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Mosasaurs (Reptilia) from the late Maastrichtian (Late Cretaceous) of northern Patagonia (Río Negro, Argentina)

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Abstract

A diverse assemblage of mosasaurs was recently recovered from the Jagüel Formation (late Maastrichtian) exposed at three localities of northern Patagonia (Río Negro, Argentina). Four taxa (three mosasaurines and a plioplatecarpine) have been identified, and three of these marine reptiles can be identified at lower taxonomic levels: *Mosasaurus* sp. aff. *M. hoffmanni*, *Plioplatecarpus* sp., and *Prognathodon* sp. These occurrences are significant because they represent the first diagnostic material at generic level exhumed from Patagonia and include one of the youngest mosasaurs found worldwide. One of the specimens described herein was found only 1.5 m below the Cretaceous/Tertiary boundary. Only mosasaurs from Antarctica found within a meter of the boundary are known to occur higher in the geologic section.

Keywords: Reptilia; Mosasauria; Maastrichtian; Patagonia; Argentina

1. Introduction

Mosasaurs inhabited the Cretaceous oceans and epicontinental seas of the entire world. The presence of mosasaurs has been recorded in all continents, including Antarctica (Gasparini and del Valle, 1981, 1984; Martin et al., 1999; Novas et al., 2002). Despite this worldwide distribution, the South American record is extremely poor compared with that of the western Interior Sea, western Tethys, or New Zealand. Except for the skull of *Yaguarasaurus* Páramo, 1994, a Turonian plioplatecarpine from Colombia, the previously found remains are fragmentary (Pierce and Welles, 1959; Price, 1953, 1957; Caldwell and Bell, 1995). In 1988, de Carvalho and Azevedo recognized the presence of Mosasaurini, Globidensini, Plioplatecarpini, and Prognathodontini in the Pernambuco–Paraíba Basin in northeastern Brazil. In Argentina, the occurrence of mosasaurs was reported by Ameghino (1893), but the material he described is very fragmentary. Until the present, the only diagnostic material from Argentina includes five caudal vertebrae found in Maastrichtian sediments from Liu Malal, Mendoza province. These vertebrae were identified as Mosasaurinae (Gasparini et al., 2001). The incompleteness of the mosasaur record in South America is due to the lack of a concentrated, systematic search for these marine reptiles.

Since 1998, several field trips have been conducted in the central area of Río Negro province (Fig. 1) by the Museo Municipal de Lamarque and the Museo de La Plata (Argentina). As a result, a significant number of marine reptiles has been recovered from the uppermost levels of the Jagüel Formation (upper Maastrichtian). Both plesiosaurs (Gasparini et al., 2002, 2003) and mosasaurs occur within this assemblage.

Mosasaurs recently found in Río Negro include the most complete mosasaurs from Argentina, the youngest records of a South American mosasaur, and one of the youngest known mosasaurs of the world.

