

Short communication

A new species of the genus *Echinorhinus* (Chondrichthyes, Echinorhiniformes) from the upper cretaceous of southern South America (Argentina-Chile)



Sergio Bogan ^{a, *}, Federico L. Agnolin ^{a, b}, Rodrigo A. Otero ^c, Federico Brissón Egli ^{b, d}, Mario E. Suárez ^c, Sergio Soto-Acuña ^c, Fernando E. Novas ^{b, d}

^a Área Paleontología, Fundación de Historia Natural 'Félix de Azara', Departamento de Ciencias Naturales y Antropología, Universidad Maimónides, Hidalgo 775 piso 7 (C1405BDB), Buenos Aires, Argentina

^b Laboratorio de Anatomía Comparada y Evolución de los Vertebrados, Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Av. Ángel Gallardo, 470 (C1405DJR), Buenos Aires, Argentina

^c Red Paleontológica U-Chile, Laboratorio de Ontogenia y Filogenia, Departamento de Biología, Facultad de Ciencias, Universidad de Chile, Las Palmeras, 3425, Santiago, Chile

^d Comisión Nacional de Investigaciones Científicas y Técnicas, Argentina

ARTICLE INFO

Article history:

Received 14 November 2016

Received in revised form

11 May 2017

Accepted in revised form 19 May 2017

Available online 19 May 2017

Keywords:

Echinorhinus

Argentina

Chile

Cretaceous

ABSTRACT

We describe isolated shark teeth collected from levels of the Calafate Formation at the SE coast of the Argentino Lake, Calafate city, Santa Cruz province, Argentina (Atlantic Ocean), and from the Algarrobo coast at the Valparaíso Region in central Chile (Pacific Ocean). The teeth belong to a new species of the echinorhiniform genus *Echinorhinus*. *Echinorhinus maremagnum* n. sp. was a taxon distributed in both the southwestern Atlantic and the southeastern Pacific. This new taxon constitutes the oldest record of echinorhiniforms from South America and one of the few Mesozoic records at a worldwide scale.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Most of the Cretaceous chondrichthyan record from southern South America is restricted to pioneering mentions made by the paleontologist Florentino Ameghino (1893, 1901, 1906). The specimens reported by Ameghino are mostly doubtful, while several taxa were never figured, making difficult any current reassessment. Further, Ameghino's works on chondrichthyans have not been reviewed up to date, except comments made by Arratia and Cione (1996). In addition to Ameghino's early records, the Mesozoic chondrichthyans record from Argentina and Chile was recently improved with new contributions (Otero and Suárez, 2008; Suárez and Otero, 2008; Bogan and Agnolin, 2010; González Riga et al., 2010; Bogan and Gallina, 2011; Cione et al., 2013; Otero et al., 2013; Bogan et al., 2016).

Living bramble sharks (Echinorhiniformes) are represented by a single genus *Echinorhinus* with two species, *E. cookei* Pietschmann, 1928 and *E. brucus* Bonaterre, 1788. These are distributed mainly along the Pacific (including Chile) and the Atlantic (including Argentina) and Indian oceans (Bass and Compagno, 1986). The fossil record of the entire clade is patchy, as teeth of echinorhiniforms are notably scarce in most fossil sites (Adnet et al., 2012). The oldest record for the clade belongs to the extinct species *E. vielhus* (Guinot et al., 2014) from the Lower Cretaceous (Valanginian) of France. A still unnamed species of the genus *Echinorhinus* is also known from the Lower Cretaceous (Hauterivian) of France (Adnet et al., 2012).

In South America, Neogene records are restricted to the extinct species *Echinorhinus pozzi* from the Miocene of Argentina (Ameghino, 1906; Pfeil, 1983; Arratia and Cione, 1996; Cione et al., 2011), and *Echinorhinus aff. cookei* from the Pliocene of Chile (Suárez, 2015). These records belong to the modern-like morphotypes in which each tooth has several additional cusplets (Pfeil, 1983).

* Corresponding author.

E-mail address: sergiobogan@yahoo.com.ar (S. Bogan).

Fossils belonging to *Echinorhinus* in the Paleogene of South America are still wanting. However, three isolated localities from the uppermost Cretaceous of Chile and Argentina have yielded teeth belonging to this genus (Otero and Suárez, 2008; Bogan et al., 2016). All these specimens belong to a new unnamed species. The aim of the present contribution is to describe this new taxon, which corresponds to the oldest described species in the South American continent.

2. Material and methods

2.1. Locality and horizon—Argentina

The fossiliferous locality corresponds to the southern margin of the Argentino Lake, approximately 500 m north from the International Airport of El Calafate city (S 50° 16' 09"; W 72° 02' 39") (Fig. 1).

