

# SMITHSONIAN MISCELLANEOUS COLLECTIONS

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PART I

## THE CRETACEOUS FISHES OF CEARÁ, BRAZIL

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(WITH EIGHT PLATES)

The first part of this paper deals with the general geology and geography of the region from which the Cretaceous fishes of Ceará come, while the second part is a systematic description of the fishes themselves. The collection is especially important because it contains all of the species hitherto described from Ceará, besides three new genera and four new species. The large number of duplicates has made it possible to restore several of these fishes almost entirely.

The collection belongs to Senhor Francisco Dias da Rocha, proprietor of the Museo Rocha in Ceará, to whom it has been returned, but Sr. Rocha has generously presented several important counterparts and duplicates to the junior author. These counterparts and duplicates are deposited with the geological collections of Stanford University, in California, and of these several specimens have been given to the Smithsonian Institution, at Washington.

### A. NOTES ON THE GEOLOGY OF THE CRETACEOUS FISH-BEARING BEDS OF CEARÁ, BRAZIL

The collection of fossil fishes described in this paper was made by Sr. Francisco Dias da Rocha, of the Rocha Museum, at Fortaleza, Ceará, Brazil. They come from several places about the base of the Serra do Araripe, in the extreme southern end of the State of Ceará, but the precise localities are not given. The region is one that has been so rarely visited by scientific men that but little is known of the details of its geology. By far the most extensive and most valuable notes on the geology of Ceará are those made by Barão de Capa-

nema in 1859. Unfortunately the results obtained by that writer were never published in full, and the paper giving a general outline of his explorations is disconnected and contains much irrelevant matter. However, the general geology of the Serra do Araripe itself is quite simple and its relations to the surrounding regions seem to be clear.

The following facts are gleaned from the scanty notes of Gardner and Capanema, and from those of a few others who have crossed adjacent portions of Maranhão, Piauhy, Parahyba, and Pernambuco.

Spix and Martius refer to fossil fishes being found at Barra do Jar-



FIG. 1.—Hypothetical section across northeastern Brazil, showing the structural and geographical relations of the fish-bearing beds of the Serra do Araripe to the coast sediments of Maranhão and Sergipe.

dim, but it is not clear from their note (*Reise in Brasilien*, II, 799) that the place was visited by either of the authors. The lithographed figure of a fish, *Rhacolepis buccalis*, published in one of the plates of the atlas accompanying their work, is reproduced here. It is the first one of the fossil fishes ever figured from that region (pl. VI, fig. 2).

The water-sheds between the State of Ceará and the States that adjoin it on the south and west are mostly flat-topped table-lands or plateaus. These plateaus are composed for the most part of horizontal sedimentary beds. They rest unconformably upon schists, gneisses, and granites, and at some places upon what seem to be folded but unaltered Paleozoic sediments. The position, distribu-



FIG. 2.—East-west section through the Serra do Araripe, constructed from the notes of Gardner and Capanema.

tion, and character of the beds show that the sediments forming the plateaus formerly had a wide distribution over northeastern Brazil, and that they have been gradually removed by the ordinary processes of denudation.

On the west these beds extend across Piauhy, probably with some interruptions, into the State of Goyaz; on the north they extend across Piauhy and into Maranhão; on the south they extend into Bahia and Pernambuco, approaching the Rio São Francisco: on the

east they form, in part at least, the flat-topped mountains of the western and southern boundaries of the State of Ceará.

The section across the Serra do Araripe given herewith has been constructed from the notes of Gardner and Capanema:

Sandstone forming the top of the mountain, 140 feet (Capanema).

Sandstone series, yellow, white, and red, 600 feet (Gardner); (this includes the top bed of Capanema).

Thin-bedded limestone (thickness not stated).

Lignite, 2 feet (Gardner); bituminous shale (Capanema).

Blue clay and gray sandstone at base (Capanema).

The sequence, character, and relations of the rocks in the Serra do Araripe are sufficiently clear from this section to render further verbal description unnecessary.

The fishes have only been found in concretions, and are said to come from the sandstone bed above the limestone layer. They have never been found in place, but occur in the talus and soil on slopes at the base of the sandstone ridges. The matrix in which the fossils occur is mostly the buff or cream-colored limestone in which these fossils have hitherto been found.

The rock matrix suggests that while some of the specimens are from sandstone beds, most of them are from beds, or at least from lenses, of limestone.

Slides were made of the matrix of two of the concretions. Under the microscope it is seen that the bulk of the rock is composed of microscopic crystals of calcite somewhat stained with iron. The calcite crystals, however, are so small that they are scarcely distinguishable, even under an enlargement of 90 diameters. Between 5 and 10 per cent of the rock is made up of clear round calcite bodies evidently of organic origin.

Fragments were broken from specimens in the Rocha Collection and chemical analyses were made of them with the following results. Care was taken not to include parts of the fossil fishes in the pieces analyzed.

*Analysis of pieces of a fossil-bearing concretion from Ceará, Brazil*

L. R. LENOX, *Analyst*

(Record Book 779)

Silica (SiO <sub>2</sub> ) .....	3.64
Oxides of iron and alumina (Al <sub>2</sub> O <sub>3</sub> Fe <sub>2</sub> O <sub>3</sub> ) .....	1.46
Lime (CaO) .....	52.23
Magnesia (MgO) .....	0.56
Loss in ignition (CO <sub>2</sub> , H <sub>2</sub> O, etc.) .....	42.28
Total .....	100.17

Equivalent to—

Carbonate of lime ( $\text{CaCO}_3$ ).....	93.26
Carbonate of magnesia ( $\text{MgCO}_3$ ).....	1.16

*Analysis of part of a concretion containing a somewhat telescoped fossil fish  
(Rhaconolepis buccalis)*

(Record Book 781)

Silica ( $\text{SiO}_2$ ) .....	4.31
Iron and alumina ( $\text{Fe}_2\text{O}_3$ and $\text{Al}_2\text{O}_3$ ).....	3.05
Lime ( $\text{CaO}$ ) .....	50.39
Magnesia ( $\text{MgO}$ ) .....	0.66
Loss ( $\text{CO}_2$ and water).....	41.53
	<hr/>
Total .....	99.94

Equivalent to—

Carbonate of lime ( $\text{CaCO}_3$ ).....	89.98
Carbonate of magnesia ( $\text{MgCO}_3$ ).....	1.38

*Analysis of part of a concretion containing a fossil fish, Calamopleurus vestitus,  
Specimen No. 15*

(Record Book 782)

Carbonate of lime ( $\text{CaCO}_3$ ).....	90.64
Carbonate of magnesia ( $\text{MgCO}_3$ ).....	1.27

*Analysis of part of the concretion containing the large specimen of Calamopleurus cylindricus received from Dr. Paula Pessoa, of Rio de Janeiro*

(Record Book 783)

Carbonate of lime ( $\text{CaCO}_3$ ).....	92.57
Carbonate of magnesia ( $\text{MgCO}_3$ ).....	1.25

Many of the specimens of fossil fishes have been crushed together lengthwise or telescoped, so that the scales are thrust farther over than they should be. This peculiarity of these fishes has been noted before by Dr. A. Smith Woodward in his paper published in the Proceedings of the Zoölogical Society of London, 1887. The chemical analyses suggest that this telescoping may be due to the partial dolomitization and consequent shrinking of the original limestone caused by the substitution of magnesium carbonate for the calcium carbonate.

The appearance of the rock and the analyses given above lead one to suppose that the composition of the concretions is fairly uniform. Some of them, however, are much more sandy than others, and the specimens in the sandy rocks are not so well preserved as those in

the limestone concretions. Possibly the sandy concretions are not from the same localities as the more calcareous ones.

The fossil fishes from Ceará are generally spoken of as coming from Barra do Jardim, but they have been found at many other localities, though always about the base of the Serra do Araripe. Gardner's collections came from Barra do Jardim, from a sugar plantation called Massapé (or Maçapé, as he spells it), five leagues east of Barra do Jardim: from Mundo Novo, three leagues west of Barra do Jardim, and from Brejo Grande, a plantation west of the Serra do Araripe and about 35 miles west of Crato. Capanema found them also at Breijinho, a locality not mentioned by Gardner, but in the same neighborhood.

A few other fossils occur in the rocks containing the fossil fishes, but no effort seems to have been made to collect these other fossils on the ground. The only ones mentioned by the collectors are noted here. Gardner found a single valve of a *Venus* half an inch long, the cast of a cephalopod an inch and a half long and supposed by him to be a *Turrilites*. Both of these came from loose pieces of sandstone. He was told of a small snake having been found rolled up in one of the concretions, but he thinks it was probably a species of cephalopod.<sup>1</sup> Judging from the Rocha Collection, it seems more likely that it was a specimen of *Belonostomus comptoni*, which is occasionally found thus coiled up.

The specimens in the Rocha Collection contain a few entomostracan remains, but none of them have been specifically identified. Dr. A. Smith Woodward notes that entomostracans found in the British Museum specimens were examined by Prof. T. Rupert Jones and Mr. C. D. Sherborn, who refer them with some doubt to *Cytheridca*.<sup>2</sup>

Barão de Capanema, who visited the Serra do Araripe in 1859, reports finding associated with the fossil fishes coprolites "the bones probably of saurians, the teeth of fishes, and an unknown plant with imbricated leaves. I heard of fossil shells and zoöphytes on the Piahy frontier."<sup>3</sup> Gardner says that flints are common on the side of the mountain northwest of Crato, and he speaks of chalk being found in the mountains near Crato. Gardner found limestone and marl beneath the fossiliferous sandstone, and beneath the limestone a bed of lignite about two feet thick. Capanema thinks that the

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<sup>1</sup> Geologia Elementar, por N. Boubé, p. 55; Rio, 1846; Trans. Brit. Assoc., 1840, 120.

<sup>2</sup> Proc. Zoöl. Soc., London, 1887, 541.

