison of a number of specimens shows, however, that the prominence is generally present; and that its size depends upon the degree of development of the anterior outer tritor, and, like it, is very variable. It is not well developed in the specimen figured by Leidy; but it is well shown in several specimens in the Cope collection, particularly so in a beautifully preserved right mandibular, No. 7206.

The vomerines of *E. mirificus* were unknown to Leidy and are here figured from a pair in the Cope collection in the American Museum (Fig. 4). They were found associated with the rest of a dentition of this species, and probably belong with it. Their characters are summarized in the diagnostic description given above.

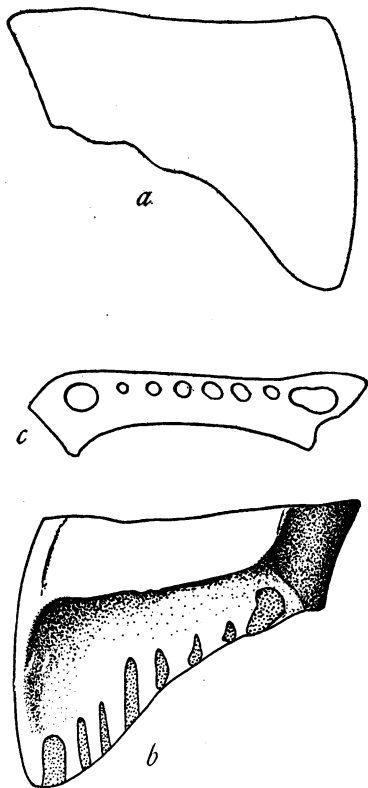


Fig. 4. *Edaphodon mirificus* Leidy. Right vomerine, in outer (a), inner (b), and top (c), views. No. 2223 Amer. Mus.  $\times \frac{1}{3}$ .

#### *Notes on the Species referred to E. mirificus.*

1. *Edaphodon "gaskillii"* (Cope) [Plate XIX, fig. 3 and text-fig. 6, A].—This supposed species was based on an imperfect left mandibular (No. 7196, Amer. Mus.), which, as I have already shown [16, p. 38], represents a young individual of *E. mirificus*. The diagnosis of it was based on the size and position of the tritors; and these seem to be only variations, due to immaturity and individual peculiarities, of the characters shown in *E. mirificus*. Apart from these features, there are none of specific value. The

curvatures of the outer and of the inner margins of the oral face agree entirely with those of *E. mirificus*.

2. *Edaphodon* (*Dipristis*) "*meirsi*" Marsh.—In 1870 Marsh [21] described a large denticulated spine from the Upper Cretaceous of New Jersey, which he correctly identified as the dorsal fin-spine of a chimæroid, and named *Dipristis meirsi*. In 1875 Cope [8, p. 292] described a fragment of a similar spine which had been found associated with a mandibular; and as this mandibular belonged undoubtedly in *Edaphodon*,<sup>1</sup> he relegated the genus *Dipristis* to the synonymy of *Edaphodon*.

Marsh's type is preserved in the geological museum of Yale University, and through the kindness of Professor R. S. Lull, a photograph of it is here reproduced (Plate XX, fig. 1). It is seen at once that Cope's view was correct; that the spine named *Dipristis* is similar to that of *Edaphodon*; indeed, it is very like the spine of *Edaphodon agassizi* figured by Newton [22, pl. iii, fig. 3].

Cope's specimen of this spine (Fig. 5) and its accompanying mandibular are preserved in the American Museum (No. 7202). The mandibular is identical with that of *Edaphodon mirificus*, the characters said by Cope to be peculiar to *E. meirsi* being only variations of those seen in *E. mirificus*. Hence *Dipristis* (*Edaphodon*) *meirsi* must be considered a synonym of *E. mirificus*.

3. *Edaphodon* "*incrassatus*" (Cope) [Plate XIX, figs. 8, 9; text-fig. 6, D].—This species was based on an imperfect right mandibular (No. 2234 Am. Mus.), distinguished from that of *E. mirificus* by the greater thickness of the "beak." In other respects it is similar to *mirificus*. Another and larger right mandibular (Fig. 6, E), in the Cope collection (No. 7198) accompanied by both palatals, is comparable with Cope's *E. incrassatus*. It is even larger, heavier and thicker than the latter, the tritoral area is almost flat and half again as wide as in a typical *E. mirificus* mandibular. Nevertheless this tooth is so suggestive of the latter species, in arrangement of tritors, conformation of outer face, direction of oral and post-oral margins, that it should not be separated specifically. The pair of palatals associated



Fig. 5. Fragment of a chimæroid dorsal fin-spine of the form named *Dipristis meirsi* by Marsh; found associated with a mandibular of *Edaphodon mirificus*. No. 7202 Amer. Mus. Natural size.

<sup>1</sup> Through a confusion of definitions, Cope referred this spine to *Ischyodus*, not to *Edaphodon*; but it is obvious that he had the latter genus in mind.

with it, and presumably belonging to the same individual, differ from those of *E. mirificus* only in size and in some minor points. It seems probable that these heavy specimens represent senile individuals of *E. mirificus*, and that with age the dental plates of this species increased greatly in thickness without a corresponding increase in length. This is borne out by arranging a series of mandibulars leading from the smallest, slenderest form to the largest and presumably oldest form (Fig. 6).

4. *Edaphodon* "monolophus" (Cope).—A species founded by Cope in 1869 [5, p. 314] on right and left mandibulars (No. 2229 Am. Mus.) belonging to different fishes. The right mandibular is fragmentary, lacking both anterior and posterior portions including the second outer tritor; nevertheless there is no doubt of its identity with the same element in *E. mirificus*, from which it does not differ in any essential feature.

The left mandibular is more perfect and shows characters suggestive of both *E. mirificus* and *E. "longirostris"*; indeed it may be regarded as a gradation between the two.

5. *Edaphodon* "longirostris" (Cope) [Plate XIX, figs. 6, 7].—The types of this species were a mandibular (No. 2230 Amer. Mus.) and a palatal. The former differs from *E. mirificus* only in minor points. The "beak" is rather longer and narrower than is usual in *E. mirificus*; but the arrangement of tritors is exactly as in *mirificus*, except that the outer anterior one is situated "on a horizontal step, which forms a strong angle of the outer border. This border is, therefore, abruptly excavated from that point forward, while the inner border descends gradually from the inner angle." The symphyseal facet occupies about three-fourths the length of the entire element. On the whole its characters do not differentiate it from *E. mirificus*.

The palatal mentioned by Cope as accompanying the type mandibular is characterized by "the small size and posterior position of the anterior [tritoral] area, so that the bone appears to be more produced. The posterior areas are large." A palatal answering to this description is No. 2239, American Museum; but it is not certain that it is the identical one described by Cope; and on the whole there is doubt whether its characters are really of specific value.

6. *Edaphodon* "fecundus" (Cope) [Plate XIX, figs. 4, 5; Plate XX, figs. 2, 3; text-fig. 6, B].—The types of this species are seven mandibulars and one palatal (No. 2225 Amer. Mus.) from the Greensand at Hornerstown, New Jersey—probably Hornerstown "K." The mandibulars are not well-preserved, being weathered along the oral faces so that the tritoral areas are imperfectly delimited. Comparison of these elements with those of *E. mirificus*, especially the "*meirsii*" form, proves that they grade into the latter and cannot be separated specifically from it.

