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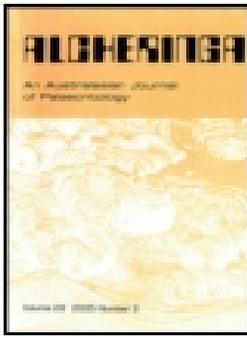
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First fossil fish (Teleostei, Siluriformes) from the Late Pleistocene of Santa Fe Province, Argentina

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The record of fossil fish from the Pleistocene of Argentina is poor. Here we describe the first ichthyofauna from Late Pleistocene riverbank beds in the Salado River of Santa Fe Province, Argentina. The material consists of isolated pectoral and dorsal fin spines, together with skull fragments. Four species-level taxa referable to three families can be identified: *Pterodoras granulatus* (Doradidae), *Pimelodus* cf. *maculatus* and *Pimelodus* cf. *albicans* (Pimelodidae) and cf. *Hypostomus* sp. (Loricariidae). Specimens attributed to *Pterodoras granulatus* and *Pimelodus maculatus* represent a minimum age for origin of these taxa. The Salado River assemblage includes the richest record of Pleistocene catfishes yet documented from southern South America.

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Key words: Ichthyofauna, Quaternary, Doradidae, Pimelodidae, Loricariidae, Argentina.

THE NEOTROPICAL region includes the richest freshwater ichthyofauna in the world. Ringuélet (1975; see also Almirón *et al.* 1997, Arratia 1997, Casciotta *et al.* 1999) divided it into two major ichthyogeographic units: the Austral and Brazilian Subregions (Fig. 1). The Austral ichthyofauna is more closely related to equivalents from West Gondwana (e.g., Australia and New Zealand; Ringuélet 1975), whereas the Brazilian ichthyofauna is similar to those from Africa (Patterson 1975). The highest taxonomic diversity is concentrated within the Brazilian Subregion, which in Argentina includes the Paraná, Paraguay and Uruguay river basins. By far the most dominant group is the Siluriformes, or catfishes, which currently comprises 40 families and 3730 species (Nelson *et al.* 2016).

The Quaternary fossil record of freshwater fishes in southern South America is poorly studied in comparison with that of coeval land mammals (e.g., Cione 1986, Cione & Báez 2007). With the exception of the Buenos Aires Province (eastern Pampean Region), Pleistocene remain in particular are unknown from the rest of southern South America (Cione & Báez 2007). Groups that have been identified include: Siluriformes with *Hypostomus* sp. Lacépède 1803, *Pimelodus* sp. cf. *P. albicans* (Valenciennes 1840), *Rhamdia quelen* (Quoy and Gaimard 1824–25), *Pimelodella* sp. cf. *P. laticeps* Eigenmann 1917, *Corydoras* sp. cf. *C.*

paleatus (Jenyns 1842) and *Callichthys callichthys* (Linnaeus 1758); Atheriniformes with *Odontesthes* sp. (Evermann & Kendall, 1906); Perciformes incorporating *Micropogonias furnieri* (Desmarest 1823) and *Pogonias cromis* (Linnaeus 1766); Cyprinodontiformes with *Jenynsia* sp. Günther 1866; Characiformes with *Oligosarcus* sp. Günther 1864; Synbranchiformes with *Synbranchus marmoratus* Bloch 1795; Mugiliformes with cf. *Mugil* sp. Linnaeus 1758; and Cupleiformes with cf. *Brevoortia* sp. Gill 1861 and aff. Clupidae indet. (see Ameghino 1898, Cione 1982, 1986, Cione & López-Arbarello 1995, Pardiñas *et al.* 1996, Bogan & Cenizo 2008, Bogan *et al.* 2008, 2009a, 2009b, 2010, 2012, Bogan & De los Reyes 2009, Vallone 2015). Most of these taxa are still inhabitants of the area today.

This contribution reports on Pleistocene fossil fishes from a new locality in the Santa Fe Province of southern Argentina and focuses upon the comparative morphology of siluriform catfish taxa in particular.

Geological setting

The fossil specimens documented here were collected from fluvial sediments on the left bank of the northern Salado River, near Manucho in Santa Fe Province (c. 31°15'16.85"S, 60°53'34.16"W). This succession crops out along 25 km of the river and is up to 3 m thick (Vezzosi 2015). The sequence is lithostratigraphically innominate and comprises two fossiliferous sandy-silty facies (Fig. 2). The lower unit (1) has produced fish

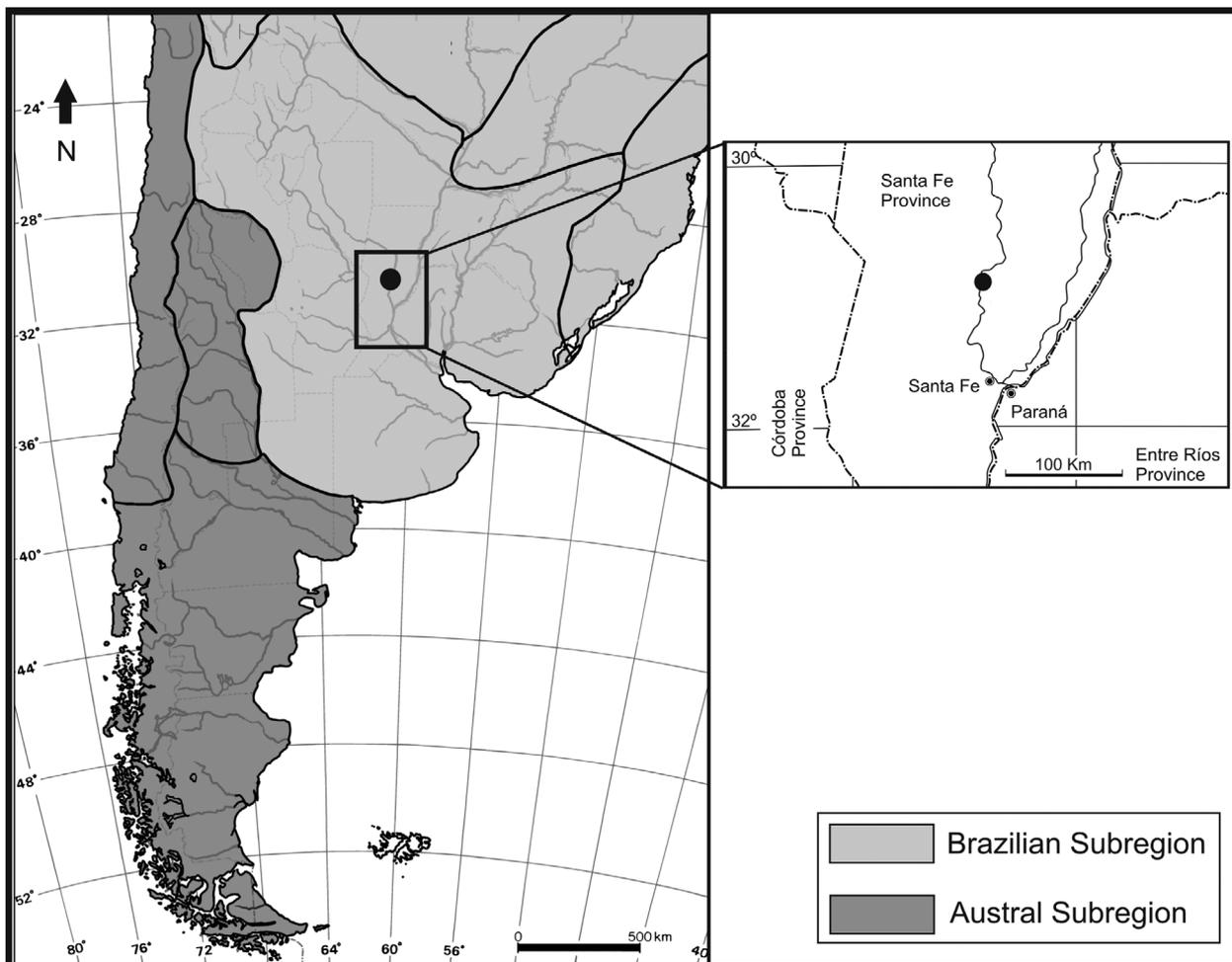


Fig. 1. Brazilian and Austral Subregions of the Neotropical Region in southern South America (modified from Arratia 1997), including a map of the Salado River area in Santa Fe Province.