The specimens were found at the upper levels of the Calafate Formation (upper Maastrichtian; Upper Cretaceous), which are dominated by sandstones with occasional beds of conglomerates and very few mudstones, showing a typically greenish coloration (Marensi et al., 2004). The greenish color of the strata is mainly

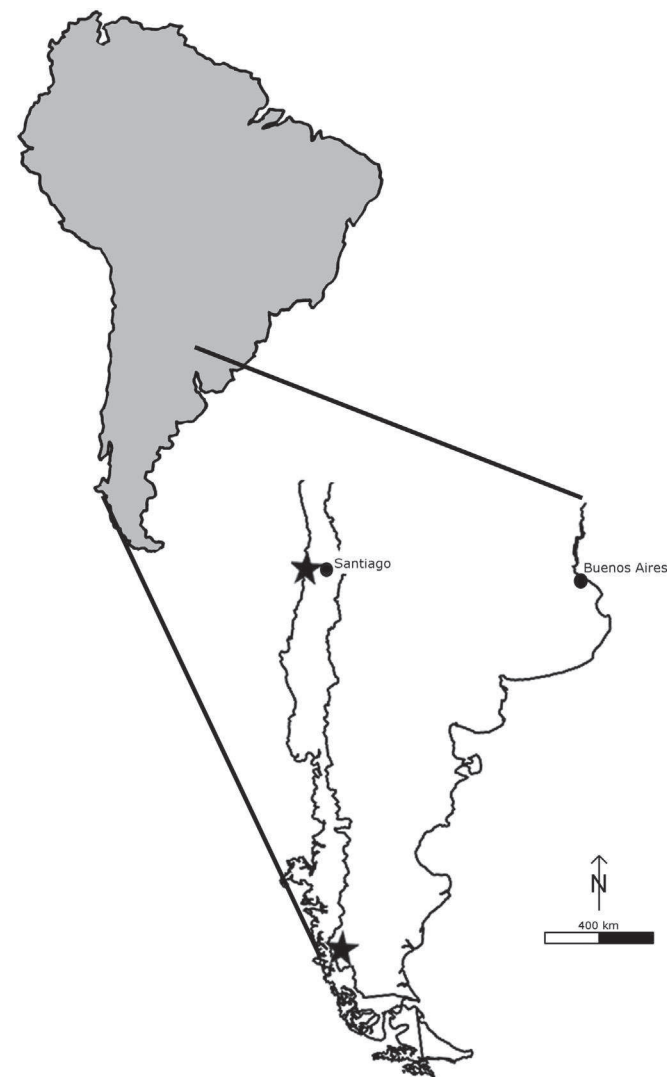


Fig. 1. Map of southern South America showing the fossiliferous localities where the *Echinorhinus maremagnum* were found. The star indicate the fossiliferous sites.

due to the abundance of glauconite, a filossilicate that is in accordance with the marine genesis of this sedimentary unit (Arbe and Hechem, 1984). The Calafate Formation is considered as mainly representing inter-to sub-tidal deposits under an estuarine regime (Arbe and Hechem, 1984). The unit is considered as part of the Austral Basin (Spalletti and Franzese, 2007).

The new *Echinorhinus* here reported was found in close association with a partial skeleton of a large elasmosaurid plesiosaur (Novas et al., 2011) and several shark species, including *Protosqualus argentinensis* (Bogan et al., 2016), *Notidanodon dentatus* (Bogan et al., 2016), and *Cretalamna appendiculata* (MPM-PV 10045).

2.2. Chile

The material from Chile was collected from the locality of Algarrobo, in the Valparaíso Region (Fig. 1). Fossil-bearing levels are part of the unit Estratos de Quebrada Municipalidad (Gana et al., 1996). This comprises ca. 40 m of transgressive-regressive coastal sediments. At least three levels have yielded chondrichthyan remains, among them, one level from the mid section (level 7 in Otero et al., 2012: fig. 2) hosted four isolated teeth referable to the genus *Echinorhinus* which are studied here. The age of the Estratos de Quebrada Municipalidad is currently considered to be early Maastrichtian based on biostratigraphy (Levi de Valenzuela and Aguirre, 1962; Perez D' and Reyes, 1978; Tavera, 1980) and radioisotopic dates (Gana et al., 1996; Suárez and Marquardt, 2003).

2.3. Sampling method

All the specimens described here coming from the Calafate fossiliferous site were found in the laboratory during the preparation of a very large elasmosaurid plesiosaur (Novas et al., 2011). The specimens were found with the naked eye and picked by the technicians who mechanically prepared the fossil sauropterygian. Because the rock is strongly consolidated and forms a very hard sedimentary unit, and the plesiosaur was found under the water level of the lake, more precise collecting techniques, screen-washing, or sedimentary sieving were not possible. This methodology resulted in the finding of a diverse shark assemblage, including four different taxa. These taxa were described in detail by Bogan et al. (2016). In such contribution, Bogan et al. (2016) described and figured part of the materials belonging to the *Echinorhinus* species here analyzed. However, those teeth were incompletely preserved and do not permitted to recognize main anatomical features of the *Echinorhinus* species recovered. Technical preparation of the last unprepared portion of the elasmosaur skeleton resulted in the finding of more teeth, including complete specimens that allowed the recognition of key features of the new *Echinorhinus* species.

On the other hand, additional specimens of *Echinorhinus* coming from Chile outcrops were found in additional field trips to the area, through prospecting the sediments with the naked eye, as well as more detailed revisions of the collections deposited at the SGO.PV collections.

2.4. Anatomical terminology and taxonomical nomenclature

The present paper follows the dental terminology employed by Cappetta (2012). The general taxonomic nomenclature follows Pfiel (1983).