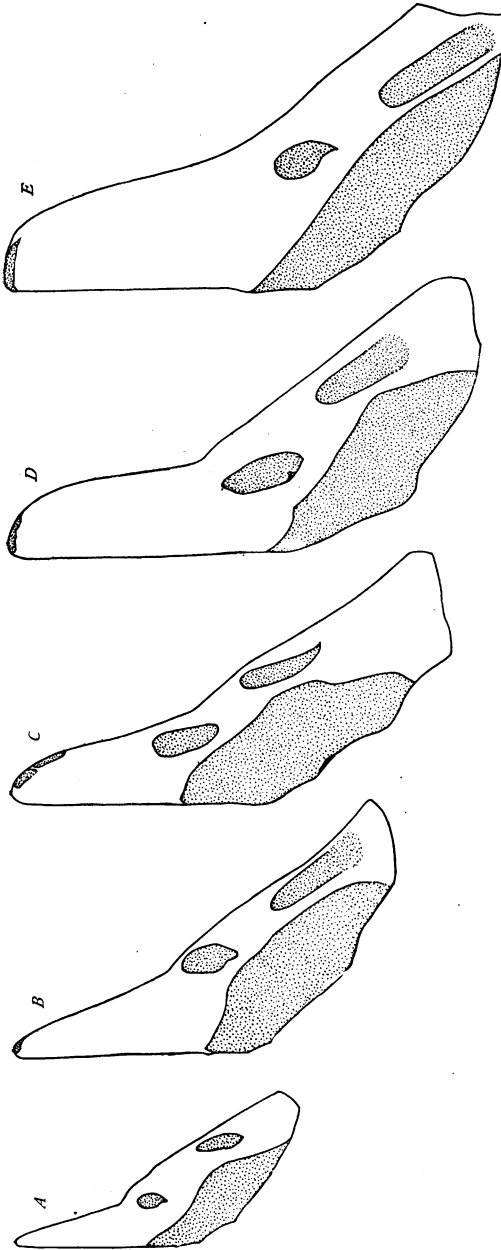


Fig. 6. Variations in the mandibular of *Edaphodon mirificus*, showing characters on which various supposed species have been based.  $\times \frac{1}{2}$ .  
A, immature mandibular of the form described as *Edaphodon* "gaskilli" and *E.* "divaricatus"; B, *Edaphodon* "fecundus"; C, *Edaphodon mirificus*, *E.* "monolophus"; D, *Edaphodon* "incrassatus"; E, a senile mandibular of the "incrassatus" variety (No. 7198 Amer. Mus.).

Cope's diagnosis was based chiefly on the size and form of the tritons — characters at present not regarded valid criteria of species. He mentions the fact that some of the eight type mandibulars are accompanied by "maxillary plates", *i. e.*, palatals. In the American Museum collection there are seven of these mandibulars and one palatal; and it is not entirely certain that the latter belongs with the mandibulars. The characters of the palatal as given by Cope are too general to be of value in separating species. He says: "The maxillaries [*i. e.*, palatals] are narrowed and truncate in front; the areas are large, especially the posterior. The superior groove is deep, and the outer face extensive and longitudinally ridged." This description would apply to the palatal of any species of *Edaphodon*.



Fig. 7. *Edaphodon* "latidens" (Cope). Type mandibular in oral aspect. No. 2232 Amer. Mus.  $\times \frac{1}{3}$ .

7. *Edaphodon* "divaricatus" (Cope) [Fig. 6, A].—Founded upon a right mandibular preserved in the Museum of the Philadelphia Academy of Sciences [see Fowler, 11, p. 124, fig. 76]. Three mandibulars which Cope subsequently referred to this species are in the American Museum (No. 2229). A careful study of these referred specimens shows that they grade nicely into *E. "fecundus"*; and this form as shown above belongs in *E. mirificus*. The symphyseal facet of the mandibular is usually narrower in the "divaricatus"

form than in typical *E. mirificus*; in one of Cope's three referred specimens, however, it is as broad as in *E. mirificus*. Other differences, such as the shape and the lateral arching of the oral face, may be passed over as variations rather than specific characters.

8. *Edaphodon* (*Diphryssa*) "solidulus" (Cope) [Plate XIX, figs. 1, 2].—This genus and species were founded on a unique left mandibular (7193 Amer. Mus.), which is smaller than that of *E. mirificus*, resembling, in this regard, the mandibulars of *Edaphodon* "divaricatus," with which it agrees almost exactly in other regards. The type is hardly distinguishable from a mandibular of *E. "divaricatus"* in the American Museum collection (one of three mandibulars, No. 2229). Concerning this form Cope wrote:

"This species is nearest the *I. [Edaphodon] divaricatus* m. It differs in many respects, among which are the absence of anterior outer [tritral] area, and of prominence of the inner lip, and the greater reduction of the



terminal column. Its lack of dental development allies it to the *Leptomylus* m." [6, p. 244.]

Whence it appears that the only differences Cope found between this mandibular and that of *E. divaricatus* were in the tritors and oral configuration; and these features, as shown above (p. 196) are not important enough to warrant specific separation.

9. *Edaphodon* (*Diphrissa*) "latidens" Cope [Fig. 7].—The mandibular named by Cope *Diphrissa latidens*, I refer, with some hesitation, to *Edaphodon mirificus*. The type and only specimen is an imperfect left mandibular (No. 2232 Amer. Mus.). It is poorly preserved, the outer face having been almost completely weathered away; and the element has been much distorted by vertical and lateral pressure, so that the oral surface has become flattened out in the region of the tritors and distorted anteriorly. None the less this dental plate has considerable resemblance to the "divaricatus" variety of *E. mirificus*; and it seems best to refer it to that genus and species.

#### ***Edaphodon laterigerus* (Cope).**

1869. *Ischyodus laterigerus* COPE, Proc. Amer. Philos. Soc., XI, p. 243.

1875. *Ischyodus laterigerus* COPE, Vert. Cret. West, pp. 284, 288.

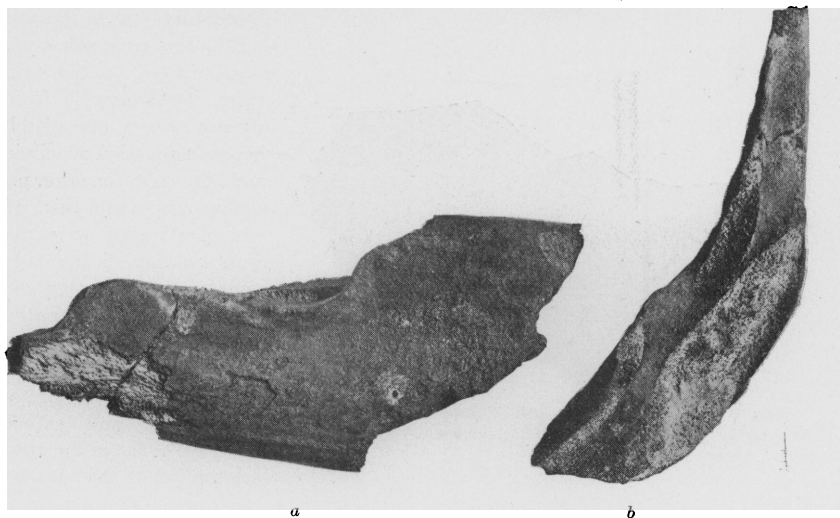


Fig. 8. *Edaphodon laterigerus* (Cope). Left mandibular in outer (a), and oral (b), views. Type, No. 2238 Amer. Mus.  $\times \frac{1}{4}$ .

1891. *Edaphodon laterigerus* (Cope) A. S. WOODWARD, Catal. Fos. Fishes, II, p. 85.

1908. *Edaphodon laterigerus* (Cope) HUSSAKOF, Bull. Amer. Mus. Nat. Hist., XXV, p. 38, pl. i, figs. 7, 8.

1911. *Edaphodon laterigerus* (Cope) FOWLER, Geol. Surv. N. J., Bull. 4, p. 113, fig. 65.

*Type*.—A left mandibular (Figs. 8, and 2, C). Cope collection, No. 2238 American Museum.