<sup>3</sup> Trabalhos de Comissão Scientifica de Exploração, I, Introdução, p. 130. Rio de Janeiro, 1862.

material reported to be chalk is only a white clay, but he confirms the existence of a thin-bedded limestone beneath the fossiliferous sandstone, and "beneath this limestone is a bed of very bituminous laminated shale. It is a kind of lignite changed to coal, only a few inches in thickness." He says that fossil wood was found by Dr. Gonçalves Dias near São Pedro, two leagues from the Villa de Milagres. The existence of the limestone and lignite induce one to hope that a careful search may yet lead to the discovery of considerable additional paleontologic material, though Gardner distinctly states that no fossils could be found in the limestones.<sup>1</sup>

In the Rocha Collection the rock inclosing the fossil fishes contains many fish scales and the remains of microscopic shells that have not been studied. One of the concretions is rather darker and more marly than the others, and in this are found many small rounded bodies evidently of organic origin. Some of these were submitted to Dr. E. O. Ulrich, paleontologist of the U. S. Geological Survey, who kindly reports as follows upon them:

The ostracod seems to be one of the simple types of *Cytheridea*, apparently closely allied to the Miocene *C. subovata* U. & B. It resembles an Eocene species also very closely, and I know of a late Cretaceous form that is not far removed. However, with specimens in rock like yours it is difficult to satisfactorily determine even the genus of the host of smooth and subovate ostracods.

Referring to the broader features of the Cretaceous geology of northeastern Brazil, the area covered by the Cretaceous rocks is not known with any certainty. Even where they are best known they have been identified at only a few places on and near the coast. On the coast, however, they form only a narrow belt approximately parallel with the present shoreline, toward which they have a general and gentle dip, except on the immediate shores, where the dip is often landward. This coast belt of Cretaceous sediments is in places from twenty-five to fifty miles or more in width, while at other places the beds have been entirely removed and the old underlying rocks of the interior are exposed on the seashore. On the land side of the Cretaceous belt the surface rocks are usually granites, gneisses, schists, and other metamorphics of uncertain age or ages.

In the region drained by the Rio Paranahyba above Theresina, and lying mostly in the State of Piahy, there is a series of horizontal sedimentary beds which appear to be the inland remnants of the series exposed along the coast. But little is known of the geology

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<sup>1</sup> Trans. Brit. Assoc., 1840, 119.

of these inland sediments, however. What is here given has been collected from the notes of Spix and Martius and of Gardner.

While the structural relations of these highland beds is not certainly known at present, such information as we have suggests the relations indicated by the accompanying theoretic section across northeastern Brazil, say from about Maranhão on the north to Sergipe on the south, and passing through the Serra do Araripe. It should be added, however, that the slates reported near Lavras in Ceará are probably Paleozoic. No attempt is made to represent those slates in this section. There are probably local variations in the dips and relations of the Cretaceous beds which are not suggested in this hypothetical section.

Barão de Capanema says that the beds of the Serra da Ibiapaba along the northwestern boundary of Ceará dip toward the west, and he appears to think that the rocks of that range are the same as those of the Serra do Araripe. This attempted correlation is not based upon paleontologic evidence, and may be altogether erroneous.

The table-lands so characteristic of the Serra do Araripe follow the water-sheds toward the south and west. Mr. J. W. Wells describes what seems to be a similar topography and similar rocks about the southern ends of the states of Piauí and Maranhão.<sup>1</sup> It is not to be inferred, however, that these sediments form the Serra Vermelha and Serra Dois Irmãos in the intermediate region, for the notes of Spix and Martius show that where they crossed the Serra Dois Irmãos the rocks are granites and schists,<sup>2</sup> a fact that lends support to the theory that this region was an archipelago during Cretaceous time.

The junior author's acquaintance with the geology of the surrounding region and the few published notes of travelers suggest that this northeast corner of Brazil was an archipelago at the time of the deposition of these Cretaceous sediments, and that the mechanical portions of these sediments were derived from islands of granites, gneisses, and schists.

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<sup>1</sup>James W. Wells: *Exploring and traveling three thousand miles through Brazil*. London, 1886, II, 144.

<sup>2</sup>*Reise in Brasilien*, II, 768.

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## B. NOTES ON THE FOSSIL FISHES OF CEARÁ

### ANALYTICAL KEY TO THE CRETACEOUS FISHES KNOWN FROM CEARÁ

- a.—GANOIDEI: Scales large, diamond-shaped or plate-like; tail strongly heterocercal; dorsal inserted behind the ventrals.
- b.—(ASPIDORHYNCHIDÆ): Scales plate-like, those on the sides of the body much deeper than the others; both jaws much elongate, pointed ..... *Belonostomus comptoni*, 1
- bb.—(SEMIONOTIDÆ): Scales large, firm, diamond-shaped; a series of spine-like scales along middle of back; jaws not greatly elongate.  
*Lepidotes tenuurus*, 2
- aa.—ISOSPONDYLI: Scales thin, cycloid or rhombic; no spines in fins; tail homocercal or slightly heterocercal; snout (in Brazilian Cretaceous species) not produced.
- d.—(LEPTOLEPIDÆ): Scales small, thin, more or less diamond-shaped, at least along back; tail somewhat heterocercal, the last vertebra reduced in size and turned upward; ventral fins inserted under front of dorsal; subopercle small, its suture horizontal; cheek and postorbital region with three large plates (gular plate unknown); distance from gill opening to dorsal not greater than depth of body.

*Tharrhias araripis*, 3

dd.—(ELOPIDÆ): Gular plate present ventrals (in Cretaceous species from Brazil) inserted under last rays of dorsal; temporal region with a bony plate or sheath; two parallel bony plates behind eye, with a third, usually larger, one sheathing the cheek.

f.—Teeth subequal, without large canines.

g.—Lateral line well developed; teeth small (less than one-tenth diameter of eye).

h.—Scales small, 30 to 33 in a cross-series from dorsal to ventral; suborbital broad, its suture oblique. *Calamopleurus cylindricus*, 4

hh.—Scales large, about 20 in a cross-series from dorsal to ventral; suborbital very narrow; its suture nearly horizontal

*Calamopleurus vestitus*, 5

gg.—Lateral line obsolete or nearly so; teeth rather large.

i.—Scales cycloid, entire; teeth strong, more than one-tenth diameter of eye.

*Notclops brama*, 6

ii.—Scales crenate; teeth probably small.

j.—Body subcylindrical, the depth not much greater than length of head.

*Rhacolepis buccalis*, 7

jj.—Body compressed, the depth much greater than length of head.

*Rhacolepis latus*, 8

ff.—Teeth very strong, unequal, many of those in each jaw canine-like (scales unknown). *Enneles audax*, 9

c.—CHIROCENTRIDÆ(?): Gular plate wanting; scales large, the surface pustulose (no lateral line).

*Cladocyclus gardneri*, 10

cc.—OSTEOGLOSSIDÆ(?): Opercle large, without suture, the subopercle wanting; scales firm, with concentric striæ; dorsal inserted over ventral, at a distance behind head greater than depth of body.

*Cearana roche*, 11

## FAMILY ASPIDORHYNCHIDÆ

### Genus BELONOSTOMUS Agassiz

*Belonostomus* AGASSIZ, Neues Jahrbuch, 1834, p. 388; type, *Aspidorhynchus tenuirostris* AGASSIZ.

*Ophirhachis* COSTA, Ittiol, Fossil, Ital., 1856, p. 13; type, *Ophirhachis desperditus* COSTA.

? *Platycerhynchus* COSTA, Atti Acad. Pontan., VIII, 1864, p. 98; type, *Platycerhynchus rhombus*.

This genus contains numerous species of large, gar-like fishes, having rhombic scales, those of the lateral line deeper than the others, and having both jaws produced, subequal in length. Accord-

ing to Woodward, the suborbitals lie in contact with the cheek-bone, without separate cheek-plate, such as exists in *Aspidorhynchus*. In both these genera the vertebræ are double-concave, not concave-convex, as in the true gar-fishes or *Lepisosteidæ*. According to Woodward, the vertebræ in *Belonostomus* are "well ossified, smooth and constricted, about as long as deep, and pierced by a small thread of persistent notochord."

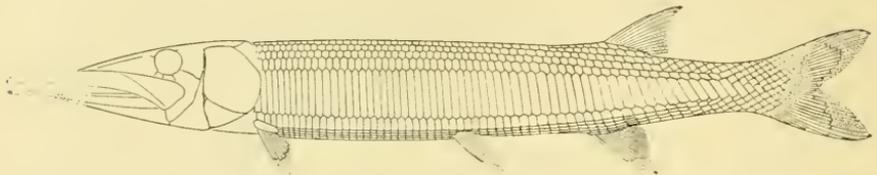


FIG. 3.—*Belonostomus comptoni* (Agassiz).  
Barra do Jardim, Brazil. (Restoration.)

The Brazilian species of *Belonostomus* differs from the type of the genus in the very much greater depth of the scales composing the lateral line. These are anteriorly about five times as deep as long. The jaws are also more robust than in the typical species.

#### 1. BELONOSTOMUS COMPTONI (Agassiz)

*Aspidorhynchus comptoni* AGASSIZ, Edinburgh Phil. Journal, xxx, p. 83, 1841; Ceará.

Agassiz, Comptes Rendus, xviii, p. 1009, 1844; Ceará.

*Belonostomus comptoni* WOODWARD, Proc. Zool. Soc. London, p. 629, pl. LIV, LV, figs. 1-10; Ceará.

Woodward, Cat. Fossil Fishes, III, p. 435, 1895; Ceará.

Of this species we have fragments of different sizes from 5 or 6 different fishes (Nos. 6, 7, 10, 23, 24, 27, 28, 29, and 31, Rocha Col-

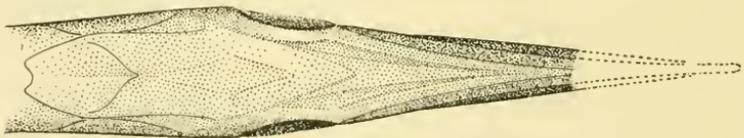


FIG. 4.—*Belonostomus comptoni* Agassiz. Top of head.

lection, the largest fish (No. 7) being about 20 inches long if restored and nearly  $2\frac{1}{2}$  to 3 inches in depth, the depth about 7 in length.

