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BULLETIN

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CONTENTS OF VOLUME XIX.

	PAGE.
Title-page	i
Officers and Trustees	iii
Scientific Staff	v
Contents	vii
Dates of Publication of Authors' Separates	ix
List of Illustrations	x
List of new names of Genera, Species, and Subspecies	xiv
Errata	xvii
ART. I.—On Certain Genera and Species of North American Cretaceous Actinopterous Fishes. By O. P. HAY. (Plates I–V, and 72 text figures)	1
II.—Notice of a Species of *Acidaspis* from a Boulder of Marcellus Shale, Found in Drift, at West Bloomfield, New Jersey. By C. H. HITCHCOCK. (Plate VI)	97
III.—Description of a New Species of *Sigmodon* from Ecuador. By J. A. ALLEN	99
IV.—Report on the Mammals Collected in Northeastern Siberia by the Jesup North Pacific Expedition, with Itinerary and Field Notes by N. G. BUXTON. By J. A. ALLEN	101
V.—Descriptions of New Rodents from Southern Patogonia, with a Note on the Genus *Euneomys* Coues, and an Addendum to Article IV, on Siberian Mammals. By J. A. ALLEN	185
VI.—The Fauna of the Titanotherium Beds at Pipestone Springs, Montana. By W. D. MATTHEW. (Nineteen text figures)	198
VII.—A Fossil Hedgehog from the American Oligocene. By W. D. MATTHEW. (One text figure)	227
VIII.—Divisions of the Parietal Bone in Man and other Mammals. By ALEŠ HRDLICKA. (Plates VII–XXII, and 39 text figures)	231
IX.—Adaptive Significance of the Shortening of the Elephant's Skull. By W. K. GREGORY. (Plate XXIII, and 4 text figures)	387
X.—On a Collection of Upper Cretaceous Fishes from Mount Lebanon, Syria, with Descriptions of Four New Genera and Nineteen New Species. By O. P. HAY. (Plates XXIV–XXXVII)	395
XI.—A New Species of Fossil Edentate from the Santa Cruz Formation of Patagonia. By BARNUM BROWN. (Two text figures)	453

PAGE

ART. XII.—*Ornitholestes hermanni*, a New Compsognathoid Dinosaur from the Upper Jurassic. By HENRY FAIRFIELD OSBORN. (Three text figures)..... 459

XIII.—A New Three-toed Horse. By J. W. GIDLEY..... 465

XIV.—On Two Species of *Platygonus* from the Pliocene of Texas. By J. W. GIDLEY. (Five text figures).... 477

XV.—Notice of Six New Species of Unios of the Laramie Group. By R. P. WHITFIELD. (Plates XXXVIII–XL)..... 483

XVI.—Observations on a Remarkable Specimen of *Halysites* and Description of a New Species of the Genus. By R. P. WHITFIELD. (Plates XLI and XLII)..... 489

XVII.—*Glyptotherium texanum*, a New Glyptodont, from the Lower Pleistocene of Texas. By HENRY FAIRFIELD OSBORN. (Plate XLIII)..... 491

XVIII.—West Indian Sponge-Incrusting Actinians. By J. E. DUERDEN. (Plates XLIV–XLVII)..... 495

XIX.—Notes on Some Species of *Catocala*. By WILLIAM BEUTENMÜLLER..... 505

XX.—Notes on Some Beetles from the Black Mountains, with Descriptions of New Species. By WILLIAM BEUTENMÜLLER. (Plates XLVIII and XLIX).... 511

XXI.—Mammals Collected in Alaska and Northern British Columbia by the Andrew J. Stone Expedition of 1902. By J. A. ALLEN..... 521

XXII.—A New Genus of Ground Sloth from the Pleistocene of Nebraska. By BARNUM BROWN. (Plates L and LI)..... 569

XXIII.—Description of a New Moth from North Carolina. By WILLIAM BEUTENMÜLLER..... 585

XXIV.—List of Mammals Collected by Mr. J. H. Batty in New Mexico and Durango, with Descriptions of New Species and Subspecies. By J. A. ALLEN..... 587

XXV.—A New Deer and a New Lynx from the State of Sinaloa, Mexico. By J. A. ALLEN..... 613

XXVI.—The Fresh-Water Tertiary of Northwestern Texas. American Museum Expeditions of 1899–1901. By J. W. GIDLEY. (Plates LII–LVIII)..... 617

XXVII.—A New Katydid from Florida. By WILLIAM BEUTENMÜLLER. (One text figure)..... 637

XXVIII.—Extraordinary Females in Three Species of *Formica*, with Remarks on Mutation in the Formicidæ. By WILLIAM MORTON WHEELER. (Three text figures)..... 639

PAGE

ART. XXIX.—Some New Gynandromorphous Ants, with a Review of the Previously Recorded Cases. By WILLIAM MORTON WHEELER. (Eleven text figures) 653

XXX.—Skull of *Triceratops serratus*. By RICHARD SWANN LULL, Ph.D. (Plates LIX and 1 text figure) .. 685

XXXI.—The Skull of *Creosaurus*. By HENRY FAIRFIELD OSBORN (Two text figures) 697

DATES OF PUBLICATION OF AUTHORS' SEPARATES.

Art. I, March 4.
" II, " 21.
" III, " 20.
" IV, " 31.
" V, May 9.
" VI, " 9.
" VII, " 9.
" VIII, July 11.
" IX, " 8.
" X, " 8.
" XI, " 8.
" XII, " 23.
" XIII, " 24.
" XIV, " 24.
" XV, Aug. 10.
" XVI, " 10.
Art. XVII, Aug. 17.
" XVIII, Oct. 15.
" XIX, Sept. 9.
" XX, " 26.
" XXI, Oct. 10.
" XXII, " 28.
" XXIII, " 24.
" XXIV, Nov. 12.
" XXV, " 14.
" XXVI, " 21.
" XXVII, " 21.
" XXVIII, " 21.
" XXIX, Dec. 5.
" XXX, " 24.
" XXXI, " 24.

The edition of separates from the present volume was 350, of which 100 were for the authors, and 250 for the Library exchange list and for sale.

LIST OF ILLUSTRATIONS.

Plates.

I–V.—North American Cretaceous Actinopterous Fishes.
VI.—*Acidaspis whitfieldi* Hitchcock.
VII–XXII.—Divisions of the Parietal Bone in Man and other Mammals.
XXIII.—Inferior view of skull of young Asiatic Elephant.
XXIV–XXXVII.—Upper Cretaceous Fishes from Mount Lebanon, Syria.
XXXVIII–XL.—New Species of *Unio* from the Laramie Group.
XLI and XLII.—Species of *Halycites*.
XLIII.—*Glyptotherium texanum* Osborn.
XLIV–XLVII.—West Indian Sponge-incrusting Actinians.
XLVIII and XLIX.—Beetles from the Black Mountains of North Carolina.
L and LI.—*Paramylodon nebrascensis* Brown.
LII.—Upper Mulberry Cañon, Northwestern Texas, showing typical Miocene scarp.
LIII.—Pleistocene Exposures, at head of Rock Creek, Swisher Co., Texas.
LIV.—Blanco Beds, near Mount Blanco, Texas.
LV.—Mulberry Cañon, Texas, showing continuity of strata.
LVI.—Head of Petrified Cañon, Texas, showing excavation in Clarendon Beds.
LVII.—Map of Texas, showing area of explorations.
LVIII.—Geological Map of Northwestern Texas.
LIX.—*Triceratops serratus* Marsh.

Text Figures.

PAGE.

Protosphyræna nitida (Cope), rostrum, two views..... 5
" " dentary, splenial, and part of pectoral fin..... 7
Protosphyræna perniciosa (Cope), cleithrum, coracoid, etc..... 11
" " cleithrum, base of fin, etc..... 13
" *dimidiata* (Cope), rostrum..... 17
" " side view of upper jaw..... 18
" " part of upper jaw, and vertebra. 19
" *ziphioides* (Cope), rostrum, two views..... 23
Anogmius sp., caudal vertebræ..... 27
" " part of caudal fin..... 30
" *favirostris* Cope, front view of head, seen from below.. 31
" " three caudal vertebræ, and anterior half of skull..... 32

PAGE

Anogmius favirostris Cope, floor and roof of mouth..... 33
" *aratus* Cope, head from above..... 37
" " roof of mouth..... 39
" " floor of mouth..... 40
" *altus*? Loomis, posterior part of skull..... 41
" " parasphenoid and presphenoid..... 43
" " inferior grinding and dental plates.... 44
" " dental plates and caudal vertebræ... 45
" *evolutus* Cope, lower jaw..... 46
Saurocephalus phlebotomus Cope, premaxilla..... 49
" *xiphirostris* (Stewart), premaxilla and palatine.... 52
" *goodeanus* (Cope), upper jaw, outer view..... 53
Ichthyodectes multidentatus Cope, skull..... 57
" " cleithrum..... 59
Pachyrhizodus caninus Cope, mandible..... 61
" " shoulder girdle..... 62
Oricardinus sheareri Cope, portion of maxilla..... 65
" *tortus* Cope, dentary, and two caudal vertebræ..... 66
Enchodus ferox Leidy, palatine and fang..... 68
" *petrosus* Cope, dentary..... 71
" *dolichus* Cope, skull..... 73
" *tetræcus* Cope, palatine fangs..... 74
" *gladiolus* Cope, jaws..... 75
" " hinder part of skull..... 76
" *sævus* Hay, right palatine and fang..... 77
" " right and left palatine fangs from in front.. 78
" " articular process of right palatine..... 78
" *petrosus* Cope, left palatine fang from in front..... 78
" " posterior end of left palatine..... 78
" *sævus* Hay, palatine bones..... 78
" " lower jaw, two views..... 79
" " interoperculum and preoperculum..... 80
Stratodus oxypogon Cope, jaws, and fragment of palatine..... 80
" " two caudal vertebræ..... 81
Empo nepaholica Cope, upper view of skull..... 85
" " part of skull, lateral view..... 86
" " skull from below..... 87
" " supports of ventral fins..... 88
Peratherium titanelix Matthew, type (lower jaw)..... 202
Apternodus mediævus Matthew, type (lower jaw)..... 203
Micropternodus borealis Matthew, type (lower jaw)..... 205
Ictops acutidens Douglas, dentition..... 206
" *thompsoni* Matthew, crown view of upper molars..... 207
Pseudopterodon minutus Douglas, crown view of upper teeth..... 209
Cylindrodon fontis Douglas, crown views of upper and lower teeth. 212

PAGE
Sciurus vetustus Matthew, crown view of upper teeth 213
Gymnoptychus minor (Douglas), lower jaws 215
" *minimus* Matthew, lower jaw 216
Stibarus montanus Matthew, part of lower jaw 219
" *obtusilobus* Cope, type specimen 219
Bathygenys alpha Douglas, upper teeth, crown view 221
Leptomeryx esulcatus Cope, lower jaw 223
" *mammifer* Cope, lower jaw, and crown view of lower premolars 224
Leptotragulus profectus Matthew, lower jaw 225
" " " crown view of teeth 226
Proterix loomisi Matthew, part of skull 228
Skull of Orang, showing a complete antero-posterior parietal division 243
Skull of Chimpanzee, showing a bilateral parietal division 246
Partial anterior parietal divisions in Apes 248
Skull of young Orang, showing a partial anterior parietal division. 249
Wormian bone in lower part of coronal suture 251
Parietal division in prehistoric human skull 258
" " " " " 260
Macacus rhesus, incisure in the sagittal border of left parietal 266
" " partial vertical division in left parietal 266
Hapale sp., division of right parietal 270
Macacus rhesus, separation in lower border of nasals, and two supra-nasal ossicles 272
Macacus rhesus, partly obliterated parietal division 273
" " vertical-oblique parietal division 276
" " partial temporo-parietal division 277
" " temporo-parietal division 279
" *erythræus*, division in the left parietal 285
" *rhesus*, suture in the mastoid angle of the right parietal. 288
" " parietal divisions 290
Cebus capucinus, incomplete parietal divisions 291
Ateles ater, parietal incisures 292
" sp. " " 293
Cebus albifrons, division of right parietal bone 306
" *hypoleucus*, antero-posterior division of left parietal 306
Ateles sp., parietal division 307
Head of human embryo, showing two separate centers of parietal ossification 323
Embryonal parietal bones, showing two centers of ossification ... 324
Left parietal of a new-born child, showing the primary fissures .. 357
Alces americanus, radiations from the metopic and coronal suture. 358
Parietal bone of child, showing advancing ossification in parietal comb, and formation of foramina or inclosures 359

PAGE
Radiations in the cranial suture in an adolescent Black Bear.... 360
Right parietal bone of child, showing remnants of anterior and posterior cleft..... 362
Temporal squamæ in young Virginia Deer, etc..... 367
Temporo-parietal suture and squama of Dog, showing defects in the bone filled in with a portion of the parietal bone..... 367
Divisions and spines from and to foramina on the parietal, temporal, and other cranial bones in mammals and man..... 368
Parietal bone of an Oryx, showing spine filling a cleft, etc.. ... 368
Asiatic Elephant, inferior view of a young skull..... 390
" " superior view of same skull..... 391
" " side view " " 392
" " orbito-sphenoidal region, showing bones, foramina, etc..... 393
Eucinepeltus complicatus Brown, type skull and casque..... 455
" " type casque..... 456
Ornitholestes hermanni Osborn, skeleton..... 461
" " palmar view of left manus..... 462
" " left manus..... 463
Platygonus bicalcaratus? Cope, right upper premolar-molar series. 477
" *texanus* Gidley, upper premolar-molar series..... 478
" *vetus* Leidy, " " " 479
" *vetus* and *P. texanus*, palatal view of skull..... 480
Diagrammatic section across Tule Cañon, Northwestern Texas... 626
" " " Blanco Cañon? " " 626
" " " Mulberry Cañon, " " 631
" " of the Clarendon beds, " " 631
Cyrtophilus floridensis Beutenmüller..... 638
Formica ciliata Mayr, female and worker..... 641
" *oreas* Wheeler, female and worker..... 644
" *microgyna* Wheeler, female and worker..... 647
" " gynandromorph; male and female.. 657
Stenamma fulvum subsp. *aquia* var. *piceum*, gynandromorph..... 660
" " " " head of gynandromorph..... 661
Leptothorax obturator, gynandromorph..... 663
Ephipheidole inguilina Wheeler, gynandromorph..... 665
Formica sanguinea, gynandromorph..... 667
Tetramorium simillimum, gynandromorph..... 668
Polyergus rufescens, reproductive organs of hermaphroditic and gynandromorphic..... 671
Polyergus rufescens, head of gynandromorph..... 672
Azteca instabilis, head of gynandromorph..... 674
Camponotus liginiperdus, gynandromorph..... 675
Triceratops serratus Marsh, skull..... 688
Creosaurus atrox Marsh, skull..... 698

LIST OF HIGHER GROUPS, GENERA, SPECIES, AND SUBSPECIES, DESCRIBED OR RENAMED IN THIS VOLUME.

Families.

PAGE.
Anguillavidæ Hay 436
Encheliidæ Hay 441

Genera.

Apternodus Matthew 202
Micropternodus Matthew 204
Prosciurus (subgen.) Matthew 213
Proterix Matthew 228
Stenoprotome Hay 407
Enbiodectes Hay 415
Anguillavus Hay 437
Enchelion Hay 441
Ornitholestes Osborn 459
Neohipparion Gidley 466
Glyptotherium Osborn 492
Paramylodon Brown 569
Epipheidole Wheeler 664

Species and Subspecies.

Protosphyræna sequax Hay 20
Enchodus sævus Hay 76
Sardinius? imbellis Hay 93
Acidaspis whitfieldi Hitchcock 97
Sigmodon puna Allen 99
Citellus buxtoni Allen 139
" *stejnegeri* Allen 142
Evotomys (Craseomys) latastei Allen 145
" *jochelsoni* Allen 148
Lemmus obensis chrysogaster Allen 153
Ochotona kolymensis Allen 154
Lepus gichiganus Allen 155
Vulpes anadyrensis Allen 167
Putorius (Arctogale) pygmæus Allen 176
Erinaceus orientalis Allen 179
Sorex buxtoni Allen 181
Ctenomys robustus Allen 185

PAGE

Ctenomys sericeus Allen..... 187
" *colburni* Allen..... 188
Oxymycterus microtis Allen..... 189
Reithrodon cuniculoides obscurus Allen..... 190
" *hatcheri* Allen..... 191
Euneomys petersoni Allen..... 192
Peratherium titanelix Matthew..... 202
Apternodus mediævus Matthew..... 202
Micropternodus borealis Matthew..... 204
Ictops thompsoni Matthew..... 207
Cynodyctis paterculus Matthew..... 209
Bunælurus infelix Matthew..... 210
Ischyromys veterior Matthew..... 211
Sciurus (Prosciurus) vetustus Matthew..... 213
Palæolagus brachyodon Matthew..... 217
Stibarus montanus Matthew..... 219
Leptotragulus profectus Matthew..... 224
Proterix loomisi Matthew..... 228
Sclerorhynchus solomonis Hay..... 399
" *hiram* Hay..... 401
" *sentus* Hay..... 402
Rhinobatus eretes Hay..... 404
Raja whitfieldi Hay..... 405
Stenoprotome hamata Hay..... 407
Coccodus insignis Hay..... 410
Ctenothrissa signifer Hay..... 417
Leptotrachelus serpentinus Hay..... 419
Osmeroides pontivagus Hay..... 424
" *ornatus* Hay..... 426
Acrognathus dodgei Hay..... 427
Microcælia dayi Hay..... 430
Rhinellus delicatus Hay..... 432
Urenchelys germanus Hay..... 434
Anguillavus quadripinnis Hay..... 437
" *bathshebæ* Hay..... 439
Enchelion montium Hay..... 441
Pycnosterinx levispinosus Hay..... 444
Aipichtys formosus Hay..... 445
Eucinepeltus complicatus Brown..... 453
Ornitholestes hermanni Osborn..... 459
Neohipparion whitneyi Gidley..... 467
Platygonus texanus Gidley..... 478
Unio æsopiformis Whitfield..... 483
" *verrucosiformis* Whitfield..... 484
" *retusoides* Whitfield..... 485
" *browni* Whitfield..... 485

PAGE

Unio percorrugata Whitfield..... 486
" *postbiplicata* Whitfield..... 487
Halysites radiatus Whitfield..... 490
Glyptotherium texanum Osborn..... 492
Catocala relicta var. *clara* Beutenmüller..... 506
" *aholibah* var. *coloradensis* Beutenmüller..... 507
" *amica*, var. *suffusa* Beutenmüller..... 508
" *unijuga* var. *fletcherii* Beutenmüller..... 509
Nomaretus debilis var. *alpinus* Beutenmüller..... 512
Cychrus viduus var. *irregularis* Beutenmüller..... 513
" *æneicollis* Beutenmüller..... 515
Platynus trifoveolatus Beutenmüller..... 516
" *gracilentus* Beutenmüller..... 517
Anthophilax hoffmanii Beutenmüller..... 518
Citellus stonei Allen..... 537
" *columbianus albertæ* Allen..... 537
Synaptomys (*Mictomys*) *andersoni* Allen..... 554
" " *chapmani* Allen..... 555
Erethizon epizanthus nigrescens Allen..... 558
Putorius microtis Allen..... 563
Paramylodon nebrascensis Brown..... 571
Olene montana Beutenmüller..... 585
Odocoileus battyi Allen..... 591
Eutamias durangæ Allen..... 594
Citellus (*Otospermophilus*) *grammurus rupestris* Allen..... 595
Peromyscus paulus Allen..... 598
" *texanus flaccidus* Allen..... 599
Sigmodon baileyi Allen..... 601
Reithrodontomys megalotis sestinensis Allen..... 602
Neotoma intermedia durangæ Allen..... 602
Perodipus obscurus Allen..... 603
Lepus (*Macrotolagus*) *texianus micropus* Allen..... 605
" " *gaillardi battyi* Allen..... 607
" (*Sylvilagus*) *durangæ* Allen..... 609
Canis impavidus Allen..... 609
Myotis californicus durangæ Allen..... 612
Odocoileus sinaloæ Allen..... 613
Lynx ruffus escuinapæ Allen..... 614
Cyrtophyllus floridensis Beutenmüller..... 637
Formica oreas Wheeler..... 643
" *microgyna* Wheeler..... 645
" " var. *rasilis* Wheeler..... 648
Epipheidole inquilina Wheeler..... 664

ERRATA.

Page 91, line 9 from top, for JORLAN read JORDAN.

Page 447, center heading, for **bicalaratus** read **bicalcaratus.**

Page 524, last line, for Sorex longicauda read Sorex longicaudata.

Page 537, line 14, for Wrangel Island, Alaska, read western end of Alaska Peninsula.[1]

Page 566, line 8, for **Sorex longicauda** (*Merriam*) read **Sorex longicaudata** (*Merriam*).

[1] The type of *Citellus stonei* proves to have been collected on the western end of the Alaska Peninsula, opposite the Shumagin Islands, instead of on Wrangel Island. Through some mistake the label bore, in pencil, the erroneous locality of Wrangel Island.

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VOLUME XIX, 1903.

Article I. — ON CERTAIN GENERA AND SPECIES OF NORTH AMERICAN CRETACEOUS ACTINOPTEROUS FISHES.

By O. P. HAY.

PLATES I–V, AND 72 TEXT FIGURES.

The present paper has resulted from observations made by the author on Cretaceous fishes in the course of his work of identifying, cataloguing, and arranging the Cope Collection of fishes and reptiles, now the property of the American Museum of Natural History. In this collection are most of the types of the fishes which Professor Cope described from the Cretaceous deposits of Kansas, South Dakota, and New Jersey; and there are likewise many other specimens which had not been carefully identified and studied. A comparison of these materials with the types, and of the types with one another, and an estimation of the value of the proposed species in the light of work done by more recent investigators, have resulted in the reduction of a considerable number of nominal species to the position of synonyms. Many of Cope's types have hitherto never been figured and the opportunity offered by the liberality of the Museum authorities has been employed to furnish many drawings and photographic reproductions of interesting specimens. My thanks are especially due to Prof. Henry F. Osborn for the opportunity to prepare and present this

paper. Of the drawings, Mr. R. Weber has made numbers 27, 58, 59, 60, 61, 62, and 65. All the others, except 32 and 72, have been prepared by Mrs. L. M. Sterling. The photographs for the plates have been made by Mr. A. E. Anderson, photographer of the Palæontological Department.

PROTOSPHYRÆNIDÆ.

The genus *Protosphyræna* is referred by Dr. A. S. Woodward to the Pachycormidæ; and in this procedure he is followed by Loomis (Palæontogr., XLVI, 1900, p. 221), by Stewart (Univ. Geol. Surv. Kan., VI, 1900, p. 362), and by the present writer (Bibliog. and Cat. Foss. Vert. N. A., 1902, p. 378). A reconsideration of the subject and the study of the materials at hand in this Museum have led me to a different view.

If we refer the genus to this family we must assume that the vertebral column was not at all ossified or only feebly so. That it was composed of well ossified vertebræ cannot yet be proved. However, accompanying the type of *P. dimidiata* there is a single vertebra which belonged close to the skull. It is figured on page 19. This vertebra may be an intrusion from some other fish, but there is nothing in its appearance to suggest this.

So far as the writer can gather from the literature, neither the Isopholidæ, hitherto called Eugnathidæ, nor the Pachycormidæ, possess ossified scapulæ and coracoids. Even the members of the more advanced family Amiidæ, with well developed vertebræ, have scapulæ and coracoids cartilaginous. *Protosphyræna*, on the other hand, has the elements of the shoulder girdle developed as in the modern Isospondyli. While there may be no necessary connection between an ossified shoulder girdle and ossified vertebræ, it seems logical to believe that, when the shoulder girdle is so advanced in its development as it is in *Protosphyræna*, there were probably also well defined vertebræ. It is remarkable that vertebræ have not been certainly collected, but neither has the tail fin been obtained, nor the anal, nor the dorsal fin.

It is proper to add to the above paragraph the statement

that in a specimen of *Hypsocormus* from Solenhofen, which the writer has been able to examine, there are evidences of the presence of ossified scapula and coracoid. If this shall prove to be the case, the fact that these elements are ossified in *Protosphyræna* will have no bearing on the question regarding the presence of vertebræ.

While there are many interesting and important characters common to *Hypsocormus* and *Protosphyræna*, there are also many striking differences. I regard the deeply socketed teeth of *Protosphyræna* as furnishing a character of family value. Woodward indeed states that the teeth of *Hypsocormus* are in incomplete sockets, those of the dentary of *H. tenuirostris* (Cat. Foss. Fishes, IV, p. 397) being fused with the bone in sockets which are incomplete on the inner side. The condition of such teeth is certainly very different from that of the teeth of *Protosphyræna*, which are in complete and very deep sockets. It evidently signifies a great departure from the primitive condition in fishes, when teeth become so deeply implanted in the bone and are replaced, not by new teeth developing in the mucous membrane of the mouth, but from germs lodged deep in sockets.

The pectoral fin of *Protosphyræna* is quite different from that of *Hypsocormus*, as may be seen by comparing the description and figures of *P. perniciosa* presented in this paper with the description of the fin given by Dr. Woodward on page 398 of the work cited above. In *Protosphyræna* there is no such intimate fusion of rays and the foremost rays are extremely short.

The condition of the shoulder girdle of *Protosphyræna* would appear to relegate the genus to the Isospondyli. Whether the possession of a splenial and a slight excess of baseosts is sufficient to exclude it from this order may have to be determined hereafter. At any rate, the genus is close to the border line between the Halecomorphi and the Isospondyli.

Protosphyræna nitida (*Cope*).

Erisichthe nitida Cope (E.D.), Proc. Acad. Nat. Sci. Phila. 1872, p. 280; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 42;

Vert. Cret. Form. West, 1875, pp. 217, 275, pl. xlviii, figs. 3–8; Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 821 (in part).

Protosphyræna nitida NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIV, 1878, p. 794. — FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 278 (in part). — WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. III, 1895, p. 409. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 227 (in part only). — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Pelecopterus chirurgus COPE (E. D.), Vert. Cret. Form. West, 1875, pp. 244E, 273, pl. xlviii, fig. 1; pl. liv, fig. 9.

Protosphyræna chirurgus HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Erisichthe penetrans COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 822.

Protosphyræna penetrans NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIV, 1878, p. 795. — FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 297, pl. xiv, fig. 1. — CROOK (A. R.), Palæontogr. XXXIX, 1892, p. 109. — WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. III, 1895, p. 409. — STEWART (A.), Kan. Univ. Quart. VII, A. 1898, p. 192; Univ. Geol. Surv. Kansas, VI, 1900, p. 369, pl. lxiii, fig. 4. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 227, pl. xix, figs. 1–5. — HAY (O. P.) Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Protosphyræna obliquidens LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 225, pl. xx, figs. 1–4. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

The type of Professor Cope's *Erisichthe nitida* is now in the American Museum of Natural History. It consists of both premaxillæ, a portion of the left dentary, and the adhering postsplenial, the supposed hyomandibular, and a bone (Vert. Cret. Form. West, pl. xlviii, fig. 7) which is as yet unidentified. Of the same specimen Cope possessed also a fragment of the fin, which lacked the anterior edge and was therefore not susceptible of comparison with other species based on parts of fins. This fragment is now missing. Dr. Loomis (Palæontogr., XLVI, p. 228) has questioned that the fragment of the dentary figured by Cope belongs with the premaxilla; but there is no reason to doubt that all the parts of the type belong to the same individual. As regards the premaxilla it may be remarked that the anterior fang is probably directed more horizontally forward than is natural, a fact due to pressure.