*Horizon and locality*.—Jerseyan, Hornerstown "K" (= Danian of Europe); Hornerstown, New Jersey.

This species is known only from the type specimen; but this offers such marked characters that there is no doubt of its specific validity.

Anterior portion of mandible elongated and laterally compressed. Symphyseal facet nearly half the length of entire element. Anterior outer tritor much elongated

antero-posteriorly; posterior outer tritor small, suboval; inner tritor large, elongated, extending forward a distance equal to about three-fifths the length of the whole element, with its greatest width contained about two and one-half times in its total length. Tritoral prominence greatly elongated, presenting, in side view, an almost straight line, more than half the total length of the dental plate; at its anterior end this line curves downward, considerably in advance of the tritor. Oral face, in front of anterior tritors, occupied by a shallow depression which slopes gradually from the outer prominence to the symphysis. If the two mandibulars were placed in natural association, the anterior median portion of the "beak" would be, as noted by Cope, occupied by an elongated excavation walled in laterally by the two anterior outer prominences, and extending backward as far as the anterior termination of the tritors.

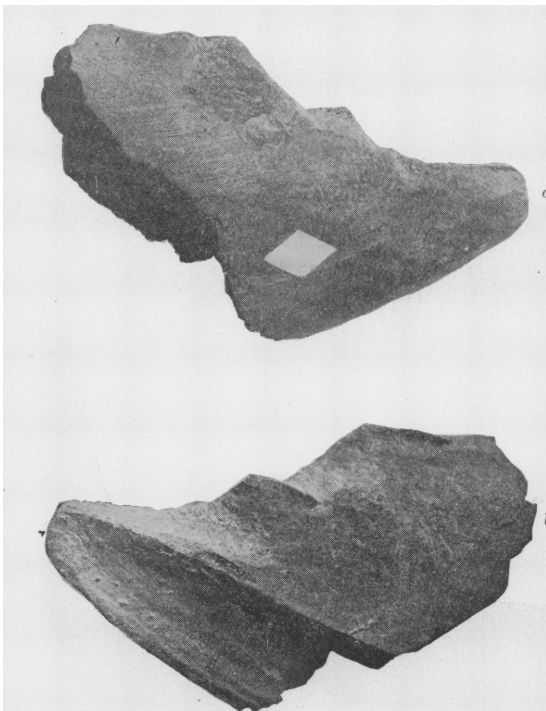


Fig. 9. *Edaphodon stenobryus* (Cope). Right mandibular in outer (a), and oral (b), views. Type. No. 7204 Amer. Mus.  $\times \frac{1}{2}$ .

#### Measurements of the Mandibular.

Total length of mandibular (slightly restored)	140 mm.
Depth in region of posterior outer tritor	68 "
Depth opposite middle of anterior outer tritor	40 "
Length of anterior outer tritor	43 "
Length of posterior outer tritor	17 "
Length of inner outer tritor	80 "

**Edaphodon stenobryus (Cope).**

1875. *Ischyodus stenobryus* COPE, Vert. Cret. West, p. 285.

1891. *Edaphodon stenobryus* (Cope) A. S. WOODWARD, Cat. Fos. Fishes, Part II, p. 85.

1908. *Edaphodon stenobryus* (Cope) HUSSAKOF, Bull. Amer. Mus., XXV, p. 39, pl. ii, figs. 6, 7.

1911. *Edaphodon stenobryus* (Cope) FOWLER, Geol. Surv. N. J., Bull. 4, p. 111, fig. 63.

*Type*.—A pair of mandibulars (Figs. 9, and 2 *E*). Cope Collection, No. 7204 American Museum.

*Horizon and locality*.—Jerseyan, probably Hornerstown "K" [= Danian of Europe]; Hornerstown, New Jersey.

A well-marked species distinguished by its form, height as compared with length, and by its lateral compression. As remarked by Cope, this species has considerable resemblance to *Leptomylus*, more so than any other species of *Edaphodon*.

**Edaphodon agassizi (Buckland).***European Materials.*

1835. *Chimæra agassizi* BUCKLAND, Proc. Geol. Soc. London, II, p. 206.

1843. *Ischyodus agassizi* (Buckland) EGERTON, Proc. Geol. Soc. London, IV, p. 156.

1843. *Chimæra (Ischyodus) agassizii* Buckland, AGASSIZ, Poiss. Foss., III, p. 341, pl. xl, a, figs. 3, 4, (?5); pl. xl, c, fig. 16.

1875. *Chimæra agassizii* Buckland, GEINITZ, Palæontogr., XX, p. 206, pl. xxxix, figs. 8–10.

1878. *Edaphodon agassizii* (Buckland) E. T. NEWTON, Chim. Fishes Brit. Cret. Rocks, p. 12, pl. iii.

1891. *Edaphodon agassizi* (Buckland) A. S. WOODWARD, Catal. Fos. Fishes Brit. Mus., II, p. 77.

*American Materials.*

1869. *Ischyodus smockii* COPE, Proc. Bost. Soc. Nat. Hist., XII, p. 316.

1875. *Ischyodus smockii* COPE, Vert. Cret. West, pp. 284, 288.

1891. *Edaphodon smockii* (Cope) A. S. WOODWARD, Catal. Fos. Fishes, II, p. 85.

1908. *Edaphodon smockii* (Cope) HUSSAKOF, Bull. Amer. Mus. Nat. Hist., XXV, p. 39, pl. ii, figs. 4, 5.

1911. *Edaphodon smockii* (Cope) FOWLER, Geol. Surv. N. J., Bull. 4, p. 115, fig. 66.

*Horizon and locality*.—Jerseyan, probably Hornerstown "K" [= Danian of Europe]; Hornerstown, New Jersey.

The three mandibulars on which Cope based his *Ischyodus smockii* are preserved in the American Museum (No. 7192). They differ from all other American species by the presence of very large angulated oral prominences which appear like steps in outer view (Figs. 10, and 2, *B*). These angula-

tions vary with age from  $90^{\circ}$  to  $105^{\circ}$ . On comparing these mandibulars with the accounts of European species it is found that they agree with the description and figures of *Edaphodon agassizi* (Buckland); indeed, the figures of this species given by Newton [22, pl. iii, figs. 4, 5] might almost have been drawn from Cope's types of *I. smocki*. It appears, therefore, that *Ischyodus smockii* Cope must be considered a synonym of *Edaphodon agassizi* (Buckland). This species and *E. sedgwicki* (= *E. tripartitus* Cope), are the two European species represented in the Upper Cretaceous of America.

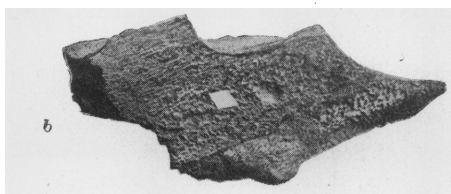
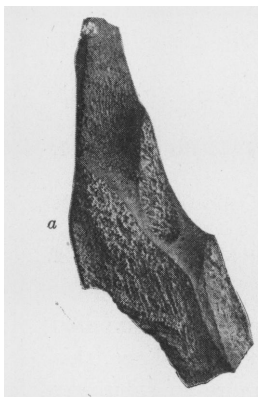


Fig. 10. *Edaphodon agassizi* (Buckland). Right mandibular in oral (a), and outer (b), views. One of the co-types of *E. "smockii"* (Cope). No. 7192 Amer. Mus.  $\times \frac{1}{2}$ .

*E. agassizi* (*smockii*) it is abbreviated. In the former the anterior marginal prominence ("step") is rounded at the angle, whereas in the latter it is sharp.