2.5. Institutional abbreviations

MPM, Museo Padre Molina, Río Gallegos city, Santa Cruz province, Argentina. SGO.PV., Área de Paleontología, Museo Nacional de Historia Natural, Santiago, Chile.

3. Systematic paleontology

Class Chondrichthyes Huxley, 1880

Subclass Elasmobranchii Bonaparte, 1838

Order Echinorhiniformes de Buen, 1926

Family Echinorhinidae Gill, 1862

Genus *Echinorhinus* de Blainville, 1816

Echinorhinus maremagnum n. sp.

Figs. 2–3

Echinorhinus sp.: Otero and Suárez, 2008. (Pp 76, Fig. 3)

Echinorhinus sp.: Bogan et al., 2016. (Pp 6, Fig 5)

Holotype. MPM-PV 10046, complete posterolateral tooth

Paratypes. MPM 10034, incomplete lateral tooth; MPM 10035, incomplete lateral tooth. MPM 10036, lateral tooth lacking the apex of the main cusp; MPM-PV 10047, incomplete anterolateral tooth; MPM-PV 10048, incomplete anterolateral tooth.

Referred material. SGO.PV.6764, lateral tooth; SGO.PV.6630, lateral tooth lacking part of the root and distal tip of main cusp; SGO.PV.6632, incomplete anterolateral tooth; and SGO.PV.6631 incomplete lateral tooth.

Locality and horizon. MPM-PV 10046 (holotype), MPM 10034, MPM 10035, MPM 10036, MPM-PV 10047, MPM-PV 10048 (paratypes); southern margin of the Argentino Lake, southern Argentina. Upper levels of the Calafate Formation, upper Maastrichtian. SGO.PV.6764, SGO.PV.6630, SGO.PV.6632, and SGO.PV.6631, Algarrobo, central Chile. Estratos de Quebrada Municipalidad unit, lower Maastrichtian, bed 7.

Etymology. *maremagnum*, from the Latin, meaning great sea.

Diagnosis. Species of the genus *Echinorhinus* with very large teeth (maximum length of 1.5 cm), showing the following unique combination of characters: anterolateral teeth with main cusp that does not overhang or barely reaches the level of the distal rear of the tooth root; deeply crenulated mesial cutting edge; distal heel tall and convex; total absence of additional cusplets; and, root with a subvertically oriented nutritious groove in lingual view.

Description. The specimens described here represent a large-sized *Echinorhinus* species (width of the holotype 1.5 cm). The available teeth show a single main cusp, and there is no evidence of additional cusplets even in the larger teeth, which represent older

ontogenetic dental stages. The crown of posterolateral teeth exhibits a single main cusp that is highly compressed labiolingually and distally recurved. Its tip slightly overhangs the distal part of the root. Additional cusplets are totally absent. The crown (including the main cusp) possesses a nearly straight and crenulated mesial cutting edge. In all the studied teeth, the distal cutting edge is smooth, lacking any sign of crenulation or denticles. The distal heel is high, and shows a convex cutting edge, which, in some specimens, exhibits a weakly crenulate margin. The enameloid of the cusp is smooth. The crown-root boundary is nearly straight, and shows an enameloid that is slightly rounded on the lingual face.

The root is high and strongly labiolingually compressed. The root is simple, of anaulacorhize type (Cappetta, 1987) with vertically oriented striae on the labial side. There is a well-defined nutritious groove displaced towards the distal third of the root.

Anterolateral teeth differ from posterolateral teeth in being relatively higher. The main cusp is distally inclined, but its tip does not overhang the distal level of the root. The mesial cutting edge is gently sigmoidal, being slightly concave near the base of the cusp, and becoming slightly convex towards the distal tip. They show a high distal heel. There is a well-defined nutritious groove located roughly at the centre of the root.

4. Discussion

The scarcity in echinorhinid fossil remains may be a result of the ecological restriction of members of this family (Adnet et al., 2012). The evolutionary history of echinorhinids is incompletely known because of their poor fossil record and lack of understanding of their dental evolution.

The oldest reports for *Echinorhinus* comprise several teeth coming from the Valanginian and upper Hauterivian of France (Adnet et al., 2012; Guinot et al., 2014). Late Early Cretaceous records belong to the Gondwanan species *E. australis* from the Aptian-Albian of Australia (Chapman, 1908; Herman, 1975; Kemp, 1991; Pledge, 1992; Siverson, 1997; Cappetta, 2012), and possible echinorhinids from Albian-Cenomanian of England (Underwood and Mitchell, 1999). In addition, coming from the Upper Cretaceous of Australia and Angola, the species *E. eyrensis* (Pledge, 1992)