In 1877, Cope, as cited, described from materials collected in Gove County, Kansas, by Mr. Russell Hill, a species which he called *Erisichthe penetrans*. The type, never figured hitherto, is now in the American Museum. Its number is 2105. Views of this type, seen from below and from above, and three cross-sections are here presented (Figs. 1 and 2). The specimen consists of the snout from the front of the orbits to the tip of the rostrum, but no other parts. On the lower side the surface of the bone has been damaged, so that the ornamentation is removed over a considerable area; but where preserved, it is not especially different from that of the upper side. It is somewhat coarser, and for a short distance in front of the vomerine fangs forms areolæ resembling those of the shell of *Trionyx*. The specimen has suffered some crushing, and this affects especially the region from the orbits to the vomerine fangs, but also to some extent nearly the whole length of the rostrum.

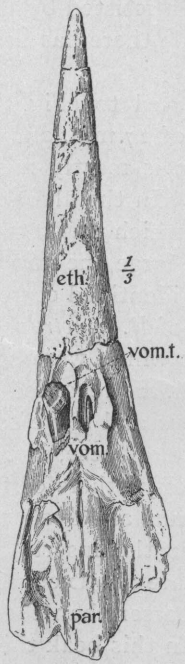


Fig. 1. *Protosphyræna nitida* (Cope). No. 2105. Type of *Erisichthe penetrans* Cope. Rostrum seen from below. × ⅓. *eth.*, ethmoid; *par.*, parasphenoid; *vom.*, vomer; *vom. t.*, vomerine tooth.

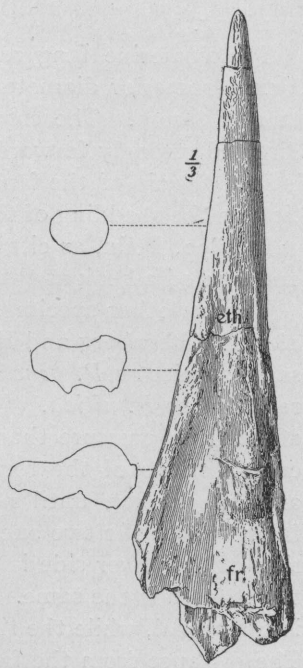


Fig. 2. *Protosphyræna nitida* (Cope). No. 2105. Type of *Erisichthe penetrans* Cope. Seen from above. × ⅓. With cross-sections. *eth.*, ethmoid; *fr.*, frontal bone.

Cope has given the vertical diameter of the base of the rostrum as 20 mm., but this is not correct. The diameter is

24 mm., and was in life probably somewhat more. The same author has also stated that the superior surface of the skull is swollen above the base of the great vomerine tooth, while no such enlargement marks the position of its young companion. This is readily explained. The downward crushing during fossilization has been resisted by the base of the great fang, while on the other side there has been nothing to resist crushing.

The vomerine fang referred to (Fig. 1, *vom. t.*) has an antero-posterior diameter of 17 mm. and a transverse diameter of 8 mm. The crown is mostly missing. It has been directed strongly forward. In the alveolus of the other side is seen the tip of the fang which was to have come into function on the shedding of the large one now present.

In 1890, Felix, as cited, identified correctly, as it appears, and figured a beak as that of *P. penetrans*.

Various other specimens which were collected for Cope in 1877, by Sternberg and Hill, are regarded as belonging to the same species as *P. penetrans* and serve to throw light on its relations to *P. nitida*. One of these, No. 1871, has been less affected by pressure than any others of the collection. The cross-sections of the rostrum are oval, with the transverse axis the longer, until near the insertions of the vomerine fangs, where the two axes are about equal. The ornamentation of the lower side is coarser than that of the upper, but the pattern is the same. In this beak the left vomerine fang is functional, while the right alveolus is a cavity 9 mm. deep. The distance from the fangs to the tip of the rostrum is 125 mm.; the transverse diameter, 27 mm.; the vertical, 26 mm. Halfway from the fangs to the tip the transverse diameter is 18 mm., the vertical, 15 mm.

No. 2121 of this Museum furnishes a complete beak, with the base of the right tooth; the anterior end of the splenial, freed from the dentary; the tip of the left dentary with three large teeth; some other fragments of the jaws and skull; and three sections of the pectoral fin blade, measuring all together 250 mm. The beak is rather slenderer than the type of *P. penetrans* and is smoother near the base. Sections of the

beak are broader than high; but the posterior portion has suffered some distortion. The right vomerine tooth has been functional, but there is hardly a vestige of even the alveolus of the other fang.

Reference must be made here to a species of this genus which has been described by Dr. Loomis (*op. cit.*, p. 225, pl. xx, figs. 1–4) under the name *P. obliquidens*. The beak of this is described as being compressed. The author has figured a portion of the pectoral fin; and this appears to agree in every respect with that of our No. 2121. There is the same front edge, without serrations or undulations; and a band along this edge is represented as being ornamented with fine enamel ridges which run at right angles with the edge. It appears to the present writer that these pectoral fins must be identified as belonging to the same species. Too much importance must not be attributed to the compressed or depressed form of the beak. Many of them have been modified by pressure, and there was probably a good deal of individual variation.

The premaxilla of No. 2121 is missing. The anterior end of the dentary and that of the splenial are well preserved and are figured (Fig. 3). These are attached to the fragment of the fin. Between these bones and the corresponding ones of *P. obliquidens* I find no differences that appear to be important. Dr. Loomis states that his species has three rows of small teeth on the splenial; but in some cases there may be one row on a portion of the splenial and more than one row in another part. The number of rows of these small teeth is probably not a constant character. The small teeth of the dentary are directed forward, as they are in *P.*

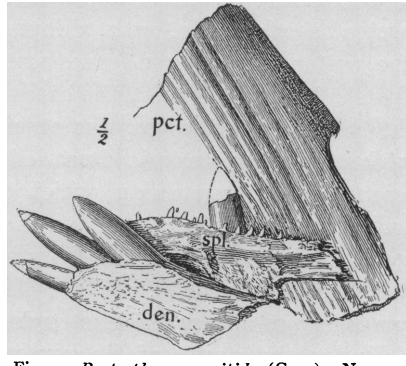


Fig. 3. *Protosphyræna nitida* (Cope). No. 2121. × ½. *den.*, dentary; *pct.*, fragment of pectoral fin; *spl.*, splenial.

obliquidens. The possession of five fangs in the premaxilla, as in *P. obliquidens*, is unusual in *Protosphyræna*, but when we consider that the number of great fang-like teeth in the jaws of *Portheus* varies, we shall not give too great value to this character. In short, it appears to the writer that *P. obliquidens* is identical with *P. penetrans*. Furthermore, it seems impossible to distinguish these two nominal species from Cope's *P. nitida*.

No. 1634 is a part of the Cope Collection, and consists of a considerable part of a crushed skull, with the basal half of the rostrum. The axis of the skull is presented from the vomerine fangs to the basioccipital articulation. A section of the rostrum 52 mm. in front of the vomerine teeth is oval, with the long axis transverse. At the vomerine teeth the section is quadrate, but this is evidently due to lateral pressure. The ornamentation is quite like that of the type of *P. penetrans*, the base of the beak not being so smooth as in No. 2121. Seen from below, it much resembles that of *P. obliquidens*. There is present a part of one of the pectoral fins, presenting about 95 mm. of the edge, and this is identical with that of No. 2121, and, so far as we may judge from the figure, with that of *P. obliquidens*. But the latter has a compressed section; No. 2121, a depressed section. It appears to the writer that the evidence furnished by the fins outweighs that to be derived from the cross-sections of the rostra.

Pelecopterus chirurgus was based on a part of a pectoral fin, with the characteristic front edge broken away. Judging from the part remaining, which comes up close to the edge, and from the angle made by the rays with the edge, there seems little doubt that this fin is identical with *P. obliquidens*, and, therefore, with *P. nitida*. The specimen bears the American Museum of Natural History's number 1894.

Under the name of *Pelecopterus chirurgus* Cope has described (Vert. Cret. Form. West, p. 244E, pl. liv, fig. 9) the articular portion of the shoulder girdle of another specimen. There is no evidence that the latter belongs to the same species as the type of *P. chirurgus;* and the specimen, which is now in the American Museum, No. 1609, cannot be distin-

guished from the corresponding part of *P. perniciosa*. Indeed, this part is probably much the same in all the species.

Impelled by the evidences furnished by the materials before me, I am compelled to regard Cope's *Erisichthe nitida*, *E. penetrans*, and *Pelecopterus chirurgus*, and Loomis's *P. obliquidens* as belonging to a single species, to which the name *Protosphyræna nitida* must be applied.

Protosphyræna perniciosa (*Cope*).

PLATE I, FIG. 1.

Ichthyodectes perniciosus COPE (E. D.), Bull. U. S. Geol. and Geog, Surv. Terrs. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, p. 275.

Pelecopterus perniciosus COPE (E. D.), Vert. Cret. Form. West, 1875, pp. 244D, 273, pl. xlviii, fig. 2; pl. lii, fig. 2.

Protosphyræna perniciosa WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. III, 1895, p. 414. — ? LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 221, text fig. 2. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

This species was established in 1874, as cited, on a fragment of a fin which was afterwards figured on Plate lii of Cope's 'Vertebrata of the Cretaceous Formations of the West.' In this work there were figured also two other fragments of fins which were referred to this species. Of these the one which furnished Fig. 2 of Plate xlviii quite certainly belongs to *P. perniciosa;* the one which is represented by Fig. 13, Plate xliv, appears to belong with those fins which have been referred to *P. tenuis*. It will be observed that the undulations of the edge of this specimen, instead of increasing in height from the base toward the tip, seem to be subsiding.

In the Cope Collection of fishes and reptiles are fragments of several pectoral fins of *P. perniciosa;* but one specimen is especially worthy of description and illustration. This bears the Museum's number 1901. The record accompanying the specimen shows that it was collected by Mr. R. Hill, in 1877, in the Niobrara beds along the South Fork of Solomon River, Kansas. The shoulder girdle accompanies the fin.

The present length of the fin blade (Pl. I, Fig. 1) is 838 mm., but it has doubtless been originally somewhat longer. It is

curved saber-like, and the greater part of the front edge is provided with coarse serrations. From the posterior border some rays are probably missing, and a few of those present have been floated away somewhat from the body of the fin. A count of the rays at the base of the fin shows the presence of 45. Even the most posterior of these may be traced to near the anterior border of the fin at the distal end. As in the specimen of *P. tenuis*, described in this paper, there must have been a posterior fringe of soft flexible rays.

The breadth of the base of the fin is about 105 mm. Here the rays midway between the two borders are very slender, the exposed edges of four of them occupying only 5 mm.; but they grow broader toward their distal ends, so that the four referred to occupy a breadth of 22 mm. Near the distal ends of those rays which outcrop in the anterior border of the fin, at the middle of its length, we find signs of a separation of each into two portions, as in *P. tenuis*. In the distal end of the fin the two components are as distinctly separated from each other as they are from the components of contiguous fins. The thickness of the fin at the middle is 9 mm. As in the case of the fin rays of fishes in general, each ray is composed of an upper and a lower half. At the base of the fin these become broader perpendicularly to the surface of the fin, so as to form plates. Finally these diverge, so as to receive between them the baseosts. Near the anterior border of the base there is a large acetabular cavity for the reception of the rounded head of the scapula.

The tooth-like projections on the front of the fin vary in distance apart from 10 to 15 millimeters. Those of the most distal half of the fin protrude beyond their bases as much as 5 mm. and are retrorse; those of the proximal half are shorter and are dentate in form. In the proximal half of the anterior border there is a tooth at the end of each fin ray; in the distal half, a tooth for each of the two subdivisions of the ray. From the tip of each tooth a rounded ridge runs backward on the surface of the fin at right angles with the course of the rays. This appears to be for the purpose of strengthening the tooth. Each ridge soon divides into two diverging

smaller ridges and at length disappears. Those of the distal portion of the fin may be traced nearly across the fin.

A considerable part of the shoulder girdle of the fin above described is present (Figs. 4, 5), and it enables me to make some corrections in Cope's account of this part of the anatomy (Vert. Cret. Form. West, p. 244A). This author affirmed that all the basilar bones, which support the fin, articulated with the scapula; and on this character he founded the order Actinochiri.

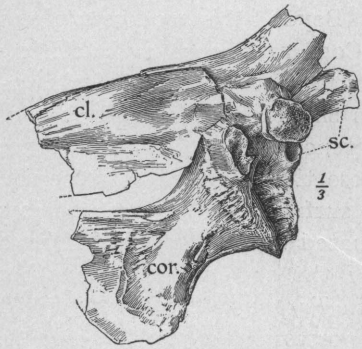


Fig. 4. *Protosphyræna perniciosa* (Cope). No. 1901. × ⅓. *cl.*, cleithrum; *cor.*, coracoid; *sc.*, scapula.

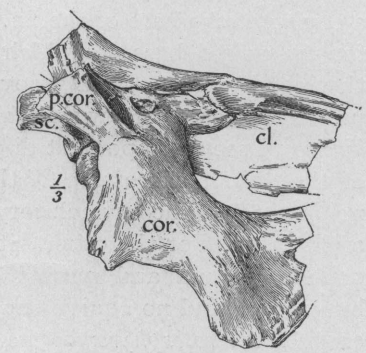


Fig. 5. *Protosphyræna perniciosa* (Cope). No. 1901. × ⅓. *cl.*, cleithrum; *cor.*, coracoid; *p. cor.*, precoracoid.

The conclusion reached by Cope is obviously erroneous; for it is certain that the greater portion of the bone which he identified as the scapula is the coracoid; while the bone supposed by him to be the coracoid is the precoracoid. The result of his erroneous determinations was that he had the shoulder girdle turned wrong end up. All this is satisfactorily proved by comparing these bones with the corresponding ones of *Tarpon* or *Salmo*. Unfortunately, most of the sutures in this complex of bones are obsolete, and Cope himself was unable to make them out in his specimens. At the base of the precoracoid of No. 1901 there is a dislocation of the latter which may indicate the position of the suture. In the tarpon the enlarged anterior fin ray and two baseosts articulate with the scapula. In the specimens of *Protosphyræna* there are no satisfactory indications of the suture that once existed between the scapula and coracoid.

The scapula (Figs. 4, 5, *sc.*) is applied to the inner side of the cleithrum, while the precoracoid, *p. cor.*, appears to be applied to the inner side of the scapula. There may, however, be some distortion here. In *Tarpon* the precoracoid is applied to the inside of the cleithrum in front of the scapula, but it also articulates with the latter.

On the united scapula and coracoid are borne the surfaces for articulation with the fin and its supports. Nearest the cleithrum there is a rounded head (Fig. 4), which fits into a cavity at the base of the fin. Beyond this are two surfaces for the paired baseosts which Cope mentions; and still further out is a row of six grooves for the reception of six unpaired baseosts. Between this shoulder girdle and that of *Tarpon* I see no important differences, except in the presence of the paired baseosts. Of these the outer one corresponds, no doubt, to the articulatory surface for the first baseost of *Tarpon*. For the other, situated below the rounded head on the scapula and mesiad of the surfaces for the other baseosts, I find no equivalent in *Tarpon*. Possibly we must credit to *Protosphyræna* the possession of eight baseosts. Of these the first has possibly been crowded out of its place to a position below the rounded head on the scapula, while the second has been crowded to a position above the head.

The disposition of the paired baseosts with reference to the rounded head and the row of unpaired baseosts must limit greatly the movements of the fin. In fishes there is generally a free movement of the fin at right angles to its plane; but it seems that in *Protosphyræna* there could have been only very restricted motion perpendicular to the plane of the fin. The action of the paired baseosts would have had the effect of steadying the motion in the plane. Such motion would have had as its end the employment of the fin as a weapon, with which its possessor could slash an enemy or a victim of its appetite. The position of the paired and the unpaired baseosts may be determined from Cope's figures (Vert. Cret. Form. West, pl. liv, fig. 9), from the figures already cited of the present paper, and from Fig. 6. In the latter figure the

front border of the fin is above, and the upper (*bas.*) rests on one of the paired baseosts.

No. 2009 of this Museum furnishes both cleithra of *Protosphyræna perniciosa*, which may be conveniently described here. One of these is represented by Fig. 7. It is possible that a small part of the bone is missing from the upper end of the element. Compared with a specimen of *Tarpon atlanticus*, 5 feet 6 inches long (1.67 m.), the cleithrum is narrower. The portion below the curve is of the same length, but the upper end of that of *Protosphyræna* is about 50 mm. shorter. How much of this deficiency is due to injury cannot be determined. The outside of the cleithrum presents no features worthy of mention; the surface probably

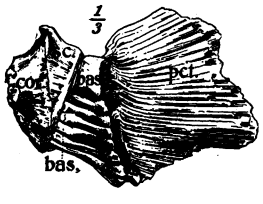
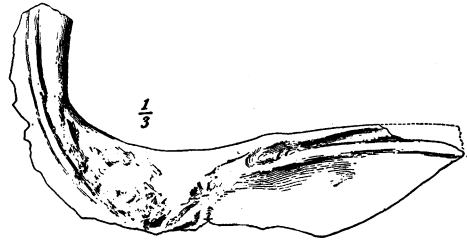


Fig. 6. *Protosphyræna* sp. No. 1646. × ⅓. *bas.*, baseosts; *cor.*, coracoid; *pct.*, pectoral fin; *sc.*, scapula.



No. 7. *Protosphyræna perniciosa* (Cope). No. 2009. × ⅓. Cleithrum seen from inner surface.

has been convex in cross-section. On the inside we see, near the upper border of the lower, or anterior, end, a deep groove which is bounded both above and below by a sharp ridge. On the hinder border of the upper, or posterior, portion there is another groove. This appears to have started at the upper end of the bone and to have run downward as far as the articulation of the fin. It is possible that, as in *Tarpon*, some accessory bone fitted in this groove.

It is remarkable that, although this is perhaps the commonest species of *Protosphyræna*, except perhaps *P. nitida*, it is represented by remains of fins and shoulder girdle bones alone. None of these have been found in association with remains of the head. It appears to be possible that *P. tenuis* Loomis and *P. perniciosa* are identical. The fins appear to differ only in the character of the anterior edge, the angle

which the rays make with the anterior border being the same in both species. Under *P. tenuis* mention is made of fins whose edges are not repand, but have the summits of the waves sharp. No. 2044 is a specimen which is evidently to be referred to *P. perniciosa*, since it has the serrations well developed on many parts of the edge. And yet, well out toward the distal end these serrations subside and the edge is nearly straight. It seems possible that there was considerable variation in the degree of development of the serrations in different individuals. Only more and better materials will enable us to settle this point.

Protosphyræna tenuis *Loomis.*

PLATE I, FIGS. 2 AND 3.

Pelecopterus perniciosus COPE (E. D.), Vert. Cret. Form. West, 1875, pl. xliv, fig. 13 (erroneous identification).

Protosphyræna tenuis LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 226, pl. xx, figs. 5–7.—HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Protosphyræna penetrans STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, pp. 370, 402, pl. lxiii, figs. 1–3.

This species is said to be based on three individuals which were collected by Mr. C. H. Sternberg in the Niobrara deposits of Kansas and are now in the Museum at Munich, Germany. The parts figured belong to one individual and consist of a rostrum, premaxilla and maxilla of the left side, and a part of one pectoral fin. This appears to be a well founded species. The rostrum is, relatively to the length of the maxilla, very long and slender. The maxilla enters into the length of the rostrum two times, while in a specimen of *P. nitida* the maxilla is contained in the rostrum only one and a half times. The teeth of the maxilla appear to be smaller than they are in *P. nitida*. The most certain evidence that this species does not belong to *P. nitida* is to be found in the pectoral fin blade. On comparing it with the figure of Dr. Loomis's *P. obliquidens* (= *P. nitida*), figured on the same plate, we find that in the latter the edge of the fin is devoid of any undulations and that the rays make an angle of nearly 10° with the edge; while in *P. tenuis* the edge is

wavy, especially near the base, and the rays make an angle of 15° with the edge. I regard these differences as important.

In the American Museum there are several specimens of fins which I refer to *P. tenuis*. One of these, No. 205 (Pl. I, Fig. 2), is 528 mm. long and is accompanied by a portion of the baseosts and a part of the cleithrum. It presents apparently 36 rays, including the shortest one at the base in front. As a result probably of maceration and some disturbance before burial, some of the hindermost rays are separated from one another, except immediately at the base. It is probable that others of the hindermost have been wholly removed. At its base, as now found, the fin is 62 mm. wide. The front edge is gently repand in the basal half; but in the distal half the edge has a uniform curve. The edge is everywhere thin and sharp, and is strengthened by a layer of enamel, as in the other species. This layer is disposed more or less in ridges at right angles to the edge; but these do not have the regularity and fineness which they present in *P. nitida*. As in other species of the genus, the anterior edge of the fin is formed by the ends of the rays which successively outcrop at their distal ends. All the rays, except a few of the first, become broader as they proceed outward. The greatest increase in width is found in the most posterior rays. At the base they are only about 1.5 mm. in diameter, but distally they may be as much as 5 mm. in diameter. At about the 20th ray we find at its distal end evidences of a division into an anterior and a posterior portion. This separation becomes still more distinct in the succeeding rays. In another specimen, No. 215, traces of the cleft condition may be found as far forward as the 12th ray from the front, and is indicated by a narrow furrow, or line of pits.

In the front of the fin in No. 215 are two holes which are made entirely through the rays, and these, with some fractures, must have been produced before the specimen was covered with the matrix. It is easy to imagine that this fish had been seized and destroyed by some *Portheus* or some mosasaur.

The fins of this species resemble those of *P. perniciosa* in the angle which the rays make with the edge of the fin. As

in the latter species, the base of the fin is undulated for a few centimeters, but beyond this the character of the edge in the two species is very different. In *P. tenuis* the undulations subside and the edge is continuous; in *P. perniciosa*, the elevations increase in height and soon take the form of hooked teeth.

No. 1620 of this Museum, a part of the Cope Collection, probably belongs to this species. It appears to differ only in having the edge resemble a series of waves whose summits are not rounded but sharp (like Figs. 1, 2, Pl. lxiii, of Stewart's memoir) and in having them continued well out toward the distal end of the fin. Such fins possibly belong to a distinct species. This specimen displays the distal end of the fin apparently to within a few centimeters of the tip (Pl. I, Fig. 3). Behind the rays which are consolidated together are several others which evidently have been only loosely connected and which have been subdivided into very fine filaments. Evidently, too, the hindermost of these loose rays did not reach quite to the tip of the fin. It is quite probable, therefore, that a considerable number of soft flexible rays occupied the hinder border of these remarkable fins. No cross-segmentation of these rays can be observed. As stated under *P. perniciosa*, there is some reason to doubt that *P. tenuis* is distinct from the species just mentioned.

Protosphyræna dimidiata (*Cope*).

Erisichthe nitida COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 822.

Protosphyræna nitida LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 227 (in part), pl. xix, figs. 6, 7.

Erisichthe dimidiata COPE (E. D.), Proc. Amer. Assoc. Adv. Sci. XXVI, 1878, p. 300.

Protosphyræna dimidiata HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

This species, the type of which is now in the American Museum of Natural History, having the number 1635, was originally described as belonging to *Erisichthe nitida*. However, within the next year, Prof. Cope came to the conclusion

that it represented a distinct species and to this he gave the name *Erisichthe dimidiata* (Proc. Amer. Assoc. Adv. Sci., XXVI, 1878, p. 300). Of this change of opinion and this new name neither Felix, writing in 1890, nor Loomis, writing in 1900, was apprised.

The most obvious characters of the species are those presented by Cope in his original description, the upward curvature of the rostrum and the flattening of the upper surface of its distal half. Felix, having before him a specimen which he regarded as belonging to the same species, denies the presence of the angular ridges on the sides of the rostrum. They are present, nevertheless. The rostrum (Fig. 8) has been broken across just in front of the vomerine fangs and a portion of the upper surface has crumbled away, perhaps for a distance of 25 mm.; but there is little or nothing missing on the lower side. About 22 mm. in front of this break there has been another break and a slight faulting in the bone. From this point there is a gradual upward curve to the tip of the beak. Just in front of the last-mentioned break the vertical diameter is 23 mm., the transverse, 26 mm., the section being oval. Halfway to the tip, the upper surface has become decidedly flat, the vertical diameter being 16 mm., the transverse, 22 mm. Beyond this section the upper surface is somewhat concave, with a sharp ridge bounding the concavity on each side. Near the tip the upper surface again becomes convex. Both the upward curvature of the beak and the concavity of the upper surface appear to be wholly natural.

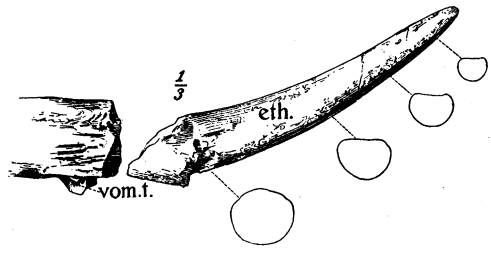


Fig. 8. *Protosphyræna dimidiata* (Cope). No. 1635. × ⅓. Type of *Erisichthe dimidiata* Cope. Rostrum seen from the side, with four cross-sections. *eth.*, ethmoid; *vom. t.*, vomerine teeth.

There appears to be less difference in the sculpture of the upper and lower sides than in the case of *P. nitida*.

The premaxilla (Fig. 9, *pmx.*) possessed four fangs. Its length has been about 75 mm.; the elevation of the hinder end about 43 mm. The maxilla (Fig. 9, *mx.*) is 137 mm. long, with a depth of only 17 mm. where narrowest, then again expanding to near 30 mm. Another bone, probably a jugal, has overlapped the hinder end of the maxilla on the upper side. There is space for about 33 teeth on the maxilla. They are lancet-shaped and are not so strongly inclined forward as they are in *P. nitida.* The same is true of the teeth of the mandible. Outside of the row of cutting teeth is a row of much smaller teeth.

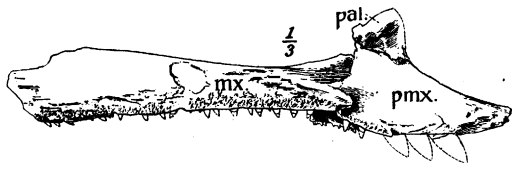


Fig. 9. *Protosphyræna dimidiata* (Cope). No. 1635. × ⅓. Type of *Erisichthe dimidiata* Cope. Upper jaw, side view. *mx.*, maxilla; *pal.*, portion of palatine; *pmx.*, premaxilla.

The lower jaws are represented by 68 mm. of the anterior end of the left mandible and by nearly the whole length of the right. The tip of the latter and a section of about 30 mm. are wanting, as well as most of the lower border of the bone. In the anterior end of the dentary we find the usual three lancet-shaped fangs. These are succeeded by an interval in which the teeth are very small or wanting. Then follows a single row of cutting teeth, of which those in front and those behind are small. The presplenial is occupied, as in the other species, by two strong fangs. Laterad of these and running nearly the full length of the presplenial is a band of small teeth. This consists of three rows where narrowest. A short distance behind the posterior presplenial fang the band of small teeth is interrupted by what may be a suture between the presplenial and the postsplenial. It is not unlikely, however, that it is only a fracture, since the whole jaw has suffered flexure at this point. In specimens of *P. nitida* no suture can be seen; although at this point the band of teeth becomes very narrow and thereafter widens rapidly. Felix was unable to find a suture between the supposed two bones. If they have ever been distinct at any time of the

animal's life, they are now probably consolidated. The "predentary" of Felix was evidently the result of erroneous observation.