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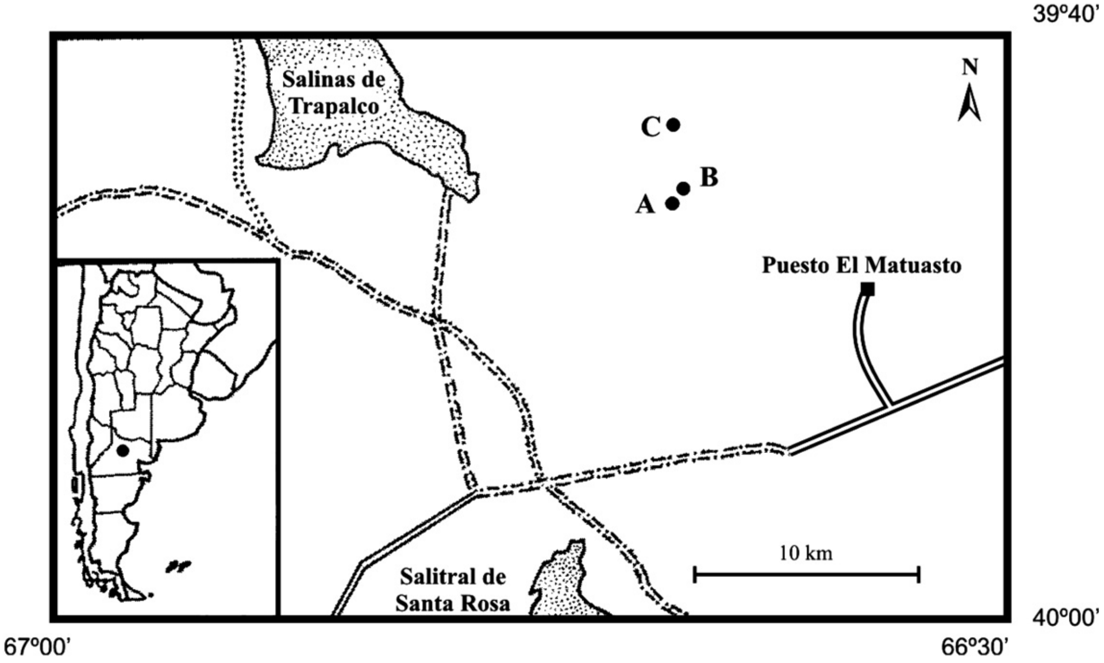

Fig. 1. Map of the study area, Río Negro Province, Argentina. (A–C) Localities mentioned in the text.

The institutional abbreviations used in this article are as follows: MML, Museo Municipal de Lamarque, Río Negro, Argentina; and SDSM, Museum of Geology, South Dakota School of Mines and Technology, Rapid City, USA.

2. Geological setting

The Late Cretaceous succession in northern Patagonia is characterized by the first marine transgression from the Atlantic. The Late Cretaceous–early Paleogene rocks in northern Patagonia are included in the Malargüe Group. This unit, widely distributed in the Neuquén Basin, is exposed at numerous localities in the province of Mendoza, along the foothills of the Andes, and north of the Somuncurá Massif in the provinces of Río Negro, Neuquén, and La Pampa.

The Malargüe Group is composed of the Allen, Jagüel, Roca, and El Carrizo formations. In the lower section of the Allen Formation (late Campanian?–early Maastrichtian), the first Atlantic marine event in northern Patagonia occurs (Parras et al., 1998). This event is represented at a few localities south of latitude 37°S by marginal marine facies.

In the middle and upper sections of the Allen Formation (early Maastrichtian–late Maastrichtian), facies change to a more clearly marine character, denoting a rise in relative sea level. During this time, more than 40 m of siltstone were deposited under subtidal conditions in the Auca Mahuida area. At the same time, in the Huantraico area to the west, the sedimentary record suggests more restricted marine conditions. Likewise, toward the eastern margin of the basin, these beds are represented by intertidal facies (Casadío, 1994). This relative sea level increase was followed by a significant drop that reduced the flooded area south of latitude 37°S, as can be inferred from the thickness of the evaporites recorded in the Auca Mahuida, Lago Pellegrini, and Aguará areas.

The Allen Formation is overlain by siltstones and claystones, included in the Jagüel Formation, whereas in the shallower proximal areas, the Allen Formation is covered mainly by the limestone beds of the Roca Formation. The Jagüel Formation contains typically subtidal Maastrichtian and Danian marine micro- and macrofossils (Bertels, 1969; Casadío, 1994; Concheyro and Villa, 1996; Pires et al., 1999). The Roca Formation is composed of bioclastic packstones and grainstones deposited in subtidal to intertidal environments (Casadío, 1994; Parras et al., 1998; Parras and Casadío, 1999), with ages ranging from late Maastrichtian to Danian. Parras et al. (1998) and Parras and Casadío (1999) confirm the diachronic character of this unit on the basis of its paleontological content and radiometric ages. They propose a late Maastrichtian age (Zone CC26, Perch-Nielsen, 1985) for the formation in the northern region of the basin (north of 36°S) and a Danian age for the outcrops in the central and southern areas.

