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Systematic paleontology (Vertebrate paleontology)

A basal Pachyrhizodontid fish (Actinopterygii, Teleostei) from the Lower Cretaceous of the Tlayúa Quarry, Central Mexico

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Abstract

Michin csernai gen. et sp. nov. from the Early Cretaceous (Albian) limestones of the Tlayúa Quarry, Puebla State, Central Mexico, is assigned to the Teleost clade Pachyrhizodontoidei as it possesses the enlarged inner premaxillary tooth, which is a unique synapomorphy of this clade. Additionally, the occurrence of relatively primitive characters (e.g., united parietals, angular and articular completely fused, caudal fin with five uroneurals) suggests that *Michin csernai* represents the most basal representative of the pachyrhizodontids. ***To cite this article: J. Alvarado-Ortega et al., C. R. Palevol 7 (2008).***
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Résumé

Un Pachyrhizodontoidei basal (Actinopterygii, Teleostei) du Crétacé inférieur de Tlayúa, Mexique. *Michin csernai* n. gen. et sp. est décrit dans les calcaires du Crétacé inférieur (Albien) de Tlayúa, État de Puebla, Mexique central. Ce nouveau téléostéen est identifié comme un nouveau membre des Pachyrhizodontoidei, en raison de sa grande dent prémaxillaire, qui représente aujourd'hui l'unique synapomorphie de ce clade. De plus, la présence de caractères relativement primitifs (par exemple, os pariétaux en contact, angulaire et articulaire fusionnés, nageoire caudale avec cinq uroneuraux), suggère que *Michin* représente le pachyrhizodontidé le plus basal. ***Pour citer cet article : J. Alvarado-Ortega et al., C. R. Palevol 7 (2008).***
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Keywords: Cretaceous; Tlayúa; Pachyrhizodontoidei; Teleostei; Mexico

Mots clés : Crétacé ; Tlayúa ; Pachyrhizodontoidei ; Téléostéen ; Mexique

1. Introduction

The Tlayúa Quarry, near Tepexi de Rodríguez, Puebla, about 150 km northwest of Mexico City, exposes a series of limestones that split easily into thin slabs, for which it is worked as a paving stone. The sequence lies wholly within, and exposes some 30 to 34 m of

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Fig. 1. *Michin csernai* n. gen et sp.; IGM 9028 holotype.
Fig. 1. *Michin csernai* n. gen et sp. ; holotype IGM 9028.

vertical thickness of the Tlayúa Formation, which is comprised of thin laminated yellow–reddish limestone of Early Cetaceous age (Albian) [6,13,14,16]. This locality is a well-known fossil Konservat Lagerstätte and is becoming increasingly known as one of the most important sources of Cretaceous fishes in Mexico. Although about 70–80% of the Tlayuan macrofossils are represented by well-preserved fishes [1–4], the assemblage also includes tetrapods and a wide variety of marine invertebrates.

The aim of this work is to describe a new genus and species of fish belonging to the Pachyrhizodontoidei (Fig. 1). This new taxon has been previously referred to as a *Notelops*-like fish by earlier authors [4,12]. Additionally, we provide a brief discussion regarding its relationship within Pachyrhizodontoidei.

2. Systematic paleontology

Suborder Pachyrhizodontoidei Forey 1977
Family *incertae sedis*
Genus *Michin* n. g.
Type species. *Michin csernai* n. sp.
Diagnosis. Monospecific genus, cf. species diagnosis.

Holotype. IGM 9028: complete specimen with disarticulated caudal skeleton, Colección Nacional de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México.

Additional material: five specimens, IGM 9029 to 9033, Colección Nacional de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México; five specimens, UERJ-PMB 105 to 109, Universidade do Estado do Rio de Janeiro

***Derivatio nominis*.** Named after the word 'fish' (=Michin) in the Mexican Náhuatl language; and *csernai* in honor to the professor Zoltan Cserna de Gömbös.