remains together with terrestrial mammals. It is finely laminated and composed of fine olive green sands and silts with a high proportion of clays. These represent a

low energy fluvial depositional setting, and are overlain by a fluvial channel succession transitioning upwards into lagoonal floodplain facies. The upper unit (2) has yielded a characteristically Pleistocene mammal assemblage comprising *Toxodon platensis* Owen 1837, *Scelidotherium leptoccephalum* (Owen 1839) and *Glyptodon reticulatus* Owen 1845 (see Vezzosi 2015). It is composed of fine reddish-brown sands and silts with a high proportion of sand. These layers are horizontally laminated with low-angle planar cross-stratification and have been interpreted as lacunar with intense pedogenesis and a well-defined calcrete (Vezzosi 2015). Finally, the Tezanos Pinto Formation caps the entire succession, and has been dated from late Pleistocene to early Holocene (TL 35.890–8.150 ka: Kröhling 1999, Kröhling & Iriondo 1999); the fish-bearing beds thus appear to be late Pleistocene in age based on mammal fossils and radiometric analyses (Vezzosi 2015).

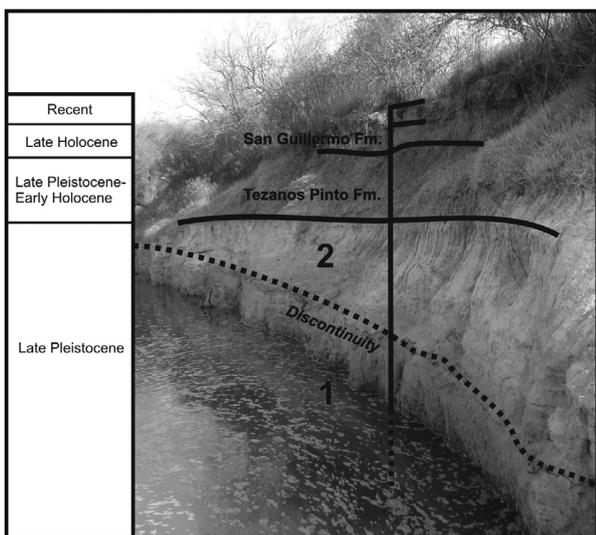


Fig. 2. Outcrops in the river banks of the Salado River, showing the two units (fishes come from unit 1).

Institutional abbreviations: CICyTTP, Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción, Diamante, Argentina; KUNHM, Division of Ichthyology, Natural History Museum, University of Kansas, Lawrence, Kansas, USA; MCP, Museu de Ciências e Tecnologia, Porto

Alegre, Brazil; MFA-PV, Museo Provincial de Ciencias Naturales ‘Florentino Ameghino’, Colección Paleontología de Vertebrados, Santa Fe, Argentina; MLP, Museo de La Plata, Buenos Aires, Argentina.

Materials and methods

All specimens studied herein were mechanically prepared under a binocular microscope using needles, and have been accessioned into the MFA-PV. Comparative skeletons of extant and fossil species from the CICyTTP, MCP, MLP and KUNHM collections included: Loricariidae (MMCIPAS 2658, MMCIPAS 3299, MMCIPAS 3709–3713), *Hypostomus* sp. Lacépède 1803 (KU 41336, MMCIPAS 1253, MMCIPAS 1506, MMCIPAS 3311, MMCIPAS 3714), *Hypostomus commersoni* Valenciennes 1836 (MLP-V-P 02), *Parapimelodus valenciennis* (Lütken 1874) (CICyTTP-V-P 05, KU 21804, MLP-V-P 65), *Parapimelodus nigribarbis* (Boulenger 1889) (MCP 12968), *Pimelodus albicans* (Valenciennes 1840) (MLP-V-P 18, MLP 79-XI-30–35, MMCIPAS 1263), *Pimelodus maculatus* Lacépède 1803 (CICyTTP-V-P 02, MLP-V-P 21, MLP-V-P 64), *Pimelodus* sp. (KU 21805, MLP-V-P 66), Doradidae (MLP 79-XI-30-18-26), *Pterodoras granulatus* (Valenciennes 1821) (MLP-V-P 22, MLP-V-P 68). Descriptions follow the anatomical nomenclature proposed by Arratia (2003) and Diogo *et al.* (2001). Distribution, biological and ecological data were taken from Liotta (2006), Casciotta *et al.* (2005) and Almirón *et al.* (2008). All drawings were prepared using stereomicroscopes equipped with a camera lucida.

Systematic Paleontology

SILURIFORMES Grande 1987

LORICARIIDAE Rafinesque 1815

cf. *Hypostomus* sp. Lacépède, 1803 (Fig. 3A–H)

Referred material. Proximal sections of four right pectoral spines (MFA-PV 1541 1561–1563), one proximal section of a dorsal spine (MFA-PV 1542) and one proximal section of a pectoral spine (MFA-PV 1564).

Description. MFA-PV 1542 (Fig. 3A–D) is a robust and well-ossified dorsal spine. It is slightly curved with a subcircular cross-section. The anterior surface has a large number of basal odontoids (shallow adjacent rings). The medial surface is longitudinally crossed by a slight midline depression parallel to the longitudinal axis. The left and right surfaces bear longitudinal ridges defining parallel furrows. The articular region of the spine base is triangular in shape with paired anterior processes. The articular surfaces of the anterior processes have a labyrinthine ornamentation, comprising ridges and troughs (Fig. 3D). The medial process has a

rugose surface. The articular foramen of the dorsal spine is small and circular, and bears two adjacent semicircular depressions on either side of the longitudinal midline (Fig. 3D).

The pectoral spines (Fig. 3E–G) are slightly curved and robust, with triangular cross-sections. The articular region has a well-developed arching dorsal process with parallel surface striations. The anterior process is preserved on all specimens, but the ventral process is visible only in MFA-PV 1563. The neck of the spine is smooth, whereas the medial margin is incised by a longitudinal sulcus that ends in the articular groove; this is triangular in outline. Both the anterior margin and the ventral surface are covered by prominent basal odontoids. The dorsal surface is ornamented with numerous crests that delimit obliquely orientated parallel grooves; these are floored by rows of small odontode bases that terminate at the crest edges.