A pair of well-preserved palatals of this species are also in the Cope collection (No. 7194 Amer. Mus.). They were found associated with mandibulars so that it seems reasonably certain that they belong to this species. Their form, in oral aspect, and the size and arrangement of the tritons is shown in Fig. 11. These palatals are relatively wide and shallow, grooved along the dorsal surface; the groove occupying about two-thirds of the width of the upper surface. The lateral walls of the elements do not converge rapidly anteriorly.

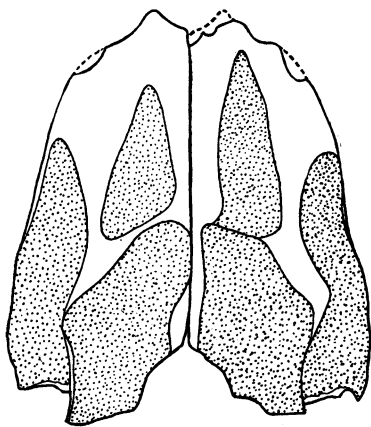


Fig. 11. *Edaphodon agassizi* (Buckland). Pair of palatal elements in oral aspect. No. 7194 Amer. Mus.  $\times \frac{1}{2}$ .

*Measurements.*

Length of right palatal.....	80 mm.
Width of tritoral surface, at middle of element.....	27 "
Depth at anterior extremity of outer tritor.....	17 "

***Edaphodon sedgwicki* (Agassiz).***European Materials.*

1843. *Chimæra* (*Psittacodon*) *sedgwickii* AGASSIZ, Poiss. Foss., III, p. 349, pl. xl, figs. 17, 18.
1843. *Ischyodus sedgwicki* (Agassiz) EGERTON, Proc. Geol. Soc. London, IV, p. 156.
1847. *Edaphodon sedgwicki* (Agassiz) EGERTON, Quart. Journ. Geol. Soc., III, p. 352.
1878. *Edaphodon sedgwickii* (Agassiz) NEWTON, Chim. Fishes Brit. Cret. Rocks, p. 7, pl. i, ii.
1901. *Edaphodon sedgwicki* (Agassiz) WOODWARD, Catal. Foss. Fishes Brit. Mus., II, p. 73.
1906. *Edaphodon sedgwicki* (Agassiz) LERICHE, Poiss. Crét. du Nord de la France, p. 52.

*American Materials.*

1875. *Ischyodus tripartitus* COPE, Vert. Cret. Formations West, p. 286.
1891. *Edaphodon tripartitus* (Cope) WOODWARD, Catal. Fos. Fishes Brit. Mus., II, p. 85.
1908. *Edaphodon tripartitus* (Cope) HUSSAKOF, Bull. Amer. Mus. Nat. Hist., XXV, p. 40, pl. iii, figs. 5, 6.
1911. *Edaphodon tripartitus* (Cope) FOWLER, Geol. Surv. N. J., Bull. 4, p. 112, fig. 64.

*Horizon and locality.*—Jerseyan [= Danian of Europe]; Hurffville, New Jersey.

It has long seemed doubtful to me whether *Edaphodon tripartitus* (Cope) should stand as a distinct species, or be merged in *Edaphodon sedgwicki* Agassiz. Considering all the evidence, it appears that the two should be merged. Cope's types of *E. tripartitus* (Figs. 12, and 2, *D*) were a pair of mandibles and a left palatal (Cope collection, No. 2224 Amer. Mus.). On going over the descriptions of *Edaphodon sedgwickii* given by Newton [22, p. 7] with one of Cope's specimens of *E. tripartitus* in hand, it is seen that there is hardly a character mentioned in the description which is not to be found in this mandibular. Cope's types resemble figures 1 and 2 of Newton's illustrations of *E. sedgwickii* [22, pl. ii]; but it should be borne in mind that the mandibulars of *E. sedgwicki*, as pointed out by Newton, are exceedingly variable, and an exact correspondence between the American form and the European specimens he figures is hardly to be

expected. Cope mentions the fact that the median tritor of his *E. tripartitus* is divided into three parts. This agrees with the European species

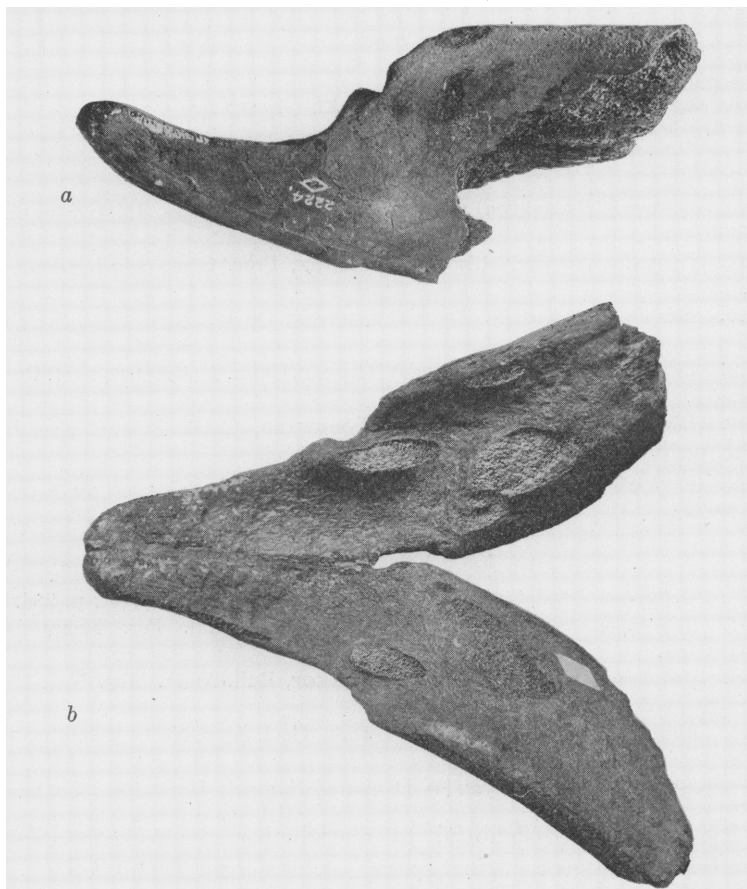


Fig. 12. *Edaphodon sedgwicki* (Agassiz). Left mandibular in outer view (a), and both mandibulars in oral view (b). Types of *E. "tripartitus"* (Cope). No. 2224 Amer. Mus.  $\times \frac{1}{2}$ .

in which the large median tritor is made up of two, and sometimes even of several, divisions.

The palatal element associated in the Cope collection with the mandibulars of *E. tripartitus*, differs somewhat in shape from the palatals figured by Newton [22, pl. ii, figs. 12, 13]; but there is no certainty that this palatal belonged with these mandibulars; it may be of a different species.

***Edaphodon laqueatus* (Leidy).<sup>1</sup>**

1873. *Eumylodus laqueatus* LEIDY, Extinct Vert. Fauna W. Terr., p. 309, pl. xix, figs. 21, 22; pl. xxxvii, figs. 13, 14.

1875. *Eumylodus laqueatus* Leidy, COPE, Vert. Cret. Form. West, p. 282.

1891. *Edaphodon laqueatus* (Leidy) WOODWARD, Catal. Fos. Fishes Brit. Mus., II, p. 86.

1902. *Edaphodon laqueatus* (Leidy) HAY, Bull. U. S. Geol. Surv., No. 179, p. 324.

*Type*.—Right vomerine (Fig. 13). No. 5324, Philadelphia Academy of Natural Sciences.

*Horizon and locality*.—Cretaceous sandstone [? = Senonian of Europe]; near Columbus, Mississippi.