Lying against the inner surface of the posterior end of the premaxilla (Fig. 10) is a bone whose edge bears a band of three rows of teeth which resemble those of the presplenial, some being two-edged, but most of them conical. This bone, now 30 mm. long, but with its anterior and posterior ends missing, I take to be the palatine. Lying against the median surface of the anterior end of this palatine and extending forward nearly to the anterior end of the premaxilla is another bone which bears a large patch of granular teeth. It is possibly a part of the palatine.

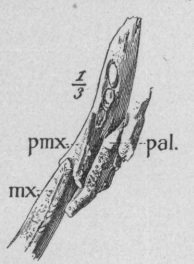


Fig. 10. *Protosphyræna dimidiata* (Cope). No. 1635. × ⅓. Type of *Erisichthe dimidiata* Cope. Part of upper jaw from below. *mx.*, anterior end of maxilla; *pal.*, portion of palatine; *pmx.*, premaxilla.

The writer sees little reason to doubt that the specimens referred to *P. nitida* by Dr. Loomis, and figured on Plate xix, Figs. 6, 7, of his paper here frequently quoted, really belong to *P. dimidiata*. There is the same narrow maxilla; but, especially, the dentary teeth are only slightly inclined forward.

Among the remains belonging to the type of *P. dimidiata* there is present a single vertebra, apparently one belonging close to the head. It is possible that this is an intrusion, either at the time of burial or after collection; but the matrix is the same and the bone is similarly fossilized. The vertebra is represented in Figs. 11 and 12. It is 12 mm. long and 19 mm. in the transverse and vertical diameters. The ends (Fig. 11) are deeply cupped. The arches have dropped away, not having been coössified. The lower surface (Fig. 12) is ornamented with a network of low ridges. The verte-

Fig. 11. *? Protosphyræna dimidiata* (Cope). No. 1635. × ½. Part ? of type of *Erisichthe dimidiata* Cope. Vertebra, view of anterior end.

Fig. 12. *? Protosphyræna dimidiata* (Cope). No. 1635. × ½. Part ? of type of *Erisichthe dimidiata* Cope. Vertebra, view of lower surface.

bra agrees in size with the basioccipital of some skulls of *Protosphyræna*. It is possible that it belongs to either *Pachyrhizodus* or *Anogmius*, but it appears to be different. Cope believed (Proc. Amer. Assoc. Adv. Sci., XXVI, 1878, p. 299) that this genus possessed well developed vertebræ, but whether or not he based his opinion on this particular vertebra is not known. It is very desirable that collectors shall give attention to the finding of such parts of the body of the fishes of this genus as have not yet been described; and such parts include practically all parts behind the shoulder girdle and pectoral fins.

Protosphyræna sequax, sp. nov.

Protosphyræna nitida FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 278, pl. xii, figs. 1–3; pl. xiii, figs. 1–2b; pl. xiv, figs. 2–7.—LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 227 (in part).—HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379 (in part).

Dr. Loomis has already concluded that, on account of the position of the teeth of the dentary bone, Felix's specimen does not belong to the same species as the dentary figured by Cope as part of *P. nitida;* but Loomis's explanation is that Cope's dentary does not belong with the premaxillary, and is, therefore, not a part of *P. nitida*, an idea already suggested by Felix (*op. cit.*). As elsewhere remarked, there is no reason for questioning the unity of Cope's type. The more reasonable explanation is that Felix's specimen does not belong to Cope's species, *P. nitida*. And one of the grounds for this conclusion is found in the fact that the teeth of the maxillæ and those of the dentary, except the three anterior fangs, are, in Felix's specimen, inserted at nearly right angles to the containing bones. Even those of the premaxillæ emerge nearly perpendicular to the border of the latter bone.

Nor can Felix's specimen belong to *P. dimidiata*. The posterior teeth of the maxilla of the type of the latter have a decided slant forward. The median and anterior teeth are nearly perpendicular. All the teeth of the premaxilla appear

to have inclined forward. The cutting teeth of the middle of the dentary are only slightly inclined forward, not greatly different from the corresponding ones of the skull described by Felix. The maxilla of the latter is quite different from that of *P. dimidiata* and that of *P. nitida*, as represented by the specimens described under that species. In the type of *P. dimidiata* the maxilla has a length of 137 mm., a width where widest of 17 mm. and where broadest, near the hinder extremity, of 30 mm. The maxilla of Felix's specimen is probably little, if any, longer. The figure gives evidence that little of that of the left side is missing. Its width, where narrowest, is 20 mm.; where widest, at least 32 mm. Of the right maxilla of Felix's specimen perhaps nothing is wanting and it measures only 130 mm. This indicates that the bone was of considerably heavier construction than in *P. dimidiata*. If it be contended that the maxilla of Felix's individual belongs to a larger animal and was both longer and broader, it may be shown that it must have contained a considerably larger number of teeth. On measuring backward from a point 25 mm. behind the anterior end of the maxilla of *P. dimidiata*, there are found 9 teeth or alveoli for them, in 32 mm. In the same distance on the left maxilla of Felix's specimen are 9 or 10 teeth, or spaces for them. This indicates either that the maxilla was no longer or that the teeth were relatively smaller. Indeed, in the portion of the left maxilla represented by Felix, 103 mm. long, there is room for as many of its teeth as are found in the 122 mm. of tooth line of *P. dimidiata*. Furthermore, the rostrum of the specimen described by Felix is very different from that described by Cope, as Felix himself has pointed out.

Protosphyræna sequax differs from the specimens which are here referred to *P. nitida* in most of the respects in which it differs from *P. dimidiata*, viz., in having teeth perpendicular, or nearly so, to the supporting bones and in having a broad heavy maxilla.

It is, of course, impossible to say that the skull here described does not belong to some species which has already received a name based on a fin blade. It may, for example,

be the skull of *P. perniciosa.* In such case *P. sequax* will become a synonym.

Protosphyræna ziphioides (*Cope*).

Erisichthe ziphioides (COPE E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 823.

Protosphyræna ziphioides NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIV, 1878, p. 795. — FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 297. — WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. 1895, p. 413. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Erisichthe xiphioides LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 222.

This species was described by Cope in 1877, as above cited. The description was quoted by Felix and accompanied with brief remarks. The type specimen is now in the American Museum of Natural History, and has the number 2131. Cope states that the specimen is the muzzle of an old individual which has lost a good deal of its apex by attrition. It is probable that he meant that this attrition had been suffered during the life of the animal. The present writer, however, finds no evidences of any attrition. It appears improbable that the beak could have been worn to any considerable amount without revealing it either in the character of the surface or in some asymmetry. Where the wear must have been suffered, the bone is dense and smooth and the form wholly symmetrical. The specimen appears to have belonged to a species having a short and blunt snout.

The following measurements are given.:

Length of the specimen	102 mm.
Width of the hinder end	30 mm.
Transverse diameter at vomerine alveoli	22 mm.
Vertical " " " "	19 mm.
Transverse " 15 mm. from tip of snout	20 mm.
Vertical " " " " " "	14 mm.

On the under side of the snout (Fig. 13, *vom. t.*) is a pair of longitudinal depressions. These Cope regarded as alveoli for vomerine fangs, from which the teeth had fallen and which

had become filled up with bone. His explanation is probably the correct one. At the hinder end of the specimen, on the under side, is a triangular depression. This appears to be produced by the parting of the hinder ends of the vomers, so as to expose the parasphenoid (Fig. 13, *par.*); but the bones are somewhat eroded. The apex of this depression is considerably farther behind the alveoli of the vomerine fangs than in any other described species of the genus, being about 25 mm.; while in the type of *P. penetrans* the interval is only 15 mm.

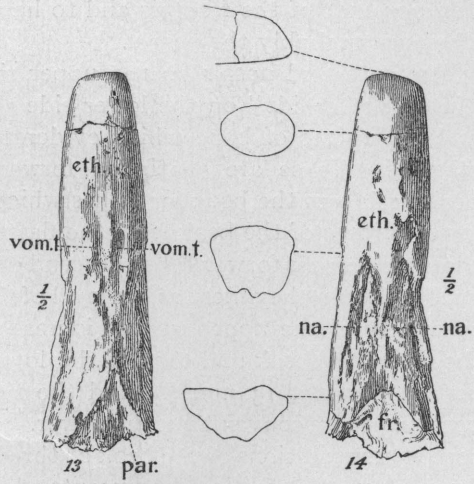


Fig. 13. *Protosphyræna ziphioides* (Cope). No. 2131. × ½. Type of *Erisichthe ziphioides* Cope, seen from below. *eth.*, ethmoid; *par.*, parasphenoid; *vom. t.*, position of vomerine teeth.

Fig. 14. Same rostrum as Fig. 13, viewed from above, with three cross-sections and a longitudinal section of tip. *eth.*, ethmoid; *fr.*, frontal; *na.*, nasals.

On each side of the basal half of the specimen and extending forward to a line crossing just in front of the vomerine alveoli is a longitudinal excavation. Cope regarded these as probably intended for the reception of the forward prolongations of the premaxillæ. It is more probable that they receive the anterior ends of those bones which Felix has called "ethmoidea lateralia." There is some reason to think that a portion of these bones is yet in these excavations. Possibly if the whole of these lateral ethmoids were present the lower surface of the beak would not be so constricted as it is.

The hinder end of the upper surface is occupied by a triangular smooth depression (Fig. 14, *fr.*). The writer takes this to mark the anterior termination of the frontals, united into one bone. In front of this depression the surface is rough, as if from erosion. On each side of this rough area

there is a moderate longitudinal excavation, which appears to be partially filled by the remains of a distinct bone (Fig. 14, *na.*). These two bones appear to have overlapped the anterior ends of the frontals and to have met in the midline. They are probably the nasals.

The supposed nasals on the upper side and the supposed "lateral ethmoids" on the lower side are separated by right and left ridges of bone which evidently form a part of the ethmoid. These are continued forward to the tip of the beak and form the boundary lines which separate the convex lower surface of the beak from the flatter upper surface. As these ridges pass forward they descend on the sides of the beak, until at its tip they meet at the level of the lower surface. The convexity of the upper surface increases as we move toward the tip of the beak and that of the lower surface diminishes, until at length, 15 mm. behind the tip, the upper surface becomes more convex than the lower. In Figure 14 are presented cross-sections of the beak at three points. The outline figure above the sections represents a longitudinal section at the end of the beak.

The specimen was found in the Niobrara deposits of Gove County, Kansas. It seems not unlikely that it represents a distinct genus.

Protosphyræna gladius (*Cope*).

Portheus gladius COPE (E. D.), Proc. Acad. Nat. Sci. Phila. 1873, p. 337; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 40.

Pelecopterus gladius COPE (E. D.), Vert. Cret. Form. West, 1875, pp. 244E, 273, pl. xliv, fig. 12; pl. lii. fig. 3. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 221, text figure 3, tail.

Protosphyræna gladius HAY (O. P.), Bibliog. Cat. Foss. Vert. N. A. 1902, p. 379.

The type of this species is now in the American Museum of Natural History, and bears the number 1849. It measures 728 mm. in length, Prof. Cope's statement making it equal to 31 inches being slightly erroneous. In his description of the specimen Cope says that Prof. Mudge, the collector, re-

ported that the original length was 41 inches. This statement is not at all improbable. The second specimen described by Cope (Vert. Cret. Form. West, p. 244F, pl. xliv, fig. 12) is also in the Museum's collection and is numbered 2064.

The type fin blade has been somewhat distorted by pressure, so that the surface, instead of being flat, as it undoubtedly was originally, is, as Cope says, trough-like. That the surface was flat is shown by other specimens in the collection which were obtained for Cope by Sternberg and Hill. The enamelled edge is sharp, sharper than the edge of the regulation table knife. The edge is not straight, but has the appearance of having been nicked here and there, as is shown by Cope's figure. This author thought that these irregularities had been produced by the rough uses which the fish had made of the fin; but, since the bottoms of the notches are as sharp as the edge elsewhere, it is not probable that there have been any injuries done to the edge.

At the base of the fin the anterior rays have been so thoroughly consolidated that they cannot be counted; but, after making proper allowances, there appear to be about 50 rays entering into the portion of the fin represented by the specimen. The rays, beyond the most anterior ones at the base, grow wider as they are followed toward the distal end; where, one after the other, they emerge at the anterior border, becoming consolidated with those in contact with them. Those which reach the distal half of the fin become divided each into an anterior and a posterior portion, as in the case of *P. perniciosa.*

In the case that the fin was originally about 1040 mm. long, that is about 312 mm. longer than it is now, there must have been about 13 more spines entering into its construction, that is 63 altogether; for the last 312 mm. of the length is now occupied by 26 outcropping ends, and these represent 13 rays at the base. If this estimate is correct, the fin must have been about 200 mm. wide at the base.

For the greater part of its length the fin is 20 mm. thick, measured at a distance of 50 mm. behind the edge. Near the base the thickness is still greater. Other specimens in the

collection show that the front border is bevelled off on both sides, as a board may be bevelled off by a carpenter's plane.

At the middle of the length of the fin the component rays make an angle of about 22° with the edge. At the distal end the angle is somewhat smaller.

This fin must have belonged to a large and powerful fish, of which no other parts are known.

Dr. Loomis in his paper on Kansas fishes holds that this fin formed one lobe of the caudal fin of some species of *Protosphyræna;* and in his restoration of *Protosphyræna* he reconstructs the caudal fin from this specimen. This is, however, manifestly an error. In the caudal fin of fishes the right and left halves of the constituent rays diverge slightly at their proximal ends, so as to receive between them the hypural bones. They are also each drawn out to a point. In the pectoral fins the two portions of the ray not only diverge strongly, but each half is broadened so as to form two processes. One of these is directed toward the corresponding surface of the fin, while the other is brought into close contact with the small bones at the distal ends of the baseosts. The fin known as *Protosphyræna gladius* has the same structure as that of the pectoral fin of ordinary fishes and of other species of *Protosphyræna.*

PLETHODIDÆ.

Anogmius *Cope.*

This genus was erected by Prof. Cope in 1871 (Proc. Amer. Philos. Soc., XII, p. 170), the type species being *A. contractus*, and the type specimen consisted of a large number of vertebræ representing a fish believed to be about four feet in length. The vertebræ were in the Agricultural College, at Manhattan, Kansas, and had been collected by Prof. B. F. Mudge. These vertebræ are further described on page 354 of the volume referred to. This description is repeated on page 241 of the same author's 'Vertebrata of the Cretaceous Formations of the West'; but on page 220A, evidently written later, he records his conclusion that the genus in question was really

identical with *Pachyrhizodus*. In 1877 (Bull. U. S. Geol. and Geog. Surv. Terrs., III, p. 584) Prof. Cope again restored his genus *Anogmius* to favor, and described the new species *A. aratus*, based on a nearly complete individual. This permitted him to define more fully the characters of the genus. In the same year he described two additional species, *A. favirostris* and *A. evolutus*, collected for him in Kansas, by Sternberg's party.

Dr. A. S. Woodward (Cat. Foss. Fishes, IV, 1901, p. 71) apparently takes the position that Cope, when he described *Anogmius aratus*, intended to employ the generic name in a new sense, and to make *A. aratus* the type of the new genus. Prof. Cope's language may give some justification to this conclusion; but it is evident that he intended to include the original species, since he cites the original description. He had evidently again changed his mind regarding the generic position of the type vertebræ. The vertebræ of the species assigned to *Anogmius* and those of *Pachyrhizodus* resemble one another closely, and Cope's vacillation is not to be wondered at as long as he possessed no other parts for comparison. But in his second description (Proc. Amer. Philos. Soc., XII, p. 354) he mentions characters which appear to separate the two genera. One of these is found in the crowded condition of the vertebræ at the base of the caudal fin of *Anogmius;* the other, in the failure of the upper and lower arches in this region to become coössified with their centra. Figures 15 and 16 of this paper represent the condition of this part of the vertebral column. In *Pachyrhizodus* there is apparently less crowding of the vertebræ, and the arches become coössified with the centra. On this point see Dr. Loomis's figure (*op. cit.*, pl. xxvi, fig. 9). Stewart (Univ. Geol. Surv. Kansas, VI, pl. lxvi) presents a tail of *Anogmius* in which the shortening and crowding are less than in any that I have seen.

Fig. 15. *Anogmius* sp., No. 1616. × ½. Caudal vertebræ.

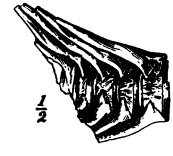


Fig. 16. *Anogmius* sp., No. 1116. × ½. Caudal vertebræ.

Just what Cope's *Anogmius contractus* was we shall probably never know. Prof. E. A. Popenoe, who has charge of the collection of the Agricultural College at Manhattan, Kansas, informs me that he is unable to find any traces of such vertebræ as Cope described. The type being lost, it seems proper to accept Cope's *Anogmius* on the definition given of it. When it becomes necessary to divide the genus as thus defined, it will be time to consider whether or not *Anogmius* is indeterminable.

Recently Dr. Loomis (*op. cit.*, p. 254) has made Cope's *Anogmius* (spelled, however, *Agnomius*) a synonym of *Osmeroides* Agassiz. Mr. Woodward properly, as it seems to me, does not follow this identification. So far as we know, the species of *Anogmius* have an elongated dorsal fin, while *Osmeroides* (*Holcolepis*) has a short dorsal. There exist undoubtedly many other distinctive characters.

Dr. Loomis (*op. cit.*, pp. 229, 235, 252) has described the new genera *Thryptodus*, *Pseudothryptodus*, and *Syntegmodus*. Stewart in his work referred to, p. 391, has expressed the opinion that the first two genera mentioned are synonymous with *Anogmius*. Dr. A. S. Woodward (Cat. Foss. Fishes, IV, pp. 84, 85) regards all three as closely related to *Plethodus*.

There are so many structures common to the genera *Plethodus*, *Anogmius*, *Thryptodus*, *Pseudothryptodus*, and *Syntegmodus*, that it appears evident that they are all closely related, and some of them are quite certainly identical with others. All appear to have an upper grinding plate developed on the parasphenoid and one or more lower plates developed on the median bones in the floor of the mouth. These plates are composed apparently of dense bone, and are often, if not always, furnished with pits, sometimes shallow, sometimes deep. The maxilla forms a considerable part of the boundary of the mouth, the bones about the mouth are similarly sculptured, and, so far as we know, the rear of the skull is similar in all.

Plethodus appears to be characterized by coössification of the premaxillæ and ethmoid and the possession of a lower dental plate composed of a single bone. The upper and lower plates are smooth or furnished with shallow pits.

Anogmius, as represented by *A. aratus* and *A. favirostris*, described on succeeding pages, has the premaxillæ free from the ethmoid, and possibly from each other, and the dental plates are deeply pitted. The lower plate is composed of two and possibly of three median bones.

Syntegmodus is described as having the parasphenoid and some other bones of the mouth covered with a thick mass of osteodentine. This is penetrated by large canals which pass from the surface to the bone on which the supposed osteodentine mass rests. This mass is probably composed of dense bone. On comparing Dr. Loomis's *Syntegmodus*, and the known remains of *A. aratus* and *A. favirostris* and a specimen resembling *Syntegmodus altus*, among one another, it is difficult to see how they may be distinguished generically.

Thryptodus is regarded by Dr. Loomis as having the premaxillæ not free, but probably consolidated with the ethmoid. The parasphenoid has developed a great oval, concave, dental plate, which is furnished with pits; while the median bones of the floor of the mouth support plates which work against the parasphenoidal plate. A study of the type of Cope's *Anogmius aratus*, figures of which are presented in this paper, have convinced me that the relation of the premaxillæ to the ethmoid has been misunderstood by both Prof. Cope and Dr. Loomis, and that *Thryptodus* is identical with the type of *Anogmius aratus*. In this form, as illustrated by the types of *A. aratus* and *Thryptodus*, the premaxillæ appear to be united, while in *A. favirostris* they are possibly, but not certainly, free from each other. If this difference is confirmed by other specimens it may require that two genera shall be recognized; but for the present it seems to the author best to unite all under *Anogmius*. *Pseudothryptodus*, with free premaxillæ, will be included.

Reference has already been made to the differences supposed to exist between the vertebræ of *Pachyrhizodus* and *Anogmius*. However much they may resemble, there is great difference in the structure of the tails of the two genera. There is apparently little difference in the form of the tail fins, both being deeply forked. In *Pachyrhizodus*, as shown

by Pl. III, Figs. 1 and 2, the rays constituting each lobe are comparatively few, and these are large, and cross-segmented. In *Anogmius*, on the other hand, the rays (Fig. 17, a fragment of the caudal fin) appear to have been in greater number and to have shown no segmentation, unless this may have appeared toward the distal ends. It will likewise probably prove true that in *Pachyrhizodus* the neural and hæmal arches of the caudal region are always consolidated with the centra, while in *Anogmius* they remain distinct.

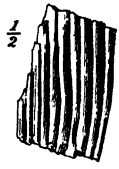


Fig. 17. *Anogmius* sp. No. 2055. × ½. Fragment of caudal fin.

Anogmius favirostris (*Cope*).

Anogmius favirostris COPE (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 178.—WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. IV, 1901, p. 73.—HAY (O. P.), Bibliog. Cat. Foss. Vert. N. A. 1902, p. 393.

Osmeroides favirostris LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 256.

This species was based on the skulls of two individuals, one of them accompanied by a number of vertebræ. These specimens are now in the American Museum of Natural History, but they appear to be somewhat less complete than when they were described by Prof. Cope. One of them, No. 2111, which must be regarded as the type, since from it the description was mostly drawn, consists of the rear of the skull and some fragments of its upper surface, the premaxillæ and maxillæ, the anterior portions of both dentaries, the anterior half of the left palatine and the whole of the right, and a considerable part of the parasphenoid. With these skull parts are 11 vertebræ.

The rear of the skull shows that the parietals are broadly joined. Behind these is a narrow area occupied by the supraoccipital and the epiotics, but the exact extent of these cannot be determined. The midline of the rear of the skull is occupied by a valley, deepest and widest between the parietals, where its width is about 10 mm.

Figure 18 presents a view of the front of the head, seen

from below. The outer surface of the right dentary is observed; also the tooth-bearing and triturating surfaces of the premaxillæ, the maxillæ, the palatines, the vomer, and the parasphenoid. The premaxillæ are sculptured with grooves superiorly and with pits nearer the tooth line. Here we find a band of 5 or 6 rows of small teeth. The outer rows of teeth become very small and some of them are found standing on the narrow walls surrounding the pits. A similar band is found on each maxilla, and on each of the dentaries. What I regard as the parasphenoid Cope has described as the vomer. It is, however, too elongated; and besides, it seems to correspond with what is certainly the parasphenoid in other specimens of the genus figured in this paper. Moreover, there is a patch of teeth farther forward which is supposed to belong to the vomer. Cope has spoken of this parasphenoid as if it were covered with small teeth. I find traces of teeth around its border and a considerable patch in front; elsewhere, the bone is occupied by pits and is devoid of teeth. Where the teeth are very small, they occupy the summit of the bone surrounding the pits. This bone, as well as the palatines, is thin, only about 2 mm., but this is probably due to pressure. The pits have the appearance of passing deeply down into the mass of the parasphenoid. The surface of the dentine-like layer of the bone presents evidences of wear. The lower surface of the palatines resembles the surface of the parasphenoid. A few small teeth are to be seen around the borders of the bone. The patches of teeth between the maxilla and palatine

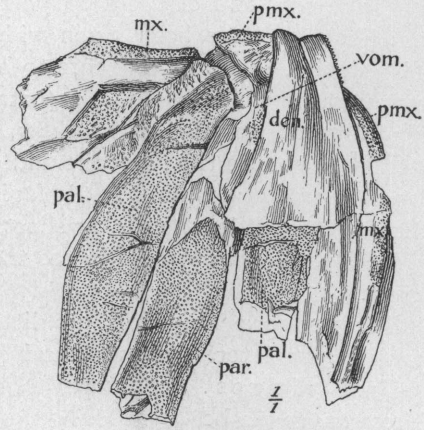


Fig. 18. *Anogmius favirostris* Cope. No. 2111. × ½. Type. *den.*, dentary; *mx.*, maxilla; *pal.*, palatine; *par.*, parasphenoid; *pmx.*, premaxilla; *vom.*, vomer.

in Fig. 18, probably, but not certainly, belong to the palatine.

The hinder end of the parasphenoid is missing; but it is not likely to have been much wider than the part present. The species, therefore, appears to be characterized by a narrow parasphenoid. In one important respect this parasphenoid differs from that of *A. aratus*, figured in this paper. In the latter species the parasphenoid extends forward nearly as far as the palatines do. In *A. favirostris* the parasphenoidal dental plate, at least, falls far short of the anterior end of the palatines. I am not able to see that this is due to displacement.

The vertebræ (Fig. 19) are little constricted, devoid of conspicuous lateral grooves, and provided with fine longitudinal ridges. There appear to be no lateral processes such as are found in some related species.

The paratype of the species, No. 2109, consists of the anterior half of the skull, and is of most interest seen from below (Fig. 20, natural size). The specimen has evidently had pressure applied to the snout, so as to drive it backward against the other bones. The anterior ends of the dentaries overlap. Just behind and

Fig. 19. *Anogmius favirostris* Cope. No. 2111. ×1. Type. Three caudal vertebræ.

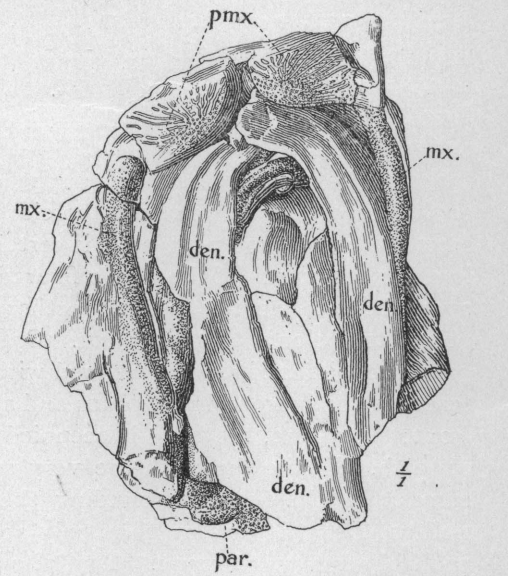


Fig. 20. *Anogmius favirostris* Cope. No. 2109. ×1. Paratype. *den.*, dentary; *mx.*, maxilla; *par.*, parasphenoid; *pmx.*, premaxillæ.

between these overlapping ends are seen the edges of two toothed bones, one in front of the other. Probably the one in front is the vomer, the other possibly a part of the glossohyal.

In front of the symphysis of the dentaries (*den.*) are seen the premaxillæ (*pmx.*) evidently pressed downward and backward. They are ornamented as in the type. As shown in the figure, the maxillæ (*mx.*) join the premaxillæ and form the greater part of the border of the mouth. The lower border is pitted, and some or all of these pits enclosed the bases of teeth. There is also a pitted band on the outer surface of the bone, above the tooth line.