Length of head about twice greatest depth, about 4 in length. Jaws apparently equal, both pointed, the tips of both broken in all our specimens. Snout half head, or perhaps less, the tip being lost. Eye about 2 in snout, nearly 5 in head; maxillary broad

behind, almost fan-shaped, extending to a little behind middle of eye; opercle large, with concentric striae, provided with small pustulations along the ridges; top of head flat, narrow, the interorbital space about width of eye; lower jaw with what seem to be traces of long, slender, unequal teeth, but this is not certain.

Scales ganoid, those of the median series very much enlarged, with parallel edges, the depth of each scale anteriorly 4 to nearly 5 times its length, each scale with vertical striae; about 4 rows of small scales above these, the small scales about as long as deep, implicated. Below the large scales are about three rows of smaller ones, those of the upper low largest. Posteriorly the large scales are progressively less deep, and at base of caudal they are scarcely deeper than those of the lowest of the upper rows or the highest of the lower row; 18 scales in a lengthwise series backward from the front of dorsal, about 33 anteriorly from the front of ventral; the scales in all probably about 60. Bands of scales anteriorly nearly vertical, those posteriorly extending downward and backward. Scales all enameled, their surface rugose.

Pectorals placed low, the upper ray broad (the fin broken); ventrals inserted at a distance behind head equal to  $1\frac{1}{4}$  length of head. Body tapering backward, subterete, but distinctly compressed, much deeper than broad; depth at dorsal fin  $2\frac{1}{4}$  in distance from front of dorsal to base of caudal; dorsal and anal opposite each other, each of about 10 rays; both fins higher and long, the posterior rays rapidly shortened, caudal broken, evidently strongly heterocercal, with rudimentary rays at base of each lobe.

Vertebrae distinctly biconcave, apparently well ossified. Two of the specimens are partly coiled within nodules of stone, their position and armature suggesting millipedes, or even snakes. From our excellent material we have ventured on a restoration of this species (fig. 3). Of these specimens numbers 7, 10, and 27 are in the United States National Museum.

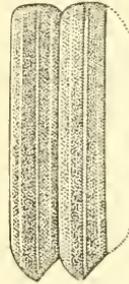


FIG. 5.—Scales of *Belonostomus comptoni*.

## FAMILY SEMIONOTIDÆ

Genus **LEPIDOTES** Agassiz

*Lepidotes* AGASSIZ, Neues Jahrbuch, 1832, p. 145; type, *Lepidotes gigas* AGASSIZ.

*Lepidotus* AGASSIZ, Poissons Fossiles, II, pt. 1, 1833, pp. 8, 233 (altered spelling).

*Lepidosaurus* VON MEYER, Palæologica, 1832, p. 208; type, *Lepidotus unguiculatus* AGASSIZ.

*Scrobodus* VON MÜNSTER, Neues Jahrb., 1842, p. 38; type, *Scrobodus subovatus*.

*Plesiodus* WAGNER, Abh. Bay. Akad. Wiss., IX, 1863, p. 632; type, *Plesiodus pustulosus* WAGNER.

*Prolepidotus* MICHAEL, Zeitschr. Deutsch. Geol. Ges. XIV, 1893, p. 729; type, *Prolepidotus gallineki* MICHAEL.

This large genus is distinguished among the Semionotidæ by the deeply fusiform body, the presence of grinding teeth on the inner part of the jaws, and by the relatively low dorsal and anal fins. The teeth have not been preserved in any specimen of the Brazilian species.

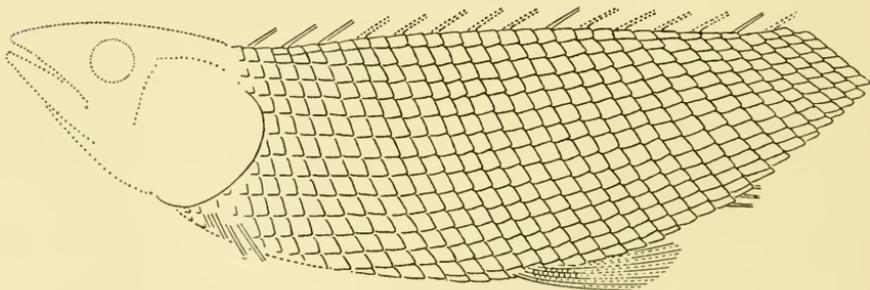
2. **LEPIDOTES TEMNURUS** Agassiz

FIG. 6.—*Lepidotes temnurus* Agassiz.  
Barra do Jardim, Serra do Araripe, Brazil.

*Lepidotus temnurus* AGASSIZ, Edinburgh Phil. Journ., xxx, 1841, p. 83; Serra do Araripe, Ceará.

Agassiz, Comptes Rendus, xviii, 1844, p. 1010; Ceará (misprinted lemurus).

Woodward, Cat. Fossil Fishes, III, p. 123, 1895; Ceará.

? *Lepidotus masoni* WOODWARD, Ann. Mag. Nat. Hist., vi, p. 135, 1888; Cretaceous at Bahia, Brazil.

Woodward, Cat. Fossil Fishes, III, p. 120, 1859; Bahia, Plataforma. Itacaranha, Pedra Furada, Brazil.

Of this species we have one specimen within a concretion (No. 2, Rocha Collection), preserved also in counterpart. It includes the greater part of the body of the fish; is somewhat distorted by being

bent downward in the middle, the head is entirely crushed, and the dorsal, anal, and tail are absent and the pectoral fin broken (fig. 6).

The head was about  $3\frac{1}{2}$  times in length to base of caudal, the greatest depth over the ventral fins about  $3\frac{2}{3}$ . The scales are rhombic, entire, deeply overlapping, most of them deeper than long. The surface of the scale is not smooth, but marked with about three coarse ridges, parallel with the anterior margins. The distance of the ventral from the head is apparently a little more than length of head. The ridge scales on the back are very distinct, spine-like, more elevated than usual in *Lepidotus*. Three are distinct behind the nuchal region, and there are traces of others farther back.

In the description of *Lepidotus marwoni* it is stated that the principal flank scales are "with frequently discontinuous enamel marked with a few broad ridges and furrows radiating from the center to the hinder border, where they form feeble indentations." The markings on *L. temmurus* do not answer to this description.

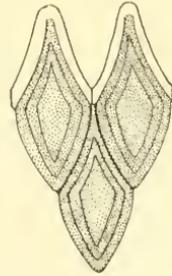


FIG. 7.—Scale of  
*Lepidotus*  
*temmurus*.

#### FAMILY LEPTOLEPIDÆ

This family stands almost intermediate between the Ganoids and the Isospondyli. It has the general fin arrangement of the latter, but the scales are more or less diamond-shaped and ganoid on their exposed parts, and the last vertebræ are more or less turned upward, although the tail is usually or always forked. The orbital plates cover the cheek as in the Elopidae, but there is no gular plate, so far as known.

#### Genus THARRHIAS Jordan and Branner, new genus

A species from Ceará is referred by us to the family of Leptolepidæ, and it is very closely allied to the typical genus, *Leptolepis*, of the Triassic and Cretaceous of Europe. It is, however, distinguishable by the much larger opercle, which is more than four times as deep as the subopercle and separated from it by a horizontal suture. The vertebræ are 50 to 55 in number, while the type of *Leptolepis*<sup>1</sup>

<sup>1</sup> *Leptolepis* AGASSIZ, Neues Jahrbuch 1832, p. 146; type, *Leptolepis bronni* AGASSIZ (1832), *Cyprinus corypanoides* BRONN (1830).

*Ascalabos* VON MÜNSTER, Beitr. Petrusfakt, 1, 1839, p. 112; type, *Ascalabos voithii* VON MÜNSTER.

*Tharsis* GIEBEL, Fauna der Vorwelt, Fische, 1848, p. 145; type, *Tharsis radiatus* GIEBEL.

*Sarginites* COSTA, Alte. Accad. Pontan, v, 1850, p. 285; type, *Sarginites pygmaeus* COSTA.

*Megastoma* COSTA, l. c., 1850, p. 287; type, *Megastoma apenninum* COSTA.

(*Leptolepis coryphanoides* Bronn, *L. bronni* Agassiz) has but 40. In *Leptolepis dubius* (subgenus *Tharsis*) the number is 50.

The name *Tharrhias*, equivalent to *Tharsis* (θάρσος, θάρρως, courage, boldness), is suggested for the Brazilian fish.

In *Tharrhias*, as in *Leptolepis*, the dorsal is inserted slightly before the ventrals.

### 3. THARRHIAS ARARIPIS Jordan and Branner, new species

Type No. 4, Rocha Collection, in Counterpart. PLATE II

Head about  $3\frac{2}{3}$  in length to base of caudal; opercle large, with radiating striæ; nearly  $\frac{1}{3}$  deeper than long; subopercle small, its depth not more than one-fourth that of the opercle, the suture horizontal; depth of opercle  $1\frac{2}{3}$  in distance from gill opening to dorsal;

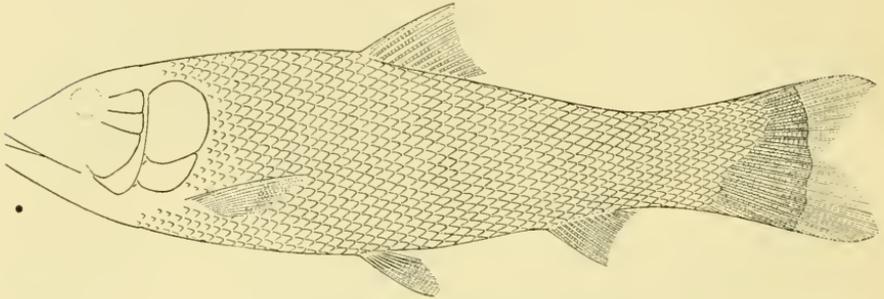


FIG. 8.—*Tharrhias araripis* Jordan & Branner.  
Barra do Jardim, Brazil. Restored.

preopercle with its upright limb nearly vertical; two bones behind eye and bone on cheek traceable, but the form not clearly made out (jaws and front of head destroyed).