Diagnosis. Pachyrhizodontoidei fish with parietals uniting in the midline; angular and articular fused, forming the articulation of the lower jaw; ventral postcleithrum wide and triangular; ventral and dorsal precaudal scutes large and lenticular in shape; five uroneurals.

3. Description

The standard length of *Michin csernai* gen. et sp. nov. in the studied specimens ranges between 116 and 175 mm. The body is subcylindrical (Fig. 1), its maximum depth varies between 23 and 28% of the standard length (SL). The head is triangular, its length is 31–33% of the standard length (SL), and its depth is about the maximum body depth. Both paired and unpaired fins are located in the borders of the body. The origin of the dorsal fin is located close to the middle of the body, at about 54–56% of the SL. The pelvic fin opposes the posterior part of the dorsal fin, located at 64–66% of the SL. The origin of the anal fin is located at about 85–87% of the SL. A narrow caudal peduncle precedes a deeply forked caudal fin, in which both lobes are similar in shape and length.

Skull. Dermethmoid roofs the nasal capsules (Fig. 2); its posterior border articulates with both frontals (the presence of the ethmoidal commissure is unclear), both of which are sutured along their sagittal margin (Fig. 3A). Parietals sutured and lacking any pit of the supraorbital sensory canal (Fig. 3A).

The intercalar shows a fine anterior projection forming part of the prootic–intercalar bridge (Fig. 3B). The lateral view of exoccipital is rectangular and shows the foramina for the glossopharyngeal (IX) and vagus (X) nerves. The orbital part of the parasphenoid is a large, straight, and edentulous bar. The vomer has a large curved tooth anteriorly (Fig. 4A–A′).

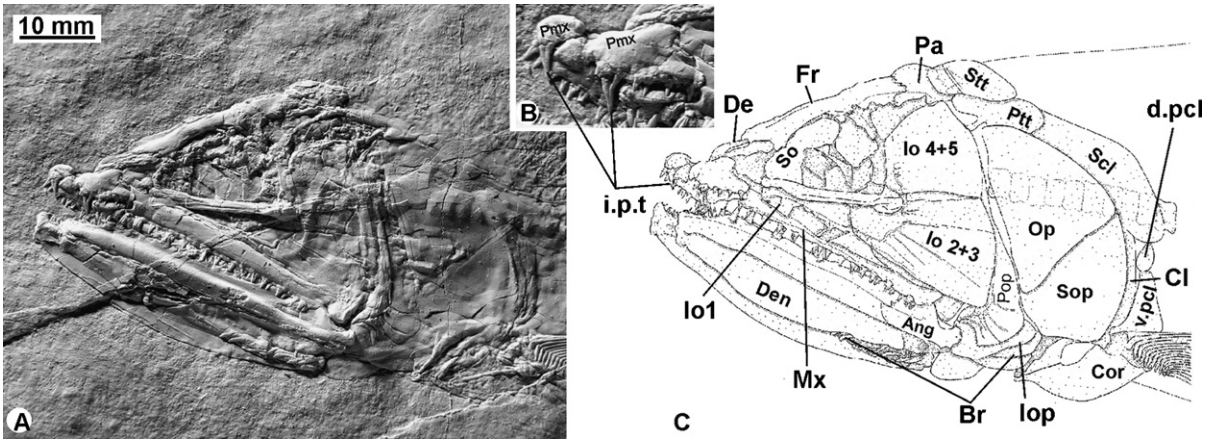

Fig. 2. *Michin csernai* n. gen. et sp., holotype IGM 9028; (**A**) head in left lateral view; (**B**) close-up of the premaxillary left and right; (**C**): drawing of A. Ang, angular; Cl, cleithrum; Cor, coracoid; d.pcl, dorsal postcleithrum; De, dermethmoid; Den, dentary; Fr, frontal; Io, infraorbital; i.p.t., inner premaxillary tooth; Mx, maxilla; Op, opercle; Pa, pariétal; Pmx, premaxillary; Pop, preopercle; Ptt, post-temporal; Scl, supracleithrum; So, supraorbital; Sop, subopercle; Stt, supratemporal; v.pcl, ventral postcleitrhum.