Comments. *Hypostomus* is one of the most diverse South American freshwater catfish genera, being represented by 24 species distributed through the Pilcomayo, Bermejo, Paraguay, Paraná, Uruguay, Río de la Plata and Salado river basins in Argentina, as well as lagoonal systems in the Buenos Aires Province (Liotta 2006). The species of *Hypostomus* dwell in small tributary environments with sandy and/or rocky bottoms, and are non-migratory. They can also tolerate short-term aerial exposure via intestinal breathing (Almirón *et al.* 2008).

Despite the high diversity among extant forms, fossils of *Hypostomus* and other loricariids are extremely rare. The few documented examples include *Taubateia paraiba* Malabarba & Lundberg, 2007 from the Tremembé Formation (Oligocene–Miocene) in Brazil (Malabarba 1988, Malabarba & Lundberg 2007), *Hypostomus* sp. from Miocene sediments of the La Venta Group in Colombia (Lundberg 1997) and indeterminate loricariid remains from the Puerto Madryn and Ituzaingó formations (Miocene) in Argentina (Cione *et al.* 2005, 2013). The most recent finds derive from Late Pleistocene beds in the northern Buenos Aires Province of Argentina (Bogan *et al.* 2008). We attribute our Salado River specimens to cf. *Hypostomus* sp. based on their morphological similarity to living species of the genus.

DORADIDAE Bleeker 1858

Pterodoras granulatus (Valenciennes 1821) (Fig. 4A–F)

Referred material. Three left pectoral spines (MFA-PV 1543, 1568, 1569), a pectoral spine fragment (MFA-PV 1544), a posttemporo-supracleithrum (MFA-PV 1545), one dorsal spine (MFA-PV 1571), two indeterminate spine fragments (MFA-PV 1572, 1573) and a supraoccipital (MFA-PV 1574).

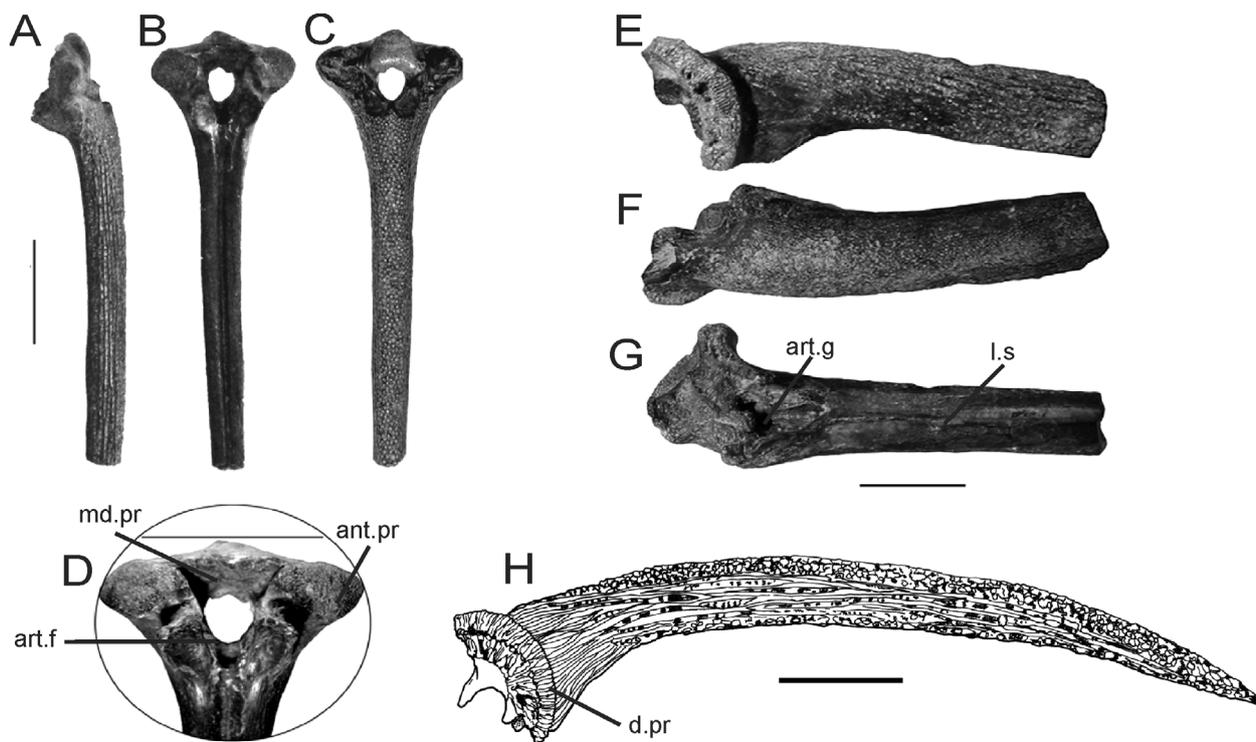


Fig. 3. *Hypostomus* sp. (MFA-PV 1542) proximal fragment of dorsal spine in lateral (A), medial (B), and anterior (C) views and details of articular region in medial view (D); proximal fragment of right pectoral spine (MFA-PV 1562) in dorsal (E), ventral (F), and medial (G) views. *Hypostomus commersoni* pectoral spine (H) modified from Bisbal & Gómez (1986). Abbreviations: ant. pr, anterior process; art.f, articular foramen; art.g, articular groove; d.pr, dorsal process; l.s, longitudinal sulcus; md.pr, medial process. Scale bars: 10 mm.

Description. The supraoccipital (Fig. 4A, B) is thickened and externally ornamented by parallel grooves and ridges along the transverse midline; these incorporate distinct protuberances and notches laterally. The transverse midline axis is also pitted. Anteriorly, there is a noticeable projection for articulation with the frontals. Posteriorly, the articulation for the nuchal plate articulation is straight.

The right posttemporo-supracleithrum is 32 mm in length. It is triradiate in shape and ornamented externally by a coarse granular surface. The ventral ramus of the bone is bifurcated with an elongate process that articulates with the dorsal part of the cleithrum.

The dorsal spine is slightly curved in lateral view with a triangular cross-section. Its articular head is triangular in outline with prominent lateral wings. It is ornamented by subparallel ridges and sulci on both lateral surfaces. The outer edge has lower retrorse denticulations (directed to the apex of the spine), whereas the inner edge has antorse (directed to the base of the spine) medium denticulations. The articular foramen is circular in shape.

The pectoral spines (Fig. 4C–F) are slightly curved, flattened dorso-ventrally and robust. Their inner edges have antorse denticulations. The outer edges have small retrorse denticulations. The denticles are triangular and flattened antero-posteriorly. Both the dorsal and ventral surfaces bear coarse subparallel ridges and longitudinal sulci. The processes are not ornamented.

Comments. There are two extant species of *Pterodoras*: *P. rivasi* (Fernández-Yépez 1950) and *P. granulatus*. *Pterodoras rivasi* is distributed throughout the Orinoco basin, while *P. granulatus* is restricted to the Amazon, Paraná, Uruguay, Paraguay and Río de la Plata basins (Eschmeyer *et al.* 2016).

The oldest known doradid fossils derive from the middle Miocene La Venta Group in Colombia (Lundberg 1997). The family has also been reported from the Miocene Urumaco Formation in Venezuela (Sabaj *et al.* 2007), and Ituzaingó Formation in Argentina (Arratia & Cione 1996, Cione *et al.* 2000, 2013). The dermal bone ornamentation of the Salado River material is similar to that found in *Pterodoras granulatus*. The spines, in particular, display comparable size and denticulations.