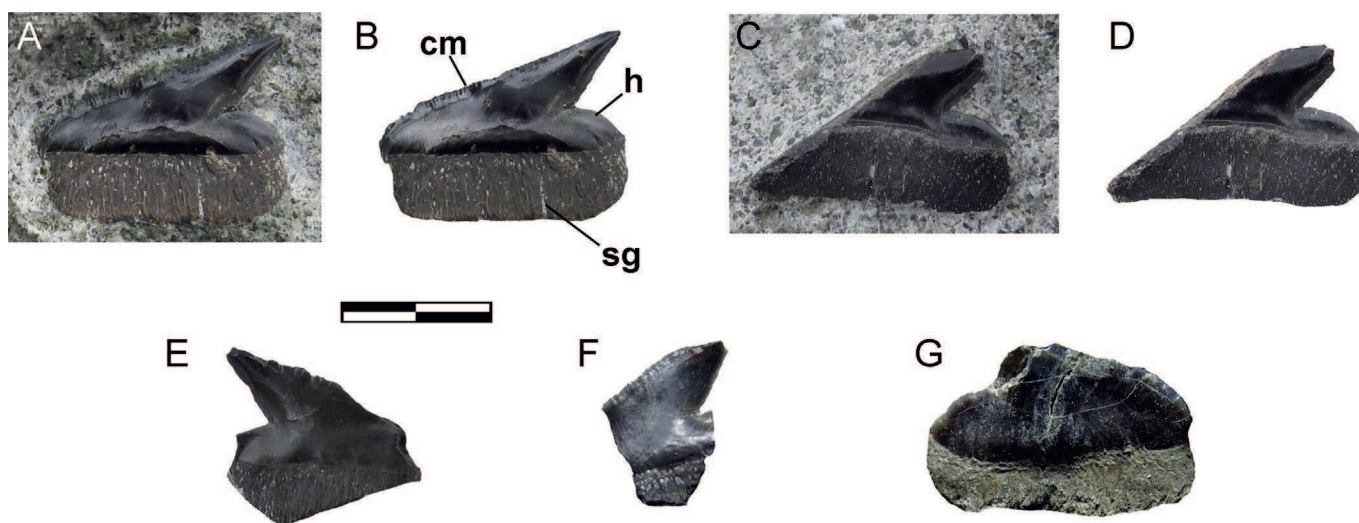


Fig. 2. *Echinorhinus maremagnum* nov.sp. Selected teeth from Argentina: A–B, posterolateral tooth (Holotype, MPM 10046) in labial view; C–D, incomplete lateral tooth (MPM 10048) in labial view; E, incomplete anterolateral tooth (MPM-PV 10047) in lingual view; F, incomplete anterolateral tooth (MPM-PV 10034) in lingual view; G, lateral tooth (MPM 10036) in lingual view. References: cm, crenulate mesial margin; h, distal heel; sg, subvertical groove. Scale bar equals 1 cm.

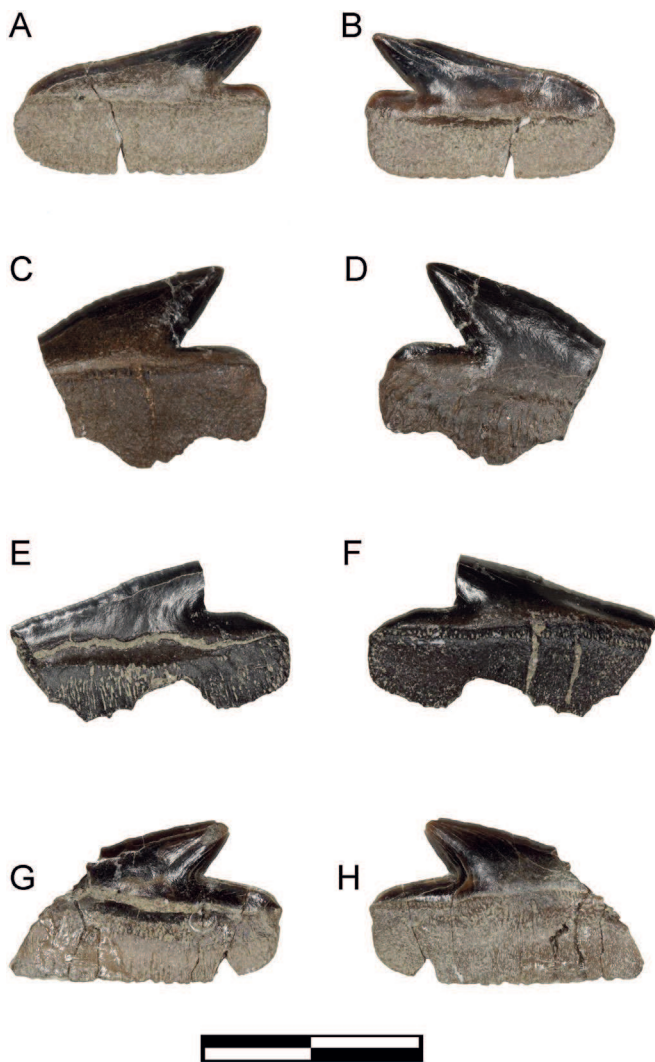


Fig. 3. *Echinorhinus maremagnum* nov.sp. Selected teeth from Chile: A–B, lateral tooth (SGO.PV.6764) in A, lingual, and B, labial views; C–D, anterolateral tooth (SGO.PV.6632) in C, lingual and B, labial views; E–F, lateral tooth (SGO.PV.6630) in E, labial, and F, lingual views; and G–H, lateral tooth (SGO.PV.6631) in G, labial and H, lingual views. Scale bar equals 1 cm.

and *E. lapaoui* (Antunes and Cappetta, 2002) were described, respectively. Finally, Kitamura (2013) described the species *E. wadanohanaensis* from the Upper Cretaceous of Japan. To this meager list we add the presence of the large echinorhinid *E. maremagnum* in southern South America, representing one of the oldest records for the order Echinorhiniformes in this continent.