Fig. 2. *Michin csernai* n. gen. et sp., holotype IGM 9028; (**A**) tête en vue latérale gauche ; (**B**) vue rapprochée des prémaxillaires gauche et droit ; (**C**) dessin A. Ang, angulaire; Cl, cleithrum ; Cor, coracoïde ; d.pcl, postcleithrum dorsal ; De, dermethmoïde ; Den, dentaire ; Fr, frontal ; Io, infraorbitaire ; i.p.t., dent interne du prémaxillaire ; Mx, maxillaire ; Op, opercule ; Pa, pariétal ; Pmx, prémaxillaire ; Pop, préopercule ; Ptt, post-temporal ; Scl, supracleithrum ; So, supraorbitare ; Sop, sous-opercule ; Stt, supratemporal ; v.pcl, postcleitrhum ventral.

The circumorbital series involves five flat, thin bones forming a closed ring. Infraorbital 1 is a long rectangular plate located in the anteroventral part of the orbit; infraorbitals 2 and 3 are fused and cover the entire cheek region; infraorbitals 4 and 5 are also fused and cover the lateral surface of the postorbital part of the skull (Fig. 2C). Only broken remains of the demosphenotic and supraorbital are preserved over the orbit. The postorbital sensory canal extends along the orbital border of the infraorbitals, and its branches extend along the surface of these bones.

The preopercle is L-shaped, with the sensorial canal presenting at least five branches.

The hyomandibular is large, with a subrectangular articular head inclined anteriorly and a short opercular process in its posterior border (Fig. 3B). The quadrate has the same shape as found in *Rhacolepis buccalis* and *Goulmimichthys arambourgi*. In IGM 9033, part of the ectopterygoid and palatine are exposed, but appear to be edentulous.

The opercular series includes a triangular opercle, a subopercle, and a small interopercle (Fig. 2).

The dentary rectangular is about four times longer than deep and comprises about 80% of the lower jaw length; its alveolar border has two or three rows of teeth (Fig. 4B–B′). Teeth are similar in shape and size, but the anterior ones are directed posteriorly and the posterior ones are directed anteriorly. About eight or nine mandibular sensory canal openings are located along the long axis of this bone.

The bones of the left lower jaw are completely fused in UERJ-PMB 105; here the angular as well as the articular are triangular, anteriorly projecting, with a convex dorsal border, and similar depth (Fig. 4C). The angulo-articular complex has a rounded massive post-articular process, in which the ventral border has two pores for the passage of the mandibular sensorial canal. The retroarticular is a small bone located in the ventral border of the angular. The angulo-articular complex forms the articular facet for the quadrate.

The premaxillary is a triangular bone bearing about 10 teeth on its ventral surface. A large inner tooth is located in the anterior flange of the premaxillary (Fig. 2B). This tooth was considered as a synapomorphy for the Pachyrhizodontoidei [8]. The maxillary is a long, rectangular and massive bone, eight times longer than deep. There appears to be three rows of 13–15 uniform, stout, conical teeth. There is only one thin and long supramaxillary bone lying above the posterior middle part of the maxilla.

Anterior ceratohyal is rectangular, with an elongate, almost obliterated fenestra. Anteriorly, this bone articulates with ventral and dorsal hypohyals (Fig. 4B). In UERJ-PMB 108, the posterior ceratohyal is triangular, smaller than the anterior ones, and without a fenestra. There are about 15 thin anterior thread-like branchiostegal rays plus five of them wider and spatulate articulating with the anterior and posterior ceratohyals.