The Malargüe Group ends with claystones, sandstones, and evaporites that transitionally overlie the Roca Formation and are referred to the El Carrizo Formation (Casadío, 1994).

The mosasaurs studied herein come from the Jagüel Formation exposed at three localities (Fig. 2), within the Trapalcó and Santa Rosa depressions in the Río Negro province. In this area, the base of the Allen Formation is not exposed but grades upward to the

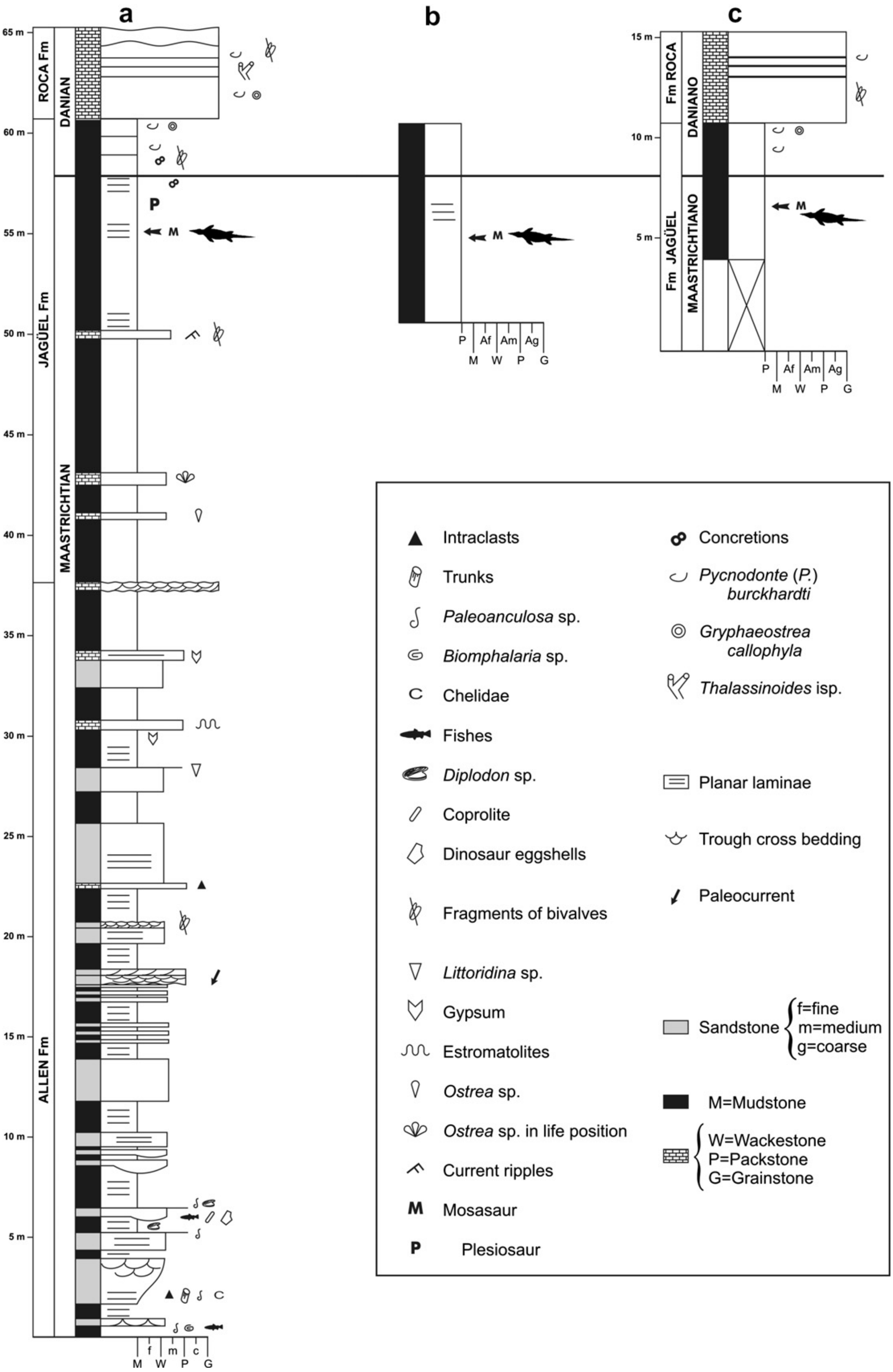

Fig. 2. Correlation of measured stratigraphic sections.

shales of the overlying Jagüel Formation. The latter formation is overlain by the limestones of the Roca Formation.

The Allen Formation consists mainly of tabular and finely stratified siltstone and fine sandstone beds. Non-marine vertebrate and freshwater mollusk remains occur frequently. In addition to the sedimentological characteristics, they suggest a dominantly lacustrine origin with fluvial influence at the base. This contention is supported by channeled sandy bodies excavated into pelitic beds, containing abundant fossil remains such as freshwater mollusks (*Diplodon* sp., *Biomphalaria* sp., and *Paleoanculosa* sp.), dinosaur eggshells, coprolites (Parras et al., 2004), and the mosasaur remains studied herein, as well as fish and chelid turtles. The turtles are similar to those described from the Los Alamitos Formation (de Broin, 1987; de Broin and de la Fuente, 1993), La Colonia Formation (Gasparini and de la Fuente, 2000), and other late Campanian?–early Maastrichtian lithostratigraphic units from Patagonia (Lapparent de Broin and de la Fuente, 2001).