Through a splitting of the specimen a view is afforded of the inside of the mouth. Fig. 21 is a view of the right-hand side of the floor of the mouth seen from above; while Fig. 22 shows the right side of the roof of the mouth turned upside down. If this piece is supposed to be rolled to the left it will fall into its place on Fig. 21, the points marked *a* in the two figures coinciding. Both these figures are of the size of the objects. In Fig. 21 the whole of the surface covered with little rings, which represent pits, except a narrow strip occupying a part of the right-hand side, appears to be made up of one or more dental plates. This is flat along the middle of the figure, but shelves off quite steeply on the right. Near the anterior end is a fold which runs obliquely outward and backward; and there is a similar fold near the hinder end of the dental plate. These folds may be artificial, but they probably represent sutures separating distinct bones. If so, the most anterior one is probably the glossohyal (*gl. h.*); the others

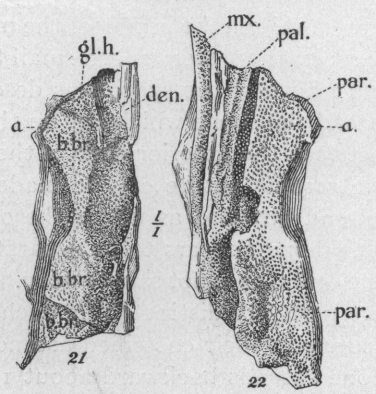


Fig. 21. *Anogmius favirostris* Cope. No. 2109. × 1. Paratype. Floor of mouth, *a*, point coinciding with *a* of Fig. 22; *b. br.*, basibranchials; *den.*, dentary; *gl. h.*, glossohyal.

Fig. 22. Same as Fig. 21. Roof of mouth, *a*, point coinciding with *a* of Fig. 21; *mx.*, maxilla; *pal.*, palatine; *par.*, parasphenoid.

are median bones behind the glossohyal, baso-branchials (*b. br.*). Certainly, the antero-posterior extent of this mass is too great to belong to any one bone in the floor of the mouth.

Along the right-hand border of Fig. 21 are seen the broken edges of the dentary bone and of at least one, perhaps two bones, between the latter and the tritoral surfaces described above. Probably the hyoid and possibly a branchial arch are thus represented.

Fig. 22 presents, on the left-hand side, the right maxilla; on the right, the tritoral surface of the parasphenoid. Between them there is a toothed and pitted bone (*pal.*) which appears to have been folded longitudinally through pressure. This bone is taken to be the palatine. The parasphenoid, as seen, probably does not represent the whole width of this bone, but posteriorly it was at least 12 mm. wide. The bones, both upper and lower, of this triturating apparatus appear to be masses of dense osseous tissue penetrated by deep pits. On the outer border of the palatine are numerous sharp teeth. No teeth are observable on the border of the maxilla, but doubtless the shallow pits there seen lodged small teeth, as in the type specimen.

In both of the specimens described here there is present a broad thin bone which lies on the snout occupying the region between the anterior ends of the frontals and the premaxillæ. No median suture can be made out. Laterally the borders extend outward as far as the outer ends of the premaxillæ. This bone appears to be separated from the premaxillæ, but the evidence is not satisfactory. The bodies of the premaxillæ are perfectly distinct from each other, but the bone referred to may be their coössified ascending plates. In No. 2111 the bone extends backward about 15 mm. The large area occupied by this bone and its scale-like appearance indicate that it is not the ethmoid.

This species differs from *A. evolutus* in having a much narrower band of teeth on the dentary.

Anogmius aratus (*Cope*).

PLATE II.

Anogmius aratus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 585.—STEWART (A.), Univ. Geol. Surv. Kan-

sas, VI, 1900, p. 340.—WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. IV, 1901, p. 72.—HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 393.

The following description is based on the type of the species. The matrix containing this fish has apparently formed a large flattened concretion. Of this there are now in the possession of the American Museum four pieces. The largest block presents the head and the anterior half of the fin. Another has been split from the right side and presents the pectoral fin and some ribs and the imprint of some of the opercular bones. A third block shows the body in the region of the anal fin. This piece does not join accurately the largest block, but Cope did not believe that any considerable part was wanting. The fourth block contains the base of the caudal fin and about 10 vertebræ. Between this section and the third there is missing an unknown number of vertebræ, probably about 8. From a specimen of *A. polymicrodus*, studied at the University of Kansas, Dr. A. S. Woodward came to the conclusion that there were altogether about 80 vertebræ, of which nearly 40 were in front of the pelvic fins. This indicates that at least 10 vertebræ are missing in the abdominal region of our specimen and several others from the caudal region. The number of the type of *A. aratus* is 2403. With regard to the dorsal fin Professor Cope's statements are not as positive as the specimen seems to justify. The fin begins just above the hinder border of the operculum. Its first ray is supported by a strong interneural bone (Pl. II, *i. n.*). The succeeding interneurals diminish rapidly in size, so that after the sixth they are slender. Cope says that the fin is "continuous as far as the specimen is preserved in this region, viz., to the fifteenth vertebra behind the scapula." But there are 22 vertebræ preserved on the block and behind these are the imprints of 8 more; and there are impressions of interneurals as far as over the 28th vertebra. There is also the base of a dorsal ray over the 21st vertebra, so that the dorsal fin must have extended to this vertebra, at least. On the succeeding block there are interneurals and fin rays (*i. n.*, *d. r.*). Of the latter several must have had their origin

considerably farther forward, possibly on the anterior block. On the hindermost block again there are remains of 4 or 5 rays. If the latter represent a distinct fin the one in front must have ended very abruptly. To the writer it appears quite certain that there was a single dorsal fin and that this extended from near the head to near the root of the tail. This must have resembled considerably the fin of *Coryphæna hippuris* (Jordan and Evermann, Fishes of North and Middle Amer., pl. cxlix, fig. 402).

Unfortunately, throughout most of its length only the bases of the fin rays remain, so that we have little idea regarding the height of the fin. On the second block there are remains of about 9 rays and some of these were at least 75 mm. high.

As stated by Cope some portions of the anal fin are present (*a. r.*). It was certainly short, but its exact length cannot be ascertained. A part of the anterior ray is seen, and about 6 interhæmal supports (*i. h.*) may be counted; but weathering has removed most of the bones.

There are present the distal ends of about 5 rays of one ventral fin (*v. r.*). Their tips have reached the front of the anal. They are cross-segmented.

One pectoral fin (*pct.*) is well preserved. It has lain in the matrix with the distal end directed across the vertebral column and with the convex anterior border directed upward. It is represented, for the sake of convenience, in a different position in the figure, the figure of it being drawn from the block split from the one bearing the body of the fish. The fin is 220 mm. long and seems to have consisted of about 20 rays.

Only the base of the caudal fin is present. The rays are supported by a fan-shaped hypural bone. In front of this are seen the crowded terminal vertebræ. The fin rays appear to have been slenderer and more numerous than in *Pachyrhizodus*. No evidences of cross segmentation appear.

The ribs are long and slender, and they have apparently been connected with the vertebral centra by means of distinct pieces of bone, parapophyses, as in *Tarpon*, *Portheus*,

and some other fishes. Intermuscular bones are well developed, those arising just behind the head being especially long and slender.

Some scales are present. One is 18 mm. long and 5 mm. wide. The exposed portion is marked with lines radiating from the centre of growth.

Cope has described the form of the upper surface of the skull. It presents three planes, a median and two lateral. The median is narrow at the supraoccipital, but increases in width to the snout. The lateral planes are widest behind and narrow anteriorly. They slope off at an angle of about 30° with the median plane. The sides of the head are about vertical.

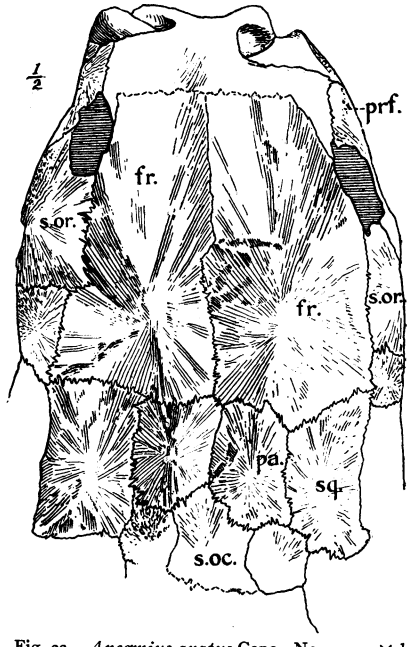


Fig. 23. *Anogmius aratus* Cope. No. 2403. × ½. Type. Head from above. *fr.*, frontal; *pa.*, parietal; *prf.*, prefrontal; *s. oc.*, supraoccipital; *s. or.*, supraorbital; *sq.*, squamosal.

The bones of the upper surface of the skull in front of the orbits have been damaged. A portion of the frontals is gone, but the imprint of these and some splinters of the bones remain. Their anterior border cannot be determined exactly. The anterior extremity of the ethmoid is present and is thick and broad, as seen at the upper end of Fig. 23. Cope regarded this bone as the consolidated premaxillaries and thought that little if any of the ethmoid was exposed. The imprint of the premaxillæ and splinters of these bones still remain on the upper surface of the snout on a portion of the matrix which overlies the ethmoid. Again, a smooth articular surface is found at the proximal end of each of the maxillæ

(Pl. II, *mx.*), and these smooth surfaces must have been applied to the premaxillæ, unless the structure of this region was entirely different from that of *A. favirostris*. The premaxillæ have quite certainly been similar to those of Loomis's *Thryptodus zitteli*, and when present have nearly concealed the ethmoid. On the other hand, Loomis is probably mistaken in thinking that the premaxillæ of his species have coalesced with the ethmoid. His specimen and the type of *A. aratus* explain each other, and the explanation is confirmed by the types of *A. favirostris*. Whether or not the premaxillæ of *A. aratus* were coössified, we cannot be sure, No evidences of a median suture appear. Nor is it absolutely certain that the ascending processes of those bones were not united in *A. favirostris*.

The nasal cavities are situated above the level of the eyes and a little in front of them.

The bones of the upper surface of the head (Fig. 23) are in general like those figured by Loomis in his *Thryptodus zitteli*. The supraoccipital (*s. oc.*) does not separate the small and square parietals (*pa.*). Laterad of the last named bones are the large squamosals (*sq.*). The eye has been surrounded by a complete ring of bones. Over the eye are two sculptured supraorbitals (Fig. 23, *s. or.*). Behind the eye is the smooth postorbital (*pt. or.*); while in front is the prefrontal (*prf.*). This bone is sculptured above, but it sends downward in front of the orbit a long smooth process. Another elongated bone, apparently the preorbital, occupies the area between the prefrontal and the maxilla. The number of the bones covering the cheeks cannot be determined. They extend to the preopercular. The preoperculum (*p. op.*) and operculum (*op.*) are as represented in the plate. The other opercular bones were doubtless present, but are not preserved. The posttemporal (*pt.*) and the supracleithrum (*su. cl.*) are present. Of the cleithrum (*cl.*) only fragments remain on the block. An imprint of the coracoid is seen on the matrix below the throat. The articulation of the pectoral fin is high, being just below the vertebral column. If the precoracoid was present, it must have been short.

The articulation of the lower jaw is below the hinder half of the orbit. The articular sends up a strong hook-like process behind the quadrate. The maxilla is curved and does not extend back as far as to the quadrate. Neither the maxilla nor the mandible appears to have differed much from those of *Thryptodus zitteli*. The mouth has been relatively small and quite oblique.

The structure of the greater portion of the dental apparatus was unknown to Cope. He states that teeth are found on the ethmoid bone, his united premaxillæ; but the present writer has been able to find there only a slight roughness. When the fish died, the mouth was left in a gaping position. Recently the matrix has been removed from it to a depth of 98 mm. from the edge of the vomer. This reveals the fact that the mouth is armed with large bony plates which closely resemble those described by Loomis as belonging to *Thryptodus*. From a gelatine mold, plaster casts have been made of the upper surface of the mouth and of the floor. These have given much assistance to the artist in making drawings of the parts. The excavation of the cavity of the mouth did not extend quite to the hinder end of the plates, but must have approached them closely. In the front of the mouth we find a short, broad vomer (Fig. 24, *vom.*) which is covered with villiform teeth. Behind this is found a dental plate (*par.*) at least 82 mm. long and about 30 mm. wide. It has nearly parallel sides, and the lower surface is concave. The concavity is greatest just behind the middle. No doubt, this plate rests on the parasphenoidal bone, as in *A. favirostris*. On each side of this parasphenoidal plate and articulating closely with it is another plate (*pal.*), long, narrow in front, broadening behind, and convex in cross-section. These plates represent the palatine

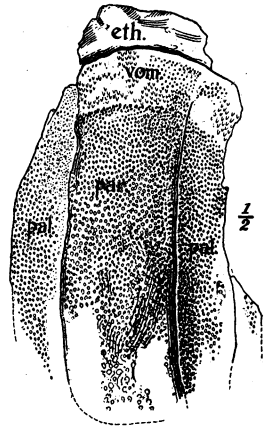


Fig. 24. *Anogmius aratus* Cope. Same specimen as Fig. 23. × ½. Roof of the mouth. *eth.*, ethmoid; *pal.*, palatine; *par.*, parasphenoid; *vom.*, vomer.

bones. The surfaces present the same structure as we have found in the case of the parasphenoid, being furnished with numerous pits. In places, all of these bones present evidences of attrition. Near the hinder end of the palatine is seen a portion of the ectopterygoid.

The floor of the mouth is occupied by two great convex plates which are joined by a transverse suture. The anterior (Fig. 25, *gl. h.*) has the form of the plate figured by Loomis (*op. cit.*, pl. xxi, fig. 4a) as the entoglossal, although it is smaller than the one figured by this writer. The length and breadth are each about 34 mm. It is strongly convex from side to side. The posterior plate (*b. br.*) is still more convex than the anterior, especially behind. The hinder border has not been exposed, so that we do not know its form and whether or not it was followed by a third plate. Both these plates are everywhere pitted, and the posterior one, which has fitted into the concavity of the parasphenoidal plate, is worn smooth over a considerable part of its surface. It is quite certain that these two plates have been developed on the glossohyal and the basi-branchials. Doubtless the structure of these plates is the same as that of the plates described under *A. altus*. Figure 26 illustrates a section across the mouth at about the middle of the basi-branchial plate (Fig. 25, *b. br.*) and some distance in front of the hinder end of the parasphenoidal plate (Fig. 24, *par.*). The line above *b. br.* represents the upper surface of the basi-branchial plate. The upper line shows the vaulted roof of the mouth as formed by the parasphenoidal plate (*par.*) and the right and left palatines (*pal.*).

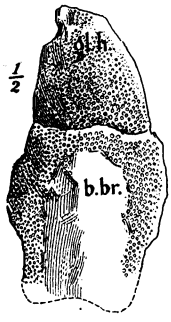


Fig. 25. *Anogmius aratus* Cope. Same specimen as Fig. 23. × ½. Floor of the mouth. *b. br.*, basi-branchial; *gl. h.*, glossohyal.

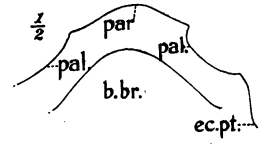


Fig. 26. *Anogmius aratus* Cope. From same specimen as Figs. 23–25. × ½. Diagrammatic section across the cavity of the mouth. *b. br.*, basi-branchial; *ec. pt.*, ectopterygoid; *pal.*, palatine; *par.*, parasphenoid.

It is quite certain that the specimen described by Dr.

Loomis as *Thryptodus zitteli* belongs to the same genus as the one here described, but it is also quite as certain that it represents a different species. It appears to have had a flatter skull and probably a blunter snout. Furthermore, the upper and the lower dental plates were all proportionally shorter and broader than in *A. aratus*.

Anogmius altus (*Loomis*).

Syntegmodus altus Loomis (F. B.), Palæontogr. XLVI, 1900, p. 253, pl. xxii, fig. 9.—Woodward (A. S.), Cat. Foss. Fishes Brit. Mus. IV, 1901, p. 84.—Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 390.

Dr. Loomis's type of this species included the hinder portion of the skull and the parasphenoid. The specimen is figured by him so as to present a lateral view.

No. 2112 of the American Museum of Natural History is a part of the Cope Collection, and was collected by C. H. Sternberg in 1877, probably in Gove County, Kansas. It furnishes about the same parts as does Loomis's specimen; but it is crushed obliquely downward. Figure 27 presents a

Fig. 27. *Anogmius altus?* (Loomis). No. 2112. × ½. Upper hinder part of skull. *b. oc.*, basioccipital; *ep. o.*, epiotic; *fr.*, frontal; *op. o.*, opisthotic; *pa.*, parietal; *sq.*, squamosal.

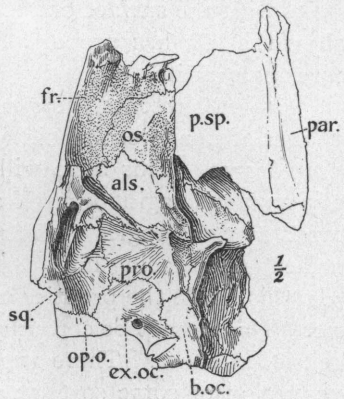


Fig. 28. Same as Fig. 27. × ½. Base of skull. *als.*, alisphenoid; *ex. oc.*, exoccipital; *op. o.*, opisthotic; *o. s.*, orbitosphenoid; *par.*, parasphenoid; *pro.*, proötic; *p. sp.*, presphenoid; *sq.*, squamosal.

view from above; Figure 28 from below. The specimen cannot be identified with certainty as *A. altus;* since, as will

be observed, in the type of the species the anterior edge of the presphenoid is but little in front of the middle of the parasphenoidal triturating surface; while in the specimen here described the presphenoid comes much farther forward. These differences may be individual, however.

As will be observed, the supraoccipital lies some 25 mm. to the right of the basioccipital, having been crushed to the right and downward. This shows that the skull must have been elevated at least that many millimeters above the foramen magnum, a conclusion which is confirmed by the skull described by Dr. Loomis. About 20 mm. in front of the hinder extremity of the supraoccipital begins an abrupt depression. It is about 10 mm. wide, and extends well forward on the frontals. From Fig. 28 the position and boundaries of the various bones may be seen. In general, these agree with those shown in the specimen described by Loomis as *Thryptodus zitteli* (*op. cit.*, pl. xxi, fig. 1). On the left the opisthotic, sphenotic, and hinder part of the frontal are in their natural positions and form the border of the skull. On the right the squamosal has been flexed downward at right angles with the surface of the skull. The border of the frontal on the left has probably been bent downward somewhat more than in life.

Figure 28 presents the skull as seen from below, only the outlines of the presphenoid (*p. sp.*) and parasphenoid (*par.*) being drawn. This bone will be described below. The observer must imagine himself as turning it to the left until it stands at right angles with the paper, and has the triturating surface (*par.*) facing him.

In this figure the proötics are drawn as meeting in the midline. This cannot be certainly affirmed; but the appearances are to that effect. There appears to have been a considerable excavation of some sort beneath the projecting edge of the squamosal and outside of the hyomandibular articulation. The alisphenoids are large, agreeing with those of Dr. Loomis's figure of *A. altus*. We come now to the bone called by Dr. Loomis the orbitosphenoid. It appears to agree with the bone so-called by Parker (Philos. Trans. Roy. Soc., CLXIII,

1874, pl. vii.). There is, however, satisfactory evidence of a pair of bones, or more probably of an unpaired bone with right and left wings, which is placed in front of the alisphenoids. This bone, marked *o. s.* in Figure 28, is certainly not the lower surface of the frontal, and there is a plain suture for union with the alisphenoid. The lateral edge of this bone is not so certainly determined, but seems to be where drawn in the figure. The surface for articulation with the large median bone (Figs. 28, 30, *p. sp.*), lies about 10 mm. to the left (right in the figure) of the midline between the frontals. This distortion could not occur if the bone (*p. sp.*) were articulated to the under surface of the frontals. Hence, I hold that the bones *o. s.* are the distinct, or more probably united, orbitosphenoids, while the bone (*p. sp.*) is the presphenoid. The latter would occupy the position of the presphenoidal cartilage shown in Fig. 10 of Pl. v and Fig. 10 of Pl. vii of Parker's paper just quoted. Dr. Loomis's figure of *A. altus* also shows an arch of bone running upward and outward from the upper edge of the bone called by him orbitosphenoid. It is above these bones that the anterior portion of the brain and the olfactory nerve must have lain.

The parasphenoid of this specimen must have had a median process behind, like that represented in Loomis's drawing (Fig. 10, Pl. xxii). At the anterior end of the lower surface of the supposed proötics, in the midline, there is an excavation in which this process must have been lodged. As already stated, the parasphenoidal grinding plate is deeply pitted (Fig. 29). Where a small fracture occurs it is seen that these pits pass down to the bone of the ordinary sort on which the denser mass reposes. Accompanying this plate is another bone which is represented by Fig. 31. This was broken, and the injured end has been ground down to show

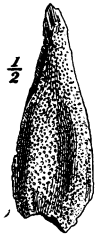


Fig. 29. *Anogmius altus?* (Loomis). Same individual as Figs. 27, 28. × ½. Parasphenoid, palatal surface.

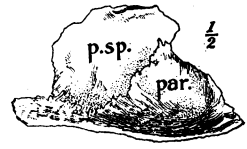


Fig. 30. *Anogmius altus?* (Loomis). Same individual as Figs. 27–29. × ½. Lateral view of parasphenoid and presphenoid.

the structure. Fig. 32 shows a small portion magnified two times. The pits and cavities in the bone are shown by the black. It will be observed that the pits penetrate nearly the whole thickness of the bony mass. Loomis has described the dense mass which forms the bulk of these triturating plates as "dentine" and "osteodentine." I do not discover the peculiar structure of dentine in any of them. The canals which Dr. Loomis calls "Haversian" appear to be the pits which open on the surface. To me the plates appear to be merely a kind of dense bone, similar to that found on the maxilla and premaxilla outside of the mouth cavity; and these bones display not very dissimilar pits. Dr. Woodward has mentioned the presence of dentinal tubules in *Plethodus* (Ann. and Mag. Nat. Hist., Ser. 7, Vol. III, p. 355). Unfortunately he has not furnished figures of these microscopical elements, or given us their dimensions. What is the function of these pits, and how they have been produced, the present writer does not attempt to explain. It would be interesting to know how these bony masses increased in thickness.

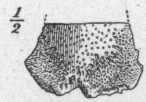


Fig. 31. *Anogmius altus?* (Loomis). Same individual as Figs. 27–30. × ½. Inferior grinding plate.

Fig. 32. *Anogmius altus?* (Loomis). Section through bone of Fig. 31. × 2.

Fig. 33. *Anogmius* sp. No. 994. × ½. Inferior dental plate.

Seen from the lower side this bone is ornamented with fine ridges, which run, for the most part, longitudinally and anastomose, but which, in some parts, run in other and often irregular directions. In cross-section these ridges form narrow perpendicular plates, as appears at the bottom of Fig. 32. They appear to be similar to the fine ridges found by Dr. Woodward in similar situations in *Plethodus*.

The convex surface of this plate fits well the concave surface of the upper plate. Fig. 33 presents a view of the grinding surface of a lower dental plate collected for the author in the region of Butte Creek, Kansas, but which is now the property of the American Museum. It is strongly convex

above, concave below. The ends have evidently been suturally joined to other bones; so that it has apparently been the middle one of a series of at least three bones forming a triturating plate. In this bone, as in No. 2112, the pitted surface gives evidences of polishing through use. No evidences of teeth are to be found on the central portions of this plate, but around the borders, especially in front, many small, sand-like teeth are observed. These are clustered on the ridges of dense bone surrounding the pits, as seen in Fig. 34, which represents an enlarged view of the surface of Fig. 32 bounded by the two fractures on the upper left-hand border. The pits are shown in black; the teeth by the small circles. This bone closely resembles the one figured by Stewart (Univ. Geol. Surv. Kansas, VI, 1900, pl. lxvii) as a pharyngeal of *Anogmius polymicrodus*.

Fig. 34. *Anogmius* sp. Enlarged view of part of Fig. 33. × 2.

Fig. 35. *Anogmius* sp. No. 1116. × ½. Lower anterior dental plate.

Fig. 36. *Anogmius* sp. No. 1116. × ½. Caudal vertebra.

Fig. 35 represents an upper view of another lower dental plate which evidently belongs to some species of *Anogmius*. The upper surface is in general convex, but the central and hinder part is somewhat concave. On each side of the concavity a ridge runs forward to about the middle of the length. Here it divides, one branch running outward to the border of its side. The other unites with the corresponding ridge of the other side, and the single ridge thus formed continues to the anterior end of the triturating surface. In front of the pitted mass of dense bone there is a thin expansion of ordinary bone. On the right-hand side of the figure this does not appear, but this is because it has been crushed downward and to the left beneath the part seen. It seems most probable that this bone is the glossohyal. It belongs to the same specimen as the piece of tail represented by Fig. 16. Fig. 36 gives a view from above of a caudal vertebra of the same specimen, No. 1116. There are seen the pits for the reception of the neural arches.

There is also presented on each side an outstanding process which is found on some of the vertebræ of some members of the genus. They occupy a position about the middle of the height of the vertebral centrum and near the hinder end.

Anogmius evolutus *Cope.*

Anogmius evolutus COPE (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 179. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 347, pl. lxv, fig. 7; pl. lxvii. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 72. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 393.

Osmeroides evolutus LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 257, pl. xxvi, figs. 5, 6.

Beryx multidentatus STEWART (A.), Kansas Univ. Quart. VII, 1898, p. 196.

The type of this species is here figured (Fig. 37). The original description given by Professor Cope seems to be sufficiently clear and accurate. Dr. Loomis has figured a mandible and premaxilla of what appears to be this species. His specimen is different from that described by Cope in having the band of teeth wholly on the inside of the dentary, instead of having it about equally distributed on the inside and the outside of the bone. Fig. 37 shows how much of the

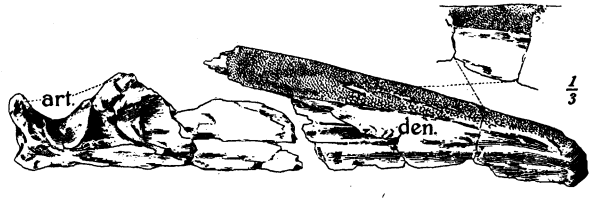


Fig. 37. *Anogmius evolutus* Cope. No. 2101. × ⅓. Type. Lower jaw, view of inner surface; detached figure, a portion of outer surface. *art.*, articular; *den.*, dentary.

band of teeth was on the inside of the jaw in the type of the species; the detached part of the figure represents the teeth on the outer side of the jaw. It is possible that the difference in the two specimens is due to the crushing of one or the other; but of which, it is now impossible to say.

A comparison of the figure of the premaxilla given by Dr.

Loomis shows that this bone must have been quite like that of *A. favirostris*, in both form and sculpture.

Cope's type of *A. evolutus* was, according to Mr. C. H. Sternberg's diary of his expedition of 1877, found near the line between Lane and Gove counties, Kansas. It is now No. 2101 of the American Museum of Natural History.

ELOPIDÆ.

Spaniodon simus *Cope.*

PLATE IV, FIGS. 1 AND 2.

Spaniodon simus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 69. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 53. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

Illustrations are herewith presented of the specimens from which Professor Cope drew his description of this species. He has mentioned the possession of three specimens, of which one, said to be nearly entire, served as his type. These specimens are now in this Museum. Fig. 1, Pl. IV, is taken from No. 2508; Fig. 2 of the same plate, from No. 2509. On the block containing the latter specimen are remains of one or more fishes lying behind and above the fish represented on the plate, but it is doubtful whether or not they belong to the latter. In any case the vertebræ are all wanting. Yet it is from this fish that most of the description of the head is derived. Both specimens are labelled by Cope as being his types.

Little criticism can be made on Cope's description. To the writer it appears evident that the lower portion of the body was scaled. The dorsal and anal seem to have had each about two rays fewer than the numbers given in the original description.

The number of vertebræ in this fish is less than in any of the other described species. *S. latus* (Agassiz) is stated by Dr. A. S. Woodward (Cat. Foss. Fishes, IV, p. 53) to have 50 vertebræ, whereas the present species has only 45.