DORADIDAE indet

Referred material. A frontal fragment (MFA-PV 1546), right cleithrum (MFA-PV 1565), and three incomplete pectoral spines (MFA-PV 1566, 1567, 1570).

Description. The frontal (MFA-PV 1546) is 39 mm in length, and noticeably thickened. Its external surface is ornamented by small ridges and parallel grooves, which are distinctive for this family. The right cleithrum (MFA-PV 1565) display similar external ornamentation, although this is restricted to its lower half. The inset articulation for the pectoral process of the dorsal spine is visible on the medial surface.

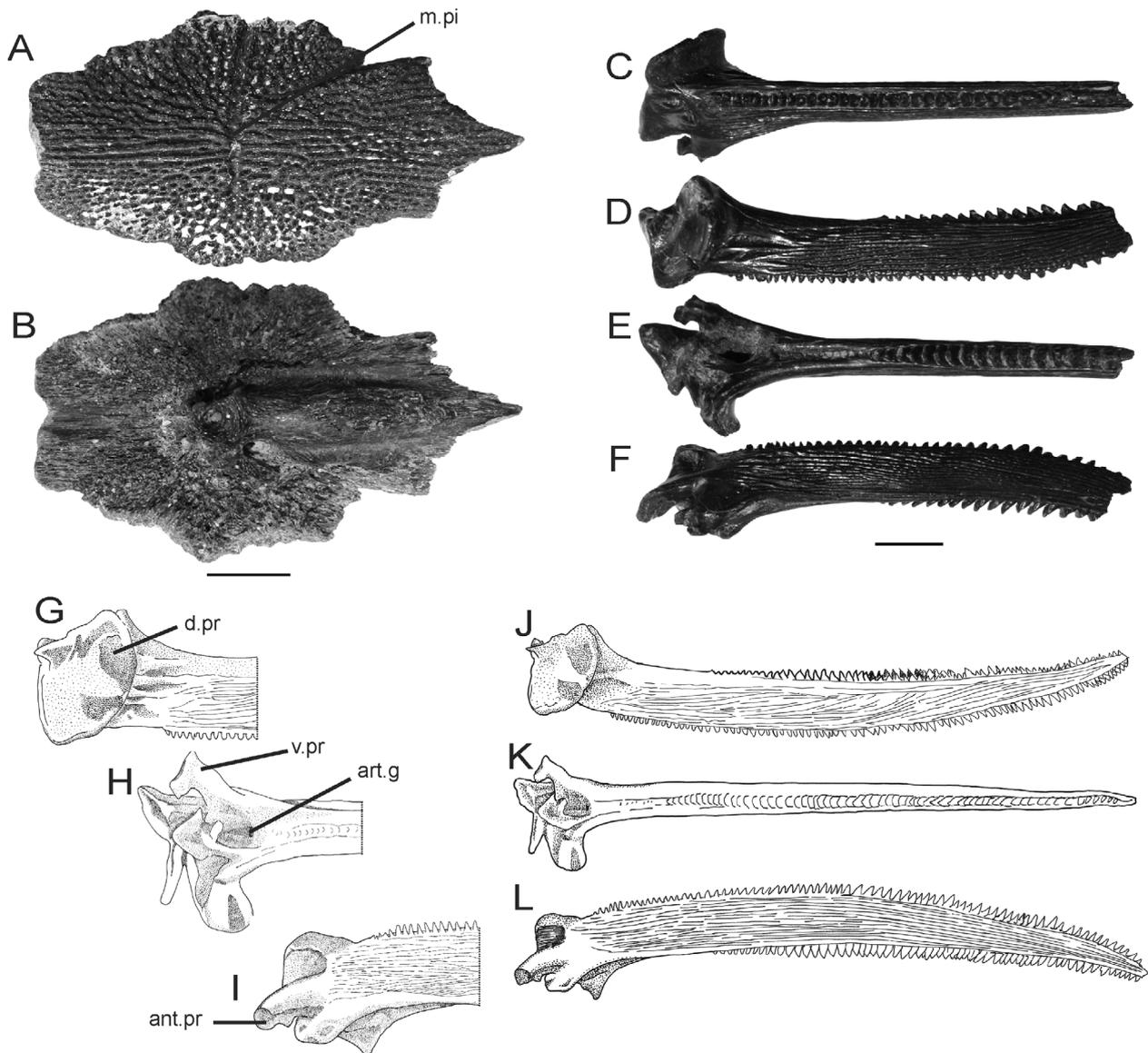


Fig. 4. *Pterodoras granulosis* (MFA-PV 1574) supraoccipital in dorsal (A), and ventral (B) views; left pectoral spine (MFA-PV 1568) in lateral (C), dorsal (D), medial (E), and ventral (F) views. Comparative material (MLP-V-P 22, 68) with details of articular region of pectoral spine in dorsal (G, J), medial (H, K), and ventral (I, L) views. Abbreviations: ant. pr, anterior process; art.g, articular groove; d.pr, dorsal process; m.pi, middle pitline; v.pr, ventral process. Scale bars: 10 mm.

The referred pectoral spines are robust and up to 24 mm in length. Their inner edges have antrorse denticulations, whereas their outer margins have small retrorse denticulations. All denticles are triangular. Coarse subparallel ridges and longitudinal sulci are present on the dorsal and ventral surfaces. The articular groove is circular in outline.

Comments. Nine extant doradid species currently occur in Argentina. The Salado River remains are comparable with all of these, but differ from the fin spines of locarids and calictids in their lack of odontodes; they also contrast with pimelodids in denticulation morphology. The lack of clearly diagnostic features on the dermal bones limits further taxonomic assignment.

PIMELODIDAE Lundberg & Littmann 2003

Pimelodus sp. cf. *P. maculatus* Lacépède 1803 (Fig. 5)

Referred material. Five left pectoral spines (MFA-PV 1553, 1575, 1579–1581).

Description. These spines (Fig. 5A) are slightly recurved in lateral view, and up to 35 mm in length. Their dorsal and ventral faces bear shallow longitudinal grooves. The articular groove is triangular in outline. The marginal denticles are smaller anteriorly but otherwise identical in morphology, being laterally flattened with non-bifurcate apices. They are largest along the posterior half of the spine and decrease in size towards the apex. The anterior margin has retrorse denticles that

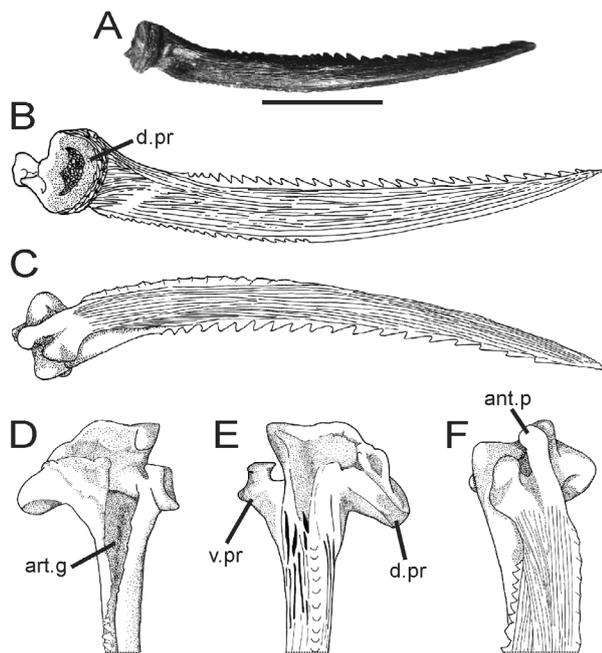


Fig. 5. *Pimelodus* sp. cf. *P. maculatus* (MFA-PV 1575) left pectoral spine in dorsal view (A). Drawing of comparative material (A) in dorsal (B), and ventral (C) views, and details of articular region in medial (D), anterior (E), and ventral (F) views. Abbreviations: ant. pr, anterior process; art.g, articular groove; d.pr, dorsal process; v.pr, ventral process. Scale bars: 10 mm.

do not extend beyond the mid-length of the spine; their distal half is occupied by a ridge of approximately equal height. The medial margin has small antrorse denticles.