The Jagüel Formation, at the studied localities, comprises siltstones with a few laminated beds and very scarce late Maastrichtian marine bivalves identified as *Ambigostrea clarae* (von Ihering, 1907) and "*Pecten*" *mahuidaensis* Weaver, 1931. This unit carries a very abundant assemblage of calcareous nannofossils, the most relevant of which are *Cribrosphaerella daniae*, *Nephrolithus frequens*, *Prediscosphaera stoveri*, *Biscutum melaniae*, *Lithraphidites quadratus*, and *Arkhangelskiella cymbiformis*. These fossils indicate a late Maastrichtian age, CC26 Biozone (Perch-Nielsen, 1985; Concheyro, 1995; Concheyro and Villa, 1996). Overlying this nannoflora and within the Jagüel Formation, the occurrence of *Biantholithus sparsus*, a guide fossil for the early Danian, NP1 Zone, is confirmed (Martini, 1971; Perch-Nielsen, 1985; Concheyro, 1995).

The top of the Jagüel Formation is marked by the base of the first shell bed with *Pycnodonte* (*Phygraea*) *burckhardti* (Böhm, 1903) and *Gryphaeostrea callophyla* (von Ihering, 1903) and included in the Roca Formation. This shell unit is 5 m thick in the studied area and contains facies deposited in a shallow subtidal environment.

3. Systematic paleontology

3.1. Taxon 1

Mosasauridae Gervais, 1853
Mosasaurinae Williston, 1897
Plotosaurini Russell, 1967 *sensu* Bell, 1997
Mosasaurus Conybeare, 1822
Mosasaurus sp. aff. *M. hoffmanni* Mantell, 1829
Figs. 3, 4a, and 5.

3.1.1. Material

MML-PV1. Fragments of both dentaries, left partial premaxilla, anterior portion of both left and right maxillae, lateral fragment of the frontal, proximal portion of the humerus with the head and postglenoid process, anterior fragment of the left angular, metacarpal I, five fragmentary teeth, atlas intercentrum, and one trunk vertebra.