Dorsal fin with strong interneural bones, its insertion behind gill opening nearly equal to length of head and greater than depth of body, which is about  $4\frac{1}{2}$  times in length to base of caudal; dorsal short, higher than long, about 12 rays traceable; ventrals about under middle of dorsal; anal inserted behind dorsal at a distance greater than depth of body and about equal to length of head; the fin smaller than the dorsal, of about 9 rays, the first longest, as in the dorsal. Vertebrae about 55, the last five small and turned upward; caudal apparently forked, the upper lobe perhaps the longer.

Scales rather small, very thin, even, diamond-shaped along back, those below obscurely shown, but apparently rounded; no enamel on scales or ganoin; no trace of lateral line or of scaly sheaths. Scales about 56-19, 18 in a longitudinal row before dorsal; those at base of upper lobe of caudal smaller and more distinctly rhombic.

The type (No. 4, Rocha Collection) is  $8\frac{1}{2}$  inches long, fairly well preserved from the preopercle backward, and represented in counterpart in a nodule of coarse sandstone.

The species may be known from the Elopidae found at Ceará, by the narrow scales, by the subheterocercal tail, and by the large opercle, which is many times larger than the horizontal subopercle. This small subopercle separates this from other species of Leptolepidae. From the Cretaceous species of Elopidae it is distinguished by the insertion of the ventrals under or slightly before the front of the dorsal. This is seen also in the genus *Cearana*, but in that genus both dorsal and ventrals are inserted farther back.

A second specimen (No. 3, Rocha Collection), also in counterpart,  $9\frac{1}{2}$  inches long, shows the thin rhomboid scales and the fins fairly well, but the head is entirely crushed.

Another nodule (No. 1, Rocha Collection) is referred provisionally to *Tharrhias araripis*, with which it agrees in general form, in the insertion of the ventrals directly below the dorsal, and in having the distance from dorsal to gill opening about equal to depth of body. The bones of the head are all crushed, and the thin scales, about equal in number to those of *Tharrhias araripis*, are not any of them enameled nor rhombic in form; but, on the other hand, none of them are well preserved. The vertebræ are well preserved and compactly inserted. There is no trace of lateral line. We do not much doubt the identity of this specimen with the type of *Tharrhias araripis*, but the difference in the scales suggests that possibly the rhombic form in the latter case may be due in part to shrivelling of the specimen before it was encased in clay. Of these specimens, No. 3 is in the U. S. National Museum and the counterpart of No. 1 in the geological collection of Stanford University.

#### FAMILY ELOPIDÆ

The family of Elopidae is characterized among the soft-rayed fishes by the presence of a triangular bone, or gular plate, between the rami of the lower jaw. This plate is present in the Amiatidae and in some other ganoids, and it furnishes strong evidence that the Elopidae are descended from extinct forms resembling *Amiatus*. In any event, the Elopidae are among the oldest and most generalized of all the bony fishes. Their occurrence at Ceará in company with extinct ganoids like *Belonostomus* and *Lepidolepis* is significant. Another character of the Elopidae is the enlargement of three bones of the suborbital ring below and behind the eye, a character which appears in others of the lower Isospondyli and points to their ganoid origin.

Genus **CALAMOPLEURUS** Agassiz

*Calamopleurus* AGASSIZ, Edinburgh Journ. xxx, 1841, p. 84; type, *Calamopleurus cylindricus* AGASSIZ.

Agassiz characterizes the fragments on which this genus is based by the following characters:

"Le long tube étroit des écailles de la ligne latérale, et par l'uniformité de ses écailles arrondies." To this Woodward (499) adds the following, based on a specimen in the British Museum: "The scales are cycloidal, very much imbricated, and apparently longer than deep; the fin-rays are widely spaced and much divided distally."

A fine, large specimen in counterpart, from Ceará, shows the lateral line with well-developed tubes, and the scales equal, cycloid, and closely imbricated. As the species is one not specifically recognized by Woodward and as it is from Agassiz's original locality, we venture to identify it with Agassiz's unrecognized *Calamopleurus cylindricus*.

The genus *Calamopleurus*, as understood by us, belongs to the Elopidae, differing from *Notelops* in the well-developed lateral line and in the small teeth, and from *Elops* in the more posterior insertion of the ventrals and in the less elongate form. Mouth large, the jaws subequal, the gape oblique, extending beyond the eye; teeth even, pointed, small, less than one-fifteenth the diameter of the eye; two large, oblong, parallel postorbital bones; below these a large trapezoidal cheek-plate, broadest posteriorly; two parallel postorbital bones above this; subopercle very broad, its depth rather more than half that of the opercle. Scales cycloid, closely imbricated, the individual scales a little longer than deep; a sheath of scales at base of dorsal, as in *Elops*; a sheathing projection on occiput and one above opercle; lateral line well developed, nearly straight and median, its tubes simple and straight; dorsal short, median, inserted at a distance behind gill opening about equal to depth of body ventrals; inserted under or perhaps behind last ray of dorsal; moderate; caudal well forked, its base closely scaly nearly to the tips of the median rays.

4. **CALAMOPLEURUS CYLINDRICUS** Agassiz

PLATES III, IV

*Calamopleurus cylindricus* AGASSIZ, Edinburgh Journ. xxx, 1841; Ceará. Agassiz, Comptes Rendus, xviii, 1844, p. 1012; Ceará. Woodward, Cat. Fossil Fishes, III, p. 499, 1894. Jordan, Bull. Cal. Univ., 1907, p. 139, pl. 12; Ceará.

We refer to this species the large specimen above mentioned. It is about 15 inches long. It was presented by Dr. Paula Pessoa, of

Rio de Janeiro, to Dr. Branner. It was found in the Barra do Jardim, Serra do Araripe, State of Ceará. This specimen in a concretion, represented in counterpart, is one of the most perfect of fossil fishes, showing most distinctly the eye-ball and the dark pigment which lies in streaks along the rows of scales. It was at first identified by us with *Notelops brama*, but the distinctness of the lateral line and the small size of the teeth render this identification untenable. The genus *Calamopleurus* is very close to *Elops*, having the same general structure of the head and the same extension of the scales on the tail.

The firmer character of the suborbital bones and the insertion of the ventrals furnish the only tangible difference, unless we consider the greater elongation of the body in *Elops*.

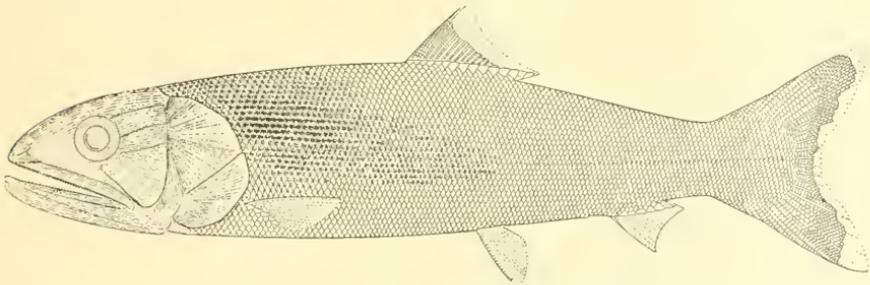


FIG. 9.—*Calamopleurus cylindricus* Agassiz.

Cretaceous of Ceará, Brazil. Partial restoration of type.

Head  $3\frac{1}{5}$  in length to base of caudal; depth about 4 in body,  $1\frac{1}{6}$  in head. Eye 5 in head,  $1\frac{1}{2}$  in snout, snout  $3\frac{2}{3}$  in head, head as long as from gill opening to last ray of dorsal (bones of head all more or less crushed). Scales about 13-120-18. Mouth large, oblique, the maxillary extending well beyond eye,  $1\frac{1}{2}$  in head; teeth small, sharp, even, not one-fifteenth diameter of eye; opercle broadly triangular, with the broad base anterior, the lower suture separating it from the subopercle, distinct and very oblique; upper part of opercle covering more than one-third of the bone separated from the rest by a horizontal mark indicating a ridge or suture, this perhaps due to crushing; subopercle nearly twice as long as deep, nearly half as large as opercle; preopercle broadly rounded, the upright limb directed somewhat forward; a large trapezoidal plate on cheek extending from level of lower part of eye to angle of mouth; this is a little longer than high and deepest posteriorly; two parallel horizontally elongate suborbital bones behind eye; these about equal in size and each about twice as long as high; rest of orbital chain obscurely shown. The

cheek-plate evidently belongs to this suborbital series. A trace of an occipital sheathing bone, as seen in *Elops*.

Scales on body small, cycloid, those along base of dorsal enlarged, forming a distinct sheath; lateral line well defined, slightly curved downward, anteriorly about 15 rows of scales between dorsal and lateral line; the tubes straight and simple, scales extending over middle part of caudal fin nearly to its posterior edge. Dorsal rays about 12 (all the fins more or less broken); ventrals inserted under last rays of dorsal (or a little farther backward); caudal deeply forked, the vertebræ of the caudal peduncle strong.

Each scale of upper anterior and middle part of body with a distinct black spot of pigment, these spots forming distinct lines along

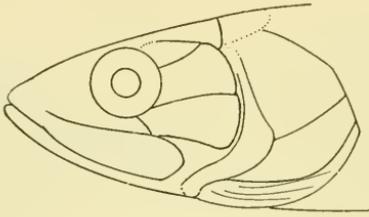


FIG. 10.—Head of *Elops saurus* Linnaeus. Honolulu.

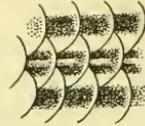


FIG. 11.—Scales of the lateral line of *Calamopleurus cylindricus*. Showing pigment.

the rows of scales. No fossil fish known to the writers shows its original coloration so clearly as this. Of this specimen we have attempted to give a restoration. The pigment stripes doubtless extended the whole length of the body.

Besides this specimen, we have another smaller one with its counterpart (No. 14, Rocha Collection). This shows the lateral scales very perfectly, but the lateral line is obliterated, being crushed against the vertebral column. Specimen No. 14 also shows black pigment underneath some of the scales. Specimen No. 23, Rocha Collection, is a crushed head, showing the opercular bones.