The specimens here described are unequivocally referable to the genus *Echinorhinus* by having transversally compressed crown and root, anaulacorhize root, and a strong distal orientation of the main cusp (Pfeil, 1983; Cappetta, 2012). Within *Echinorhinus*, the large size of the available teeth and the presence of a single cusp in the crown resemble the morphology seen in several basal Cretaceous and Paleogene species of the genus, being different from derived multi-cusped taxa (e.g., *E. wadanohanaensis*, *E. eyrensis*, *E. blakei*, *E. pozzii*; Pledge, 1992; Purdy et al., 2001; Kitamura, 2013). In this sense, the common absence of cusplets in all Cretaceous species of *Echinorhinus*, plus the lack of cusplets in young replacement teeth of extant species *E. brucus* and *E. cookei*, strongly supports the appearance of cusplets as a derived trait (Pfeil, 1983).

In this way, comparison of the new *Echinorhinus* species is focused on basal species. Among them, most Cretaceous and early Cenozoic taxa (e.g., *E. vielhus*, *E. lapaoui*, *E. australis*, *E. schoenfeldi*), differ which *E. maremagnum* by their much smaller size. Further, the Paleogene species *E. pfauntschi*, *E. priscus*, and *E. schoenfeldi* differ by having an additional cusplet, a relatively low distal heel that do not conforms a gibbosity, and strongly sigmoidal and irregular contact between root and crown (Pfeil, 1983). In size and morphology, *Echinorhinus maremagnum* is similar to the Palaeogene species *E. weltoni* (Pfeil, 1983; Adnet et al., 2012; Bogan et al., 2016). However, it differs from the latter in the presence of a well-developed transverse groove with nutritive foramina (Adnet et al., 2012), a feature widespread in younger species, including living ones (Pfeil, 1983). In addition, in *E. weltoni*, the contact between the root and the crown is not straight, the distal heel is not crenulated, and shows a rudimentary additional cusplet which is totally absent in *E. maremagnum*. In addition, *E. maremagnum* is clearly distinguishable from the Australian species *E. eyrensis* in being single-cusped and by having a main cusp with crenulated mesial cutting edge (Pledge, 1992).

On the other side, *Echinorhinus maremagnum* may be included within single-cusped *Echinorhinus* species, mainly restricted to Cretaceous strata. The specimens here described resemble *E. australis*, from the Cretaceous of Australia, because they share a similar cusp and root morphology, and by the presence of crenulated mesial margin of the teeth (Chapman, 1908). However, *E. maremagnum* differs from the latter in lacking crenulated distal cutting edges. In addition, one of the specimens (MPM 10036) exhibits a higher crown with rounded edges, a condition absent in the available teeth of *E. australis* figured by Chapman (1908) and Kemp (1991). The distal tip of the main cusp in *E. australis* notably overhangs the distal level of the root, a condition different from that described in *E. maremagnum* in which the cusp does not reaches such level, or only slightly overhangs it.

Furthermore, *E. maremagnum* differs from species *E. vielhus* from the Valanginian of France by their much larger size, apico-basally lower root, less distally inclined main cusp, and serrated cutting edges (Guinot et al., 2014). From *E. wadanohanaensis*, it differs in having notably higher teeth, poorly distally inclined main cusp, and serrated cutting edges (Kitamura, 2013). *E. maremagnum* further differs from the late Campanian–early Maastrichtian species *E. lapaoui* in having a shorter main cusp with a crenulated mesial margin, and in lacking a convexity on the mesial cutting edge (Antunes and Cappetta, 2002). It also differs from *E. lapaoui* by possessing a comparatively more squared root.

E. maremagnum shows noticeable differences with the indeterminate *Echinorhinus* specimens from Lower Cretaceous of France. The latter lacks an extensively serrated mesial cutting edge. Only the apex is serrated in the material from France (Adnet et al., 2012). Further, *E. maremagnum* has shorter main cusp that diverges in a wider angle from the main axis of the root when compared with specimens from France. From the putative echinorhinid reported from the Lower Cretaceous of England (Underwood and Mitchell, 1999) the new species differs by being single-cusped, and by lacking the strongly concave mesial edge (Underwood and Mitchell, 1999). A single incomplete tooth belonging to *Echinorhinus* was described from the Maastrichtian of Denmark. This specimen differs from *E. maremagnum* in having strongly distally offset main cusp that has a median kink turning the apex downward, in having smooth cutting edges and a very low distal heel (Adolfsson and Ward, 2014).

It is worth to mention, that we are not aware of any *Echinorhinus* species having a crenulate distal heel, a condition that is here considered as autapomorphic of *E. maremagnum*.