The depth is contained in the length to the end of the vertebral column three and one-half times; the length of the head in the same distance about three and one-third

times. Three other species, *S. blondeli* Pictet, *S. elongatus* Pictet, and *S. latus* (Agassiz) are found in the upper Cretaceous of Sahel Alma, Mt. Lebanon.

On the block bearing No. 2509 are found written in pencil the words "Yankton, Neb." Professor Cope merely stated that the specimens came from Dakota. The formation and locality are therefore as follows: Niobrara Cretaceous, Yankton, South Dakota.

ICHTHYODECTIDÆ.

Saurocephalus *Harlan.*

So far as has yet been shown the only difference between *Saurocephalus* Harlan and *Saurodon* Hays is found in the presence in the former of a row of foramina, one foramen for each tooth, placed some distance from the dental border of the jaws, upper and lower, while in *Saurodon* there is at the base of each tooth a deep notch. In the latter genus the notches are often converted into foramina by the growth of bone across the notch. There can be little doubt that the foramina of *Saurocephalus lanciformis* originated from notches like those of *Saurodon leanus*. Whether or not this difference shall be regarded as sufficient to indicate distinct genera may be a matter of individual judgment. The writer has preferred to retain all the species under *Saurocephalus*.

These openings in the bones of the jaws have been called nutritive foramina, and as such Dr. Woodward speaks of them in the final volume of his work on fossil fishes. There can be little doubt that it is through these foramina that the young teeth enter the sockets. The writer has ground down a small piece of a jaw of this genus and found the very young tooth at the bottom of one of these foramina, lying against the functional tooth. As growth occurs, the root of the tooth pushes itself above the foramen, while the blade grows toward the dental border. It is very improbable that any nutrient vessels enter the sockets through these foramina. From Dr. Loomis's memoir I gather that the view here presented is also that of Dr. Röse.

Saurocephalus phlebotomus *Cope.*

Saurocephalus phlebotomus COPE (E. D.), Proc. Amer. Philos. Soc. XI, 1870, p. 530; U. S. Geol. Surv. Wyoming, etc. 1871, p. 416; Proc. Amer. Philos. Soc. XII, 1871, p. 343. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 386.

Daptinus phlebotomus COPE (E. D.), Proc. Acad. Nat. Sci. Phila. 1873, p. 339; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, pp. 213, 275, pl. xlvii, figs. 3, 4, 6; pl. xlix, figs. 1–4. — NEWTON (E. T.), Quart. Jour. Geol. Soc. XXIV, 1878, p. 440. — ZITTEL (K. A.), Handbuch Palæont. III, 1890, p. 264.

Saurodon phlebotomus COPE (E. D.), Bull. U. S. Geol. Surv. III, 1877, p. 588. — STEWART (A.), Kansas Univ. Quart. VII, A. 1898, p. 186; Univ. Geol. Surv. Kansas, VI, 1900, p. 312, pl. lvii, figs. 4, 5. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 248, pl. xxiv, figs. 1–5. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 112.

Daptinus phlebotonum CROOK (A. J.), Palæontogr. XXXIX, 1892, p. 123.

The type of this species is in the American Museum and has the number 1906. There are present all of the left maxilla, except the distal end; the alveolar border of the right maxilla; both palatine malleoli; and considerable parts of both dentaries, including the symphysis and surface for articulation of the predentary. All the parts are more or less fragmentary; but it is believed that they furnish a correct idea of the tooth lines, both of the maxillæ and the dentaries. The conclusion is reached that there were not more than 40 teeth in each dentary and about 30 in each maxilla.

Fig. 38. *Saurocephalus phlebotomus* Cope. No. 1907. × ½. Premaxilla, inner view.

The specimen which Stewart has described and figured as *Saurodon phlebotomus* (Univ. Geol. Surv. of Kansas, VI, p. 312, pl. lvii, figs. 4, 5) is quite certainly such. On the other hand, the specimens described and figured by Loomis (Palæontogr., XLVI, p. 248, pl. xxiv, figs. 1–5) are probably not of this species. In these there are 47 teeth in the dentary. Likewise, the premaxilla does not resemble that of one of

the specimens which Cope has (and, so far as I can see, correctly) identified as *S. phlebotomus*. This specimen, No. 1907, is here figured (Fig. 38) and it will be seen that it is much more pointed than is the one figured by Dr. Loomis. The latter is probably *S. xiphirostris* Stew., the premaxilla of which is shown here by Fig. 39.

There seems to be only one objection to Stewart's identification of his specimen, and that is found in the relative lengths of the dentary and maxilla. Cope's specimens indicate that the dentary projected farther in front of the premaxillaries than Stewart's figures would suggest. The tooth line of the dentary of Cope's type must have had a length of 98 mm.; the maxillary tooth line a length of 60 mm. If now we add to the latter 20 mm. for the premaxilla, we have 18 mm. for the distance which the dentary projected beyond the premaxillary. How the discrepancy is to be explained is now uncertain.

Saurocephalus lanciformis *Harlan.*

Saurocephalus lanciformis HARLAN (R.), Jour. Acad. Nat. Sci. Phila. (1), III, 1824, p. 337, pl. xii; Trans. Geol. Soc. Penn. I, 1834, pt. i, p. 83; Med. and Phys. Res. 1835, pp. 286, 289, 366. — ? MORTON (S. G.), Amer. Jour. Sci. XXVIII, 1835, p. 277. — OWEN (R.), Odontog. 1845, p. 130, pl. lv. — GIEBEL (C. G.), Fauna Vorwelt, I, pt. iii, 1848, p. 89. — LEIDY (J.), Proc. Acad. Nat. Sci. Phila. 1856, p. 302; Trans. Amer. Philos. Soc. XI, 1857, p. 87, pl. vi, figs. 8–11. — PICTET (F. J.), Traité Paléont. 1854, ed. 2, p. 93. — ?? SPILLMAN (W.), Hilgard's Rep't on Geol. Miss. 1860, pp. 142, 389. — COPE (E. D.), Proc. Amer. Philos. Soc. XI, 1870, p. 530; U. S. Geol. Surv. Wyom. 1871, p. 415; Vert. Cret. Form. West, 1875, pp. 216, 275. — DAVIES (W.), Geol. Mag. (2), V, 1878, p. 260. — NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIII, 1878, p. 786. — STEWART (A.), Kansas Univ. Quart. VII, 1898, p. 186. — HAY (O. P.), Amer. Jour. Sci. (4), VII, 1899, p. 299, figs. 1–4. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 251, pl. xxv, figs. 2–5. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 392. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 113. — HAY (O. P.), Bibliog. and Cat. Foss, Vert. N. A. 1902, p. 386.

Saurodon lanciformis HAYS (I.), Trans. Amer. Philos. Soc. (2), III. 1830, p. 477, pl. xvi, fig. 11.

Saurocephalus arapahovius COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 343; U. S. Geol. Surv. Mont. 1872, pp. 344, 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, pp. 216, 275, pl. xlix, fig. 5. — WOODWARD (A. S.), Cat. Foss. Fishes IV, 1901, p. 114. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 385.

Saurocephalus arapalovius LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 251 (syn. of *S. lanciformis*).

The type of Cope's *Saurocephalus arapahovius* is in the Cope Collection, now belonging to the American Museum of Natural History, and has the number 2073. It is a fragment of the maxilla. Cope distinguished his species from *S. lanciformis* on the ground that the facets shown by Leidy to exist on the roots of the teeth of the latter were absent in the former. Loomis unites the two species because he regarded the presence of facets to be variable. I have exposed the root of one of the teeth of the type of *S. arapahovius* and find that there are very distinct facets. There appears, therefore, to be no reason for retaining it as a distinct species.

Saurocephalus xiphirostris (*Stewart*).

Saurodon xiphirostris STEWART (A.), Kansas Univ. Quart. VII, 1898, p. 178, pl. xiv; Univ. Geol. Surv. Kansas, VI, 1900, p. 314, pl. lv. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 247. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 113.

Saurocephalus xiphirostris HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 386.

Saurodon phlebotomus LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 248, pl. xxiv, figs. 1–5.

I find difficulty in estimating the value of Stewart's species, *Saurodon broadheadi*, *S. ferox*, and *S. xiphirostris*. There is at least one good species among these; if only one, it must bear the earliest name, *broadheadi*. *S. ferox* appears to differ from *S. broadheadi* in having the maxilla proportionally a little higher. It has also an unusually large number of teeth in the maxilla, 40; an unusually small number, 46, in the dentary; and only 10 in the premaxilla. The number is variable, however; a specimen, No. 1614, referred to *S.*

xiphirostris, having 32 in one maxilla, 35 in the other; 50 teeth in the dentary; and 11 in the premaxilla. Another has 32 and 34 teeth in the maxillæ, 50 in the dentary, and 13 in the premaxilla. However, it is probably better for the present to regard the three species as distinct.

No. 1614 (Figs. 39, 40) was collected in 1877, in Gove County, Kansas, by Mr. R. Hill, for Professor Cope. It consists of both upper jaws complete; the left palatine complete, or nearly so; the greater part of both lower jaws; one quadrate; and the predentary. The number of the teeth has been stated. The predentary has a length of 55 mm., a vertical diameter of 27 mm. at the base, and a transverse diameter of 16 mm. It does not appear to have suffered any crushing. The premaxilla is represented by Figure 39 for comparison with that of *S. phlebotomus*.

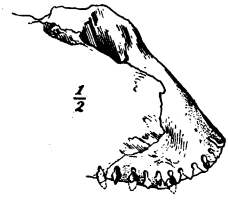


Fig. 39. *Saurocephalus xiphirostris* (Stewart). No. 1614. × ½. Premaxilla, inner view.

The palatine has the form represented in Fig. 40, seen from the outside. The mesial surface is concave in cross-section. On this surface are seen two considerable patches of small teeth, and probably the whole surface was originally furnished with teeth. Attached to the hinder end of the upper border of the maxilla is a supramaxilla.

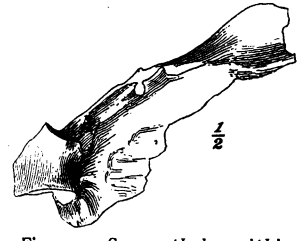


Fig. 40. *Saurocephalus xiphirostris* (Stewart). No. 1614. × ½. Palatine, outer view.

No. 2012 has 35 teeth in the maxilla. The predentary is 66 mm. long and 28 mm. high.

Saurocephalus goodeanus (*Cope*).

Ichthyodectes goodeanus COPE (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 176. — HAY (O. P.), Amer. Jour. Sci. (4), VI, 1898, p. 227; Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 385. — WOODWARD, (A. S.), Cat. Foss. Fishes, IV. 1901, p. 107.

In the Cope Collection of fossil fishes has been found Cope's type of his *Ichthyodectes goodeanus*. It proves to be a species

of *Saurocephalus*, belonging to the section or subgenus *Saurodon*. Its number is 2110. It is difficult to understand how Professor Cope came to refer the species to *Ichthyodectes*, since the forms of the maxillary, premaxillary, and palatine,

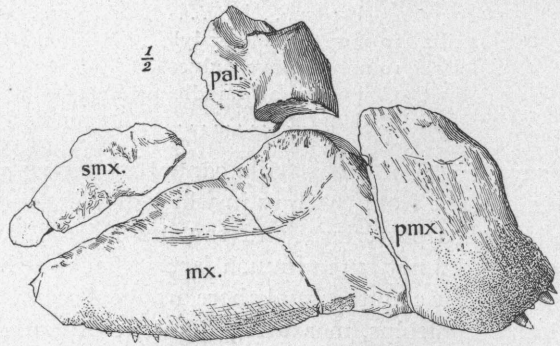


Fig. 41. *Saurocephalus goodeanus* (Cope). No. 2110. × ½. Type. Upper jaw, outer view. *mx.*, maxilla; *pal.*, palatine; *pmx.*, premaxilla; *smx.*, supramaxilla.

and the presence of notches at the bases of the teeth plainly indicate its relationship with *Saurocephalus phlebotomus* (Fig. 41).

Cope's description agrees in almost every respect with the specimen, but in one or two cases there is some apparent lack of agreement, due evidently to a misuse of terms. He states that "the maxillary border is incurved at its anterior extremity," etc. This is exact, if instead of maxillary we read premaxillary. That the latter is meant is indicated by the statements "the middle part of the border being most prominent," and "the anterior border is sigmoidally curved," statements true of the premaxilla, but having little or no significance when applied to the maxilla. The statements as to the number and character of the premaxillary teeth are correct. As Cope says, the maxillary teeth are round in section; but there can be little doubt that if we had the crowns of these teeth they would be found to be two-edged, as are those of the premaxilla. Cope's measurements are correct.

This species differs from all other described species of

Saurocephalus in its heavy structure. The bones are much thicker than those of specimens which I refer to *S. xiphirostris*, as the following measurements indicate.

	S. xiph.	*S. good.*
Thickness of premaxilla 20 mm. above alveolar border	8 mm.	12 mm.
" " maxilla 10 mm. below condyle	8 mm.	12 mm.
" " " 10 mm. above alveolar border at middle of length	5.5 mm.	7.5 mm.

The exact length of the maxilla cannot be determined, but it is quite evident from the way in which the alveolar border is curved upward posteriorly and the small size of the teeth that the bone did not extend much farther backward. Alveoli for 31 teeth are counted; and there are six alveoli in 20 mm. The palatine malleolus, measuring from the articular surface for the maxilla to that for the prefrontal, is high; not low, as we find it in *Ichthyodectes*.

The supramaxilla (Fig. 41, *smx.*) is present. In the drawing this bone is lifted somewhat above its natural position. It is flat on the outside. On the mesial side it is traversed longitudinally by a sharp ridge.

This species was collected by C. H. Sternberg's party during the year 1877, probably in Gove County, Kansas.

The maxilla figured by Stewart as the type of *Saurodon broadheadi* resembles in outline and proportions that of *Saurocephalus goodeanus*, but Dr. S. W. Williston has kindly given me measurements which show that Stewart's species is everywhere much thinner. At 10 mm. below the condyle the thickness is only 7 mm.; at middle of length, 10 mm.; above the lower border, only 4.5 mm.

Ichthyodectes anaides *Cope.*

Ichthyodectes anaides Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 339; 5th Ann. Rep. U. S. Geol. Surv. Mont. etc. 1872, p. 343; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 40; Vert. Cret. Form. West, 1875, pp. 206, 274, pl. xliv, figs. 14, 15; pl. xlv, figs. 1–8. — Crook (A. R.), Palæontogr. XXXIX, 1892, pp. 111, 123, pl. xv. — Hay (O. P.), Amer. Jour. Sci. (4),

VI, 1898, p. 226, fig. 2; Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 384. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 244. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 296, pl. xlix, figs. 1–3. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 100.

Portheus arcuatus COPE (E. D.), Vert. Cret. Form. West, 1875, p. 274, pl. xlvii, figs. 7–9.

This is one of the commoner species found in the Niobrara beds of Kansas, and it has been figured by Cope, Crook, Hay, and Stewart. As shown by some of the published figures and by specimens in the American Museum, the mouth has been very oblique. The eyeball is large, as shown by the preserved sclerotic bone.

Crook has figured portions of the shoulder girdle and the first pectoral ray. As in the case of *Portheus*, he has mistaken the upper end of the clavicle for the lower, and consequently the right for the left fin. The first pectoral ray has the same structure as that of *Portheus*, but has evidently been proportionately shorter and more curved distally.

An examination of the original of Cope's figures 7–9, pl. xlvii, 'Vertebrata of the Cretaceous Formations of the West,' has convinced me that they belong to this species and not to *Gillicus arcuatus*. Crook has already surmised this to be true (Palæontogr., XXXIX, p. 112). The skull is shorter and broader and of heavier construction.

After examining skulls of *Portheus*, *Saurocephalus*, and *Gillicus* I am confirmed in my opinion that the parietals are united in the mid-line and lie in front of the supraoccipital. They form the base of the great crest at the back of the head, and extend slightly backward on each side like the horns of a crescent. Posteriorly these horns join the anterior prolongations of the epiotics. I have not been able in any case to discover sutures between the parietals and the epiotics, but doubtless these exist.

No. 2005 of the American Museum was collected in 1877, in Gove County, Kansas, by Russell Hill. It furnishes a complete head, 19 anterior vertebræ, the shoulder girdle, and the first rays of both pectoral fins. Unfortunately, the head

is somewhat distorted and crushed, and the greater part of the shoulder girdle hidden. Above each orbit are two supra-orbitals, one behind the other and each about 25 mm. wide. There are remains of a supramaxilla, but its limits are not definable. A portion of the palatine behind the malleolus has been exposed in life. Below and behind the eye the bones of the palatopterygoid arch have been wholly hidden by the suborbitals. The boundaries between these latter bones cannot be made out, the bones themselves having probably been very thin. If correctly identified, the supra-cleithrum is large, about 160 mm. long and 50 mm. or more wide. The preopercular resembles that of *Portheus*. The opercle is large. All the opercular bones are roughened, as if there had been here and there bony nodules. The cleithrum appears to have a backwardly extending flap behind the articulation of the jaw.

The head of this specimen has been shortened by distortion, but must have been, from snout to gill clefts, about 300 mm. long. The length of the whole fish must have been about 5 feet (1.64 m.).

The vertebræ of this species resemble those of *Portheus*. In his description of these (Vert. Cret. Form. West, p. 207) Cope states that the ribs are not articulated directly to the centra, but by means of free elements which were inserted into the lateral grooves. Had I been aware of this fact when writing my observations on the vertebral column of *Portheus* (Zoöl. Bull., II, 1898, pp. 25–54) I might have been saved from the blunder which I there made, that of calling the upper side of the vertebral column the lower. The sections of the column there studied had been crushed so that the ribs of opposite sides had been brought into close contact and so as to resemble neural arches. In *Tarpon*, with which they were being compared, there are also free parapophyses, but posteriorly these diminish and disappear. In *Portheus*, on the contrary, as is now realized, these parapophyses increase in size toward the tail region, and the same is probably true in the cases of other members of the family.

Ichthyodectes multidentatus *Cope.*

Ichthyodectes multidentatus COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, pp. 339, 342; 5th Ann. Rep. U. S. Geol. Surv. Montana, etc. 1872, p. 343; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, pp. 212, 275, pl. 1, figs. 6, 7. — CROOK (A. R.), Palæontogr. XXXIX, 1892, p. 123. — HAY (O. P.), Amer. Jour. Sci. (4), VI, 1898, p. 227; Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 385. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, pp. 243, 245, text figs. 8, 9; pl. xxiii, fig. 9. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 107.

This species was based on a premaxilla and a fragment of the maxilla, and these parts were figured as cited above. The type now bears No. 2186 of the American Museum of Natural History. Afterward a more complete specimen was secured and described. This is now No. 1743 of this Museum and is represented in Figure 42. The identification of this with the type is doubtless correct. Only a part of a single tooth of the type remains, but this shows the presence of the ridges and furrows which are so distinctly seen in Cope's second specimen (Fig. 42, *t.*).

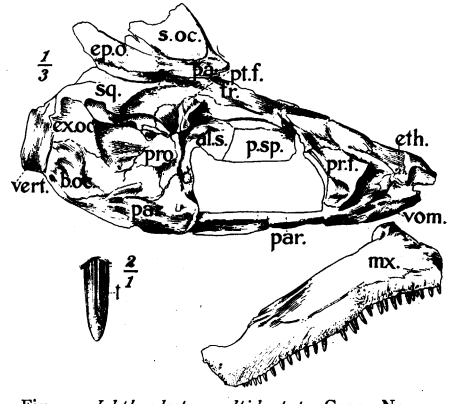


Fig. 42. *Ichthyodectes multidentatus* Cope. No. 1743. Skull × ⅓; tooth × 2. *als.*, alisphenoid; *b. oc.*, basioccipital; *ep. o.*, epiotic; *eth.*, ethmoid; *ex. oc.*, exoccipital; *fr.*, frontal; *mx.*, maxilla; *pa.*, parietal; *par.*, parasphenoid; *prf.*, prefrontal; *pro.*, proötic; *p. sp.*, presphenoid; *ptf.*, postfrontal; *s. oc.*, supraoccipital; *sq.*, squamosal; *vert.*, vertebra; *vom.*, vomer.

The skull of this specimen is much crushed and broken, but nevertheless much may be learned from it. In general form it resembles that of *Gillicus arcuatus* (Cope), although the bones are not so thin. As in that species, there is a strong upward flexure of the axis in the basisphenoidal region. The snout is pointed, and there is a high supraoccipital crest. The maxilla has been described by Cope. It bears teeth, or spaces for them, to the

number of about 50. Loomis states that there are about 44 teeth. The maxilla which he figures in outline (*op. cit.*, p. 45) is slenderer than the one here figured and of a somewhat different form. Loomis also figures what he regards as the mandible of this species.

In No. 1743 there is a deep excavation in the sides of the skull just below the articulation of the hyomandibular. This is seen also in the skull of *Portheus*, and is probably found in the skulls of all members of the family. The supraoccipital and the epiotic have been broken from the skull and replaced, as shown. Just above the line of fracture is the very distinct suture which passes between this bone and the squamosal. Another suture starts well up on the front of the supraoccipital crest, descends for a short distance, then turns backward. The bone in front of and below it is undoubtedly the unpaired parietal. Cope mistook the epiotic for the parietal. The suture in front of and below the parietal is effaced by the fracture. I have not been able to find a suture separating the parietal from the epiotic, but such no doubt exists. In a former paper (Zoöl. Bull., II, 1898, pp. 25–54) I have announced such to be the position of the single parietal; but its bounding sutures are not often easily seen. One specimen will reveal one suture, another specimen another suture. In a specimen of *Portheus*, No. 2373 of this Museum, both the upper and the lower sutures are distinct. Such a disposition of the parietals doubtless characterizes all members of the family.

The palatine has been provided with a patch of small teeth. The malleolus for union with the maxilla is low, broad, and flat.

The interorbital septum of the species under consideration appears to be occupied by a presphenoid; and above this there were probably orbitosphenoids. The vomer is beset by a patch of teeth.

As has been stated by Cope, the scapula and part of the cleithrum are present. This author states that the width of the cleithrum ("clavicle") below the scapula is 40 mm. This shows that he mistook the upper for the lower end of the

cleithrum; for the lower end is missing (Fig. 43). On the inside of the cleithrum there is a precoracoid which ascends from the coracoid three-fifths the distance to the upper end of the cleithrum. This precoracoid, which is like that of *Portheus*, was doubtless regarded by Cope as the coracoid. There are two large convex surfaces for articulation with the fin, the uppermost with the large first ray, the lowermost with the first baseost. On a level with the latter, but more mesiad, are two pits, undoubtedly for the reception of the next two baseosts. The proper interpretation of these parts is made easy by comparison with the shoulder girdle of a tarpon or salmon.

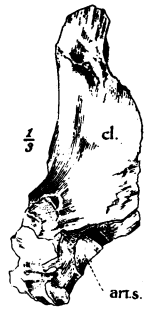


Fig. 43. *Ichthyodectes multidentatus* Cope. No. 1743. × ⅓. *cl.*, cleithrum; *art. s.*, articular surface for fin ray.

Gillicus *Hay.*

The type of this genus is Cope's *Portheus arcuatus*, later called by him *Ichthyodectes arcuatus*. Dr. A. S. Woodward (Cat. Foss. Fishes, IV, 1901, p. 101, pl. viii) has recently described a second species, *Gillicus serridens*, from the Albian epoch, Kent, England, under the name *Ichthyodectes serridens*. It differs in having the anterior mandibular teeth relatively larger. The members of this genus are well characterized by the falcate maxillæ, the reduced dentition, and the thin skull bones.

PACHYRHIZODONTIDÆ.

Pachyrhizodus *Agassiz.*

Cope originally made this genus the type of the family Pachyrhizodontidæ (Proc. Amer. Philos. Soc., XII, 1872, p. 343). Later he placed it in the family Stratodontidæ (Vert. Cret. Form. West, 1875, p. 219). Loomis and Stewart regard the relationships of the genus to be with the Salmonidæ. Dr. A. S. Woodward in his latest volume places the genus in the Elopidæ. To the present writer it seems best to retain it and its related genera in a special family as Cope originally did, until more is known regarding the anatomy.

Pachyrhizodus caninus *Cope.*

PLATE III, FIGS. 1 AND 2.

Pachyrhizodus caninus COPE (E. D.), Proc. Amer. Philos. Soc., XII, 1872, p. 344; Rept. U. S. Geol. Surv. Mont. etc. 1872, p. 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 42; Vert. Cret. Form. West, 1875, pp. 221, 276, pl. 1, figs. 1–4. — CROOK (A. J.), Palæontogr. XXXIX, 1892, p. 109. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 262, pl. xxvii, figs. 10–12. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 355, pl. lxx, figs. 2–6. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 44. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Pachyrhizodus latimentum COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 346; Rept. U. S. Geol. Surv. Mont. etc. 1872, p. 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 42; Vert. Cret. Form. West, 1875, pp. 223, 276, pl. 1, fig. 5; pl. li, figs. 1–7. — LOOMIS (F. B.), Palæontogr., XLVI, 1900, p. 263, pl. xxvi, figs. 7, 8. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 357, pl. lxviii; pl. lxx, figs. 9, 10. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 42. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

Pachyrhizodus curvatus LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 265, pl. xxv, figs. 6–8. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 44. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

The writer has ventured to unite the two species which Prof. Cope has described under the names *Pachyrhizodus caninus* and *P. latimentum.* The types of these are in this Museum, that of *P. caninus* having the number 1881; that of *P. latimentum* the number 1758. Besides these, there are various jaws and other parts which were collected for Prof. Cope by Messrs. Sternberg and Hill during the year 1877. In attempting to apply to this material the characters assigned by Cope to his two species the writer has become convinced that the differences are due partly to individual variations and partly to distortions during fossilization. The various collections indicate that the bones of this species were soft and spongy, so that they easily suffered compression and distortion. Jaw bones of the opposite sides of the same individual are sometimes so different that one is convinced with difficulty of their identity. The groove which divides

the symphyseal surface of the dentary of *P. latimentum* is very distinct in specimens which on account of the small height of the coronoid process would have to be assigned to *P. caninus*. The height of the coronoid process will, with little doubt, be found to vary in all degrees between the measurements given by Cope for his two species.

The mandible of the species (Fig. 44) appears to have had an external vertical surface and an inferior nearly horizontal surface. In some specimens these are separated by a sharp ridge; in others they are with difficulty distinguishable, a condition probably due to distortion during fossilization. Similarly, the maxilla has presented an external nearly flat surface separated by a sharp border from a flat superior surface. This surface, again, meets a flat palatal surface at a sharp internal, or mesial, border. The section of the maxilla

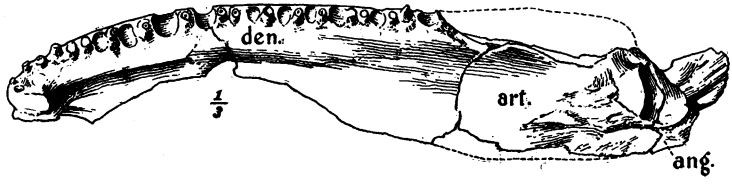


Fig. 44. *Pachyrhizodus caninus* Cope. No. 1662. × ⅓. Mandible. *ang.*, angular; *art.*, articular; *den.*, dentary.

is, therefore, nearly triangular. In one specimen, however, the maxilla of one side has the form described, while the other is so distorted that its section is nearly parallelogrammic. These modifications are mentioned in order to show the necessity of guarding against giving too much value to variations in the forms of the bones of this genus.