Another nodule (No. 20, Rocha Collection) shows the side of the head and the anterior part of the body; the lateral line is traceable, though obscured by the telescoping of the scales, which are abnormally crowded together.

Another fine specimen (No. 21, Rocha Collection) has the anterior part of the head crushed, but the anterior part of the body is very well shown. The bones of the head are as in the larger specimen. The distance from gill opening to dorsal is a little less than greatest depth of body and considerably less than length of head. There are 25 scales along the lateral line before dorsal and about 30

(14 + 1 + 15) between dorsal and ventrals. The lateral line is very distinct. The well-preserved ventral is under the very last rays of the dorsal, a character which at once distinguishes *Calamopleurus* from the living genus *Elops*, in which the dorsal is inserted directly over the ventrals.

Another specimen (No. 12, Rocha Collection) shows much the same parts, but not nearly so well preserved. The head is somewhat crushed and telescoped; the teeth are obliterated. The gular plate is apparently present. The lateral line is evident, but its position is distorted. There are 25 scales before the dorsal along the course of the lateral line. The ventrals are under the last rays of the dorsal, at a distance from base of caudal but little more than the length of the head. Vertebrae about 50.

Another nodule (No. 13, Rocha Collection) is a badly telescoped individual of *Calamopleurus cylindricus* showing the scales of the sides.

#### 5. CALAMOPLEURUS VESTITUS Jordan and Branner, new species

##### PLATE V

A nodule contains the outline of the body and of part of the side of the head of a fish with cycloid scales, similar to those of *Calamopleurus cylindricus*, but very much larger. The specimen when complete would be about a foot in length.

We here describe this specimen (No. 11, Rocha Collection) as a new species of *Calamopleurus*. It differs from the type species, however, in the very much smaller size of the subopercle, a character which may distinguish it generally. We call the species *Calamopleurus vestitus*, as the body is well clothed with scales.

Head about  $3\frac{1}{2}$  in length to base of caudal. Greatest depth about equal to length of head. Distance from gill opening to dorsal a little more than greatest depth. Anterior part of head destroyed; traces of three plates behind and below eye, as in other Elopidae. Upright limb of preopercle directed forward above. Opercle large, convex, with some black pigment within the bone as long as deep. Subopercle with concentric striæ, its depth about  $3\frac{1}{2}$  times in depth of opercle. Suture between opercle and subopercle very oblique and somewhat curved.

Scales cycloid, deeper than long, much larger than in any other of the Cretaceous Elopidae from Brazil, about 28 along lateral line to front of dorsal; 8 in a vertical series from front of dorsal to lateral line, 10 to 12 between lateral line and ventrals. In *Calamopleurus cylindricus* there are about 32 scales before dorsal on lateral line, about 15 above it and 18 to 20 below.

Lateral line very distinct, nearly median, slightly decurved anteriorly. Dorsal mostly obliterated, and pectorals also. Ventrals and anal wholly wanting, as is the whole caudal peduncle. Gular plate obliterated.

This fish is undoubtedly one of the Elopidae. It is near *Calamopleurus*; distinguished from *C. cylindricus* by the large scales and (perhaps generically) by the narrow subopercle.

A second nodule (No. 15, Rocha Collection) shows a portion of the posterior part of the body of a large example. The ventral fins, as in *Calamopleurus cylindricus*, are inserted under the last rays of the dorsal, both fins being apparently rather small. Between the dorsal and ventrals there are apparently only about 20 scales. The lateral line, although abraded, is readily traceable. Opercle and subopercle separate, separated by a distinct suture.

The relatively large size of the scales leads us to refer this example to *Calamopleurus vestitus*.

The counterpart of No. 11 is in the geological collections at Stanford University.

#### Genus NOTELOPS Woodward

*Notelops* WOODWARD, Cat. Fossil Fishes, IV, p. 27, 1901; type, *Rhacolepis brama* AGASSIZ.

This genus is close to *Calamopleurus*, from which it differs in the much stronger teeth and in the absence of a distinct lateral line. From *Rhacolepis* it differs in the entire scales, and, according to Woodward, in having the parietal bones not separated by a supraoccipital. This character we have been unable to verify.

#### 6. NOTELOPS BRAMA (Agassiz)

##### PLATE VI, FIG. 1

? *Amblypterus olfersi* AGASSIZ, Poissons Fossiles, II, pt. 1, p. 40, 1833; Ceará, Brazil (fragment; said to be unidentifiable).

Agassiz, Poissons Fossiles, IV, p. 293, 1844; Ceará.

(Not *Rhacolepis olfersi* AGASSIZ, Comptes Rendus, XVIII, p. 1012, 1844, which is based expressly on a figure of *Rh. buccalis*.<sup>1</sup>)

*Phacolepis brama* AGASSIZ, Edinburgh Phil. Journ., xxx, p. 83, 1841.

Barra do Jardim, based on a better specimen (misprint for *Rhacolepis*).

*Rhacolepis brama* WOODWARD, Proc. Zool. Soc. London, p. 539, pl. XLVI, fig. 1; pl. XLVII, fig. 4; Ceará.

*Notelops brama* WOODWARD, Cat. Fossil Fishes, IV, p. 27, 1901; Ceará.

<sup>1</sup> In the Comptes Rendus, Agassiz thus refers to "*Rhacolepis olfersi*."

"C'est au genre *Rhacolepis* qu'appartient l'espèce figurée par Spix; elle est plus large que la vôtre (*R. buccalis*), ses écailles sont plus grandes, et le second sous-orbitaire est plus étroit que les autres. Je l'ai appelée *R. olfersi*."

Of this species, well described and figured by Woodward, we have one head (No. 25, Rocha Collection), more or less crushed and split through the middle, but showing the long jaws armed with long, sharp, slender, even teeth, each  $\frac{1}{4}$  to  $\frac{1}{6}$  the diameter of the eye. Maxillary more than half head, extending far behind eye; subopercle about half size of opercle and nearly  $\frac{2}{3}$  its depth; the suture horizontal, the lower bone with radiating ridges; orbital bones obscurely shown.

This head corresponds fairly well to Woodward's figure of the head of *Notelops brama*, but the postorbital bones are wanting and no scales are preserved. Whether this is the same as the *Rhacolepis brama* of Agassiz we are not certain.

The name *brama* should apparently stand for this species, the name *olfersi* being rather a synonym of *buccalis*.

#### Genus RHACOLEPIS Agassiz

*Phacolepis* AGASSIZ, Edinburgh Phil. Journ., xxx, p. 83, 1841; type, *Phacolepis buccalis*; misprint for *Rhacolepis*.

*Rhacolepis* AGASSIZ, Comptes Rendus, xviii, 1844, p. 1011 (*buccalis*).

This genus is very close to *Notelops*, the only difference evident in our specimens being the subcylindrical form of the body, the more pointed head, and the crenate edges of the scales. According to Woodward, the genus differs in having the parietals separated by the intervention of the supraoccipital. The lateral line is obsolete, though a few traces of tubes can be seen on the anterior region.

#### 7. RHACOLEPIS BUCCALIS (Agassiz)

##### PLATE VI, FIG. 2

Spix and Martius, Reise Brasilien, pl. xxii, fig. 5; Ceará.

*Rhacolepis buccalis* AGASSIZ, Edinburgh Phil. Journ., xxx, p. 83; Cre-taceous of Ceará.

*Rhacolepis buccalis* AGASSIZ, Comptes Rendus, xviii, p. 1011, 1844; Agassiz, Poiss. Fossiles, iv, p. 293, 1844; Ceará.

Woodward, Proc. Zoöl. Soc. London, 1887, p. 539, pl. xlvi, figs. 2-7; pl. xlvii, figs. 1 to 3; Ceará.

Woodward, Cat. Fossil Fishes, iv, 1901, p. 30; Ceará.

? *Amblypterus olfersi* AGASSIZ, Poissons Fossiles, II, pt. 1, p. 40, 1833; Ceará; a fragment said to be unidentifiable.

*Rhacolepis olfersi* AGASSIZ, Comptes Rendus, xviii, p. 1012, 1844; based expressly on the figure of Spix and Martius.

Body subcylindrical, a little compressed, more slender than in *Calamopleurus*. Scales small, with crenate edges, about 12 above and 12 below lateral line. Lateral line inconspicuous or obsolete,

traceable anteriorly as a narrow streak or faint ridge on nearly all our specimens. Size small, the length about 6 inches. Of this species we have fragments of five individuals (Nos. 8, 9, 16, 17, Rocha Collection), besides a geodized trunk (Pessoa Collection)

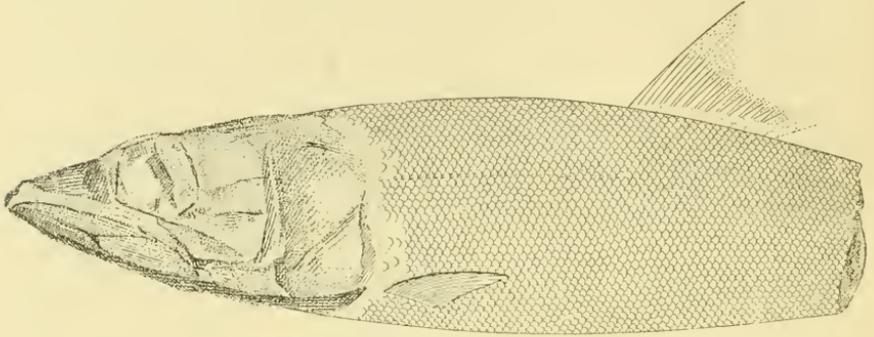


FIG. 12.—*Rhacolepis buccalis* Agassiz.

Barra do Jardim. The head restored after Woodward.

filled with quartz crystal, more or less telescoped, showing the scales well, but without head or fins. This specimen shows no trace of ventral fins, although the belly is completely preserved. In most of

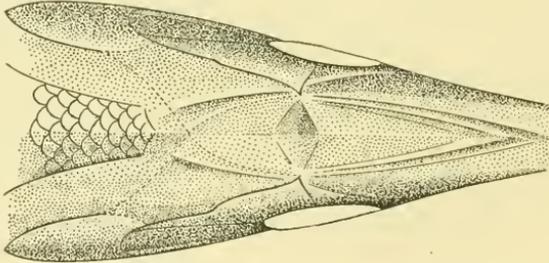


FIG. 13.—*Rhacolepis buccalis* Agassiz. Ceará. Top of head.

these specimens the substance under the scales is jet black. This is apparently due to the presence of the original pigment, in which case we may assume that the fish itself was black in life.