In addition, *E. maremagnum* differs from the Maastrichtian genus *Gibbechinorhinus* by lacking the large gibbosity seen in the mesial cutting edge of this genus, and in lacking a cusp on its distal cutting edge (Cappetta, 1990). It differs from the Paleogene genus *Pseudoechinorhinus* in several features, including a well-developed distal heel, crenulate margins of main cusp, main cusp distally oriented, among other features (Pfeil, 1983). In the same way, it is noticeably different from the Miocene genus *Paraechinorhinus* by having wider teeth, with much lower main cusp, and having main cusp distally oriented and lacking a strong mesial concavity at the crown, among other features (Pfeil, 1983).

In this way, we conclude that *Echinorhinus maremagnum* differs from all known species of the genus, and constitutes a new taxonomic entity.

A shared distribution of *E. maremagnum* in Arauco and Austral basins has been also described in other elasmobranch taxa (Otero et al., 2013). This is consistent with a probable marine connection of both basins occurring at some point during the Maastrichtian (Le Roux, 2012).

5. Conclusion

The material here studied can be unequivocally referred to the genus *Echinorhinus* by its conspicuous morphological features. The isolated teeth studied here were recovered from Upper Cretaceous units in both sides of Southern South America, from basins opened to the ancient Atlantic (Arauco Basin) and to the ancient Pacific (Arauco Basin). Remarkably, all the studied teeth share identical morphological traits such as a crenulated mesial cutting edge, a total lack of accessory cusplets, and main cusps that do not extend beyond the root length. This combination of characters is not found among other representatives within the genus *Echinorhinus*, and therefore, a new species, *E. maremagnum* sp. nov. is here proposed. This species seems to be restricted to shallow environments along the southern basins of South America during the Maastrichtian. Its presence in the lower Maastrichtian of central Chile and the upper Maastrichtian of southern Argentina contrasts with the lack of Paleogene records in the continent.

The new species constitutes an important addition to the still poorly known Mesozoic record of echinorhiniforms, and particularly, to the selachian faunas of southern South America.

Acknowledgments

We thank J. Pollerspöck and N. Pledge for sharing important bibliography and unpublished data that improved the quality of the present manuscript. We especially thank M. Isasi, C. Alsina, R. Stoll, G. Stoll, D. Piazza, and A. Moreno for their accurate preparation work of the elasmosaurid skeleton that allowed the recovery of most of the material here described. We thank Fundación de Historia Natural “Félix de Azara” for its support during the making of this contribution. Finally we thank the detailed review and comments of two anonymous reviewers, which greatly improved the quality of the present manuscript.