Pimelodus* sp. cf. *P. albicans (Valenciennes 1840) (Fig. 6A–C)

Referred material. Two right pectoral spines (MFA-PV 1576, 1577), the distal end of a dorsal spine (MFA-PV 1582).

Description. The pectoral spines (Fig. 6A–C) are slightly recurved in lateral view and up to 45 mm long. Their dorsal and ventral faces are incised by shallow parallel grooves. The articular grooves are triangular in outline. The denticles are regular and retrorse anteriorly along proximal length of the spines, but become perpendicular towards the mid-length. The distal section bears a ridge of equal height to the denticulations. The medial margin bears antrorse denticles.

Comments. Eight species of *Pimelodus* are today found in Argentina: *P. absconditus* Azpelicueta 1995, *P. albicans*, *P. argenteus* Perugia 1891, *P. britskii* Garavello & Shibatta, 2007, *P. mysteriosus* Azpelicueta 1998, *P. ornatus* Kner 1858, *P. ortmanni* Haseman 1911 and *P. maculatus* (see Liotta 2006, Eschmeyer *et al.* 2016). Their pectoral and dorsal spine morphology is variable, but the Salado River specimens most closely resemble *P. maculatus* and *P. albicans*. Both of these species inhabit the Paraná, Paraguay, Uruguay and Río de la

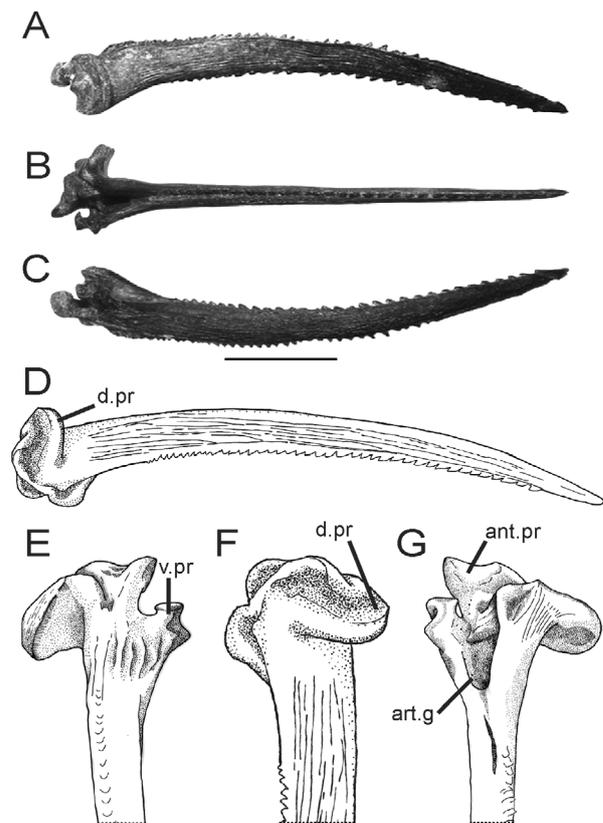


Fig. 6. *Pimelodus* sp. cf. *P. albicans* (MFA-PV 1576) right pectoral spine in dorsal (A), medial (B), and ventral (C) views. Drawing of comparative material (MLP-V-P 18) in dorsal (D, F), anterior (E), and medial (G) views. Abbreviations: ant. pr, anterior process; art.g, articular groove; d.pr, dorsal process; v.pr, ventral process. Scale bars: 10 mm.

Plata rivers basins. *Pimelodus maculatus* occupies lotic environments such as rivers and streams, and can migrate over short distances (Almirón *et al.* 2008). *Pimelodus albicans* is a benthopelagic fish within lotic and lentic environments, and also migrates between water courses (Agostinho *et al.* 2004).

The earliest records of *Pimelodus* are Paleogene in age (see Lundberg *et al.* 2010). The genus has also been documented from Miocene sediments in Argentina and Colombia (see Cione 1986, Lundberg *et al.* 2010). Remains identified as cf. *Pimelodus albicans* were found in the Pleistocene of Buenos Aires Province (Bogan *et al.* 2010).

Discussion

Palaeoenvironmentally, the Salado River fossil fish assemblage infers the presence of freshwater lagoons and deep canals within a warm-temperate climatic setting. This concurs with existing sedimentological evidence (see Geological settings) and the presence of semi-aquatic mammals (Vezzosi 2015), which include *Neochoerus* sp. Brisson 1762, *Hydrochoerus* sp. Hay 1926, and myocastorids indet. With the exception of *Neochoerus*, these taxa still inhabit the area today, and maintain comparable habitat preferences.

The Salado River siluriforms represent the first such occurrences from the Santa Fe Province, Argentina. The material can be attributed to four discrete taxa based on fin spines and dermal bone ornamentation, and all correlate with extant faunal representatives: cf. *Hypostomus* sp., *Pterodoras granulosus*, *Pimelodus* sp. cf. *P. maculatus* and cf. *P. albicans*. Concurrently, the occurrence of *Pterodoras granulosus* is the first fossil record of the genus, and of *Pimelodus maculatus* the first record of the species. This assemblage is significant because it constitutes the most diverse association of Pleistocene catfishes identified to date from southern South America, and is the first yet described from the southern Chaco Region, which is comparable with the northeastern Pampean Region (Iriondo 2010).

Lundberg *et al.* (2010) suggested that the Neotropical ichthyofauna of South America has maintained a largely stable taxonomic configuration since the Miocene. However, Cione *et al.* (2013) noted that several Miocene freshwater taxa have since become extinct (e.g., *Austroclupea* Bardack 1961; *Paleocichla* Casciotta & Arratia, 1993; *Megapiranha* Cione *et al.* 2009). This might reflect the profound geological and climatic events that affected terrestrial megafauna in the region during the Pleistocene (Clapperton 1993, Iriondo 1994, 1999, Cione *et al.* 2015); however, the persistence and distribution of coeval freshwater fish communities do not appear to have been substantially altered. This observation is consistent with the previous Pampean records including those of Chaco Region in Santa Fe Province, and might be related to aquatic buffering effects as well as the presence of permanent river basins such as the Paraná River (see Cione & Barla 1997, Cione *et al.* 2005), which were maintained even during arid cycles in the southwestern Mesopotamian and northern Pampean regions (Toledo *et al.* 2014, Brunetto *et al.* 2015).