The plate or sheath-like projection above the opercle, more or less developed in all the Elopidae, is very distinct in this species.

### 8. RHACOLEPIS LATUS Agassiz

PLATE VI, FIG. 3

*Rhacolepis latus* AGASSIZ, Edinburgh Phil. Journ. xxx, p. 83, 1841; Cretaceous of Ceará.

*Rhacolepis latus* AGASSIZ, Comptes Rendus. xviii, p. 1012, 1844; Ceará.

Agassiz, Poiss. Fossiles, iv, p. 293, 1844; Ceará.

Woodward, Proc. Zool. Soc., London, 1887, p. 539, pl. XLVII, fig. 5; Ceará.

Woodward, Cat. Fossil Fishes, iv, 1901, p. 322; Ceará.

Of this small species we have two fragments (18, 19, Rocha Collection) from Ceará. The best of these (No. 18) shows a crushed head and part of the side of the body. Scales in about 15 rows above lateral line and 15 below. It seems to differ from *Rhacolepis buccalis* in the greater depth and compression of the body, the head being rather abruptly reduced in depth. Three orbital plates subequal, parallel; distance from gill opening to ventrals less than length of head. Opercle more than twice as large as subopercle, the suture very oblique; nuchal plate distinct. A trace of lateral line. The other specimen shows mainly the scales on the side anteriorly. Our specimens, however, add nothing to the account given by Woodward, and it may be possible that these specimens are simply *Rhacolepis buccalis* crushed flat.

#### Genus ENNELES Jordan and Branner, new genus

Allied to *Elopopsis* (Heckel, Denkschr. Akad. Wiss. Wien., XI, 1856, p. 251; type, *Elopopsis fenzi* Heckel). Among the *Elopidæ* this genus is distinguished by the very wide-set teeth, and by the wide gape which extends beyond the eye. From the type of the genus *Elopopsis* our Brazilian species differs in having a series of short, compressed teeth in the posterior part of the mandible, and the teeth on maxillary sharp and equal in length.

*Pachyrhizodus*, Agassiz, another Cretaceous genus with similarly large teeth, is closely related, but in that genus the teeth are closer set and more uniform.

#### 9. ENNELES AUDAX Jordan and Branner, new species

##### PLATE VII

Type a skull six inches in length, from Ceará (No. 22, Rocha Collection). With this is a partial counterpart showing the anterior part of the head without the lower jaw, the teeth of the maxillary being well preserved.

Depth of head  $1\frac{2}{3}$  in its length. Snout rather pointed, longer than eye,  $3\frac{1}{2}$  in head; eye about  $5\frac{1}{2}$ . Gape of mouth extending far beyond eye, its length about  $1\frac{3}{4}$  in head; supraoccipital crest somewhat elevated; branchiostegals numerous, 10 behind the end of the gular plate. Gular plate well preserved, very large, narrowly fan-shaped, its length nearly half that of head, its breadth at posterior end nearly half its length; mandible very strong, about  $1\frac{2}{3}$  in length of head; jaws even in front.

Teeth large, robust, wide-set, broadened at base and bluntly and rather abruptly narrowed at tip, the free portion of the longest about

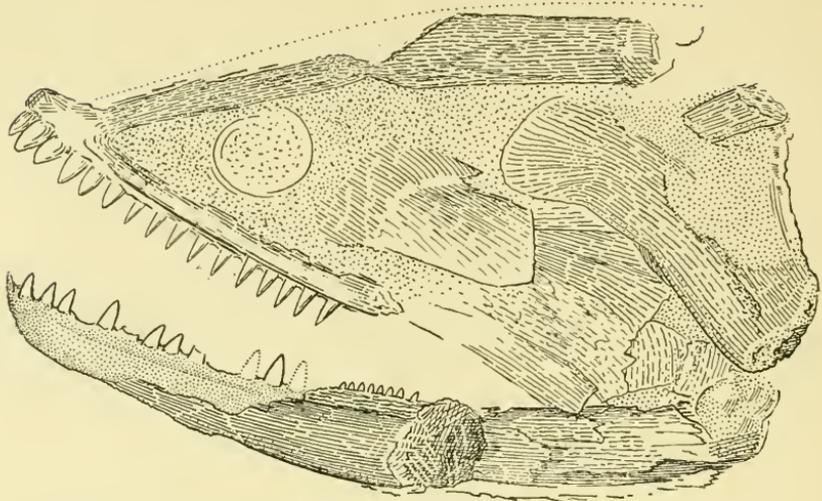


FIG. 14.—Skull of *Enneles audax* Jordan and Branner. Barra do Jardim. Type.

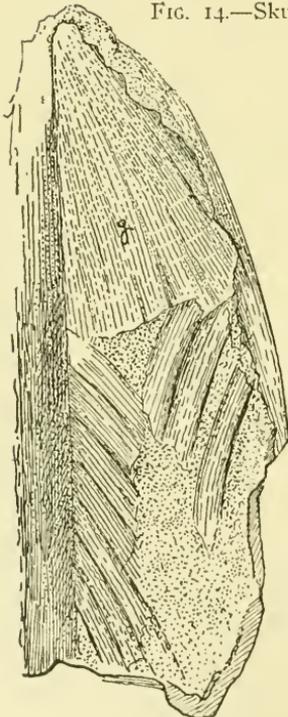


FIG. 15.—Skull of *Enneles audax* from below, showing gular plate and branchiostegals.

one-third diameter of eye. Premaxillary with four very large teeth at its tip, these thicker and rather longer than any other teeth in the mouth. Similar teeth at tip of lower jaw, these followed by slenderer teeth; those in the middle of the jaw also very robust and nearly as large as the front teeth; posterior part of lower jaw with a row of small compressed teeth, not very dissimilar and not one-third the length of the middle teeth; about eight of these teeth are evident. Teeth all one-rowed, none of them close-set; maxillary with a row of 8 or 10 stout, large, equal, sharp-pointed teeth, the anterior teeth most robust, similar to those of the middle of lower jaw; suborbital region narrow, the space between the eye and the roots of the maxillary teeth about half diameter of eye. Edge of maxillary straight. The maxillary teeth seem to be equal, not increasing in size backward, as in *Elopopsis fenzi*. The lower teeth

do not increase in size backward, the large fangs being followed by a series of short, compressed teeth.

The species is apparently new. On the characters at hand it is separable from *Elopopsis* by the form of the small teeth on the posterior part of the mandible, the presence of sharp subequal teeth on the maxillary, and by the relative size of other teeth. This may be held to indicate generic difference. In *Pachyrhizodus* the teeth of the mandible are subequal and close-set. The type of this species is in the possession of Senhor da Rocha at Ceará; the broken counterpart is in the geological collections at Stanford University.

The genera of Brazilian Cretaceous Elopidae may be thus compared with the living genera:

- a.—ELOPINÆ: Pseudobranchiæ large (in living species); scales relatively small; last ray of dorsal not prolonged; anal smaller than dorsal; base of caudal more or less scaly.
- b.—Dentition even, the teeth slender and close-set; dorsal with a sheath of scales.
- c.—Ventrals inserted behind middle of dorsal.
- d.—Lateral line well developed; teeth small. . . . . *Calamopleurus*
- dd.—Lateral line obsolete or developed on the anterior scales only.
- e.—“Parietals not separated by the supraoccipital”; scales entire or nearly so. . . . . *Notelops*
- ee.—Parietals separated by the supraoccipital; scales crenate. *Rhacolepis*
- cc.—Ventrals inserted under first ray of dorsal; lateral line well developed; body elongate; teeth small, even. . . . . *Elops*
- bb.—Dentition uneven, some of the teeth large, robust canines. . . . *Enneles*
- aa.—MEGALOPINÆ: Pseudobranchiæ none; scales large, firm; anal fin larger than dorsal; last ray of dorsal produced in a long filament; postorbital bones very thin, membranaceous.
- e.—Dorsal fin inserted above ventrals (*cyprinoides*). *Megalops*
- ce.—Dorsal fin inserted behind ventrals (*atlanticus*) . . . *Tarpon*

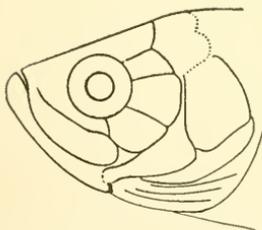


FIG. 16.—Head of *Megalops cyprinoides* Broussonet. Riu Kiu Islands.

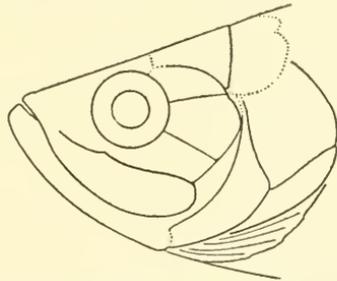


FIG. 17.—Head of *Tarpon atlanticus* C. & V. Porto Rico

## FAMILY CHIROCENTRIDÆ (?)

## Genus CLADOCYCLUS Agassiz

*Cladocyclus* AGASSIZ, Edinburgh Phil. Journ., xxx, 1841, p. 83; type, *Cladocyclus gardneri* Agassiz.

*Anadopogon* COPE, Proc. Am. Phil. Soc., xii, 1871, p. 53; type, *Anadopogon tenuidens* COPE.

This genus is notable for its large scales. The teeth are said to be small and nearly uniform.

## 10. CLADOCYCLUS GARDNERI Agassiz

## PLATE VIII, FIG. 1

*Cladocyclus gardneri* AGASSIZ, Edinburgh Phil. Journ., xxx, p. 83, 1841; Cretaceous of Ceará.

Agassiz, Poiss. Fossiles, v, pl. 1, pp. 8, 103, 1844; Ceará.