References

- Adnet, S., Guinot, G., Cappetta, H., Welcomme, J.L., 2012. Oldest evidence of bramble sharks (Elasmobranchii, Echinorhinidae) in the Lower Cretaceous of southern France and the evolutionary history of orbitostylic sharks. *Cretaceous Research* 35, 81–87.
- Adolfsson, J., Ward, D., 2014. Crossing the boundary: an elasmobranch fauna from Stevns Klint, Denmark. *Palaeontology* 57, 591–629.
- Ameghino, F., 1893. Sobre la presencia de vertebrados de aspecto mesozoico en la formación Santacrucense de la Patagonia austral. *Revista del Jardín Zoológico de Buenos Aires* 1, 76–84.
- Ameghino, F., 1901. L' age des Formations sédimentaires de Patagonie. *Anales de la Sociedad Científica Argentina* 52, 189–197.
- Ameghino, F., 1906. Les formations sédimentaires du Crétacé Supérieur et du Tertiaire de Patagonie, avec un parallèle entre leurs faunes mammalogiques et celles de l' ancien continent. *Anales del Museo Nacional de Buenos Aires* 15, 1–508.
- Antunes, M.T., Cappetta, H., 2002. Sélaciens du Crétacé (Albien—Maastrichtien) d'Angola. *Palaeontographica, Abteilung A* 264 (5–6), 85–146.
- Arbe, H., Hechem, J., 1984. Estratigrafía y facies de depósitos continentales, litorales y marinos del Cretácico Superior, Lago Argentino, Provincia de Santa Cruz. *Noveno Congreso Geológico Argentino, San Carlos de Bariloche, Actas VII* 124–158.
- Arratia, G., Cione, A.L., 1996. The Record of Fossil Fishes of Southern South America, p. 9–72. In: Arratia, G. (Ed.), *Contributions of Southern South America to Vertebrate Paleontology. Müncher Geowissenschaftliche Abhandlungen, Reihe A, Geologie und Paläontologie*, 30.
- Bass, A.J., Compagno, L.J.V., 1986. Echinorhinidae. p. 63. In: Smith, M.M., Heemstra, P.C. (Eds.), *Smiths' sea fishes*. Springer-Verlag, Berlin.
- de Blainville, H.M., 1816. *Prodrome d'une nouvelle distribution systématique du règne animal*. Bulletin de la Société Philomatique de Paris 8, 105e124.
- Bogan, S., Agnolin, F.L., 2010. Primera ictiofauna marina del Cretácico Superior (Formación Jagüel; Maastrichtiano) de la provincia de Río Negro, Argentina. *Papéis Avulsos de Zoología* 50, 175–188.
- Bogan, S., Gallina, P.A., 2011. Consideraciones sobre el registro de *Hypolophodon* (Chondrichthyes, Myliobatiformes) en el techo de la Formación Jagüel (Maastrichtiano), provincia de Río Negro, Argentina. *Studia Geológica Salmanticensia* 47, 57–67.
- Bogan, S., Agnolin, F.L., Novas, F.E., 2016. New selachian records from the Upper Cretaceous of southern Patagonia: paleobiogeographical implications and the description of a new taxon. *Journal of Vertebrate Paleontology* 36 (3), 1105235.
- Bonaparte, C.L., 1838. *Selachorum tabula analytica, Systema Ichthyologicum*. *Memoires de la Societe Neuchateloise des Sciences Naturelles* 2, 1–16.
- Bonaterre, J.P., 1788. *Ichthyologie. Tableau encyclopédique et méthodique des trois règnes de la nature*. Paris, 215 p., pl. A–B + 1–100.
- de Buen, F., 1926. *Catálogo ictológico del Mediterraneo Español y de Marruecos, recopilando lo publicado sobrepeces de las costas mediterraneas y proximas del Atlantico (Mar de España)*. Resultados de las amparías Realizadas por Acuerdos Internacionales, 2. Instituto Español de Oceanografía, 1e221x.
- Cappetta, H., 1987. *Chondrichthyes II: Mesozoic and Cenozoic Elasmobranchii*, p. 1–193. In: Schultz, H.P. (Ed.), *Handbook of Paleoichthyology*, vol. 3B. Gustav Fischer Verlag, Stuttgart.
- Cappetta, H., 1990. Echinorhinidae nouveau (Neoselachii, Squaliformes) du Crétacé supérieur du Negev (Israel). *Neues Jahrbuch für Geologie und Paläontologie* 1990, 741–749.
- Cappetta, H., 2012. *Handbook of Paleoichthyology*, Vol. 3E: Chondrichthyes Mesozoic and Cenozoic Elasmobranchii: Teeth. Verlag Dr. Friedrich Pfeil, 512 pp.
- Chapman, F., 1908. On the occurrence of the selachian genus *Corax* in the Lower Cretaceous of Queensland. *Proceedings of the Royal Society of Victoria* 21, 452–453.
- Cione, A.L., Cozzuol, M.A., Dozo, M.T., Hospitaleche, C.A., 2011. Marine vertebrate assemblages in the southwest Atlantic during the Miocene. *Biological Journal of the Linnean Society* 103, 423–440.
- Cione, A.L., Tejedor, M., Goin, F.J., 2013. A new species of the rare batomorph genus *Hypolophodon* (?latest Cretaceous to earliest Paleocene, Argentina). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 267, 1–8.
- Gana, P., Wall, R., Gutiérrez, A., 1996. *Mapa Geológico del área de Valparaíso-Curacaví, Región de Valparaíso y Región Metropolitana*. Servicio Nacional de Geología y Minería, Mapas Geológicos N° 1. Escala 1:100.000. Santiago, 20 pp.
- Gill, T.N., 1862. Analytical synopsis of the order Squali, and revision of the nomenclature of the genera, 7. *Annals of the Lyceum of Natural History, New York*, pp. 367–413.
- Guinot, G., Cappetta, H., Adnet, S., 2014. A rare elasmobranch assemblage from the Valanginian (Lower Cretaceous) of southern France. *Cretaceous Research* 48, 54–84.
- Herman, J., 1975. Les sélaciens des terrains néocrétacés et paléocènes de Belgique et des contrées limitrophes éléments d'une biostratigraphie intercontinentale. *Mémoires pour servir à l'explication des Cartes géologiques et minières de la Belgique* 15, 1–401.
- Huxley, T.H., 1880. On the application of the laws of evolution to the arrangement of the Vertebrata, and more particularly of the Mammalia. *Proceedings of the Zoological Society of London* 1880, 649–662.
- Kemp, N., 1991. Chondrichthyans in the Cretaceous and Tertiary of Australia, p. 497–568. In: Vickers, R.P., Monaghan, J.M., Baird, R.F., Rich, T.H. (Eds.), *Vertebrate Palaeontology of Australia*. Lilydale. Pioneer Design Studio, Victoria.
- Kitamura, N., 2013. Description of a new species of the family Echinorhinidae (Chondrichthyes, Elasmobranchii) from the Upper Cretaceous Himenoura Group in Kumamoto Prefecture, Southwestern Japan. *Paleontological Research* 17 (2), 189–195.
- Levi de Valenzuela, B., Aguirre, L., 1962. El conglomerado de Algarrobo y su relación con las formaciones del Cretácico Superior de Chile central. *Anales de las Primeras Jornadas Geológicas Argentinas, Tomo II*, 1962. Buenos Aires, Argentina. Re-edited by Instituto de Investigaciones Geológicas (Chile), Apartado N° 17, 417–431.
- Marensi, S., Guler, V., Casadío, S., Guerstein, R., Papú, O., 2004. Sedimentology and palynology of the Calafate Formation (Maastrichtian), Austral basin, Southern Patagonia, Argentina. *Cretaceous Research* 25, 907–918.