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

- AGOSTINHO, A.A., GOMES, L.C.G., SUZUKI, H.I. & FERREIRA, J.H., 2004. Migratory fishes of the upper Paraná river basin, Brazil. In *Migratory Fishes of South America. Biology, fisheries, and conservation status*. CARLSFIELD, J., HARVEY, B., ROSS, C. & BAER, A., eds, World Fisheries Trust/Banco Mundial/IDRC 2004, Ottawa, 19–98.
- ALMIRÓN, A., AZPÉLICUETA, M., CASCIOTTA, J. & LÓPEZ CAZORLA, A., 1997. Ichthyogeographic boundary between the Brazilian and Austral subregions in South America, Argentina. *Biogeographica* 73, 23–30.
- ALMIRÓN, A., CASCIOTTA, J., CIOTEK, L. & GEORGIS, P., 2008. *Guía De Los Peces del Parque Nacional Pre-Delta*. Administración de Parques Nacionales, Buenos Aires, 215 pp.
- AMEGHINO, F., 1898. Sinopsis geológico-paleontológica de la Argentina. *Segundo Censo Nacional de la República Argentina, Territorio I*, 115–228.
- ARRATIA, G., 1997. Brazilian and Austral freshwater fish faunas of South America. A contrast. In *Tropical Biodiversity and Systematic*. ULRICH, H., ed. *Proceedings of the International Symposium on Biodiversity and Systematics in Tropical Ecosystems*, Museum Alexander Koenig, Bonn, 1994, 179–187.
- ARRATIA, G., 2003. The siluriform postcranial skeleton—An overview. In *Catfishes*. ARRATIA, G., KAPOOR, B.G., CHARDON, M. & DIEGO, R., eds, Science Publishers, Enfield, NH, & Plymouth, 121–157.
- ARRATIA, G. & CIONE, A.L., 1996. The fish fossil record of Southern South America. *Münchener Geowissenschaft Abhandlungen* 30, 9–72.
- AZPÉLICUETA, M.M., 1995. *Pimelodus absconditus*, a new species of pimelodid catfish from the La Plata basin (Siluriformes: Pimelodidae). *Ichthyological Exploration of Freshwaters* 6, 71–76.
- AZPÉLICUETA, M.M., 1998. A new species of *Pimelodus* (Siluriformes: Pimelodidae) from the Paraguay and lower Paraná rivers. *Neotropica* 44, 87–94.
- BARDACK, D., 1961. New Tertiary teleosts from Argentina. *American Museum Novitates* 2041, 1–27.
- BISBAL, G.A. & GÓMEZ, S., 1986. Morfología comparada de la espina pectoral de algunos Siluriformes bonaerenses (Argentina). *Physis* 44, 81–93.
- BLEEKER, P., 1858. *Ichthyologiae archipelagi Indici predromus, I. Siluri. De visschen van den Indischen Archipel. beschreven en toegelicht*. I. Siluri. Lange & Co., Batavia, 1–370 p. + index v–xii.
- BLOCH, M.E., 1795. *Naturgeschichte der ausländischen Fische*. Berlin. v. 9: i–ii + 1–192, Pls. 397–429. [Also a French edition, *Ichthyologie, ou Histoire naturelle des Poissons*, v. 12, published 1797.]
- BOGAN, S. & CENIZO, M.M., 2008. Sobre la presencia de un Sciaenidae (Teleostei: Perciformes) en el “Belgranense” (= Fm. Pascua, Pleistoceno Superior) de Centinela del Mar, Buenos Aires (Argentina). *Studia Geologica Salmanticensia* 44, 213–220.
- BOGAN, S. & DE LOS REYES, M.L., 2009. Primer registro fósil del género *Oligosarcus* Günther, 1864 (Teleostei: Characiformes). *Studia Geologica Salmanticensia* 45, 41–52.
- BOGAN, S., DE LOS REYES, M.L. & RAMÍREZ, J.L., 2008. Registros fósiles de “Viejas del Agua” (Teleostei: Siluriformes) del Pleistoceno Superior de la localidad de Salto, Buenos Aires, Argentina. *Studia Geologica Salmanticensia* 44, 203–212.
- BOGAN, S., DE LOS REYES, M.L. & CENIZO, M., 2009a. Primer registro del género *Jenynsia* Günther, 1866 (Teleostei: Cyprinodontiformes) en el Pleistoceno medio-tardío de la provincia de Buenos Aires (Argentina). *Papéis Avulsos de Zoologia* 49, 81–86.
- BOGAN, S., DE LOS REYES, M.L. & CENIZO, M., 2009b. Primeros registros fósiles de pejerreyes (Teleostei: Atheriniformes) en el Pleistoceno medio de la provincia de Buenos Aires, Argentina. *Revista Museo Argentino de Ciencias Naturales* 11, 185–192.
- BOGAN, S., AGNOLIN, F. & RAMÍREZ, J.L., 2010. Ictiofauna y herpetofauna del Pleistoceno Superior continental de la localidad de Salto, provincia de Buenos Aires, Argentina. *Studia Geologica Salmanticensia* 46, 83–97.
- BOGAN, S., ZURITA, A.E., MIÑO-BOILINI, A.R., SUÁREZ, P., FRIEDRICH, J., LUTZ, A.I. & FRIEDRICH, J., 2012. Primer registro de Synbranchiformes (Teleostei) para el Holoceno temprano de Argentina. *Revista Museo Argentino de Ciencias Naturales* 14, 41–45.
- BOULENGER, G.A., 1889. Description of a new snake and two new fishes obtained by Dr. H. Von Ihering in Brazil. *Annals and Magazine of Natural History* 22, 265–267.
- BRISSON, M.J., 1762. *Regnum animale in classes IX distributum, sive synopsis methodica*. T. Haak, Leiden, 296 pp.
- BRUNETTO, E., FERRERO, B.S. & NORIEGA, J.I., 2015. Late Pleistocene lithostratigraphy and sequences in the southwestern Mesopotamia (Argentina): evidences of the last interglacial stage. *Journal of South American Earth Sciences* 58, 111–128.