The type is the only element of this species known. It undoubtedly belongs in the genus *Edaphodon*, as was long ago pointed out by Woodward [27, p. 86], and not in a distinct genus. In trivial characters this vomerine differs from all others yet known, and must be retained, for the present at least, as a distinct species. Its chief characters are shown in Fig. 13. The salient parts of Leidy's description of it may here be quoted:

"The outer surface is nearly flat, but slightly depressed below, and bent outwardly behind from the triturating surface. The inner surface is fluted; the anterior third presents a succession of three curved ridges separated by two grooves; the median third forms a wide, concave groove; and the posterior third forms a nearly square plane, sloping from the triturating surface backward and inward, and defined by a subacute border from the outer surface of the bone."

Leidy speaks of three tritons along the cutting edge, but four are present, the very small, lowermost one having been apparently overlooked.

<sup>1</sup> I am indebted to Dr. Witmer Stone for very kindly having permitted me to study the type of this species, which is in the collections of the Academy of Natural Sciences, Philadelphia.

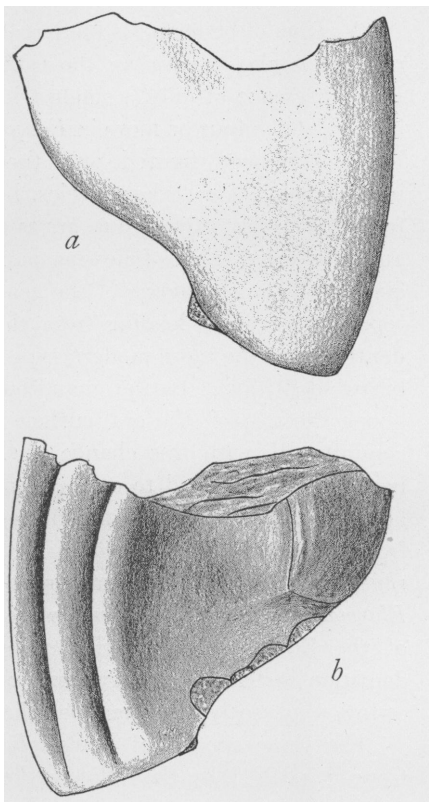


Fig. 13. *Edaphodon laqueatus* (Leidy). Right vomerine in outer (a), and inner (b.) views. Type of *Eumylodus laqueatus* Leidy, No. 5324 Acad. Nat. Sci. Philadelphia.  $\times \frac{1}{4}$ .

Genus **Leptomylus** Cope.

*Leptomylus* COPE, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 313.

A genus of chimæroids known only from mandibular elements, founded on *Leptomylus densus* as the type species. Its distinguishing character is the presence of only a single tritor on the oral face of the mandibular, instead of the four or more in *Edaphodon* and *Ischyodus*. The type species has never been figured and the whereabouts of the type specimen is unknown. Two other species, however,—*L. cooki* and *L. forfex*—referred by Cope to this genus, are available for study and these are described and illustrated in the following pages. *Leptomylus forfex* illustrates especially well the characters of the genus. From it one sees that *Leptomylus* represents a stage leading from the Edaphodonts, with typical crushing dentition, to the more modern type of chimæroid with typical cutting-and-biting dentition. In the mandibular the outer oral margin has risen above the rest of the oral surface into a sharp cutting edge. And concomitantly with this change the tritors, which functioned in attrition, have become reduced to a single small area. However, on account of its large size, *Leptomylus* cannot be regarded as the connecting form leading from *Ischyodus* and *Edaphodon* to the modern chimæroids such as *Callo-rhynchus*; the transition was probably through forms like *Elasmodus* and *Elasmodectes*. But *Leptomylus* represents an interesting side branch of the Edaphodonts, which developed a more or less cutting-and-biting dentition instead of the grinding one. None the less it became extinct owing, apparently, to other specializations which had arisen.

The three species of *Leptomylus* may be distinguished, according to Cope [8, p. 281], by the following key:

- I. Mandibular tooth without apical tritor:  
     Large, massive, and not compressed.....*L. densus*
- II. Mandibular tooth with apical tritor:  
     a. Outer margin much elevated; inner much depressed; large...*L. forfex*  
     b. Outer margin less elevated; inner equally so; smaller.....*L. cooki*

**Leptomylus densus** Cope.

- 1869. *Leptomylus densus* COPE, Proc. Bost. Soc. Nat. Hist., XII, p. 313.
- 1875. *Leptomylus densus* COPE, Vertebr. Cret. N. Amer., p. 281.
- 1891. *Leptomylus densus* COPE, WOODWARD, Catal. Foss. Fishes Brit. Mus., II, p. 86.
- 1911. *Leptomylus densus* COPE, FOWLER, Geol. Surv. New Jersey, Bull. 4, p. 138.



*Type*.— A mandibular tooth. A palatal tooth was found at the same locality but Cope was not certain that it belonged with the type mandibular.

*Horizon and locality*.— Cretaceous marl pit (probably Hornerstown "K"); Birmingham, New Jersey.

The writer has not seen the type specimen, which has never been figured. Cope's description of it is as follows:

"Anterior extremity [of mandibular] prolonged, and slightly narrowed. The posterior face is plane, transversely concave longitudinally. When the external margin rises, the internal falls off, and the narrow area of dentine is directed obliquely upwards and inwards. The inner face, above an anterior thickened margin as deep as the prolonged beak, is concave, but is again convex near the superior margin. It is marked with coarse and obscure curved lines, which are parallel to the posterior outer margin. The inferior or anterior margin is a contracted ridge, its inner plane vertical, while the superior part of the inner face expands inwards. The dentinal column supporting the tubercle is as large as a goose quill. There are no other columns."

### ***Leptomylus cooki* Cope.**

1870. *Leptomylus cookii* COPE, Proc. Amer. Philos. Soc., XI, p. 384.

1875. *Leptomylus cookii* COPE, Verteb. Cret. N. Amer., p. 382.

1899. *Leptomylus cookii* Cope, Woodward, Catal. Foss. Fishes Brit. Mus., II, p. 87.

1908. *Leptomylus cooki* Cope, HUSSAKOF, Bull. Amer. Mus. Nat. Hist., XXV, p. 41.

1911. *Leptomylus cookii* Cope, FOWLER, Geol. Surv. New Jersey, Bull. 4, p. 137, fig. 85.

*Type*.— An imperfect right mandibular (Fig. 14). Cope Collection, No. 7195 American Museum.

*Horizon and locality*.— "Greensand No. 5" (now Hornerstown "K"; probably equivalent to the Danian of Europe). Near Mt. Holly, New Jersey.

Cope's description of this species is as follows:

"In general form the ramus resembles that of *Ischyodus* [*Edaphodon*] *divaricatus*, the posterior portion being curved outwards from the symphy-



Fig. 14. *Leptomylus cooki* Cope. Right mandibular in oral (a), and outer (b), views. Type. No. 7195 Amer. Mus.  $\times \frac{1}{2}$ .

seal. The latter region is much compressed and moderately prolonged, the inner face quite concave; posteriorly the outer face is also slightly concave. There is a single external crest, which is obtuse, and descends gradually to the plane of the beak, and presents no dentinal area. A single