Agassiz, Comptes Rendus, xviii, p. 103, 1844.

Woodward, Cat. Fossil Fishes, iv, 1901, p. 108, pl. 9, fig. 1; Ceará.

*Anadopogon tenuidens* COPE, Proc. Am. Phil. Soc., xii, 1871, p. 53; Ceará.

We refer to this species a piece of a broken nodule (No. 26, Rocha Collection), showing a cast of part of the side of a very large fish. It shows little except that the scales are very large, about half an inch in diameter, with uneven or pustulose sur-

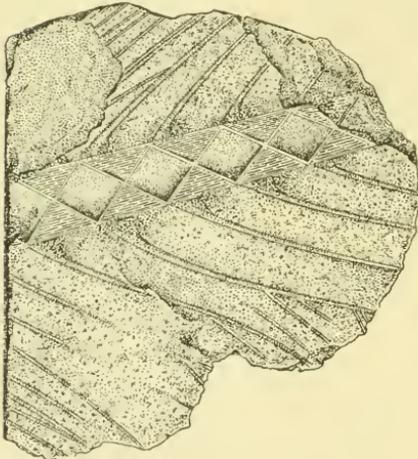


FIG. 18.—Species unknown. Barra do Jardim. Perhaps *Cladocyclus gardneri*.

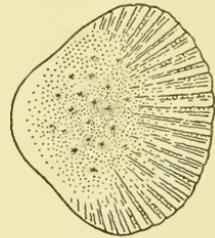


FIG. 19.—Scale of *Cladocyclus gardneri*. Ceará, Brazil.

face and edges. No trace of lateral line. We follow Woodward in referring the genus *Cladocyclus* to the Chirocentridæ.

Besides this specimen we have also a fragment of the caudal portion of the backbone of some unknown species (No. 30, Rocha Collection), possibly *Cladocyclus gardneri*. The fragment is remarkable for the regular rhombic form of the interspaces between the vertebræ and for the extreme narrowness of the centrum of each vertebra as seen in section.

## FAMILY OSTEOGLOSSIDÆ (?)

**Genus CEARANA** Jordan and Branner, new genus; type, *Cearana rochæ*

A specimen, badly preserved in a sand nodule, of different and harder texture than most of the others from Ceará, seems to represent a new genus, which we refer very doubtfully to the Osteoglossidæ, because, as in *Osteoglossum*, there is no division between the opercle and subopercle. The elongate body distinguishes this genus from *Pharcodus* (*Dapedoglossus*) and *Brychatus*; fossil genera of the Eocene, referred to the Osteoglossidæ.

In *Cearana* the head is oblong, forming about two-sevenths of the length to base of caudal. The greatest depth of the body is a little less; the body is oblong; the distance from the gill opening to the dorsal is considerably more than the greatest depth, a character apparently important in this group. About two-fifths of the length of the head is formed by the very large convex opercle, which is a single undivided bone marked by radiating striæ; preopercle with the upper limb erect and forming nearly a right angle. Jaws and teeth not preserved, and mouth apparently large and oblique, extending past the eye. Two postorbital bones behind eye and one on cheek approximately subequal in size; vertebræ 50. Distance of ventrals from gill opening about equal to length of head. Dorsal short, rather high, inserted over ventrals, its basal bones strong; ventrals midway between gill opening and anal. Caudal rays fine, the fin well forked, the tail a little heterocercal. Scales not well preserved, apparently small, firm and somewhat bony, with marked striæ.

II. CEARANA ROCHÆ Jordan and Branner, new species

PLATE VIII, FIG. 2

Of this species we have two specimens (No. 5 and No. 32, Rocha Collection), one in a nodule and represented in counterpart and one small one not in a nodule. In one specimen (No. 5) part of the body and the posterior portion of the head are very badly preserved. The head must have been a little less in length than the distance from the gill opening to the ventral fin. The preopercle is rounded, its upright portion nearly vertical. The opercle is very large, very convex, and in one piece, without separation of the subopercle. Its length is about equal to its depth and about three-fifths the greatest depth of the body, which is two-thirds the distance from gill opening to central. Surface of opercle nearly smooth. Pectoral fin placed low, a little longer than the opercle. Dorsal few-rayed (8 to 10) and rather high, the first rays longest, the first interneural large and

wedge-shaped, broadest below. Ventrals rather large, inserted opposite front of dorsal; vertebræ spool-shaped, about 22 before dorsal. Scales mostly lost, apparently firm and cycloid, with marked concentric striæ, about 14 in a cross-series below dorsal, these much larger than in *Calamopleurus*.

This specimen is about 5 inches long, represented in counterpart, the portion in front of the preopercle and that behind the vent being lost. A small example (No. 32, Rocha Collection) of the same species and showing nearly the same parts is not quite 3 inches long.

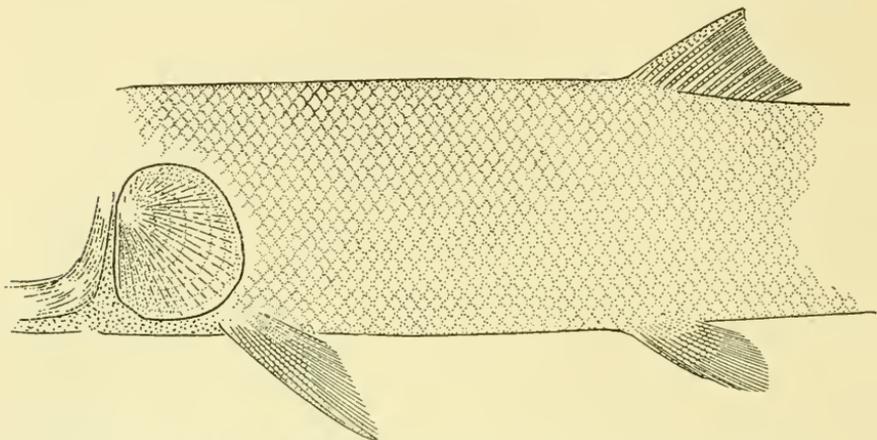


FIG. 20.—*Cearana rocha* Jordan and Branner. From type. Ceará, Brazil.

This shows the large, undivided opercle. The eye is shown also, its diameter about two-thirds that of the opercle, and the space between eye and opercle about two-thirds eye.

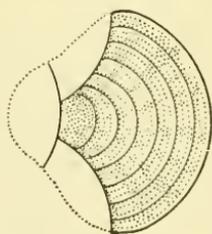


FIG. 21.—Scale of  
*Cearana rocha*.

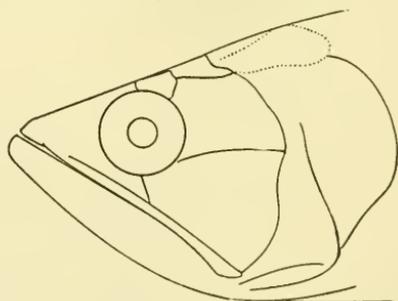


FIG. 22.—*Ostcoglossum bicirrhosum*  
(a living form). Itaituba, Brazil.

What seems to be the maxillary is also evident, rather broad, and extending behind the eye. About 18 vertebræ before dorsal, which is rather higher than long. On the same stone is a faint impression of another specimen still smaller.

The species cannot be fully described without better material, but in any event it may be known at once among Brazilian Cretaceous fishes by the character of the large convex undivided opercle, very conspicuous in all these specimens. It is also distinguishable at once from *Calamopleurus*, *Notelops*, and *Tharrhias* by the much greater distance from the gill opening to the dorsal fin. This is greater than length of head or than depth of body. At the request of Senhor Dias da Rocha, its discoverer, this genus is named for his native province of Ceará, where the type was obtained; the species is named for Senhor Rocha himself, who brought together this remarkable collection.

The counterpart of No. 5 is in the department of geology at Stanford University; the type is with Senhor Francisco Dias da Rocha at Ceará.

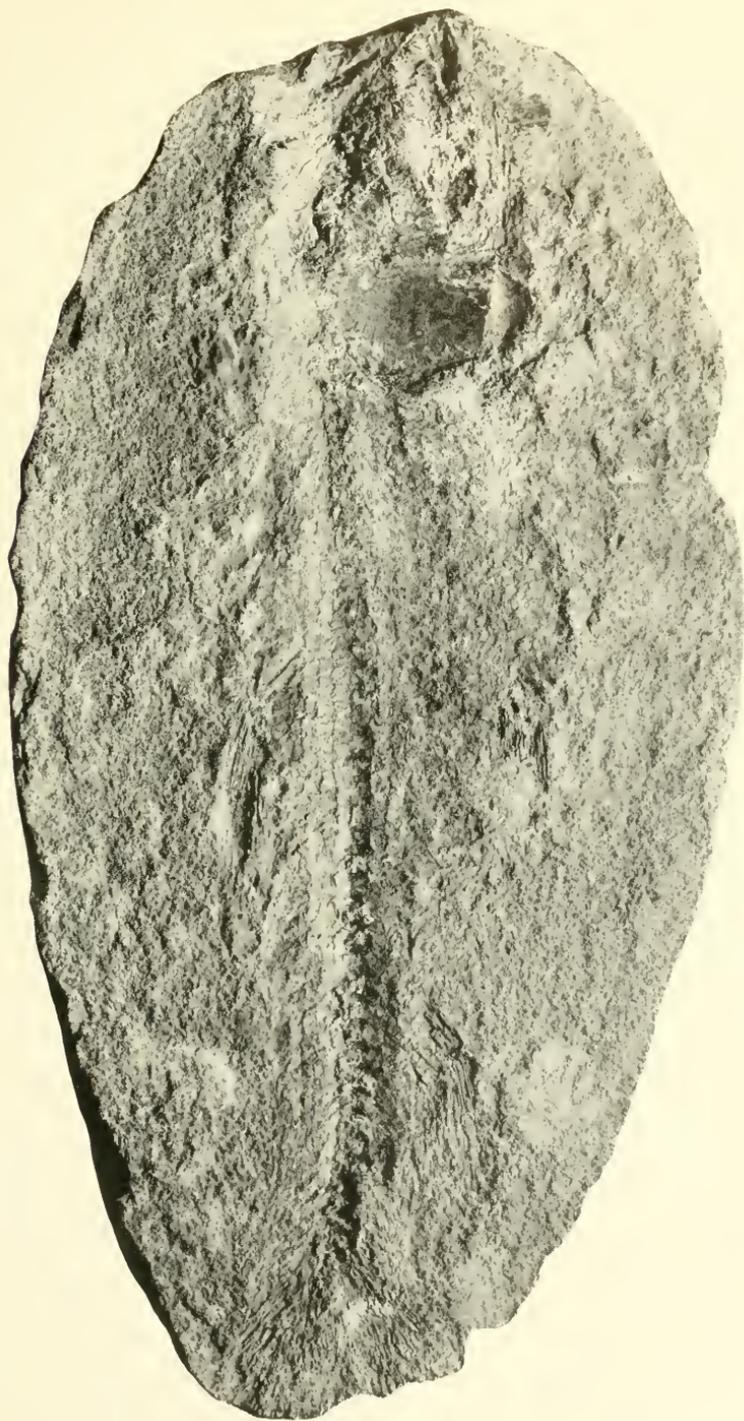
It may be noted that a peculiar interest attaches to this, as to any other accessible portion of the Cretaceous fish fauna. This period represents the decline and partial disappearance of the ganoid types, with rhombic enameled scales, represented by *Belonostomus* and *Lepidotes*. This is contemporaneous with the first appearance of the lowest of the bony fishes, of which the Leptolepidæ and the Elopidae are both among the most primitive, followed later by Chirocentridæ, Osteoglossidæ, and other forms allied to the herring.