3.1.2. Horizon and locality

Locality A (S39°46′20″; W66°40′42″). Upper part of the Jagüel Formation (upper Maastrichtian).

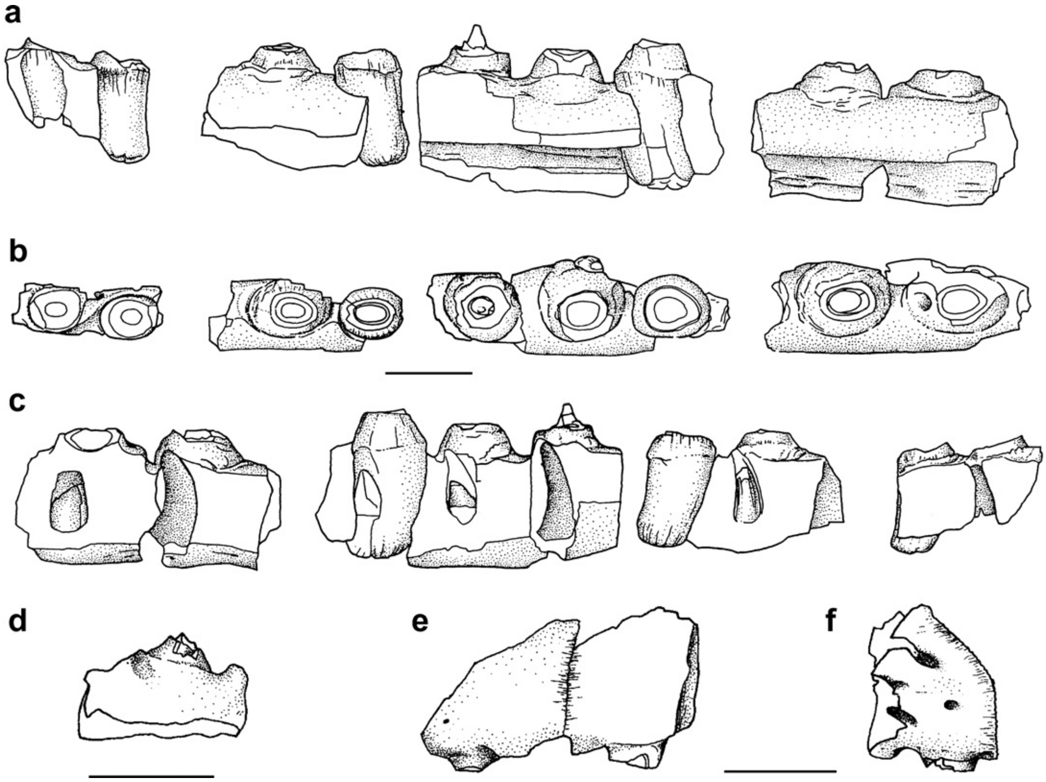

Fig. 3. MML-PV1: *Mosasaurus* sp. aff. *M. hoffmanni*. (a–c) Lateral, occlusal, and medial views of the left dentary; (d) most anterior fragment of the right dentary; (e) left premaxilla and maxilla fragments in lateral view; (f) anterior fragment of the right maxilla in lateral view. Scale bars equal to 5 cm.

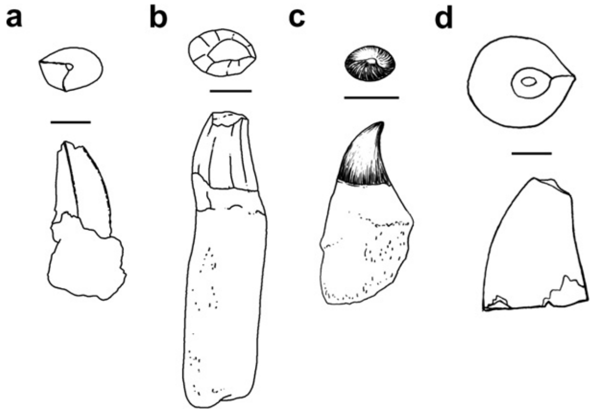

Fig. 4. Marginal teeth occlusal and lingual views. (a) MML-PV1, *Mosasaurus* sp. aff. *M. hoffmanni*; (b) MML-PV2, Mosasaurinae, genus and species indet; (c) MML-PV7, *Plioplatecarpus* sp.; (d) MML-PV8, *Prognathodon* sp. Scale bars equal to 1 cm.