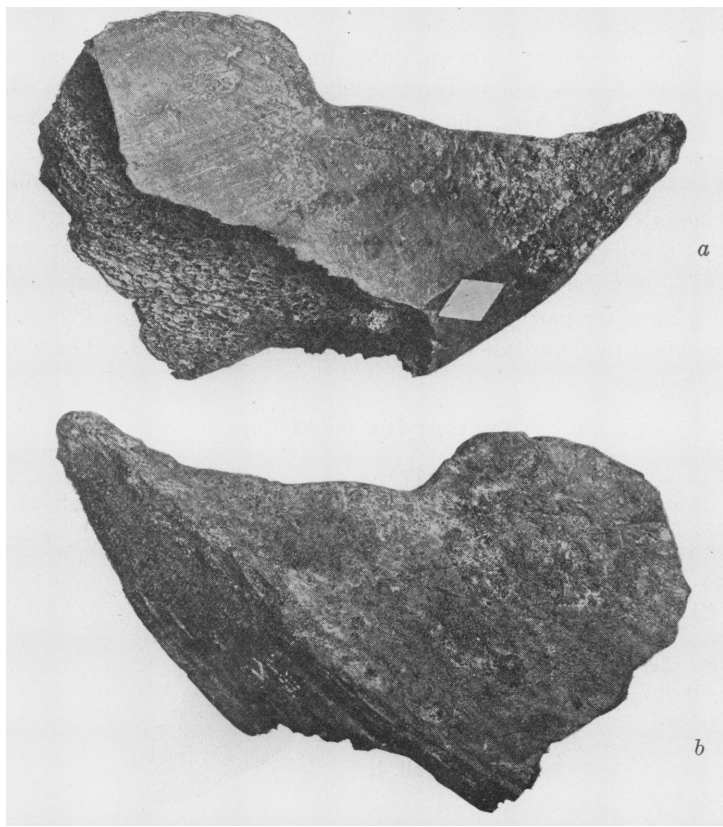


Fig. 15. *Leptomylus forbesi* Cope. Right mandibular in outer (a), and oral (b), views. Cotype. No. 2233 Amer. Mus.  $\times \frac{1}{2}$ .

small oval area represents the internal, so large in *Ischyodus*. It lies along the inner margin. This margin is much thickened, and rolled over inwards; symphyseal face very narrow. The extremity of the beak is broken away, and the section shows that there is no inferior plate-like column, which produces the terminal area in most species of *Ischyodus*, but a round column, which issues on the upper surface of the beak, behind the apex.

"The apical dentinal column of this species, distinguishes it from the *L. densus*, Cope, where no such column exists. It may be noted that at the

posterior fractured section of the jaw, the apical column is seen, while [the] internal dental area is not, the latter occupying only a pocket, not a column."

### ***Leptomylus forfex* Cope.**

1875. *Leptomylus forfex* COPE, Cret. Verteb. N. Amer., p. 281.

1891. *Leptomylus forfex* Cope, WOODWARD, Catal. Foss. Fishes Brit. Mus., II, p. 87.

1908. *Leptomylus forfex* Cope, HUSSAKOF, Bull. Amer. Mus. Nat. Hist., XXV, p. 41, pl. iii, figs. 1, 2.

1911. *Leptomylus forfex* Cope, FOWLER, Geol. Surv. New Jersey, Bull. 4, p. 139, fig. 86.

*Cotypes*.—(1) A right mandibular (Fig. 15); (2) a mandibular and palatine (Fig. 16) of another fish; Cope Collection, Nos. 2233 and 7207 American Museum.

*Horizon and locality*.—"Greensand No. 5" (now Hornerstown marl, "K," which is equivalent to the Danian of Europe). (1) is from Hornerstown, New Jersey, and (2) from near Barnesborough, N. J.

This is a well-marked species characterized by Cope as follows:

"This chimæroid is represented by two mandibles from distant localities, and probably by a maxillary [palatine] bone. The form of these elements is highly characteristic. The mandible is much elevated; but the elevation is confined to the outer side, which rises as a lamina, causing the masticating face to be nearly vertical for much of its length; but a short extent is level to the apex. There is a slight marginal swelling where the anterior outer dental area should be, and an abrupt rise in the margin to the position occupied in *Ischyodus* by the posterior outer area. The inner border of the masticating surface is parallel to the inferior border of the jaw, except where the two converge to the apex; here the entire face included between them is occupied by the large symphyseal facet. The inner dental area is represented by a narrow acuminate patch on the inner angle of the masticatory face, opposite the tuberosity which represents the anterior outer.

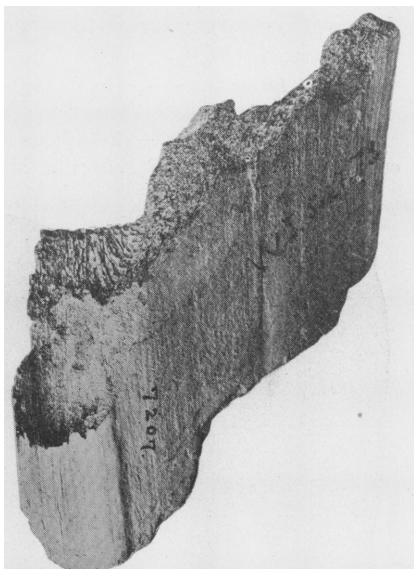


Fig. 16. *Leptomylus forfex* Cope. Left palatal viewed from above. Cotype. No. 7207 Amer. Mus.  $\times 1$ .

The apical area is very narrow, and extends for some distance along the exterior angle of the superior face."

### Genus *Isotænia* Cope.

*Isotænia* COPE, Verteb. Cretac. Formations West, 1875, p. 293.

The genus *Isotænia* is known only from a unique dental plate — a palatal — described and named by Cope in 1875. It represents, apparently, a good genus although little is yet known concerning it. This palatal differs from that of *Edaphodon*, (1) in the absence of a furrow on the upper surface; (2) in having only two tritors; these extend the entire length of the oral face and are separated from each other in the median line of the element by a thin lamina of bone. Type species, *Isotænia neocæsariensis* Cope.

### *Isotænia neocæsariensis* Cope.

1875. *Isotænia neocæsariensis* COPE, Vert. Cret. Forma. West, p. 293.

1908. *Isotænia neocæsariensis* Cope, HUSSAKOF, Bull. Amer. Mus. Nat. Hist., XXV, p. 41, pl. iii, figs. 3, 4.

1911. *Isotænia neocæsariensis* Cope, FOWLER, Geol. Surv. N. J., Bull. 4, p. 135.

Type. — A left palatal (Fig. 17). Cope Collection, No. 7208 American Museum.

Horizon and locality. — Cretaceous "Greensand No. 5" [Hornerstown marl, "K"; equivalent to Danian of Europe]. Hornerstown, New Jersey.

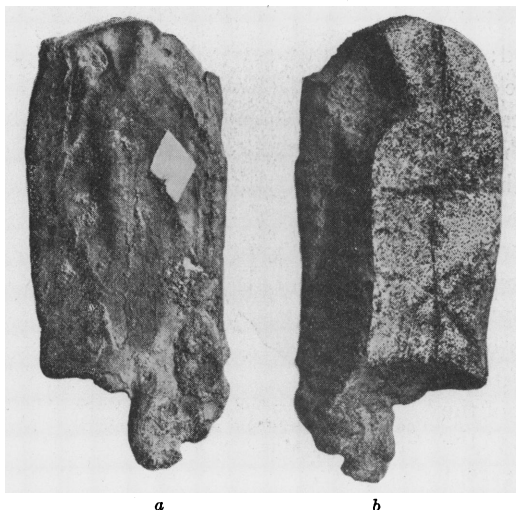


Fig. 17. *Isotænia neocæsariensis* Cope. Left palatal viewed from above (a), and in oral aspect (b). Type. No. 7208 Amer. Mus.  $\times \frac{1}{2}$ .