Of the palatines and the pterygoids of this species the writer has been able to learn little. Loomis (*op. cit.*, pl. xxvii, fig. 12) has figured what he regards as a palatine, but it seems to be identical with a left maxilla in this Museum's collection. Besides, one would hardly expect to find a palatine of a length so great that it would reach nearly to the quadrate.

In the National Museum at Washington there is a specimen of this species which I have been permitted to study.

It appears to have been about six feet (1.83 m.) in length. The skull measured about 275 mm. Unfortunately, the right preopercular and some other bones are lying on the top of the skull, so that the relations of the elements were not determined. The preopercle had a length of at least 225 mm.; and at the lower end, a part of which is missing, a width of about 112 mm. A quadrate has a height of 85 mm. There are 53 vertebræ present, but they are considerably disturbed. Of these apparently 27 belong to the caudal region. The neural arches appear to have been slender and not high. The tail is deeply forked. The lower lobe only is present. Its length is about 375 mm., but a ray near the bottom of the fork is only about 90 mm. long. There are about 10 rays in the lobe, not including 5 rudimentary rays on the front edge. The first of the latter is a lunate bone, the others are slenderer and straight or irregularly bent. The terminal vertebræ are not shorter than those farther forward in the caudal peduncle and hence do not display the crowded condition seen in *Anogmius*. There is a fan-shaped hypural. The pectoral fin is long and falcate. The anterior ray measures close to 595 mm. It has a width of 27 mm. at the base and tapers gradually to the tip. It is not divided or segmented. Eleven rays may be counted in this fin, but probably a few are missing. The shortest one observed measures 135 mm. All except the most anterior divide distally into slender filaments. At the base of the fin are seen two or three baseosts. There appear to be no remains of dorsal, ventral, and anal fins. The shoulder girdle of the left side is displayed from the inner surface (Fig. 45). It is

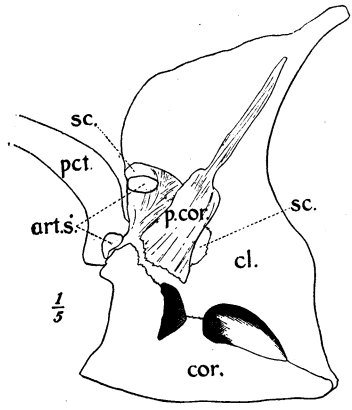


Fig. 45. *Pachyrhizodus caninus* Cope. U. S. Nat. Mus. × ⅕. Shoulder girdle. *art. s.*, articular surfaces for fin; *cl.*, cleithrum; *cor.*, coracoid; *p. cor.*, precoracoid; *pct.*, pectoral fin ray; *sc.*, scapula.

much like that of *Tarpon*, but the precoracoid is larger than in the latter genus. On the other hand, it is smaller than in *Portheus*. In the specimen under consideration it is about 125 mm. long. The shoulder girdle is here illustrated from a rough sketch.

On Plate III, Fig. 1 is shown a view of the tail of this species taken from No. 1900 of the American Museum. The tips of the lobes are broken away so that the original dimensions cannot be known, but the lobes are now respectively about 265 mm. and 335 mm. in length. There is a large terminal fan-shaped bone, which supported the principal rays. On each side there is a triradiate bone, apparently a modified ray, lying on the terminal vertebral bodies. Ryder (Report U. S. Fish. Com. for 1884, pl. vi, fig. 2) has figured a similarly placed bone which he regards as growing out from a displaced epural. In front of the lower lobe of the fin of *Pachyrhizodus* here described is an excavation which probably has been occupied by a lunate bone such as that referred to above as being found in the specimen at Washington. Fig. 2 of Plate III shows a nearly complete lobe. Its length is 435 mm. In these fins the rays are few in number, large, and cross-segmented. The fin resembles considerably that of *Tarpon*. Its number is 1658.

Dr. Loomis has described a species which he calls *P. curvatus*. It is small, the tooth line of the dentary measuring only 50 mm. In this space are alveoli for 38 teeth. The maxilla possessed alveoli for 41 teeth. The species appears to the present writer to be a young individual of *P. caninus*. In the type jaw of *P. caninus* are spaces for 38 or 40 teeth, and in a maxilla I count at least 40 teeth. Professor Cope regarded this fish as probably a ground feeder, but the form of the tail seems to indicate a swift, free-swimming, predaceous animal.

No. 2041 of this Museum consists of 9 caudal vertebræ and apparently 15 rays of an unpaired fin. There can be little, if any, doubt that the fin belongs with the section of the vertebral column, but whether it is the anal or the dorsal cannot be ascertained. The longest rays measure 147 mm.

in length, but the tips are broken off. From the anterior they grow shorter and slenderer to the last. Probably nearly the whole, if not the whole, of the fin is present. The rays divide longitudinally into slender portions but show no signs of segmentation. The nine vertebræ have a length of 185 mm., and the fin has about the same length along its base.

Pachyrhizodus leptopsis *Cope.*

Pachyrhizodus leptopsis COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 42; Vert. Cret. Form. West, 1875, pp. 225, 276, pl. li, figs. 8–8c. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 354, pl. lxx, fig. 1. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 45. — HAY (O. P.), Bibliog. and Cat. Foss Vert. N. A. 1902, p. 388.

Pachyrhizodus lepitopsis LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 264.

This species was based on a fragment of a right dentary which presents the symphyseal surface. The specimen bears the Museum's number 1756. The species is characterized by the large size of the bases of the teeth and the narrow symphyseal articulation. The bases on which the teeth rest are large, fully as wide as long, and the empty spaces from which the teeth have fallen are about circular. In *P. caninus* the teeth are crowded, so that the tooth bases, measured across the jaw, are wider than long, and the empty spaces are of greater extent across the jaw than parallel with it.

Oricardinus sheareri *Cope.*

Pachyrhizodus sheareri COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 347; U. S. Geol. Surv. Wyoming, etc. 1872, p. 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 43; Vert. Cret. Form. West, 1875, pp. 225, 276. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 45.

Oricardinus sheareri COPE (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, pp. 177, 178. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

Pachyrhizodus sheari LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 264.

The type of this species is supposed to be a portion of the left maxilla. A figure and section of the specimen is here-

with presented (Fig. 46). The anterior end of the fragment is directed toward the right. The teeth are pleurodont, as they are in *Pachyrhizodus*. They have been crowded, as in *Pachyrhizodus caninus*, but none of the crowns has been preserved. The roots present at least one difference from the species of *Pachyrhizodus*, so far as I have been able to observe. In the latter, when the tooth separates from the root, which is buried in the bone of the jaw and becomes anchylosed with it, the ring-like edge of the root is very sharp. In *O. sheareri* the remains of the root form a nearly flat ring around the pulp cavity. This, looked at with a lens of high power, shows radiating and concentric lines of dense bone. Nearly all the teeth of the specimen appear to have been shed at the time of its death; very few seem to have been broken off afterward. The Museum number of the type is 1998.

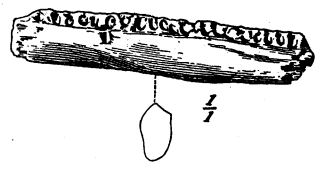


Fig. 46. *Oricardinus sheareri* Cope. No. 1998. × 1. Type. Maxilla and section.

Oricardinus tortus *Cope.*

Oricardinus tortus Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 177. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 46. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

The type of this species is in the American Museum of Natural History and has the catalogue number 2114. The material consists of a part of the left mandible, including the symphysis, and possibly about twenty vertebræ. Figures of the mandible are here presented showing it from the lingual side (Fig. 47) and from the dental border (Fig. 48). In his description, Cope deals much with the internal and external ribs of this mandible, but it is difficult even with the specimen in hand to understand his meaning. The jaw has evidently suffered some distortion and this has resulted in making some of the anterior teeth appear to lie on the outer side of the jaw. The teeth are much like those of *Pachyrhizodus*, but the symphysis is different and the jaw is narrower in

front, like that of *Empo*. Nevertheless, the narrowness may be due to crushing, and cannot be relied on. The vertebræ accompanying the jaw may be said to be identical with those

Fig. 47. *Oricardinus tortus* Cope. No. 2114. × 1. Type. Dentary. *sym.*, symphysis.

Fig. 48. Same as Fig. 47. Shows tooth line.

Fig 49. *? Oricardinus tortus* Cope. No. 2114. × 1. Two caudal vertebræ, lateral view.

of *Empo* in structure, and it is not improbable that they did not belong to the individual that possessed the jaw. Two caudal vertebræ are figured here of natural size (Fig. 49). Until more is known about the species it seems best to retain it in the genus *Oricardinus*, of which it is the type.

ENCHODONTIDÆ.

Enchodus *Agassiz.*

Remains of fishes of this genus are very common in collections made in the Cretaceous of Kansas, and they likewise occur in collections made in New Jersey. Fourteen species have been described from these two States and another, *E. shumardii*, from South Dakota. The greater part of the species have been based on detached teeth. The most conspicuous bone of the skull and the one most likely to be preserved is the greatly swollen palatine, bearing a long fang. This bone was regarded by Cope as the premaxilla, and the pterygoid, which articulates with it behind, was supposed to be the maxilla. The correct interpretation was afforded by Dr. A. S. Woodward (Proc. Geologists' Assoc., X, 1888, p. 315). Dr. Loomis has more recently discussed the anatomy of the genus, but in his restoration of the skull he has not represented the palatine as swollen nor drawn the boundary between it and the ectopterygoid. He also describes the

palatine as a mass of osteodentine; but to the present writer this mass, as also that composing the tritoral plates of *Anogmius*, appears to be merely very compact bone.

Dr. Loomis has probably given us the correct explanation of the replacement of the palatine fangs. The new fang is produced in front of the senescent one. Originally the latter had stood on the very anterior extremity of the palatine bone, but after the tooth had become affixed, the bone prolonged itself in front of the base of the tooth and thus provided a surface for the attachment of the next fang in succession. When the new tooth has taken its position, its predecessor, through absorption of its base, is loosened and drops away, leaving a crescentic scar. Sometimes several of these scars may be observed on the palatine. The new tooth probably became firmly fixed before its predecessors fell away; otherwise it would have been easily wrenched from its moorings. It will probably also be found that there is an alternation in the replacement of the fangs. Evidence of this is found in the palatines of No. 2098. The right palatine has a conspicuous process of bone extending forward over the base of the fang. The left palatine has only the slightest trace of such a process.

The large teeth on the anterior end of the pterygoid are replaced also by the development of others in front of them; and the scars resulting from the falling away of the old teeth may be seen. On the other hand, the great fang on the anterior end of the dentary is replaced by the growth of another behind it, and the scars of former teeth lie in front of the functional fang. Prof. Cope's figure (Vert. Cret. Form. West, pl. liv, fig. 3) shows the end of the right dentary from without. The functional fang is broken off some distance above its base. In front of it is an elevation of bone on which stood the replaced fang. In the specimen, the surface of the scar looks as if the old fang had only recently been broken off. Cope's figure 3*a* is unsatisfactory. Other specimens of *Enchodus* confirm the conclusion that the new fang of the dentary is produced behind the old one. Thus, while the fang of the palatine is moving forward, that of the dentary is

moving backward; but it is probable that growth of other parts makes compensations, so that the two fangs are always closely opposed to each other. Cope (*op. cit.*, p. 301) has described the mode of succession of the teeth of the dentary.

Enchodus ferox *Leidy.*

Enchodus ferox LEIDY (J.), Proc. Acad. Nat. Sci. Phila. 1855, p. 397. — EMMONS (E.), Man. Geol. 2nd ed. 1860, p. 214, fig. 1824. — COPE (E. D.), Vert. Cret. Form. West, 1875, p. 277. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 277. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 204. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Enchodus pressidens COPE (E. D.), Proc. Amer. Philos. Soc. XI, 1869, p. 241; Vert. Cret. Form. West, 1875, p. 277. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 277. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

"*Sphyræna*" MORTON (S. G.), Synop. Org. Rem. Cret. U. S. 1834, p. 32, pl. xii, fig. 1.

In the Cope Collection are two palatines belonging to the genus *Enchodus*, both of which are labelled in Cope's handwriting. One of these, No. 2251, is labelled "*Enchodus ferox*"; the other, No. 2250, "*Enchodus pressidens*, not typical." Fig. 50 represents the specimen of *E. ferox*. A study of these has led to the conclusion that the two species, *E. ferox* and *E. pressidens*, are identical. The characters which are relied on to distinguish *E. pressidens* are the crescentic section of the base of the palatine fang, the triangular section of the middle of the tooth, the grooves bounding the cutting edges, and the projection of the base of the tooth beyond the anterior margin of the palatine.

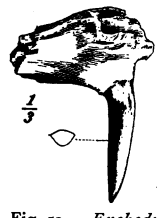


Fig. 50. *Enchodus ferox* Leidy. No. 2250. × ⅓. Palatine and fang, with section.

As to the crescentic base, this results from the pressure of the hinder side of the new tooth against the base of the old tooth, and there is some reason for believing that the concavity of the posterior side of the new tooth diminishes somewhat after the old tooth has fallen out. At any rate, such an explanation is suggested by a

difference found in the form of the bases of the two fangs of a specimen of *E. petrosus*. As regards the cross-section at the middle of the tooth, I find no considerable difference. The specimen labelled "*E. pressidens*" agrees with the description of that species, but the "*E. ferox*" also has the inner face considerably more convex than the outer, and the sections of these faces may be regarded as forming two sides of a triangle, with the separating angle rounded off. The grooves bounding the cutting edges of "*E. pressidens*" are hardly apparent, while there are indications of them in the specimen called *E. ferox*. Doubtless there were individual variations in this character.

If Loomis's explanation of the manner of replacement of the palatine fangs is correct, as it quite certainly is, we can see why in some cases the palatine bone projects beyond the base of the fang, while in other cases the fang projects beyond the bone. After the new tooth has taken its position in front of the old tooth and at the very extremity of the palatine bone, the latter proceeds to extend itself forward in order to provide a seat for the base of the next tooth in succession. Thus we sometimes get a palatine bone in one stage, sometimes in another. In the "*ferox*" specimen the palatine had extended considerably in front of the fang; in the "*pressidens*" specimen the fang had only recently taken its place.

The specimen called *E. pressidens* is a little more than one-half the size of that called *E. ferox*, the tooth being 32 mm. long, that of *E. ferox* 51 mm. The palatine bone of the "*pressidens*" is also relatively slenderer than the other; but all these differences are probably due to difference in age of the animals.

E. ferox appears to differ from *E. petrosus* in three respects. The inner face of the palatine fang is smooth, while in *E. petrosus* it is coarsely striated. In *E. ferox* the cutting edges of the palatine fang are minutely serrated; in *E. petrosus* they are smooth. In both species there is, on the outside of the palatine, a broad shallow groove which runs from the lower hinder portion of the bone upward and forward. In *E. ferox* this groove meets the upper edge of the bone over

the base of the fang; in *E. petrosus*, well behind its base. The drawings of *E. ferox* furnished by both Morton and Emmons of this species represent the teeth only and are very unsatisfactory. I find no reason for questioning the correctness of Cope's identification of the tooth here figured as *E. ferox*. *E. ferox* and *E. pressidens* Cope were both described from the Cretaceous of New Jersey.

Enchodus petrosus *Cope.*

Enchodus petrosus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 44; Vert. Cret. Form. West, 1875, pp. 239, 278, pl. liv, figs. 4–7. — ? LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 278, pl. xxvii, figs. 13–15. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, pl. lxx, fig. 11. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Tetheodus pephredo COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 43; Vert. Cret. Form. West, 1875, pp. 237, 277, pl. liv, figs. 1–3. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Tetheodus pephero LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 278 (syn. of *Enchodus petrosus*).

The present writer agrees with Dr. Loomis in referring Cope's *Tetheodus pephredo* to *Enchodus petrosus*. The type of this supposed species is in this Museum and has the number 1605. Cope's description and figures are for the most part correct.

Prof. Cope states that in *Tetheodus pephredo* there is no surface for the attachment of a tooth and no scar or other trace of the former existence of one. However, a close examination of one of the palatine masses shows that there are traces, faint but undeniable, of at least four fangs which at different times have occupied the lower border of the bone. Moreover, where we would expect to find a functional fang, the surface is somewhat rough; while on the oral border of the bone there is a ragged area which looks as if some of the bone had been broken away. All this makes it appear probable that in some conflict both fangs had been torn away at their

bases, and that sufficient time had not elapsed for the scars to be wholly healed. In front of and above the base of the supposed former fang, on the anterior extremity of the palatine, there is a process of bone which may be regarded as an outgrowth preparatory to the attachment of a new fang. It is rather thin from side to side, only about one half as thick as would be required for the fang, but it is possible that its thickness might become greater in due time. Whether or not a new fang could be produced and effect an attachment without the support and protection of a fang already in place seems to be doubtful. It seems likely that every victim by its strugglings would destroy any incipient connections that had been formed.

Fig. 51 represents a damaged dentary bone of this species, with two teeth nearly complete. The most anterior of these is shown two-thirds of the natural size, in order to display the rather strongly developed ridges on the posterior half of the tooth. On the lingual face of the tooth these ridges are found well forward, but here they are rather short. Toward the hinder border of this face they rise well toward the tip of the tooth. About three millimeters above the base of the tooth the ridges cease suddenly, and the portion of the surface below them is provided with very fine striations. The anterior fang is broken away, but its outlines are restored from another specimen. The number is 2062.

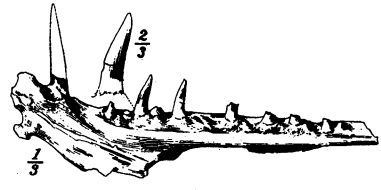


Fig. 51. *Enchodus petrosus* Cope. No. 2062. Dentary, × ⅓; one tooth, × ⅔.

The surfaces by means of which the palatine bone comes into contact with the bone which acted as its suspensory, doubtless the prefrontal, deserve description. These articulatory surfaces are found at the hinder end of the palatine, and those of Cope's type are shown in Fig. 62; those of *E. sævus* in Fig. 61. In the former we have two processes, one below and directed upward and outward. The posterior face of this is smooth and forms one of the articulatory surfaces.

Another process is considerably in front of the one just described, and is directed upward. Its posterior face is flat and smooth. The inner face of the lower and hindermost process looks upward and inward, and is slightly convex and smooth. It connects the two articulatory surfaces which are directed backward and form a third surface. A thin perpendicular plate of bone has extended backward from the inner border of the anterior articular surface near the base of the posterior process, but it is now broken away. It is seen in the figure of the corresponding parts of *E. sævus*. It appears evident that the posterior process in *E. petrosus* has been distorted, so that its upper surface is directed more outwards than in life. For the same reason, it is now lower than originally. This is indicated by another specimen. Through these smooth articulatory surfaces the palatine must have had a very free movement on the prefrontal.

Portions of the palatine fangs of an *Enchodus* from the Fox Hills Group of New Mexico are not distinguishable from those of *E. petrosus*. (Cope, Amer. Naturalist, XXI, 1887, p. 566.)

Enchodus dolichus *Cope.*

Enchodus dolichus COPE (E. D.), Vert. Cret. Form. West, 1875, pp. 239, 278, 300, pl. liv, figs. 8, 8a; Proc. Amer. Philos. Soc. XXIII, 1885, p. 3. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 279, pl. xxvii, figs. 16, 17. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 377, pl. lxx, fig. 12. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 204. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Of this species the type, a fragment of the palatopterygoid, is in the Museum and bears the number 1820. There are likewise considerable portions of three skulls, including those described by Cope on page 300 of his 'Vertebrata of the Cretaceous Formations of the West.' One of these skulls, Cope's "No. 1," No. 1837 of this Museum, is represented by Fig. 52. It displays both palatines, the right much out of its natural position, the left pushed backward about 25 mm. Its great fang is crossed by the anterior end of the ectopterygoid. The long teeth of the latter bone are well shown.

The anterior end of the mandible is broken away. Above the palatine is the right premaxilla with about 23 teeth and spaces for others. Between the upper and the lower thirds of the figure lie the occipital bones and the frontals. The left articular runs forward beneath the left palatine. The

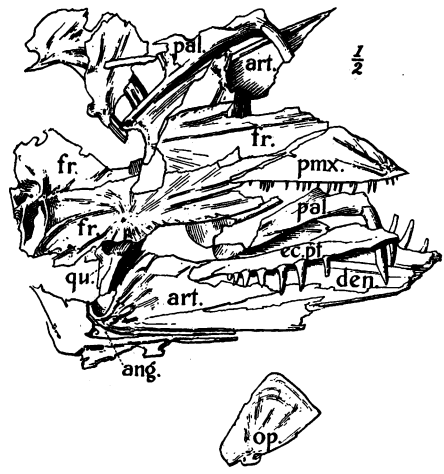


Fig. 52. *Enchodus dolichus* Cope. No. 1837. × ½. Disturbed skull. *ang.*, angular; *art.*, articular; *den.*, dentary; *ec.pt.* ectopterygoid; *fr.*, frontal; *op.*, opercular; *pal.*, palatine; *pmx.*, premaxilla; *qu.*, quadrate.

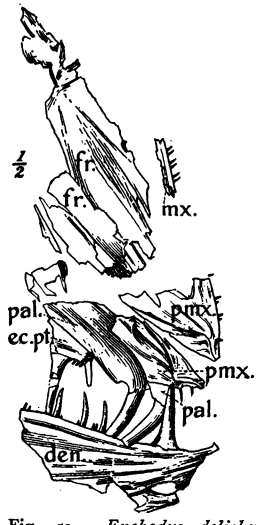


Fig. 53. *Enchodus dolichus* Cope. No. 1685. × ½. *den.*, dentary; *ec.pt.*, ectopterygoid; *fr.*, frontal; *mx.*, maxilla; *pal.*, palatine; *pmx.*, premaxilla.

right quadrate is displaced so that its articular surface (above *qu.*) looks upward.

Figure 53 represents No. 1865 of this Museum. This displays both palatines and their fangs; the anterior end of the ectopterygoid and two teeth; the lower jaw, with its fang and teeth of two sizes; both premaxillæ, with their small teeth; and the anterior end of the frontal. Alongside of the frontal is a fragment of a toothed bone which lies on a line with the dental border of the premaxilla. It is probably a portion of the maxilla.

The palatine fang was missing in the type. No. 1837 shows, as Cope has already stated, that the palatine fangs are finely striated on the outer surface. On the hinder por-

tion of the inner face of the left palatine and of two mandibular teeth we find a moderately coarse striation. Cope's specimen " No. 2," which is No. 1890 of this Museum, presents both palatines, one with the fang complete. The ornamentation is as in No. 1837. The same is true of the fang of No. 1865, except that the striation, both on the inner and the outer face, is somewhat coarser. The striation of the hinder part of the inner face of No. 2385 is decidedly coarser than that of any of the other specimens. All these teeth show that *E. dolichus* differs from *E. petrosus* in having the outer face with practically the same convexity as the inner. The latter seems also to have attained a considerably larger size. We must, however, keep in mind that there are likely to be small specimens of *E. petrosus*.

Enchodus tetræcus *Cope.*

Enchodus tetræcus COPE (E. D.), Vert. Cret. Form. West, 1875, p. 278. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.
Enchodus tetracus LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 277. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 375.

This species is said to have been based on various teeth from the Greensand of Delaware and New Jersey. One whole tooth, which is labelled as the type, is in the Museum and has been given the number 2248. There is another with the distal end missing. Cope's description is sufficient, but it is thought to be proper to present here a drawing of the type (Fig. 54). Figure 55 represents the paratype, an imperfect tooth designated as No. 2249. The sharply defined striations of the very convex inner face distinguish this species from *E. ferox*. The teeth are apparently slenderer than those of *E. petrosus*, and the shallow

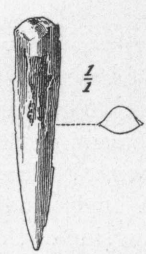


Fig. 54. *Enchodus tetræcus* Cope. No. 2248. × 1. Type. Palatine fang and cross-section.

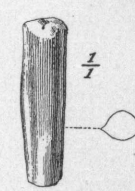


Fig. 55. *Enchodus tetræcus* Cope. No. 2249. × 1. Paratype. Palatine fang and cross-section.

grooves running along the inner face, one close to and parallel with each cutting edge, are somewhat more distinct; but these characters are hardly satisfactory. On account of the little that is known about *E. tetræcus* and on account of the different geographical distribution, the two species may best be regarded for the present as distinct.

Enchodus gladiolus *Cope.*

Cimolichthys gladiolus COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 353.

Phasganodus ? gladiolus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1872, p. 43; Vert. Cret. Form. West, 1875, pp. 235, 277.

Enchodus gladiolus COPE (E. D.), Vert. Cret. Form. West, 1875, p. 301, pl. xlii, fig. 7. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 204. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

The type of this species was a single detached tooth, and this has not yet come to light in the examination of the Cope collection. Cope states (Vert. Cret. Form. West, p. 301) that he had a better specimen; but while he figured the type tooth, he did not figure or describe the better example. In the collection there is found a specimen which bears the label in Cope's handwriting "*Enchodus ?gladiolus*," the interrogation doubtless belonging, according to Cope's usage, with the specific name. To these remains have been given the number 1818. The specimen presents the left palatine, with its great tooth complete; the left ectopterygoid, with several teeth; and the tip of the left dentary with its fang. As shown in Fig 56, the ectopterygoid has been turned so that the teeth point in a direction opposite to that of the palatine teeth. On another block and apparently belonging to the same individual is shown the upper surface of the hinder half of the skull. The palatine fangs differ from those of *E. dolichus* in

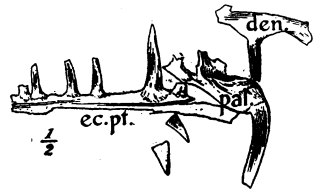


Fig. 56. *Enchodus gladiolus* Cope. No. 1818. × ½. Jaws. *den.*, dentary; *ec.pt.*, ectopterygoid; *pal.*, palatine.

having nearly the whole of both the inner and the outer face coarsely striated. The ridges and intervening furrows are easily seen with the unaided eye, while in the case of *E. dolichus* this requires a close observation. The striation subsides close to the anterior very thin edge. As in *E. dolichus*, the two faces are equally convex. The pterygoid and the mandibular teeth are similarly marked by coarse ridges and grooves.

It is possible that this specimen is only an example of *E. dolichus* with unusually coarse grooving of the teeth; but I think that it is distinct.

Fig. 57 represents the upper surface of the skull. The more anterior portions of the frontals have left their impression on the matrix but are not represented in the drawing. From each epiotic region a grooved ridge runs forward to the prefrontal region. From this ridge, at the centre of growth of the frontal bone, a less prominent ridge runs outward and backward to the middle of the squamosal. The epiotics are prominent and are connected by a sharp ridge, behind which the occiput drops off steeply. The parietals are apparently separated by the small supraoccipital. The parietals seem to form a narrow band along the ridge connecting the epiotics. The sutures are very indistinct.

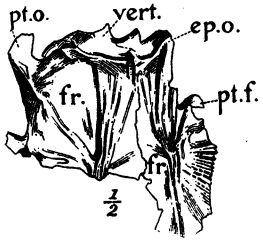


Fig. 57. *Enchodus gladiolus* Cope. No. 1818. × ½. Hinder part of skull. *ep.o.*, epiotic; *fr.*, frontal; *pt.f.*, postfrontal; *pt.o.*, pterotic.

Enchodus sævus, sp. nov.