- Novas, F.E., Isasi, M.P., D'Ángelo, J.S., Busker, F., D'Amato, M., Bogan, S., Ibicuri, L.M., Lacovara, K.J., 2011. Hallazgo de un esqueleto de plesiosaurio asociado con dientes de seláceos en la Formación El Calafate (Cretácico Superior) de la provincia de Santa Cruz, p. 344. In: Congreso Latinoamericano Paleontología de Vertebrados, El Calafate, Santa Cruz.
- Otero, R.A., Suárez, M.A., 2008. Primer registro de tiburón espinoso (Squaliformes, Echinorhinidae) en el Cretácico Superior (Maastrichtiano) de Chile y Sudamérica, p. 74–77. In: Rubilar, A.R., Rubilar-Rogers, D., Gutstein, C.S. (Eds.). Actas del I Simposio de Paleontología en Chile, Santiago.
- Otero, R.A., Parham, J., Soto-Acuña, S., Jimenez-Huidobro, P., Rubilar-Rogers, R., 2012. Marine reptiles from Late Cretaceous (early Maastrichtian) deposits in Algarrobo, central Chile. *Cretaceous Research* 35, 124.
- Otero, R.A., Oyarzún, J.L., Soto-Acuña, S., Yury-Yáñez, R.E., Gutiérrez, N.M., Le Roux, J.P., Torres, T., Hervé, F., 2013. Neoselachians and Chimaeriformes (Chondrichthyes) from the latest Cretaceous –Paleogene of Sierra Baguales, southernmost Chile. Chronostratigraphic, paleobiogeographic and paleoenvironmental implications. *South American Journal of Earth Sciences* 48, 13–30.
- Perez D', E., Reyes, R., 1978. *Buchotrignia (Buchotrignia) topocalmensis* sp. nov. (Trigoniidae, Bivalvia) del Cretácico Superior de Chile. *Revista Geológica de Chile* 9, 37–55.
- Pfeil, F.H., 1983. Zahnmorphologische Untersuchungen an rezenten und fossilen Haien der Ordnungen Chlamydoselachiformes und Echinorhiniformes. *Palaeo Ichthyologica* 1, 1–315.
- Pietschmann, V., 1928. Neue Fischarten aus dem Pazifischen Ozean. *Anzeiger der Akademie der Wissenschaften in Wien* 65 (27), 297–298.
- Pledge, N., 1992. Fossil shark teeth dredged from the Great Australian Bight. Bureau of Mineral Resources. *Journal of Australian Geology and Geophysics* 13, 15–18.
- Purdy, R.W., Schneider, V.P., Applegate, S.P., McClellan, J.H., Meyer, R.L., Slaughter, B.H., 2001. The Neogene sharks, rays and bony fishes from the Lee Creek Mine, Aurora, North Carolina, p. 71–202. In: Ray, C.E., Bohaska, D.J. (Eds.), *Geology and Paleontology of the Lee Creek Mine, North Carolina, III. Smithsonian Contributions to Paleobiology* 90.
- Riga, González, Bernardo, J., Prámparo, M., Cione, A.L., Previtera, E., 2010. Hallazgo de tiburones Cretácicos (Chondrichthyes) en la provincia de Mendoza (Argentina): aspectos estratigráficos and paleoambientales, p. 171. In: X Congreso Argentino de Paleontología and Bioestratigrafía — VII Congreso Latinoamericano de Paleontología, La Plata.
- Le Roux, J.P., 2012. A review of tertiary climate changes in southern South America and the Antarctic Peninsula. Part 1: oceanic conditions. *Sedimentary Geology* 247/248, 1–20.
- Siverson, M., 1997. Sharks from the mid-Cretaceous Gearle Siltstone, southern Carnarvon Basin, Western Australia. *Journal of Vertebrate Paleontology* 17, 453–465.
- Spalletti, L.A., Franzese, J.R., 2007. Mesozoic paleogeography and paleoenvironmental evolution of Patagonia. pp. 29–49. In: Gasparini, Z., Salgado, L., Coria, R. (Eds.), *Patagonian Mesozoic Reptiles*. Indiana University Press, Bloomington and Indianapolis, 402 pp.
- Suárez, M.E., 2015. Tiburones, Rayas y Quimeras (Chondrichthyes) Fósiles de Chile, 63. *Publicación Ocasional del Museo Nacional de Historia Natural, Chile*, pp. 17–33.
- Suárez, M.E., Marquardt, C., 2003. Revisión preliminar de las faunas de peces elasmobranchios del Mesozoico y Cenozoico de Chile. Congreso Geológico Chileno n° 10, Sesión temática 3, Paleontología. Actas, CD-ROM. Universidad de Concepción, Concepción, 9 pp.
- Suárez, M.E., Otero, R.A., 2008. Nuevos hallazgos de vertebrados marinos en el Campaniano—Maastrichtiano de Loanco, VII Región, p. 78–82. In: Rubilar, A.R., Rubilar-Rogers, D., Gutstein, C.S. (Eds.), *Actas del I Simposio de Paleontología en Chile, Santiago*.
- Tavera, J., 1980. Cretáceo y Terciario de la localidad de Algarrobo. *Imprentas Gráficas Conchalí*, 45 pp. Santiago.
- Underwood, C.J., Mitchell, S.F., 1999. Albian and Cenomanian (Cretaceous) selachian faunas from north east England. *Special Papers in Palaeontology* 60, 9–56.