The principal characters of the species are given above under the generic description. Other trivial features are well brought out in the figures (Figs. 17, 18). Comparative cross-sections of the *Edaphodon* and *Isotænia* palatals are shown in Fig. 18. To facilitate reference to the original description, Cope's account may here be quoted:

"The solid planes of the maxillary bone of this species are three; the widest is opposite to the dentinal columns and parallel with them; it is nearly as wide as they. The lateral planes are not parallel

with each other: the wider forms an acute angle with the last described; the narrower, a very obtuse angle, so as to be nearly continuous with the same, running out into it posteriorly. The more vertical side retains the

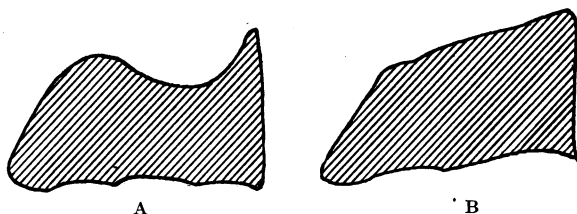


Fig. 18. Cross-sections of *Edaphodon* (A), and of *Isotænia* (B), palatals. Natural size.

same depth throughout. One end of the bone is rounded and truncate; the other is excavated directly at right angles to the dentinal arææ, and then continued as an edentulous plate, which is soon broken off in the specimen."

#### Measurements.

Total length.....	90 mm.
Length of the dentinal columns.....	66 "
Width of the dentinal columns.....	30 "
Depth on the vertical side.....	20 "

### OTHER CHIMÆROID REMAINS FROM THE AMERICAN CRETACEOUS.

#### 1. The So-called Genus *Bryactinus* Cope. (Figs. 19, 20.)

The fragmentary dental plate on which Cope based the genus *Bryactinus* (Verteb. Cretac. Formations West, p. 282, pl. xlv, figs. 13-13b), is preserved

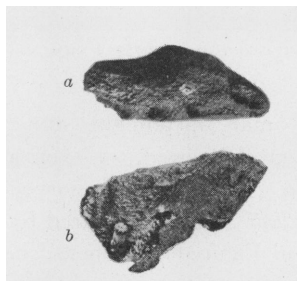


Fig. 19. Fragment of an *Edaphodon* vomerine, type of the genus *Bryactinus* Cope; viewed from above (a), and from the side (b). No. 7197 Amer. Mus.  $\times \frac{1}{2}$ .

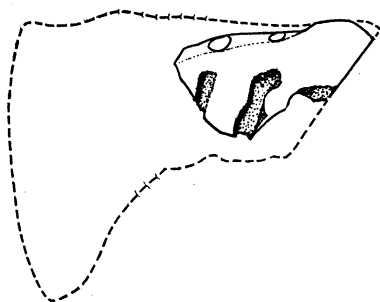


Fig. 20. Diagram showing the part of the *Edaphodont* vomerine named by Cope, *Bryactinus*.  $\times \frac{1}{2}$ .

in the American Museum collections (No. 7197). It was refigured by the writer in 1908 [16, p. 37, fig. 13], when its true nature was still not under-

stood. It is clearly part of a chimæroid dental plate, but one so fragmentary that it should not have been made a type, certainly not the type of a genus. While restudying the element recently, its true nature became apparent. It is a fragment representing the postero-lateral angle of a left vomerine of *Edaphodon*, as indicated in Fig. 20. Three of the six to nine tritors present in a complete vomerine, are preserved.

As a result of this interpretation, *Bryactinus* is to be considered a synonym of *Edaphodon* and not a distinct genus.

## 2. The Upper Cretaceous Chimæroid Egg-case.

A fossil egg-case has been described from the Upper Cretaceous of Wyoming, which should here be briefly referred to. A preliminary notice of it was published by Gill [13], and an analysis of its principal characters, accompanied by an excellent photograph, by Dean [10]. The genus to which the capsule belongs cannot, of course, be definitely determined. All one may conclude is, in the words of Professor Dean, that "it presents features which recall the capsules of what have generally been regarded as the older forms [among recent genera] of chimæroids,—callorhynchids, harriottids and rhinochimæroids." [10, p. 265]. Professor Dean considers that "*Elasmodus* (possibly the closely related *Elasmodectes*) might well have been the parental form" of this egg-case.

The main value of this capsule, from the standpoint of the present study, is the evidence it affords of the existence of chimæroids in the Cretaceous sea of the western portions of North America—the so-called Coloradoan sea [Schuchert, 24]; possibly, too, it may indicate the existence, in American waters, toward the close of the Cretaceous, of another genus in addition to those described in the preceding pages.

## 3. The Supposed Chimæroid Fin-spine, *Sphagepæa aciculata* Cope. (Fig. 21.)

In 1869, Cope [6, p. 241] described a very small, incomplete spine, which he thought might represent a pycnodont, a chimæroid, or even a plectognath, which he named *Sphagepæa aciculata*. The type is preserved in his collection in the American Museum (No. 2235), and was figured by the present writer, in his 'Catalogue of Types and Figured Specimens,' in 1908 [16, p. 50, fig. 22]. The only reason for referring to this spine here is the opinion expressed by Cope that it might belong to a chimæroid, and the statement by Woodward [27, p. 84] that it might "possibly" belong to *Edaphodon*.

The spine is well represented in Fig. 21. It is very small, probably not over  $1\frac{1}{2}$  or 2 centimeters in length when complete, and armed on the

anterior margin with small, sharp, upwardly-pointing denticles. The lateral faces bear several striations which extend the entire preserved portion of the spine; and posteriorly it presents two ridges separated by a deep groove.

To the writer it has seemed doubtful whether *Sphagepæa* represents a chimæroid, and in the 'Catalogue' mentioned above, he placed the genus among the Ichthyodorulites. This view has been adopted by Fowler [11, p. 144]. In all chimæroids, from *Myriacanthus* up, the dorsal fin-spines are singularly constant in general character. The anterior margin is a sharp edge without denticles; whereas the posterior face is armed with two rows of small denticles, separated from each other by a furrow extending nearly the whole length of the spine. (Cf. figure of *Edaphodon* spine, Fig. 5). Now in the small spine, *Sphagepæa*, both these characters are lacking: the anterior margin, instead of being smooth, has a row of denticles, and the posterior face lacks the double row of denticles always present in chimæroid spines. It seems best, therefore, not to express any positive opinion regarding the affinities of *Sphagepæa*, but to place it, for the present at least, among the Ichthyodorulites.

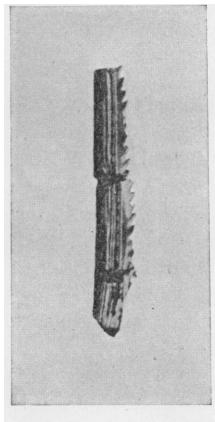


Fig. 21. *Sphagepæa aciculata*  
Cope. Incomplete fin-spine.  
Type. No. 2235 Amer. Mus.  
× 4.

#### SUMMARY OF GENERAL CONCLUSIONS.

It is shown in this paper that:

1. The genera of Cretaceous chimæroids which have been described from North America are reducible to three — *Edaphodon*, *Leptomylus*, *Isotænia*.

2. *Edaphodon* is the most common form. The 12 species which have been referred to it are reducible to six.

3. Of these six, the two named by Cope, *Edaphodon smocki* and *E. tripartitus*, are identifiable with the European forms *E. agassizi* and *E. sedgwicki*, respectively.

4. These two species survived to a later time (Danian) in America than in Europe (Senonian). The time relations between Europe and America at the close of the Cretaceous were similar to those of the present day; *i. e.*, certain species still living in America which had but recently (in a geological sense) become extinct in Europe.

5. *Leptomylus* represents the advancing line with a tendency to develop cutting, instead of crushing, dental plates. This genus, however, is too specialized to be considered ancestral to the modern forms. Their ancestor is probably a genus like *Elasmodus* or *Elasmodectes*.

6. There are three localities in America from which Cretaceous chimæroids are at present known: New Jersey, Mississippi and Wyoming. The first has yielded 9 of the 11 American forms, the other two localities only one species each.

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## EXPLANATION OF PLATES.

### PLATE XIX.

*Edaphodon mirificus* Leidy.  $\times \frac{1}{2}$ .