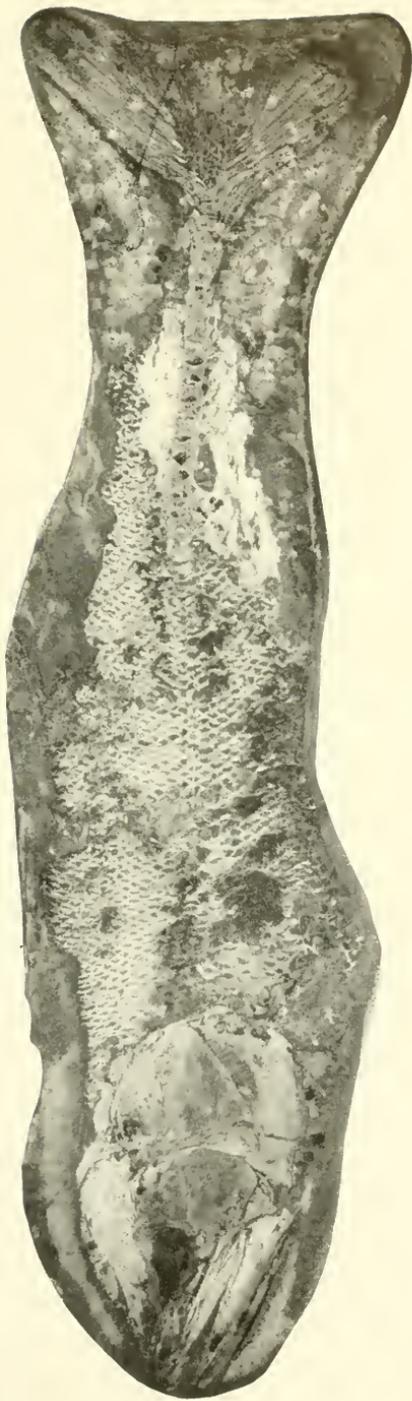
2  
BELONOSTOMUS COMPTONI Agassiz  
3  
1.—Head and anterior parts, 2.—Caudal region, 3.—Example coiled in a nodule





THARRHIAS ARARIPIS Jordan and Branner. Type, Serra do Araripe, Ceará, Brazil





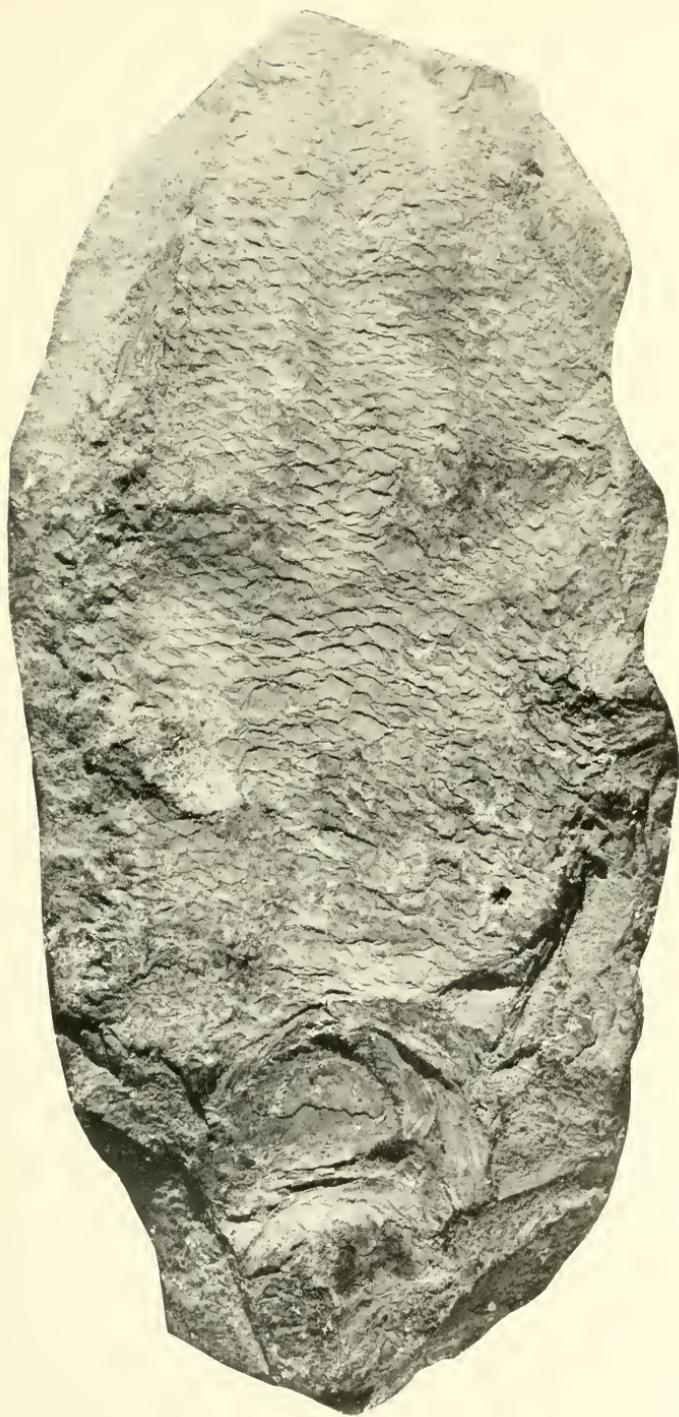
GALAMOPLEURUS CYLINDRICUS Agassiz. *Ceati*





CALAMOPLEURUS CYLINDRICUS Agassiz  
Counterpart of Plate III





CALAMOPLEURUS VESTITUS JORDAN AND BRANNER. Type, Ceará





1. HEAD OF *NOTELOPS BRAMA* (Agassiz). Ceará, Brazil



2. *RHACOLEPIS BUCCALIS* Agassiz

(From figure of Spix & Martius, type of *Rhacolepis olfersi*)

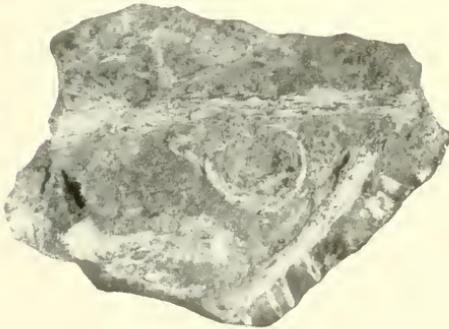


3. *RHACOLEPIS LATUS* Agassiz. Ceará



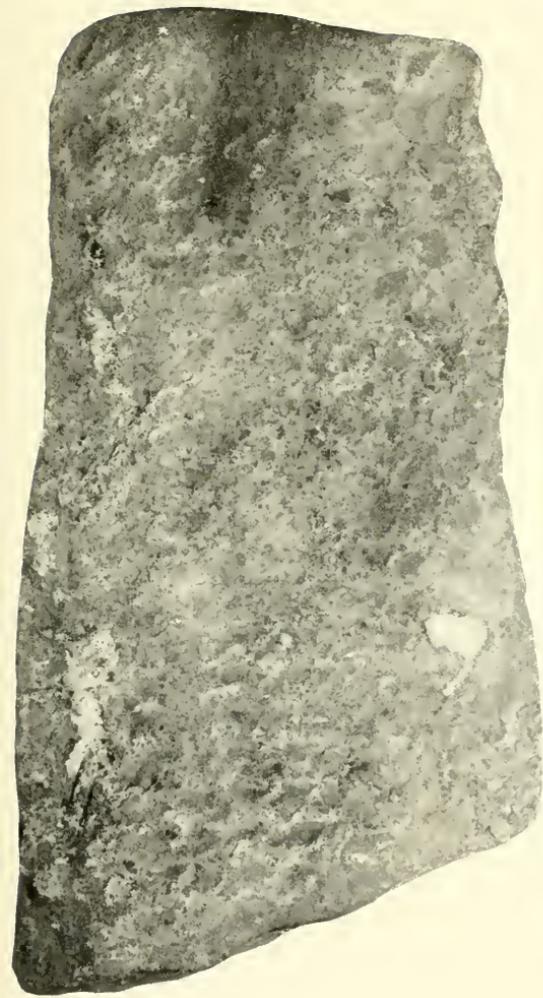


1. ENNELES AUDAX Jordan and Branner  
Head. Cretaceous of Ceará



2. ENNELES AUDAX Jordan and Branner  
Counterpart of part of head. Cretaceous of Ceará





1. CLADOCYCLUS GARDNERI Agassiz. Ceará



2. CEARANA ROCHAE Jordan and Branner. Ceará