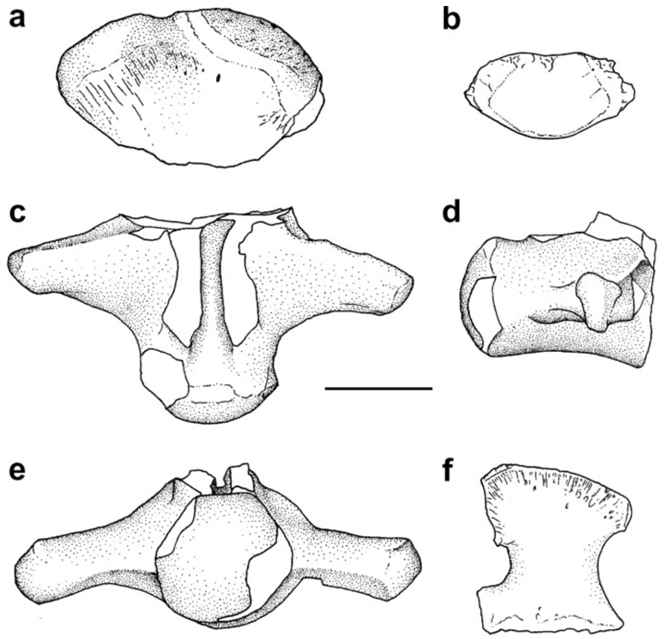

Fig. 5. MML-PV1: *Mosasaurus* sp. aff. *M. hoffmanni*. (a) Proximal fragment of the right humerus; (b) intercentrum of the atlas; (c–e) vertebra in dorsal, lateral, and posterior view; (f) metacarpal I. Scale bars equal to 5 cm.

3.1.3. Description

The robustness and size of the fragments found indicate that the MML-PV1 was a very large mosasaur in the size range of *Mosasaurus hoffmanni* from the type area of the Maastrichtian in Europe (Lingham-Soliar, 1995).

Frontal

Only the lateral part of the frontal has been preserved, and no diagnostic features can be observed.

Dentary

The left dentary is the best preserved and consists of four large fragments, including nine tooth bases (Fig. 3a–c). In dorsal view, the alveoli are circular but slightly laterally compressed (Fig. 3b). In the two anterior teeth, the diameter at the base equals 30 mm. The alveoli are well spaced, and a thick wall of bone intervenes. The medial wall of this bone is well developed and is as high as the lateral wall. Part of the medial wall has been eroded, and as a result, the crowns of four replacement teeth and the dental pocket of the other two are exposed. The replacement teeth are located posterior and medially to the marginal teeth. The right dentary consists of the most anterior fragment containing the base of the first tooth (Fig. 3d). The anterior end of the dentary is rugose and strongly convex antero-posteriorly. The diameter at the base of the first tooth is 31 mm. The root of this tooth differs from all other roots; it is not vertically implanted but directed anteriorly. Consequently, no anterior dentary projection occurs, because the first tooth is located at the anterior end of the jaw, but the anterior terminus possesses a low, robust, pointed dorsal projection.