Figs. 1, 2. Type of "*Diphrissa solidulus*" (Cope). Left mandibular in outer (1), and oral (2), views. No. 7193 Amer. Mus.

Fig. 3. Type of *Edaphodon* "*gaskilli*" (Cope). Left mandibular in oral aspect. No. 7196 Amer. Mus.

Figs. 4, 5. Two of the types of *Edaphodon* "*fecundus*" (Cope). Left mandibular in outer (4), and oral (5), views. No. 2225 Amer. Mus.

Figs. 6, 7. Type of *Edaphodon* "*longirostris*" (Cope). Left mandibular in outer (6), and oral (7), views. The tip of the mandibular is restored. No. 2230 Amer. Mus.

Figs. 8, 9. Type of *Edaphodon* "*incrassatus*" (Cope). Right mandibular in outer (8), and oral (9), views. No. 2234 Amer. Mus.

All from the Jerseyan, probably Hornerstown "K" division [= Danian of Europe]; mostly Hornerstown, N. J.

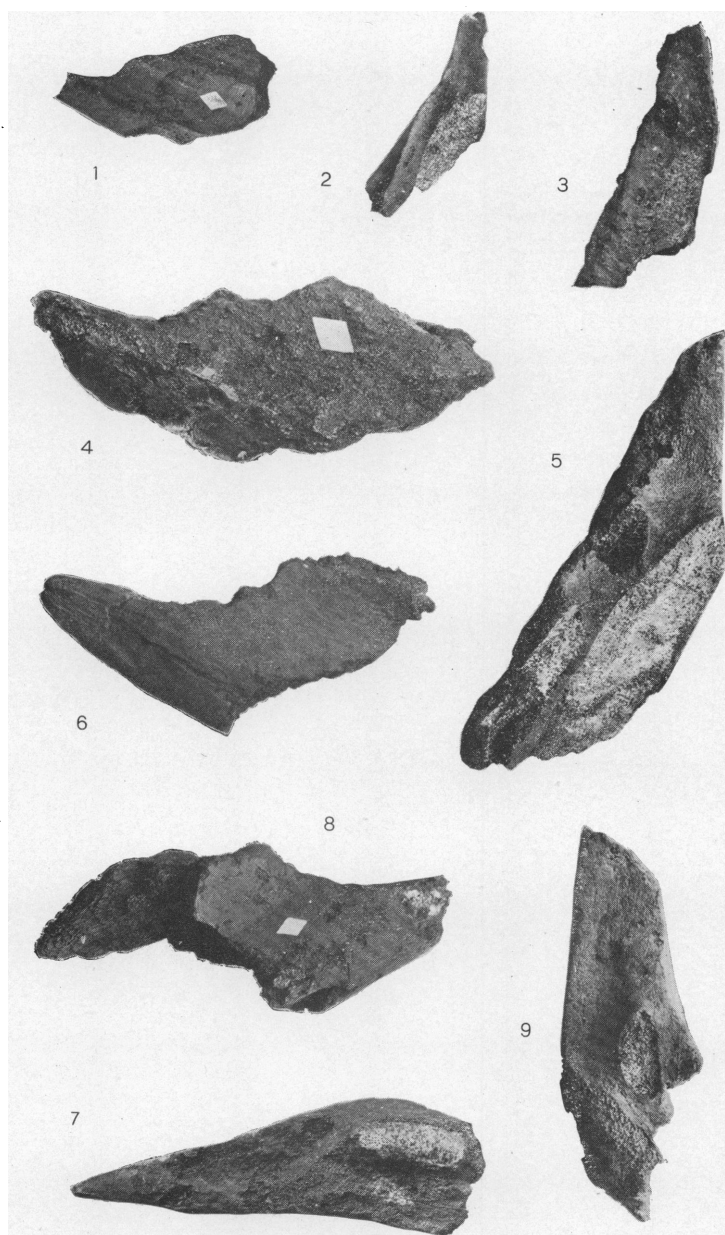
### PLATE XX.

Fig. 1. Large chimæroid dorsal fin-spine, type of Marsh's genus *Dipristis* (*D. meirsii*); probably identical with *Edaphodon mirificus* Leidy. *den.*, posterior denticles.

Upper Cretaceous (Hornerstown, "K"); Hornerstown, New Jersey. No. 292 Yale University Museum.  $\times \frac{3}{4}$ .

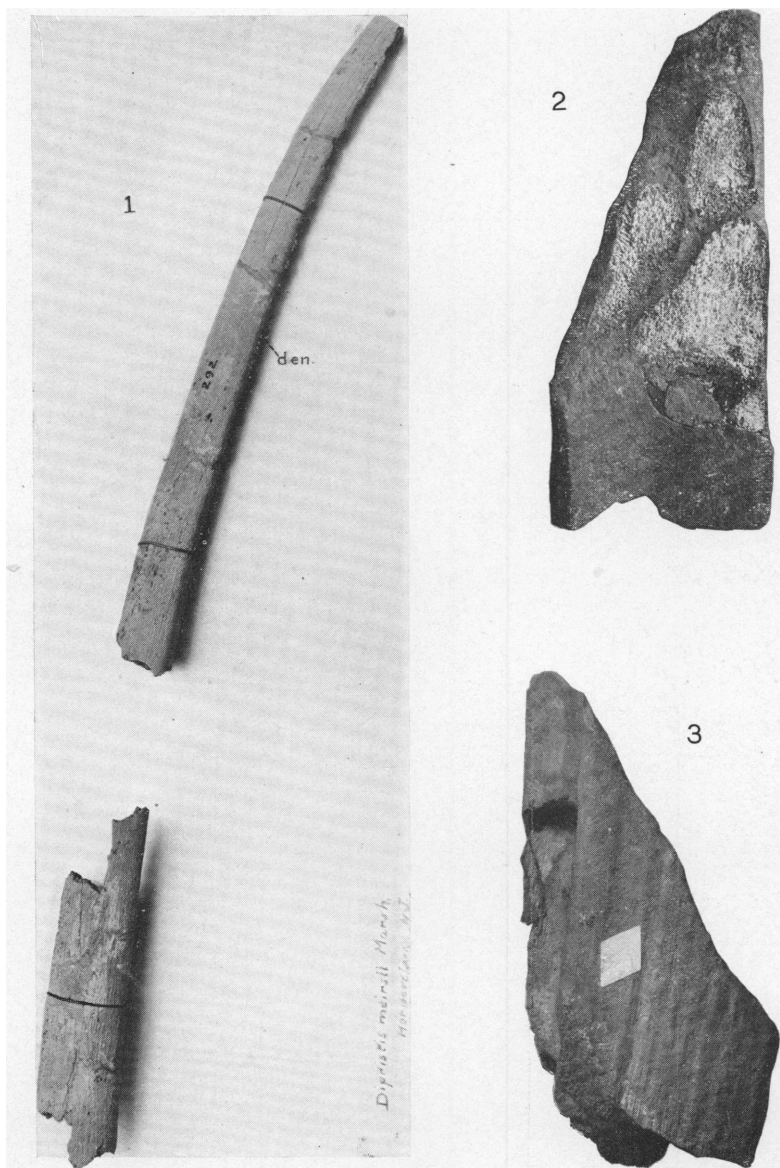
Figs. 2, 3. *Edaphodon mirificus* Leidy. Palatal plate in oral (2), and lateral (3), views. Cotype of *Edaphodon* "*fecundus*" (Cope). No. 2225 Amer. Mus.  $\times \frac{3}{4}$ .

Jerseyan, probably Hornerstown "K" division [= Danian of Europe]; Hornerstown, New Jersey.



CHIMÆROID DENTAL PLATES (*Edaphodon*).





CHIMÆROID FIN-SPINE AND PALATAL PLATE (*Edaphodon*).