This species, which appears to be distinctly different from any hitherto described, was collected near Elkader, Logan County, Kansas, by Dr. W. D. Matthew, in 1897. The collector regarded the beds as belonging to the Pierre formation; but Dr. Williston, who is familiar with the locality, informs me that the deposits belong to the Niobrara. The species has been a large one, as is indicated by the following measurements:

Length of the lower jaw from the chin to the articular condyle	223 mm.
Height of the jaw at the coronoid process	67 mm.
Breadth of the skull at the postorbitals	111 mm.
Length of the palatine and prefrontal to the front of the fang	72 mm.

Unfortunately the whole surface of the specimen has been covered and in some places injured by a deposit of crystals of gypsum, so that it is difficult to determine some structures. Other structures and the general forms of the bones are distinct enough. The number of the specimen is 198.

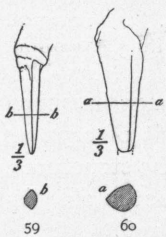
The distinguishing character of this species is found in the great palatine fang. In other American species of the genus where the palatine fang is known the latter is compressed laterally. In the present species the compression is nearly antero-posterior. The species is nearest to *E. petrosus*, with which it was at first identified.

The right palatine bone (Fig. 58) is in excellent condition, barring the deposit of gypsum on its surface. It has suffered little or no distortion or compression. No part of the ectopterygoid adheres to it. The figure represents the inner side of the tooth and shows the position of the inner, or posterior, cutting edge. The greater part of the fang is preserved. The left palatine is distorted and has lost all but the base of the fang.

Fig. 58. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Right palatine bone and fang.

In *E. petrosus* a sharp cutting edge begins at the base of the fang in front and runs downward to the tip (Fig. 59). This is very distinct from the first, and it pursues its course near the anterior midline of the tooth, separating an outer from an inner face. The section shown in Fig. 59, *b*, ought to have been taken somewhat higher up on the tooth, in which case the inner face (on the left) would have been somewhat more convex, but it would still have differed much from Fig. 60, *a*. In *E. sævus* (Fig. 60) there is a faint trace of a corresponding edge and it may once have been stronger, but it lies much nearer the inner side of the tooth. Another cutting edge starts at the outer side of the base of the tooth; but, instead

of soon getting near the middle of the hinder surface of the tooth, as it does in *E. petrosus*, it forms the outer border of the tooth when this is looked at directly from behind or front. These two edges divide the surface of the distal end of the tooth into two nearly equal faces, of which one, somewhat smaller, is nearly anterior, but is directed somewhat outward, while the larger and somewhat more convex one is directed backward and inward. About the middle of the length of the tooth, where the section (Fig. 60, *a*) is taken, the inner face is far larger and more convex. The palatine bone, from which Fig. 60 is taken, was only slightly larger than that from which Fig. 59 was obtained.

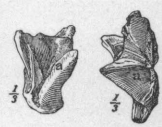


59 60

Fig. 59. *Enchodus petrosus* Cope. No. 2062. × ⅓. Left palatine fang from in front. The line, *bb*, marks position of section *b*.

Fig. 60. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Right palatine fang from in front. The line *aa* marks position of the cross-section *a*.

The palatine bone has about the size of that of *E. ferox*, figured in this paper, and the fang has probably had about the same length. If we measure the greatest diameter of this fang of *E. ferox* at a point 10 mm. below its base we find it to be 10 mm., and this diameter is the antero-posterior, while the transverse diameter is not quite 8 *mm.* At the same height the diameter of *E. sævus* is 10 mm. in the transverse axis of the cross-section, and 9 mm. in the antero-posterior. The same proportions and directions of the axes are found in *E. petrosus* as in *E. ferox*.



61 62

Fig. 61. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Posterior end of right palatine bone. *a*, articular process.

Fig. 62. *Enchodus petrosus* Cope. No. 1608. × ⅓. Type. Posterior end of left palatine bone.

The posterior end of the palatine (Fig. 61) appears to differ somewhat from that of *E. petrosus* (Fig. 62). It presents the same smooth articular surfaces as are observed in the latter species, but, as will be observed in the figures, the lower process, *a*, of the bone in *E. sævus*, is much thinner and higher than in *E. petrosus*. This difference may not be specific but due in some part to accidents of fossilization. Fig. 61 represents the bone of the right side; Fig. 62, that of the left side.

Fig. 63 represents the lower jaw seen from the outside. It is everywhere ornamented with radiating ridges and grooves. In front are three deep notches, as in many species of the

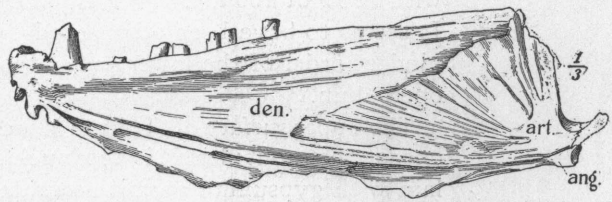


Fig. 63. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Lower jaw, outer view. *ang.*, angular; *art.*, articular; *den.*, dentary.

genus. Fig. 64 shows the lower jaw from the lingual side, together with the ectopterygoid and quadrate. The two last-mentioned bones are somewhat displaced. Attention is called to the great raptorial tooth on the anterior end of the

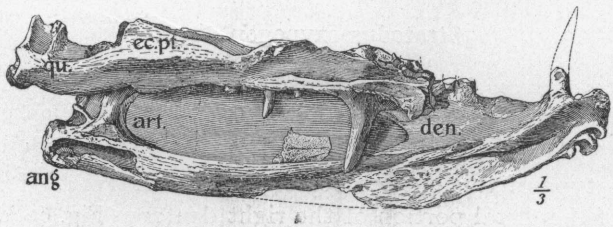


Fig. 64. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Lower jaw, quadrate, and ectopterygoid; inner view. *ang.*, angular; *art.*, articular; *den.*, dentary; *ec. pt.*, ectopterygoid; *qu.*, quadrate.

ectopterygoid. It is about 30 mm. long. The upper border of the ectopterygoid is excavated in front and received the lower border of the palatine.

One preoperculum is present (Fig. 65). It appears to me to belong to the left side. It is very narrow above, but broadens somewhat below. The exterior surface is convex transversely and has ridges and grooves running lengthwise. A conical process from its front border fits into a groove in the hinder border of the quadrate. On the inner face of the preoperculum there is a deep channel running nearly the full length and opening forward. What I regard as the left interoperculum is shown in Fig. 65, *i. op.* A portion of its

hinder border has been broken away. It is a rather heavy bone and is ornamented with radiating ridges and grooves. The anterior border has been furnished with a row of about eight sharp processes. It seems to have been overlapped by the hinder border of the lower end of the preoperculum.

Fig. 65. *Enchodus sævus* Hay. No. 198. × ⅓. Type. *i. op.*, interoperculum; *p. op.*, preoperculum.

The upper surface of the head is present, except the snout; but it is too much overlain with gypsum to permit accurate description. It resembles the skull of *E. faujasi* Agassiz, which is figured by Dr. A. S. Woodward (Cat. Foss. Fishes, IV, pl. xi, fig. 6). A deep and broad excavation runs along the middle of the head from the supraoccipital.

Stratodus oxypogon *Cope.*

Stratodus oxypogon Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 180. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p, 189. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

The type of this species bears the number 2113. It consists of the distal portion of the right dentary (Fig. 66, *den.*), a portion of what Prof. Cope regarded as a maxilla (Fig. 66, *mx.*) a piece of a palatine (Fig. 67), and eight vertebræ. Cope

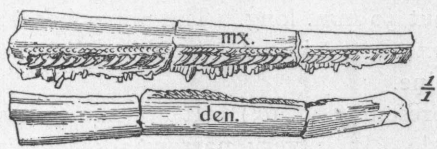


Fig. 66. *Stratodus oxypogon* Cope. No. 2113. × 1. Type. Jaws, outer view. *den.*, dentary; *mx.*, maxilla.

Fig. 67. *Stratodus oxypogon* Cope. No. 2113. × 1. Type. Fragment of palatine, showing teeth.

has given sufficient description; but no figures have hitherto been furnished of the specimens. The dentary and maxilla are here shown as seen from the outer side, and the fragment of palatine is represented from the toothed surface. Most of the teeth are pressed against the surface in such a way as to

suggest that they were hinged; as Cope also inferred from the form of the alveolar fossæ. This author has described the tips of the teeth as being simple; but in the case of some of them I find the peculiar spade-shaped apices which Cope has described in the case of *S. apicalis*. Fig. 68 shows two of the caudal vertebræ. They are much like those of *Empo*, but lack the longitudinal ribs of that genus. Under the lens, however, a fine longitudinal striation is seen on the sides of the centra. Dr. Woodward has placed this genus in the Dercetidæ, but notwithstanding the union of the parietals in the midline, it appears to the writer to belong to the Enchodontidæ.

Fig. 68. *Stratodus oxypogon* Cope. No. 2113. × 1. Type. Two caudal vertebræ, side view.

Empo *Cope*

This genus was erected by Cope in 1872 (Proc. Amer. Philos. Soc., XII, p. 347). The type species is *E. nepaholica*, later emended by Cope to *nepæolica*. The species belonging to this genus have been referred by Loomis (Palæontogr., XLVI, 1900, p. 267) to *Cimolichthys;* and Dr. A. S. Woodward has more recently (Cat. Foss. Fishes, IV, p. 221) adopted the same course. That the two genera are not identical the present writer will not affirm; but the type species of *Cimolichthys*, *C. levesiensis*, is, as Dr. Woodward has said, not satisfactorily definable, many parts of the skull not being known. Likewise, we are in ignorance regarding various structures of *Empo*. It is therefore not at all improbable that differences of generic importance may yet be discovered in these types. It is as well to be conservative in suppressing genera as in establishing them. For these reasons the writer prefers to retain *Empo*.

Empo nepaholica *Cope.*

Pl. I. Fig. 4.

Empo nepaholica Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 347; Rep't U. S. Geol. Surv. Mont. etc. 5th Ann. Rep't, 1872, p. 345. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Empo nepœolica COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 230, 279, pl. xlix, fig. 9; pl. l, fig. 8; pl. lii, fig. 1; pl. liii, figs. 3–5. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 332, pl. lix, figs. 1–9; pl. lxi, figs. 2–5.

Cimolichthys nepœolica LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 271, pl. xxvii, figs. 1–3. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 225, text figs. 8, 9.

Cimolichthys semianceps COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 351; Rep't U. S. Geol. Surv. Mont. etc. 1872, p. 326. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 273, pl. xxvii. figs. 4–6. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 228.

Empo semianceps COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 233, 279, pl. liii, figs. 1, 2, 6–9. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 338, pl. lxi, figs. 6–9. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Cimolichthys sulcatus COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 351.

Empo sulcata COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 46.

Empo contracta COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 232, 279, pl. liii, figs. 14–17. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 339. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Cimolichthys contracta LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 273, pl. xxvii, figs. 8, 9. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 228.

Empo merrillii COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 232, 279, pl. liii, figs. 10–13. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Cimolichthys merrillii LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 272, pl. xxvii, fig. 7. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 228.

The type specimen of *Empo nepaholica* is a fragment of the hinder end of the palatine, which bears the bases of two large teeth and parts of smaller teeth, or bases thereof. It is figured by Cope as cited in the synonomy. The specimen is in the American Museum, and has the number 1904. After-

wards Cope identified as belonging to the same species much more satisfactory materials. One lot of these, No. 1736 of this Museum, was figured on plate lii, fig. 1, of his large work of 1875. Another, No. 1735, furnished figures 3–5 of plate liii of the same work. From these more complete materials many additional characters of the species were determined. In the paper in which *E. nepaholica* was described, Cope proposed also the new species *Cimolichthys sulcatus*, which he afterwards made a synonym of *E. nepaholica*. The type of this, No. 1882, is the left dentary, showing thirteen large teeth. The distal end of this dentary afterwards furnished figure 8 of plate l of the monograph of 1875.

The type of *Cimolichthys semianceps* consists of vertebræ, a palatine, portions of the dentaries with teeth, and some other parts. The vomer mentioned by Cope has not been recognized. The number of this type is 1989. In the monograph just mentioned Cope figured other specimens which he had identified as belonging to this species. One of these, now No. 1740, furnished figures 1 and 1*a* of plate liii; another, No. 1741, furnished figure 2 of the same plate; while No. 1742 was represented by figures 6–9.

Empo merrillii was based on fragments now included under the number 1737. There are present nearly the whole left palatine, of which figure 11 of plate liii of Cope's monograph represents the anterior end; a considerable part of the right palatine, one fragment of which is shown by figure 12; a flat bone, represented by figure 10, and which is probably the entopterygoid; and the vomer, represented by figure 13.

Empo contracta is likewise founded on fragments of jaws. There are present the right palatine, except its anterior extremity; the anterior extremity of the left palatine; the vomer; and the anterior portion of the left dentary. Most of these parts are represented on plate liii of Cope's work. The Museum number of this lot is 1738.

It may be said that the figures which Cope has published represent the originals adequately, and that nothing would be gained by refiguring them. If the figures are in some cases unsatisfactory the fault lies in the materials.

What is the value of these species? *E. contracta* is said to be characterized by the flatness of the "maxillary bone," by which is meant the palatine; but in the types the palatine of *E. merrillii* is still flatter, especially at the anterior end. To what extent the flatness of this bone in both species is due to its original form and to what extent to distortion during fossilization is hard to determine. There was probably considerable individual variation among these fishes. As regards the sizes of the teeth in different parts of the palatine, the writer has found, in looking through the collection of this Museum, so much variation that he regards the distinctions specified by Cope as of little or no value. Considerable differences are often to be observed on the opposite sides of the head. Cope also found characters in the "tongue-shaped pharyngeal bone," which is really the vomer; but after diligent comparison on the part of the present writer the attempt to find specific characters in this part was abandoned.

Prof. Cope has given extended and accurate descriptions of *E. nepaholica* and *E. semianceps;* but when we seek for the characters by which they may be distinguished from each other, they are found to be rare and elusive. The character which is most definitely stated is found in the structure of the mandibular teeth. In *E. nepaholica* these are said to possess no cutting edge on the posterior face. Unfortunately the crowns of the teeth are nearly always broken off, so that it is impossible to apply this test. The types themselves cannot, at least now, be distinguished in this respect. In another specimen I find a mandibular tooth with a posterior edge, but there is no other indication that it is not *E. nepaholica.* Both species possess such two-edged teeth on the palatines. On the lower jaw of a very large specimen in the Museum I find that the teeth are two-edged; and observation makes it certain that if such teeth belong only to *E. semianceps* this was not a smaller species than *E. nepaholica.* Stewart says that the mandibular teeth of specimens which he identified as *E. nepaholica* seemed to have both anterior and posterior cutting edges.

Having made an earnest effort to apply to the specimens in this Museum the characters presented by Cope as belonging to his species and such other characters as could be found, the writer has been compelled to abandon the attempt to retain the species founded by Cope and has found it necessary to reduce them all to the one having priority of description, *E. nepaholica*.

Dr. Loomis has furnished an excellent figure of the skull of this species, seen from the side, and other figures of the rear of the skull. A view of a well preserved skull is presented here (Fig. 69). The number of the specimen is 2522. The squamosal region of the left side has been damaged somewhat, and the drawing of this part is completed from another skull, No. 1888. On the right side a vertebra and some other elements are lodged against the skull behind the postorbital region. As both Loomis and Woodward have indicated, the very large frontals (Fig. 69, *fr.*) extend close to the hinder end of the skull. However, there is a narrow band of bone showing behind each frontal on the upper surface and extending from the supraoccipital outward to the epiotic process. These bands are doubtless the parietals. No suture is to be observed between the parietal and the epiotic, but it may have been present. The supraoccipital meets the frontals, thus separating the parietals. It sends on each side outward and backward a process which passes behind the inner end of the parietal. There is a deep fossa

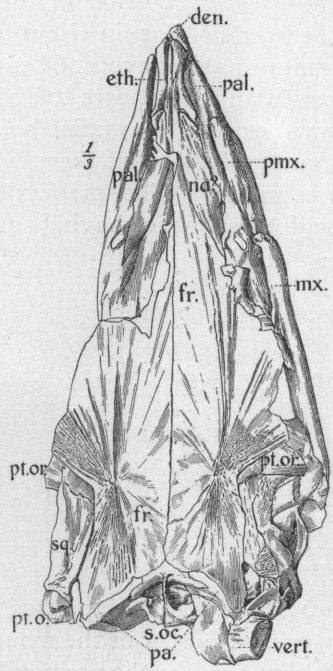


Fig. 69. *Empo nepaholica* Cope. No. 2522. × ⅓. Upper view of skull. *den.*, dentary; *eth.*, ethmoid; *fr.*, frontal; *mx.*, maxilla; *pa.*, parietal; *pal.*, palatine; *pmx.*, premaxilla; *pt. o.*, pterotic; *pt. or.*, postorbital; *s. oc.*, supraoccipital; *sq.*, squamosal; *vert.*, vertebra.

intervening between the epiotic and pterotic processes. There appear to be good reasons for drawing as we have, the lateral boundaries of the frontals; but the suture between the squamosal, *sq.*, and the postorbital, *pt. or.*, cannot be determined. The frontals extend far forward, so that they occupy by far the greatest portion of the upper surface of the skull. In the median line in front is the ethmoid, *eth.* The exact limits of this have not been determined. Posteriorly it expands and it appears to divide, sending a branch, *na?.*, backward close to the mesial border of each premaxilla; but it is more probable that these lateral branches are distinct bones, the nasals. The premaxilla, *pmx.*, is a thin, elongated, sculptured bone, having small teeth along the lower border, except in front. It is applied closely to the palatine. Its teeth appear to have been directed forward. This is shown in Figure 70, *pmx.*, and the same appearance is presented by so many specimens that this position of the teeth appears to be the normal one.

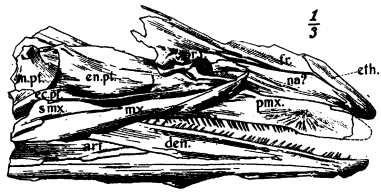


Fig. 70. *Empo nepaholica* Cope. No. 1776. × ⅓. Part of skull, lateral view. *art.*, articular; *den.*, dentary; *ec.pt.*, ectopterygoid; *en.pt.*, entopterygoid; *eth.*, ethmoid; *fr.*, frontal; *m.pt.*, metapterygoid; *mx.*, maxilla; *na?*, nasal?; *pa.*, parietal; *pmx.*, premaxilla; *pt.o.*, postorbital; *smx.*, supramaxilla.

The maxilla, Figs. 69, 70, *mx.*, is a long, compressed, toothless bone which forms the posterior border of the mouth. Its anterior end overlaps for a long distance the premaxilla, its extremity in both the specimens figured here rising above the upper border of the premaxilla. The same position is shown in the skull figured by Loomis. Figure 71, No. 1969, shows the skull seen from below. The parasphenoid is very broad in front. It has possessed no teeth. The articular surface for the hyomandibular is short. The vomer does not appear in this specimen. It is the bone which Cope called and figured with doubt a pharyngeal. Stewart calls it the ethmoid. It is possibly consolidated with the ethmoid, but certainly both bones are represented. It possesses a varying number, one to four, of rows of teeth. Various specimens indicate that other

bones within the mouth were furnished with small teeth, but which they are has not been accurately determined. It appears likely that the ectopterygoid had minute teeth on its surface and some larger ones near one border.

I have had the opportunity of studying No. 4186 of the U. S. National Museum. In this the cleithrum has its external face presented. The first ray of the pectoral is segmented transversely, and was not a spine. Its anterior border is furnished with square notches and teeth, as is seen in Cope's work, pl. lii, fig. 1. On lifting the cleithrum from its bed the base of the fin is seen more distinctly. Besides the first ray about seven others are present. The precoracoid is present and is somewhat larger than in a salmon which has a jaw two-thirds as long as that of the fish here described. A portion of the coracoid is present and perhaps some of the scapula. The presence of the precoracoid fixes the position of the fish among the Isospondyli.

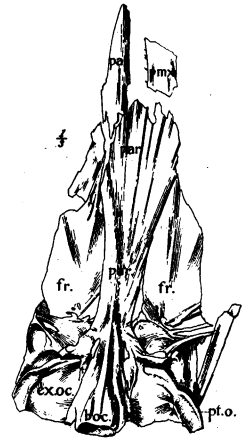


Fig. 71. *Empo nepaholica* Cope. No. 1969. × ½. Skull from below. *b.oc.*, basioccipital; *ex.oc.*, exoccipital; *fr.*, frontal; *pa.*, parietal; *pmx.*, premaxilla; *pt.o.*, pterotic.

In No. 4719 of the U. S. National Museum there is a series of 25 vertebræ, together with ribs and the supports of the pelvic fins. Of these, apparently 10 belong to the caudal region, possibly only 9. Many ribs are present and several of them in their natural relation with the vertebræ. They are strongly developed, broad, and with much broadened heads. They resemble those of the common carp. They have been attached to distinct parapophyses. In some cases the latter have been freed by maceration and disturbance, and falling out have left long and deep cavities along the sides of the vertebræ. The hæmal arches of the tail region are apparently consolidated with their corresponding vertebral centra.

The supports of the pelvic fins are preserved and a portion of one fin (Fig. 72). It seems probable that the fin supports

have not been removed from their natural position. If so the base of the fin is placed between the 5th and 6th vertebræ in front of the first caudal. The fin itself is overlaid with fragments of ribs, so that the number of its rays cannot be accurately determined, but there were at least eight of them, the most anterior one being apparently rudimentary.

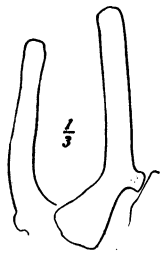


Fig. 72. *Empo nepakolica* Cope. No. 4719. U. S. Nat. Mus. × ½. Supports of ventral fins.

At the upper ends of the 4th and 5th caudal vertebræ are two bones which resemble interneurals with enlarged upper ends. They may represent the supports of the dorsal fin. They are rather weak and may be the more posterior ones of the series. In the region of the three or four most anterior hæmal arches are slender bones which may have been the supports of the anal fin.

No. 2032 of the American Museum of Natural History furnishes most of the tail fin (Pl. I, Fig. 4). The principal rays are large and coarsely segmented, but distally the rays divide into extremely fine filaments. The lobes of this fin were probably about 175 mm. in length.

The following fishes, as well as *Spaniodon simus*, described on page 47 were, as we learn from Prof. Cope (Bull. U. S. Geol. and Geog. Surv. Terrs., IV, 1878, p. 66), collected by Dr. F. V. Hayden in the "Niobrara Cretaceous of Dakota." No more accurate information has been afforded us regarding the locality where these specimens were found; but on several of the blocks of soft limestone, on which these fishes are preserved, some person has written in lead pencil the words "Yankton, Neb." From this label we may be quite sure that the specimens were found in the region of Yankton, South Dakota. We know likewise that the Niobrara deposits are abundantly developed in that region.

These fishes are of great interest from the fact that they belong to genera found in Upper Cretaceous deposits at Mount Lebanon, in Syria, or to genera very closely related to those of the latter region. It is greatly to be desired that further search shall be made in the country about Yankton for more

satisfactory specimens of those described by Cope, and for other species which may be yet unknown. That fishes are abundant in the soft limestone whence Dr. Hayden obtained his specimens, is shown by Plate V, which reveals three types on one side of a block, while a fourth type is found on the other side, besides a part of a large undescribed fish.

The figures of the species furnished on the plates are of the natural size and may be of some value in identifying other specimens, but they are difficult subjects to illustrate.

DERCETIDÆ.

Triænaspis *Cope.*

This genus was established by Cope in the 'Bulletin of the U. S. Geological and Geographical Survey of the Territories,' Volume IV, 1878, page 67. The type is *T. virgulatus* Cope. Dr. A. Smith Woodward unites the genus with *Leptotrachelus*, but the present writer is inclined, for the present, to regard it as distinct on account of the backward position of the ventral fins and the relatively short head. The type of the genus *Leptotrachelus*, *L. armatus*, possesses a dorsal fin of apparently about 12 rays, with the ventrals beneath the front of this dorsal. In *Triænaspis* the dorsal is still shorter, not having beyond 10 rays, and the ventrals are placed a distance behind the origin of the dorsal equal to one-third of the distance from the head to the dorsal.

Triænaspis virgulatus *Cope.*

PLATE V, FIG. 1.

Triænaspis virgulatus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 67. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 397.

Leptotrachelus virgulatus WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 187.

Of this species Professor Cope possessed, so far as can be determined, only the specimen here figured (Pl. V, Fig. 1) and a fragment of another. The present number of the type

is 2516. The describer concluded that the anal fin was absent in the species, but the present writer finds no warrant in the specimens for making any statements regarding this fin. The length of the head, including the opercular apparatus, is contained in the distance from the end of the operculum to the beginning of the dorsal fin something over one and one-half times. The head has not been prolonged into a beak such as we find in the species of *Leptotrachelus*.

Leptotrachelus longipinnis *Cope.*

PLATE IV, FIG. 3, and PLATE V, FIG. 4.

Leptotrachelus longipinnis COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 68. — WILLISTON (S. W.), Kansas Univ. Quart., VIII, 1899, p. 115; Univ. Geol. Surv. Kansas, VI, 1900, p. 382. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 187. —HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 397.

Of this species Cope possessed two specimens. Of these his "No. 1" bears the Museum's catalogue number 2521 (Pl. V, Fig. 4) while his "No. 2" has the number 2520 (Pl. IV, Fig. 3). The former displays indistinctly the head, with its long beak, the neck consisting of much elongated vertebræ, the rays of the dorsal fin, and the ventral fins. Under a lens traces of the pectoral fin may be found close to the head. The other specimen shows more distinctly the dorsal and ventral fins, and some ribs, triradiate scales, and longitudinally directed hair-like bones in front of the dorsal. In No. 2521 a considerable part of the bones of the beak have been flaked away, leaving only their impression on the matrix. The letters *sn* indicate approximately the end of this beak. Pl. V, Fig. 4 shows the vertebræ of the neck forming a curve at the left of the head. Above and at the left of this curve is a blotch formed by the rays of another fish.

Besides the American species, six others may be recognized, as follows: *L. armatus* Marck and *L. sagittatus* Marck, from the Upper Cretaceous of Westphalia, *L. triqueter* Pictet, *L. gracilis* Davis, *L. hakelensis* Pictet and Humbert, all from the

Upper Cretaceous of Mount Lebanon, and *L. elongatus* (Agassiz), from the Senonian and Turonian of England.

It seems not unlikely that of the species of *Leptotrachelus* those having a long dorsal fin, *L. triqueter*, *L. longipinnis*, and *L. gracilis*, will have to be separated as a distinct genus, while *L. armatus* and *L. hakelensis* will be retained in *Leptotrachelus*.

MYCTOPHIDÆ.

Myctophidæ JORLAN and EVERMANN, Fishes of North and Middle America, 1896, p. 550.

Scopelidæ of most authors.

Leptosomus *Marck.*

To this genus the present writer assigns the species from the Niobrara of South Dakota, which Cope placed in the genus *Sardinius*. The latter genus has the scales pectinated, the pectoral fins with about 18 rays, the anal with about 20 rays, and about 45 vertebræ. The American species agree with *Leptosomus* in having, so far as can be determined, cycloid scales, narrow pectorals, a short anal, and about 30 vertebræ. Cope regarded *Leptosomus* as a synonym of *Sardinius*, but Woodward properly separates it. The author last named recognizes four species of this genus, *L. guestphalicus* Marck and *L. elongatus* Marck, both from the Upper Cretaceous of Westphalia, and *L. macrourus* Pictet and Humbert, and *L. minimus* (Agassiz), both from the Upper Cretaceous of Mount Lebanon.

Leptosomus nasutulus (*Cope*).

PLATE IV, FIGS. 4 AND 5.