Pectoral fin and girdle. The supratemporal bone is oval and located behind the skull. In IGM 9028,

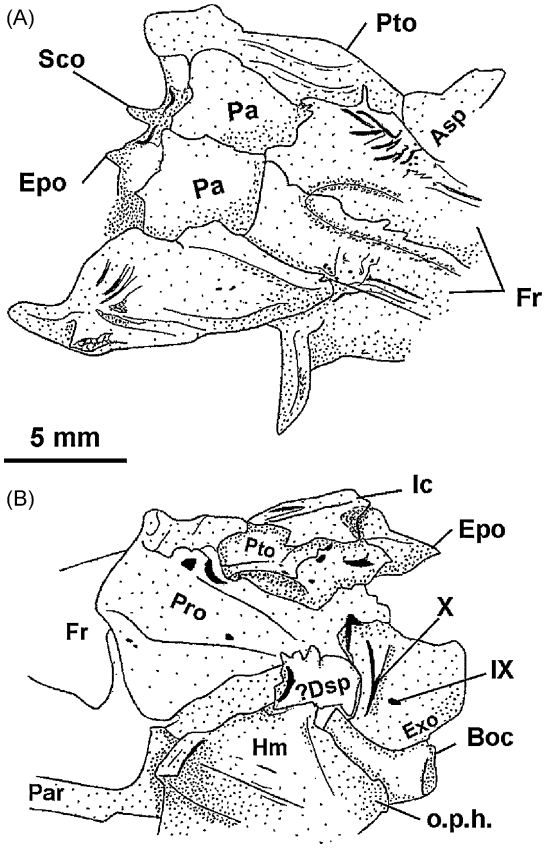

Fig. 3. Osteological skull details of *Michin csernai* n. gen et sp. (**A**) Skull roof restoration of UERJ-PMB 107; (**B**) drawing of IGM 9029, showing semi-disarticulated skull bones. Asp, autosphenotic; Boc, basioccipital; Dsp, demosphenotic; Epo, epoccipital; Exo, exoccipital; Fr, frontal; Hm, hyomandibular; Ic, intercalar; o.p.h, opercular process of the hyomandibular; Pa, parietal; Par, parasphenoid; Pro, prootic; Pto, pterotic; Soc, supraoccipital; IX, foramen for glossopharyngeal nerve; X, foramen for vagus nerve.

Fig. 3. Détails ostéologiques du crâne de *Michin csernai* n. gen et sp. ; (**A**) reconstitution du spécimen UERJ-PMB 107 ; (**B**) dessin interprétatif du spécimen IGM 9029, montrant les os du crâne semi-désarticulés. Asp, autosphénotique ; Boc, basioccipital ; Dsp, demosphénotique ; Epo, épioccipital ; Exo, exoccipital ; Fr, frontal ; Hm, hyomandibulaire ; Ic, intercalaire ; o.p.h, processus operculaire du hyomandibulaire ; Pa, pariétal ; Par, parasphénoïde ; Pro, prootique ; Pto, ptérotique ; Soc, supraoccipital ; IX, foramen du nerf glossopharyngien ; X, foramen du nerf vague.

the supratemporal commissure is partly seen. The posttemporal is ovate, with a pair of anterior projections, a short epiotic limb dorsally and the larger intercalar limb ventrally. The dorsal postcleithrum is ovate and about three times smaller than the ventral one, which forms a triangular plate (Fig. 2).

The cleithrum has a boomerang-like shape, with both limbs of similar size. In IGM 9029, the mesocoracoid joins the horizontal limb of the coracoid anteriorly and posteriorly, and shows a central curvature that forms part of the interosseous foramen between these bones. In UERJ-PMB 105, the mesocoracoid is a C-shaped bone, while the scapula is O-shaped. The pectoral fin comprises fifteen ranched rays.

Pelvic fin and girdle. The pelvic fin commences at the level of the posterior end of the dorsal fin and contains about 13 branched rays. The pelvic girdle is composed of a unique structure, the pelvic bone. The iliac region is a stout rod-like structure attached to the wing plate that forms the ischial region. At the base of the pelvic bone, there is a cleaver-shape radial bone.

Dorsal and anal fins. The dorsal fin is triangular, with 15 branched and segmented rays, except the first one, supported by 14 pterygiophores. The anal fin is short, formed by about seven small and branched rays, supported by the same number of small pterygiophores.

Vertebral column. The exact number of vertebrae is unknown because the opercle is obscuring the first postcranial centra. Nevertheless, the total number could be about 50–55. The centra are slightly deeper than long and have a median longitudinal ridge. The hemal and neural arches are autogenous. Epineurals and neural arches are fused in the abdominal region.