- CASCIOTTA, J.R. & ARRATIA, G., 1993. Tertiary cichlids from Argentina and reassessment of the phylogeny of New World cichlids (Perciformes: Labroidae). *Kaupia* 2, 195–240.
- CASCIOTTA, J.R., ALMIRÓN, A., CIONE, A.L. & AZPÉLICUETA, M.M., 1999. Brazilian freshwater fish assemblages from southern Pampean area, Argentina. *Biogeographica* 75, 67–78.
- CASCIOTTA, J., ALMIRÓN, A. & BECHARA, J., 2005. *Peces del Iberá. Hábitat y Diversidad*, Administración de Parques Nacionales, La Plata, 244 pp.
- CIONE, A.L., 1982. Peces del Pleistoceno tardío de la provincia de Buenos Aires. Consideraciones biogeográficas. *Circular informativa de la Asociación Paleontológica Argentina* 8, 12.
- CIONE, A.L., 1986. Los peces continentales del Cenozoico de Argentina. Su significación paleoambiental y paleogeográfica. 4º Congreso Argentino de Paleontología y Bioestratigrafía, Mendoza, Actas 2, 101–106.
- CIONE, A.L. & BÁEZ, A.M., 2007. Peces y anuros cenozoicos de Argentina: los últimos cincuenta años. *Publicación Especial de la Asociación Paleontológica Argentina* 11, 195–220.
- CIONE, A.L. & BARLA, M.J., 1997. A new locality for the synbranchid eel *Synbranchus marmoratus* (Teleostei: Percomorpha) in southern Buenos Aires province, Argentina. *Neotrópica* 43, 113–115.
- CIONE, A.L. & LÓPEZ-ARBARELLO, A., 1995. Los peces de agua dulce del área Pampeana. In *Registro continental de la evolución climática y biológica de los últimos 5 millones de años en el Hemisferio Norte (SO de Europa) y el Hemisferio Sur (Argentina)*. ALBERDI, M.T., LEONE, G. & TONNI, E.P., eds, Monografías CSIC, España, 12, 129–142.
- CIONE, A.L., AZPÉLICUETA, M.M., BOND, M., CARLINI, A.A., CASCIOTTA, J.R., COZZUOL, M.A., DE LA FUENTE, M., GASPARINI, Z., GOIN, F.J., NORIEGA, J., SCILLATO-YANE, G.J., SOIBELZON, L., TONNI, E.P., VERZI, D. & VUCETICH, G., 2000. Miocene vertebrates from Paraná, eastern Argentina. In *El Neógeno de Argentina*. ACEÑO-LAZA, F.G. & HERBST, R., eds, Volume 14. Serie Correlación Geológica, Tucumán, 191–237.
- CIONE, A.L., AZPÉLICUETA, M.M., CASCIOTTA, J.R. & DOZZO, M.T., 2005. Tropical freshwater teleosts from Miocene beds of eastern Patagonia, southern Argentina. *Geobios* 38, 29–42.
- CIONE, A.L., DAHDUL, W., LUNDBERG, J. & MACHADO-ALLISON, A., 2009. *Megapiranha paranensis*, a new genus and species of Serrasalminae (Characidae, Teleostei) from the Upper Miocene of Argentina. *Journal of Vertebrate Paleontology* 29, 350–358.
- CIONE, A.L., CABRERA, D.A., AZPÉLICUETA, M.M., CASCIOTTA, J.R. & BARLA, M.J., 2013. Peces del Mioceno marino y continental de Entre Ríos, oriente central de Argentina. In *El Neógeno de la Mesopotamia argentina*. BRANDONI, D. & NORIEGA, J.I., eds, Volume 14 Asociación Paleontológica Argentina, Publicación especial, 71–83.
- CIONE, A.L., GASPARINI, G.M., SOIBELZON, E., SOIBELZON, L.H. & TONNI, E.P., 2015. *The Great American Biotic Interchange. A South American perspective*. Springer Briefs South America and the Southern Hemisphere, 97 pp. doi 10.1007/978-94-017-9792-4
- CLAPPERTON, C.M., 1993. *Quaternary geology and geomorphology of South America*, Elsevier, Amsterdam, 779 pp.
- DESMAREST, A.G., 1823. Première Décade Ichthyologique, ou, Description complète de dix espèces de poissons nouvelles, ou imparfaitement connues, habitant la mer qui baigne les côtes de l'île de Cuba. *Mémoires de la Société linnéenne de Paris* 2, 163–210.
- DIOGO, R., OLIVEIRA, C. & CHARDON, M., 2001. On the osteology and myology of catfish pectoral girdle, with a reflection on catfish (Teleostei: Siluriformes) plesiomorphies. *Journal of Morphology* 249, 100–125.
- EIGENMANN, C.H., 1917. The American Characidae. *Memoirs of the Museum of Comparative Zoology (Harvard University)* 43, 1–102.
- ESCHMEYER, W.N., FRICKE, R. & VAN DER LAAN, R., 2016. *Catalog of Fishes: Genera, Species, References*. <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp> (accessed 22.12.2016).
- EVERMANN, B.W. & KENDALL, W.C., 1906. Notes on collection of fishes from Argentina, South America, with descriptions of three new species. *Proceedings of the United States National Museum* 31, 67–108.
- FERNÁNDEZ-YÉPEZ, A., 1950. Algunos peces del río Autana. *Novedades Científicas. Contribuciones Ocasionales del Museo de Historia Natural La Salle* 682, 1–18.
- GARAVELLO, J.C. & SHIBATTA, O.A., 2007. A new species of the genus *Pimelodus* La Cépède, 1803 from the rio Iguacu basin and a reappraisal of *Pimelodus ortmanni* Haseman, 1911 from the rio Paraná system, Brazil (Ostariophysi: Siluriformes: Pimelodidae). *Neotropical Ichthyology* 5, 285–292.
- GILL, T.N., 1861. Synopsis of the subfamily of Clupeinae, with descriptions of new genera. *Proceedings of the Academy of Natural Sciences of Philadelphia* 13, 33–38.
- GRANDE, L., 1987. Redescription of *Hypsidoris farsonensis* (Teleostei: Siluriformes), with a reassessment of its phylogenetic relationships. *Journal of Vertebrate Paleontology* 7, 24–54.
- GÜNTHER, A., 1864. Catalogue of the fishes in the British Museum. Catalogue of the Physostomi, containing the families Siluridae, Characidae, Haplochitonidae, Sternoptychidae, Scopelidae, Stomatidae in the collection of the British Museum. *Catalogue of Fishes* 5, 1–455.
- GÜNTHER, A., 1866. Catalogue of fishes in the British Museum. Catalogue of the Physostomi, containing the families Salmonidae, Percopsidae, Galaxidae, Mormyridae, Gymnarchidae, Esocidae, Umbridae, Scombroideae, Cyprinodontidae, in the collection of the British Museum. *Catalogue of Fishes* 6, 1–368.
- HASEMAN, J.D., 1911. Some new species of fishes from the rio Iguassú. *Annals of the Carnegie Museum* 7, 374–387.
- HAY, P.O., 1926. A collection of Pleistocene vertebrates from southwestern Texas. *Proceedings of the U.S. National Museum* 68, 1–18.
- IRIONDO, M.H., 1994. Los climas cuaternarios de la región pampeana. *Comunicaciones del Museo Provincial de Ciencias Naturales Florentino Ameghino* 4, 1–48.
- IRIONDO, M.H., 1999. Climatic changes in the South American plains: records of a continent-scale oscillation. In *Quaternary Palaeoclimates of Southern Hemisphere*. PARTRIDGE, T., KERSHAW, A. & IRIONDO, M., eds., *Quaternary International* 57/58, 93–112.
- IRIONDO, M.H., 2010. *Geología del Cuaternario de Argentina*. Museo Provincial de Ciencias Naturales “Florentino Ameghino”. *Moglia Ediciones* 437 pp.
- JENYNS, L., 1842. Fish. In *The zoology of the voyage of H. M. S. Beagle, under the command of Captain Fitzroy, R. N., during the years 1832 to 1836*. London, UK, Smith, Elder, & Co., Issued in 4 parts. Fish, Voyage Beagle: i-xvi + 1–172, Pls. 1–29, 115–117.
- KNER, R., 1858. Ichthyologische Beiträge. II. Abtheilung. Sitzungsberichte der kaiserlichen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse 26, 373–448.
- KRÖHLING, D.M., 1999. Upper Quaternary geology of the lower Carcarañá Basin. North Pampa, Argentina. *Quaternary International* 57–58, 135–148.
- KRÖHLING, D.M. & IRIONDO, M.H., 1999. Upper Quaternary Paleoclimates of the Mar Chiquita area. North Pampa, Argentina. *Quaternary International* 57, 149–163.
- LACÉPÈDE, B.G.E., 1803. Histoire naturelle des poissons, par le citoyen La Cépède, membre de l'Institut National, et Professeur du Museum d'Histoire Naturelle 1798–1803. Paris 5 (1), i–lxviii, 1–803.
- LINNAEUS, C., 1758. *Systema natura per regna tria naturae secundum classes, ordines, genera, species, cum characteribus, differentiis, locis*. 10th ed., L. Salvii, Stockholm, 1, 1–824.
- LINNAEUS, C., 1766. *Systema naturae sive regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Laurentii Salvii, Holmiae. 12th ed., 1, 1–532.
- LIOTTA, J., 2006. *Distribución geográfica de los peces de agua continentales de la Argentina*. ProBiota, Serie Documentos 3, 701 pp.
- LUNDBERG, J., 1997. Fishes of the La Venta fauna: additional taxa, biotic and paleoenvironmental implications. In *Vertebrate paleontology in the Neotropics. The Miocene fauna of La Venta*, Colombia. KAY, R.F., MADDEN, R.L., CIFELLI, R.H. & FLYNN, J.J., eds, Smithsonian Institution Press, Washington D.C., 67–91.
- LUNDBERG, J. & LITTMANN, M.W., 2003. Family Pimelodidae (long-whiskered catfishes). In *Check List of the Freshwater Fishes of South and Central America*. REIS, E.R., KULLANDER, S.O. & FERRARIS, C. Jr, eds, Edipucrs, Porto Alegre, 432–446.