Sardinius nasutulus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 70. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 248. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

Of this species there are in this Museum three specimens as follows: The type No. 2512 (Pl. IV, Fig. 4), No. 2513 (Pl. IV, Fig. 5), and No. 2523.

Most of Cope's measurements are taken from the type, but the distance from the snout to the base of the ventral fins is taken from No. 2513. This was necessary because in the type the ventrals have been washed forward to beneath the lower jaw, as may be seen from the figure.

On the block containing No. 2523 are scratched in pencil the words "Yankton, Neb." The other specimens are without doubt from the same locality.

Leptosomus lineatus (*Cope*).

PLATE IV. FIG. 6 AND PLATE V. FIG. 2.

Sardinius lineatus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV., 1878, p. 71. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 248. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

This species was based on two specimens, No. 2538 (Pl. IV, Fig. 6) and No. 2511 (Pl. V, Fig. 2). The former specimen displays the body as far back as the rear of the dorsal fin; the latter specimen shows the hinder half far enough forward to show the tips of the ventral fins; but neither specimen shows both the dorsal and the ventrals. Hence, the exact relation of these fins to each other can not be determined.

The block on which No. 2538 is preserved, and which also bears *Spaniodon simus*, is marked "Yankton, Neb."

Leptosomus percrassus (*Cope*).

PLATE V, FIG. 3.

Sardinius percrassus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 72. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 248. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

This species is represented by a single specimen, No. 2510 (Pl. V, Fig. 3). It differs from the other species in having a much deeper body. Although there is no record either on the block bearing this species, or in Professor Cope's description, there can be do doubt that it came from the same

locality and deposit as the other species here recorded from South Dakota.

Sardinius? imbellis *sp. nov.*

PLATE IV, FIG. 9.

The block of soft limestone which bears the type of Cope's *Sardinius nasutulus* presents also parts of two other small fishes which appear to be undescribed. One of these, No. 2550, lacks the head and the whole of the body above the vertebral column, except a portion of the upper lobe of the caudal fin. The other specimen, No. 2549, presents the body from the front of the dorsal fin to the extremity of the caudal. Perhaps it would be wise to refrain from describing these specimens, as Cope refrained. Nevertheless, they appear to differ from any species yet described and to furnish characters which will make it possible to recognize other specimens when they shall be found. So far as can be determined from the remains at hand, the species belongs to the Myctophidæ, and it stands nearer to *Sardinius cordieri* than to any other related form. From *Sardinius* it appears to differ in having fewer vertebræ, fewer rays in most of the fins, in the position of the dorsal, and in the character of the scales. It appears safer, however, to await the finding of additional and better materials before proposing a new generic name. The longitudinally divided specimen, No. 2550 (Pl. IV, Fig. 9), is taken as the type.

From the caudal fin to the insertion of the pectoral 36 vertebræ are counted. The whole number probably has been about 40. Of these, 15 appear to have belonged to the caudal region. The ribs are slender. The pectoral fin is broad and consists of 15 rays; but it is rather short and lacks somewhat of reaching the ventrals. The latter fins are pressed down, the one on the other, so that the exact number of rays cannot be determined. Six may be counted. These fins are placed nearer to the pectorals than to the anal. The dorsal is missing in the type. The anal has a long basis and consists of 15 or 16 rays. The caudal is deeply forked. No evidences

appear of any pectination of the scales. The body has been rather deep.

The second specimen presents an anal fin of 16 rays. In front of it is the dorsal, which appears to be supported by 12 interneurals. The front of the dorsal begins above the tenth vertebra in front of the origin of the anal. Three or four neural arches and two or three hæmal arches at the base of the caudal are expanded somewhat. Besides the slender neural arches and ribs, there are numerous fine intermuscular bones. No part of the ventrals appears in this specimen. Assuming both fishes to belong to the same species, it is evident that the dorsal fin is placed in the interval between the ventral and the anal fins. The whole length of the type has been close to 65 mm.

Niobrara Cretaceous, region of Yankton, South Dakota.

Rhinellus *Agassiz.*

Dr. A. .S. Woodward has properly, as it appears to the writer, reduced Cope's genus *Ichthyotringa* to a synonym of *Rhinellus* Agassiz. The scales along the lateral line of the American species also may have been somewhat thickened, and the dorsal fin has about the same number of rays as in *R. furcatus*, the type of the genus.

Rhinellus tenuirostris (*Cope*).

PLATE IV, FIGS. 7 AND 8.

Ichthyotringa tenuirostris COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 69. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 297.

Rhinellus tenuirostris WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 269.

This species is based on two specimens, No. 2514, the type (Pl. IV, Fig. 7), and No. 2515 (Pl. IV, Fig. 8). The former shows the head, with its long beak, and the body above the vertebral column as far backward as the rear of the dorsal fin. The latter, a small fish, displays the anterior portion of the body from below. Both pectoral and both ventral fins are presented.

The block on which this specimen is found is marked "Yankton, Neb." Of the other valid species of this genus *R. furcatus* Agassiz is found in the Upper Cretaceous of Mount Lebanon and Westphalia; *R. ferox* Davis and *R. damoni* Davis, in the Upper Cretaceous of Mount Lebanon.

Explanation of the abbreviations employed in the figures and on the plates to indicate the names of the bones and other structures.

a. f. = anal fin,
als. = alisphenoid,
ang. = angular,
a. r. = anal fin rays,
art. = articular,
art. s. = articular surface,
bas. = baseosts,
b. br. = basibranchial,
b. oc. = basioccipital,
cl. = cleithrum,
cor. = coracoid,
den. = dentary,
d. f. = dorsal fin,
d. r. = dorsal fin rays,
ec. pt. = ectopterygoid,
en. pt. = entopterygoid,
ep. o. = epiotic,
eth. = ethmoid,
ex. oc. = exoccipital,
fr. = frontal,
gl. h. = glossohyal,
i. h. = interhæmals,
i. n. = interneurals
i. op. = interoperculum,
m. pt. = metapterygoid,
mx. = maxilla,
na. = nasal,
op. = operculum,
op. o. = opisthotic,
os. = orbitosphenoid,
pa. = parietal,
pal. = palatine,
par. = parasphenoid,
p. cor. = precoracoid,
pct. = pectoral fin,
p. f. = pectoral fin,
pmx. = premaxilla,
p. op. = preoperculum,
pr. f. = prefrontal,
pro. = proötic,
p. sp. = presphenoid,
pt. f. = postfrontal,
pt. o. = pterotic,
pt. or. = postorbital,
sc. = scapula,
smx. = supramaxilla,
sn. = tip of snout,
s. oc. = supraoccipital,
s. op. = suboperculum,
s. or. = suborbital,
sq. = squamosal,
su. cl. = supracleithrum,
vert. = vertebra,
v. f. = ventral fin,
vom. = vomer,
vom. t. = vomerine tooth,
v. r. = ventral fin rays.

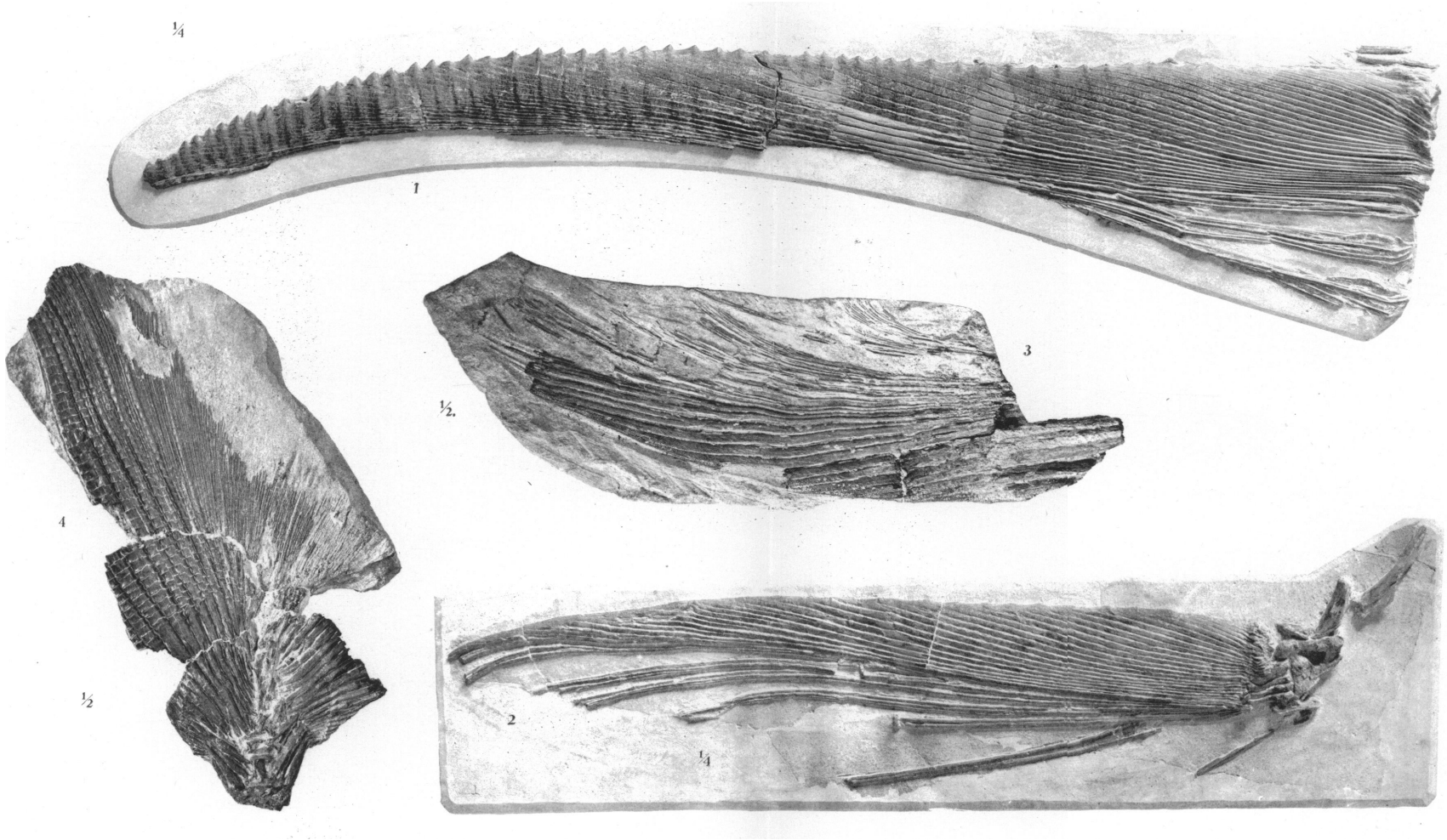
EXPLANATION OF PLATE I.

Fig. 1.—*Protosphyræna perniciosa* (Cope). Page 9. Pectoral fin. × ¼. No. 1901.

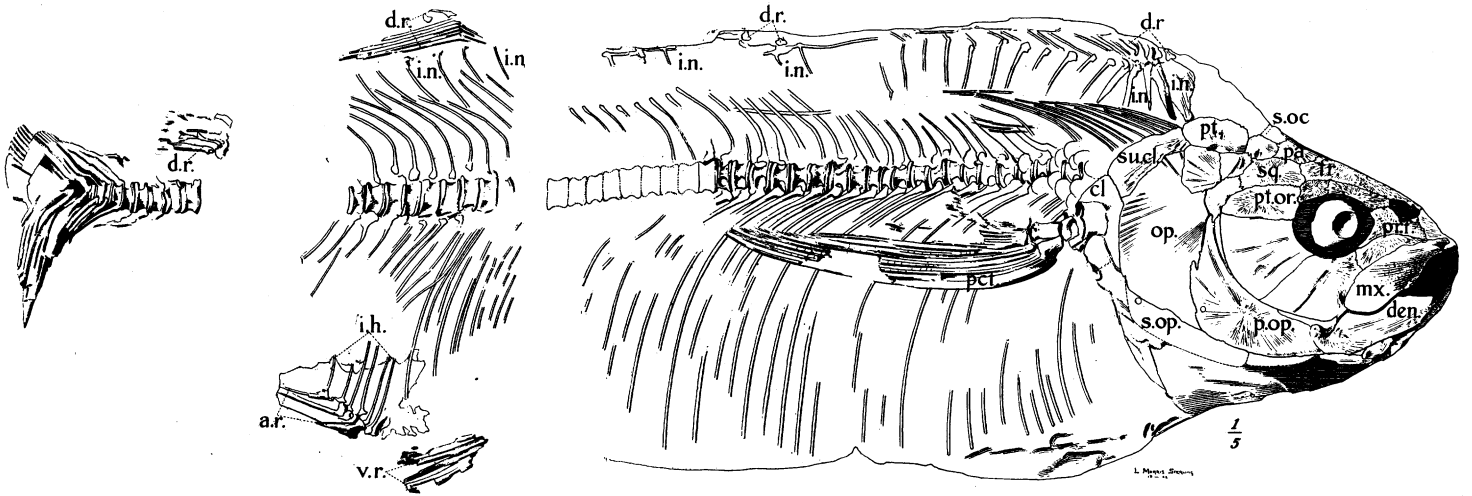
Fig. 2.—*Protosphyræna tenuis* Loomis. Page 15. Pectoral fin. × ¼. No. 205.

Fig. 3.—*Protosphyræna tenuis* Loomis. Page 16. Distal end of pectoral fin. × ½. No. 1620.

Fig. 4.—*Empo nepaholica* Cope. Page 88. Part of caudal fin. × ½. No. 2032.



Protosphyræna and Empo.



ANOGMIUS ARATUS COPE.

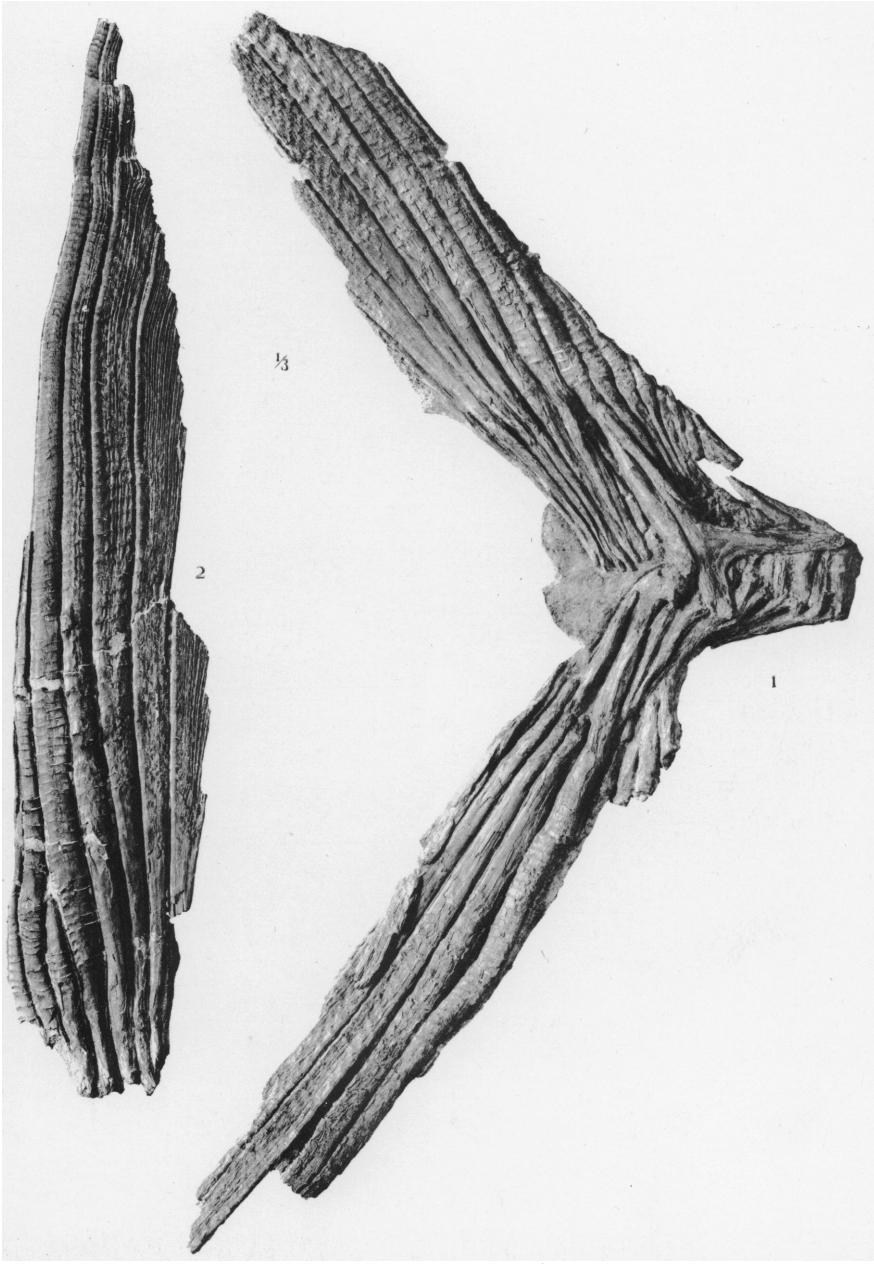
Anogmius aratus Cope. No. 2403. × ½. Type. *a. r.*, rays of anal fin; *cl.*, cleithrum; *d. r.*, rays of dorsal fin; *den.*, dentary; *fr.*, frontal; *i. h.*, interhæmal bones; *i.n.*, interneural bones; *mx.*, maxilla; *op.*, opercular; *pa.*, parietal; *pct.*, pectoral fin; *p op.*, preoperculum; *pr. f.*, prefrontal; *pt.*, post-temporal; *pt. or.*, postorbital; *s. oc.*, supraoccipital; *s. op.*, suboperculum; *sq.*, squamosal; *su. cl.*, supracleithrum; *v. r.*, rays of ventral fin.

EXPLANATION OF PLATE III.

Pachyrhizodus caninus Cope. Page 63.

Fig. 1.—Caudal fin and vertebræ. × $\frac{1}{8}$. No. 1900.

Fig. 2.—One lobe of caudal fin. × $\frac{1}{8}$. No. 1658.



Pachyrhizodus.

EXPLANATION OF PLATE IV.

Fig. 1.—*Spaniodon simus* Cope. Page 47. Nearly complete fish. Type. × ½. No. 2508. *a. f.*, anal fin; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 2.—*Spaniodon simus* Cope. Page 47. Anterior half of fish. Paratype. × ½. No. 2509. *den.*, dentary; *p. f.*, pectoral fin; *pmx.*, premaxilla.

Fig. 3.—*Leptotrachelus longipinnis* Cope. Page 90. Part of trunk. Cotype. × ½. No. 2520. *d. f.*, dorsal fin; *v. f.*, ventral fin.

Fig. 4.—*Leptosomus nasutulus* (Cope). Page 91. Nearly complete fish. Type. × ½. No. 2512. *a. f.*, anal fin; *d. f.*, dorsal fin; *v. f.*, ventral fin (displaced).

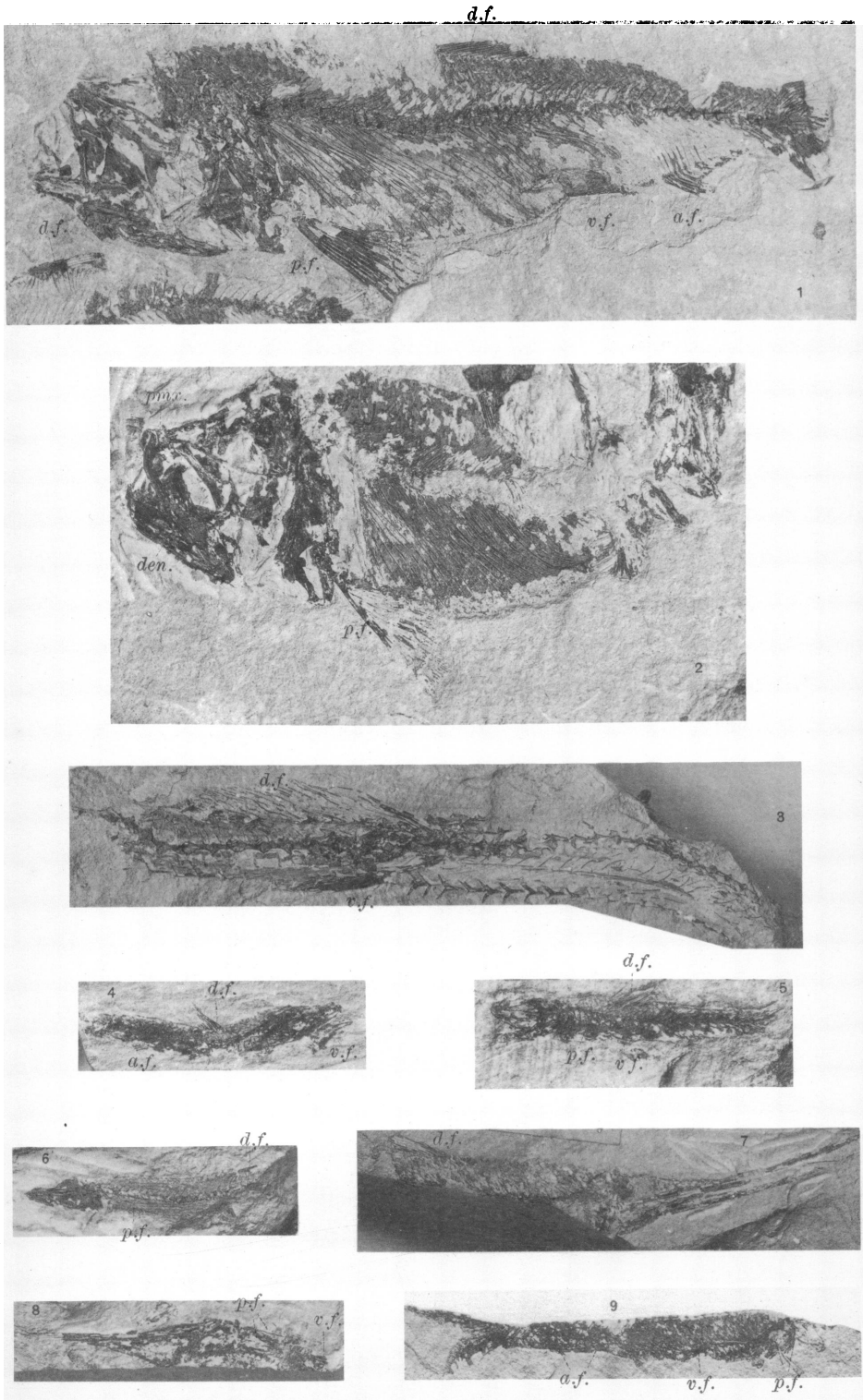
Fig. 5.—*Leptosomus nasutulus* (Cope). Page 91. Nearly complete fish. × ½. No. 2513. *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 6.—*Leptosomus lineatus* (Cope). Page 92. Fish with tail missing. Cotype. × ½. No. 2538. *d. f.*, dorsal fin; *v. f.*, ventral fin.

Fig. 7.—*Rhinellus tenuirostris* Cope. Page 94. Head and part of trunk. Cotype. × ½. No. 2514. *d. f.*, dorsal fin.

Fig. 8.—*Rhinellus tenuirostris* Cope. Page 94. Head and part of trunk. Cotype. × ½. No. 2515. *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 9.—*Sardinius ? imbellis* Hay. Page 93. Lower half of fish. Type. × ½. No. 2550. *a. f.*, anal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.



CRETACEOUS FISHES.

Heliotype Co, Boston.

EXPLANATION OF PLATE V.

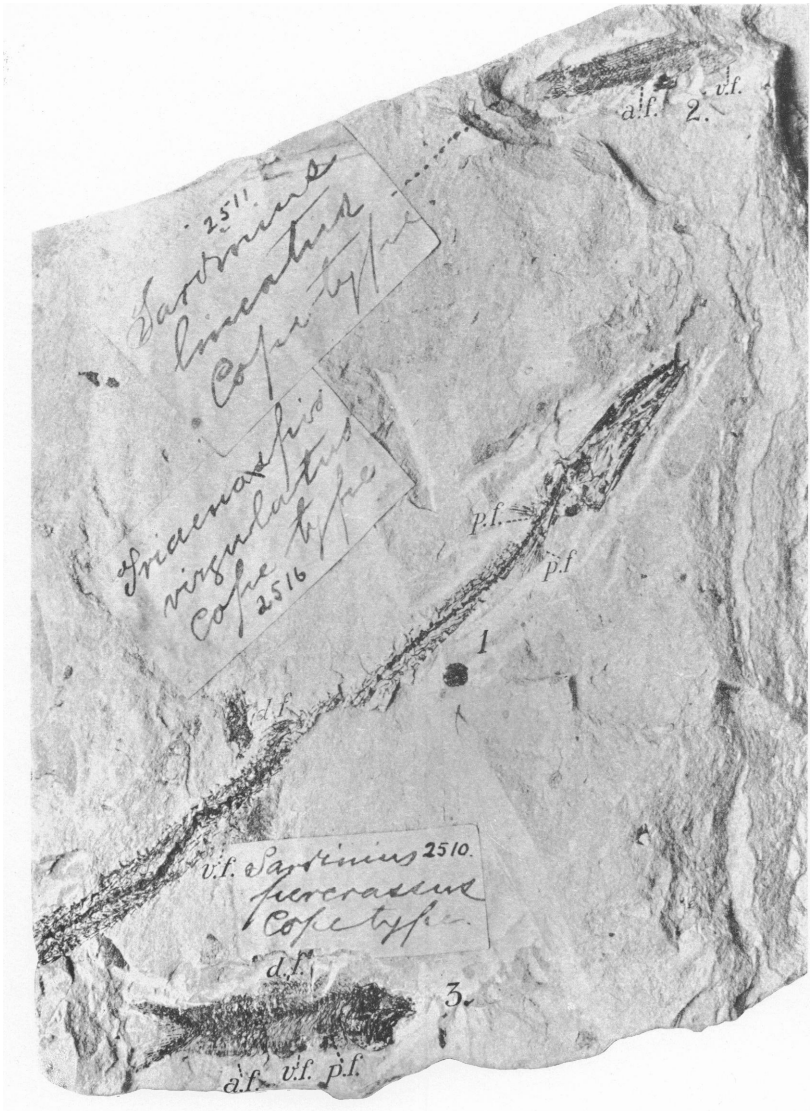
Fig. 1.—*Triænaspis virgulatus* Cope. Page 89. Head and part of trunk. Type. × ½. No, 2516. *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

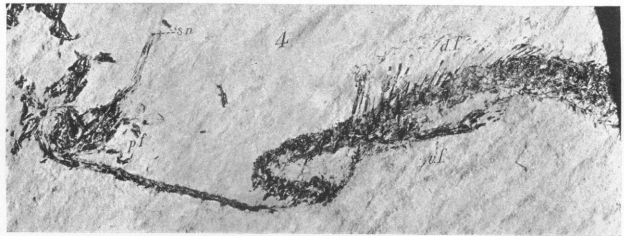
Fig. 2.—*Leptosomus lineatus* (Cope). Page 92. Hinder half of fish. Cotype. × ½. No. 2511. *a. f.*, anal fin; *v. f.*, ventral fin.

Fig. 3.—*Leptosomus percrassus* (Cope). Page 92. Complete fish. Type. × ½. No. 2510. *a. f.*, anal fin; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 4.—*Leptotrachelus longipinnis* Cope. Page 90. Head, neck, and part of trunk. Cotype. × ½. No. 2551. *d. f.*, dorsal fin; *p. f.* pectoral fin; *sn.*, snout; *v. f.*, ventral fin.

Lying against the bend in the neck are some remains of another fish.





CRETACEOUS FISHES