Caudal fin. The hemal and neural spines of the last four preural centra of the caudal fin are inclined posteriorly, supporting part of the caudal fin's skeleton (Fig. 5). There are five uroneurals. The uroneurals are curved, anteriorly rounded and wide, and cover a large part of the lateral face of the ural one and the first two preural centra. The other four uroneurals are progressively smaller posteriorly. There are at least five hypurals. The first two hypurals and the first ural centrum are fused to each other. Remaining hypurals are unfused and join ural two. The most posterior hemal spine is as wide as the parahypural, which is not fused to the preural centrum one.

The posterior neural arches are modified, with the neural arch of preural centrum 3 associated with the neural spine as are all the anterior preural centra; however, the spine on the neural arch of preural 2 is reduced, and the neural arch on the preural one is reduced and lacks a spine. There are three epurals. There is one dorsal and one ventral precaudal scute. These scutes are enlarged, ovate, with a mid longitudinal ridge, and they possess acute anterior and posterior tips. The anterior projection of the dorsal caudal scute is as large as three preural centra. The caudal fin contains 24 principal rays, 13 segmented and branched principal rays in the upper lobe and 11 in lower lobe.

Squamation. The entire trunk is covered with oval, small, cycloid scales.

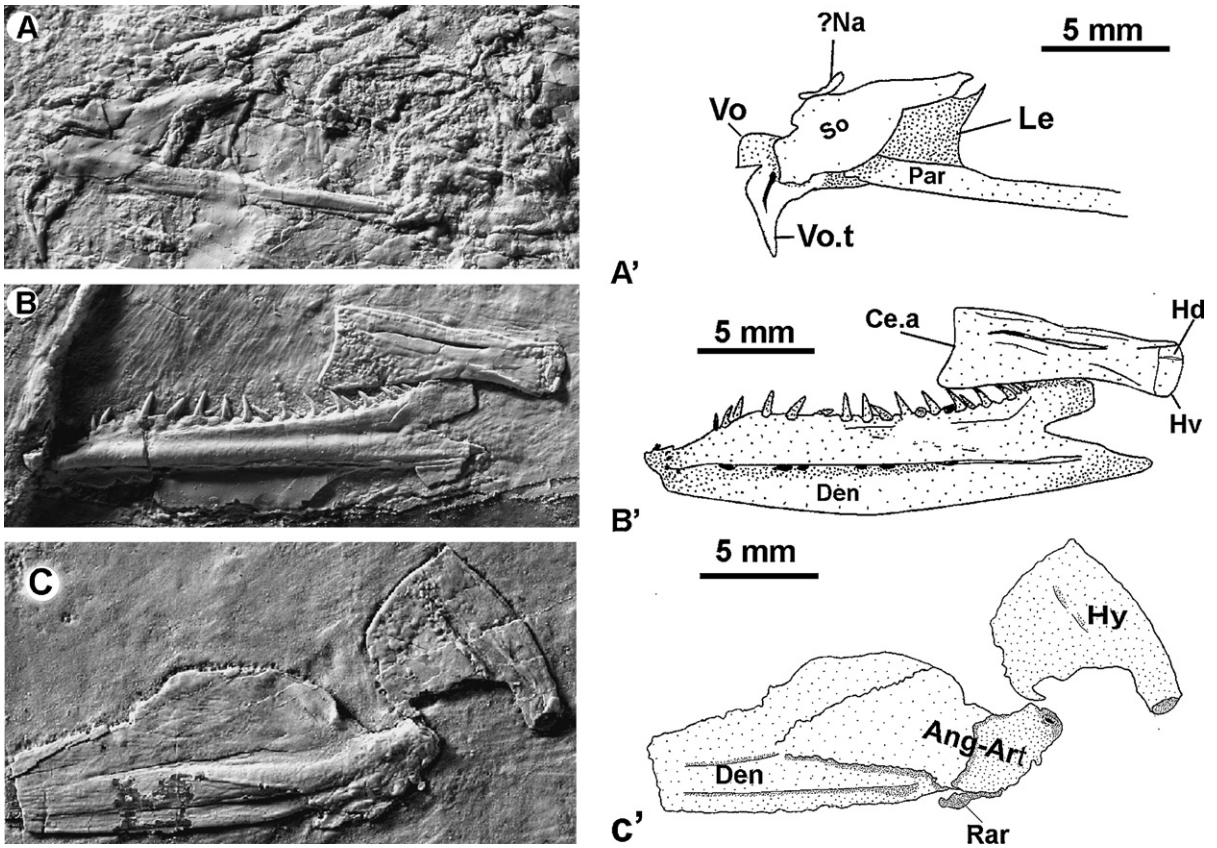

Fig. 4. (**A**–**A**′) Photo and drawing of bones in the vomer region preserved in IGM 9031; (**B**–**B**′) photo and drawing of dentary bone disarticulated as preserved in UERJ-PMB 105; (**C**–**C**′) photo and drawing of angular-articular complex in medial view. Ang–Art, angular–articular complex; Ce.a, anterior ceratohyal; Den, dentary; Hd, dorsal hypohyal; Hv, ventral hypohyal; Hy, hyomandibular; L.e, lateral ethmoid; Na, nasal; Par, parasphenoid; Rar, retroarticular; So, supraorbital; Vo, vomer; Vo.t, vomer tooth.