- LUNDBERG, J., SABAJ PÉREZ, M.H., DAHDUL, W.M. & AGUILERA, O., 2010. The Amazonian Neogene fish fauna. In *Amazonia: Landscape and Species Evolution. A Look into the Past*, 1st Edition. HOORN, C. & WESSELINGH, F., eds, Wiley-Blackwell, Chichester, UK, 281–300.
- LÜTKEN, C.F., 1874. Siluridae novae Brasiliae centralis a clarissimo J. Reinhardt in provincia Minas-geraës circa oppidulum Lagoa Santa, praecipue in flumine Rio das Velhas et affluentibus collectae, secundum caracteres essentialia, breviter descriptae. *Översigt over Selskabets virksomhed, Kongelige Danske Videnskaberne selskab. Kjobenhavn 1873*, 29–36.
- MALABARBA, M.C.S.L., 1988. Loricariid termal plate and pectoral fin spines (Osteichthyes, Siluriformes). *Comunicações do Museu de Ciências da PUCRS, Série Zoologia* 5, 1–5.
- MALABARBA, M.C.S.L. & LUNDBERG, J.G., 2007. A fossil loricariid catfish (Siluriformes: Loricarioidea) from the Taubate Basin, eastern Brazil. *Neotropical Ichthyology* 5, 263–270.
- NELSON, J., GRANDE, T. & WILSON, M., 2016. *Fishes of the World*. Fifth edition. John Wiley & Son, Inc., Hoboken, New Jersey, 752 p.
- OWEN, R., 1837. A description of the cranium of the *Toxodon platensis*, a gigantic extinct mammiferous species, referrible by its dentition to the Rodentia, but with affinities to the Pachydermata and the herbivorous Cetacea. *Proceedings of the Geological Society of London* 2, 541–542.
- OWEN, R., 1839. Fossil Mammalia (3). In *The Zoology of the Voyage of H.H.M.S. Beagle*, Smith, Elder & Co., London, UK, 65–80.
- OWEN, R., 1845. *Descriptive and Illustrated Catalogue of the Fossil Organic Remains of Mammalia and Aves Contained in the Museum of the Royal College of Surgeons of England*. pp. vii + 1–391, láms. 1–10. R. and E. Taylor, London, 391 pp.
- PARDIÑAS, U.F.J., GELFO, J., SAN CRISTÓBAL, J., CIONE, A.L. & TONNI, E.P., 1996. Una tafocenosis de organismos marinos y continentales en el Pleistoceno superior en el sur de la provincia de Buenos Aires. *13º Congreso Geológico Argentino y 2º Congreso de Exploración de Hidrocarburos (Buenos Aires)*, *Actas* 5, 95–111.
- PATTERSON, C., 1975. The distribution of Mesozoic freshwater fishes. *Memoires du Museum nationale d'Histoire naturelle, Paris* 88, 156–173.
- PERUGIA, A., 1891. Appunti sopra alcuni pesci sud-americani conservati nel Museo Civico di Storia Naturale di Genova. *Annali del Museo Civico di Storia Naturale 'Giacomo Doria' 10*, 605–657.
- QUOY, J.R.C. & GAIMARD, J.P., 1824–25. Description des Poissons. Chapter IX. In *Voyage autour du Monde...exécuté sur les corvettes de L. M. "L'Uranie" et "La Physicienne," pendant les années 1817, 1818, 1819 et 1820*. FREYCINET, L. DE, eds. Chez Pillet Aîné, Paris, 192–401. [1–328 in 1824; 329–616 in 1825], Atlas pls. 43–65.
- RAFINESQUE, C.S., 1815. *Analyse de la Nature, ou Tableau de l'Univers et des Corps Organisés*. Palermo, 224 pp.
- RINGUELET, R.A., 1975. Zoogeografía y ecología de los peces de aguas continentales de la Argentina y consideraciones sobre las áreas ictiológicas de América del Sur. *Ecosur* 2, 1–122.
- SABAJ, PÉREZ M.H., AGUILERA, O.A. & LUNDBERG, J.G., 2007. Fossil catfishes of the families Doradidae and Pimelodidae (Teleostei: Siluriformes) from the Miocene Urumaco Formation of Venezuela. *Proceedings of the Academy of Natural Sciences of Philadelphia* 156, 157–194.
- TOLEDO, M.J., SCHEWENNINGER, J.L., KINOSHITA, A., BAFFA, O. & MANGINI, A., 2014. Dataciones OSL, ESR y U-Th del sitio paleontológico Spósito (San Pedro, provincia de Buenos Aires). Registro de los OIS 6/7 Y OIS 5. Geología del Cuaternario, Geomorfología y Cambio Climático. *XIX Congreso Geológico Argentino (Córdoba)*, *Actas* 513, 6.
- VALENCIENNES, A., 1821. *Histoire Naturelle des Poissons*. Paris, vol. XV, 145–224.
- VALENCIENNES, A., 1836. Poissons. In *Voyage dans L'Amérique Méridionale (le Brésil, la République Orientale de l'Uruguay, la République Argentine, la Patagonie, la République du Chili, la République de Bolivia, la République du Pérou), exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1832 et 1833*. D'ORBIGNY A, ed, Bertrand et Levrault, Paris, Pls. 4–7.
- VALENCIENNES, A., 1840. *Histoire naturelle des poissons. Siluroïdes* 14:1–xxxii.
- VALLONE, E.R., 2015. *Los peces continentales del Cuaternario de Argentina. Su importancia para la comprensión del origen de la ictiofauna actual del área austral de América del Sur*. PhD thesis, Universidad Nacional de La Plata, Buenos Aires, 262 pp. (unpublished)
- VEZZOSI, R.I., 2015. *Diversidad de los mamíferos del Pleistoceno de la Provincia de Santa Fe, Argentina: aspectos taxonómicos, bioestratigráficos y paleobiogeográficos relacionados*. PhD thesis, Universidad Nacional de La Plata, Buenos Aires, 870 pp. (unpublished).