Fig. 4. (**A**–**A**′) Photo et dessin de la région vomérienne du spécimen IGM 9031 ; (**B**–**B**′) photo et dessin du dentaire désarticulé, spécimen UERJ-PMB 105; (**C**–**C**′) photo et dessin de l'angulaire–articulaire. Ang–Art, angulaire–articulaire en vue médiale ; Ce.a., cératohyal antérieur ; Den, dentaire ; Hd, hypohyal dorsal ; Hv, hypohyal ventral ; Hy, hyomandibulaire ; L.e, ethmoïde latéral ; Na, nasal ; Par, parasphénoïde ; Rar, rétroarticulaire ; So, supraorbital ; Vo, vomer ; Vo.t, dent du vomer.

4. Affinities

Cope [9] erected the family Pachyrhizodontidae based on *Pachyrhizodus* and related forms. Forey [10] reviewed this group, creating the suborder Pachyrhyzodontoidei including two families, Notolepidae for *Notelops* and Pachyrhizodontidae for *Pachyrhizodus*, *Rhacolepis*, and *Elopopsis*. Later, *Platnix* (see Taverne 1980), *Greenwoodella*, *Goulmimichthys*, and *Tingitanichthys* were included in this suborder.

Cavin [8] demonstrated that suborder Pachyrhizodontoidei is a monophyletic group that includes *Notelops*, *Rhacolepis*, *Goulmimichthys*, *Pachyrhizodus*, and *Elopopsis*, based on a single synapomorphy: the presence of a hypertrophied inner premaxillary tooth. *Michin csernai* n. gen. and sp. shares this character, supporting its inclusion within this group.

Michin and *Notelops* share the occurrence of parietals uniting along the middle part of the skull; in contrast, other Pachyrhizodontoidei have parietals separated from each other. *Michin* and the other Pachyrhizodontoidei have the articular and angular bones fused, forming the angulo-articular bone complex [10,17]. The large size of the articular of *Michin*, which is almost as deep as the angular, is very similar to the ones presented by *Rhacolepis* and *Goulmimichthys*. In addition, *Michin csernai* differs from other Pachyrhizodontoidei by possessing five uroneurals and a wide triangular ventral postcleithrum, in contrast to the three V-shaped uroneurals and ventral postcleithrum found in other members of the group, including *Notelops* [8,10].

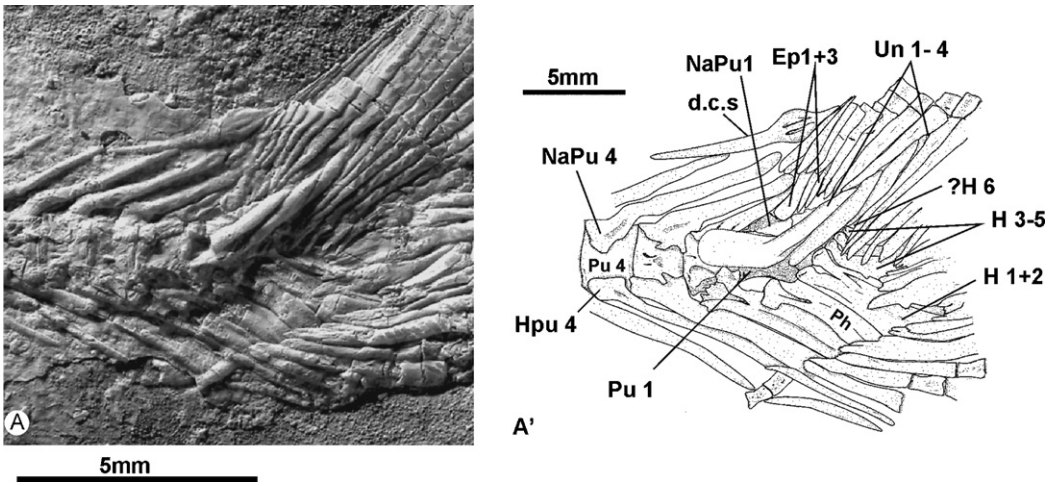

Fig. 5. (**A**–**A**′) Photo and drawing of the caudal fin as preserved in IGM 9030. d.c.s., dorsal caudal scute; Ep 1 + 2, epurals; H 1–6, hypurals; HPu, hemal arch of preural centra; NaPu, neural arch of preural centra; Ph, parhypural; Pu, preural centra; Un 1–5, uroneurals.
Fig. 5. (**A**–**A**′) Photo et dessin interprétatif de la nageoire caudale du spécimen IGM 9030. d.c.s., écusson dorso-caudal ; Ep 1 + 2, épuraux ; H 1–6, hypuraux ; HPu, arc hémal du centre préural ; NaPu, arc neural du centre préural ; Ph, parhypural ; Pu, centre préural ; Un 1–5, uroneuraux.

5. Systematics implications

Cavin [8] performed the most recent phylogenetic analysis to include the Pachyrhizodontoidei, concluding that this monophyletic clade is part of the Clupeocephala *sensu* Arratia [5], which is supported by a combination of four characters: (1) the retroarticular bone is excluded from the articulation with the quadrate, (2) the articular and angular are fused, (3) the ural one has no neural arch, and (4) there are six or less hypurals. The primitive condition of character 2, articular and angular unfused, is found only in *Notelops* [10,11], but was interpreted as a homoplasy [8]. The occurrence of some of these characters in *Michin* n. gen., which is characterized by a peculiar mixture of plesiomorphic characters with respect to those found in other Pachyrhizodontoidei [including the presence of five uroneurals, parietals joined versus parietals separated from each other], suggests that this previous interpretation must be reviewed. At the same time, these primitive characters observed in *Michin* allow us to recognize this species as the most basal Pachyrhizodontoidei, suggesting that the group might have a more basal position within the teleosts than previously thought. However, the performance of a comprehensive phylogenetic analysis to establish the relationships of *Michin* will require detailed descriptions of other presumed Pachyrhizodontoidei reported from Brazil, Venezuela, Colombia, and Mexico [12,15].

6. Conclusion

The phylogenetic position of the Pachyrhizodontoidei among Teleostei remains unclear, although some of the primitive characters possessed by *Michin csernai* (e.g., presence of precaudal scutes, five uroneurals, angular and articular fused) suggest that this is the most basal Pachyrhizodontoidei. Its inclusion in future phylogenetic analysis will help us to test the validity and the relationships of these groups that were once included within the Pachyrhizodontoidei (e.g., Elopomorpha, Clupeocephala, Euteleosts, and Paracanthopterygii; see [7]).

Acknowledgements

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