Premaxilla and maxilla

The premaxilla and maxilla are fragmentary but well preserved. The most complete fragment corresponds to the left postero-ventral portion of the premaxilla (Fig. 3e). Its lateral surface is smooth with only three small dorsal foramina preserved. The most anterior part is broken but preserved enough to indicate its convexity and a short predental rostrum. On this fragment of the premaxilla, the base of the first tooth and a high, wide alveolus corresponding to the second tooth is preserved. In the medial wall at the base of the first tooth, a preserved part of a high, narrow replacement tooth crown exhibits smooth enamel.

Both anterior fragments of the maxillae retain the premaxillary–maxillary sutures, but they are more complete on the right (Fig. 3f). The most remarkable feature of this suture is its relatively vertical position of the anterior portion of this suture. The outline of this suture in its anterior part is comparable to that of *M. hoffmanni* and somewhat resembles *Prognathodon*. The anterior portions of both maxillae have been preserved and bear the base of the first maxillary tooth. On the lateral surface of the maxilla behind the suture are two prominent foramina.

Marginal dentition

Several tooth crowns were found associated with the cranial and dentary fragments, and in the dentary, the bases of the teeth are preserved. Because none of the crowns were preserved in their natural position, they cannot be identified as maxillary or dentary teeth. The teeth are slightly laterally compressed, with a U-shaped lingual surface in cross-section (Fig. 4a). The enamel is smooth without striations. The buccal face is relatively flat, whereas the lingual face is strongly convex, with two slight facets. The anterior and posterior carinae have small serrations. These serrations are more evident in the replacement teeth.

Humerus

The proximal part of the right humerus is preserved, and the best preserved face is the dorsal (Fig. 5a). The anterior and ventral borders of the glenoid condyle are broken; nevertheless, the main part of its proximal face is preserved. The surface of the glenoid condyle is flat and smooth posteriorly, whereas the anterior part is characterized by several small foramina. The ornamentation of this surface suggests no cartilaginous epiphyses, due to the lack of distinctive canals and foramina for transepiphyseal circulation.

Posterior to the glenoid condyle, the postglenoid process is separated by a shallow depression from the condyle. The degree of development of this process is comparable to that described by Russell (1967) for *Clidastes*.

Atlas

The intercentrum is the only preserved part of the atlas (Fig. 5b). As pointed out by Russell (1967), the morphology of this element is relatively consistent in mosasaurs. In MML-PV1, the anterior face of the atlas possesses a concave elliptical surface for articulation with the occipital condyle. Dorsolaterally, two subtriangular rugosities mark the union with the neural arches. The ventral surface is not well preserved and exhibits no sign of the hypapophyseal peduncle.

Vertebra

Only one complete vertebral centrum with both synapophyses has been recovered (Fig. 5c–e). The location and projection of the synapophyses suggest a middle trunk vertebra. The anterior cotyle is not very deep and is slightly broader than tall. The centrum is elongate relative to its diameter, particularly posterior to the synapophysis. In lateral view, the base of the centrum is concave. The synapophyses originate on the anterior portion of the lateral surface of the centrum in a central position, and they project laterally. The synapophyses are prominent, and in lateral view, their distal faces are oval with their maximum axis oriented dorso-ventrally. The posterior condyle is nearly circular in outline and slightly broader than tall. Its maximum width is located below the center of the condyle. Measurements of the centrum are as follows: ventral interarticular length = 102 mm; anterior cotyle height = 66 mm; anterior cotylar width = 68 mm; posterior condyle height = 60 mm; and posterior condyle width = 65 mm.

Metacarpal I

The metacarpal I is well preserved and almost complete (Fig. 5f). As in *Plotosaurus* and *Mosasaurus*, this element is broad. Both proximal and distal articular surfaces are equally expanded. The most conspicuous feature is the distinct notch on the anterior border of the bone, with a prominent overhanging proximal crest. The development of this crest is interpreted as a synapomorphy of Plotosaurini (Bell, 1997). Within this clade, the metacarpal 1 of the MML-PV1 strongly resembles the metacarpal I of *Mosasaurus*. It differs from the metacarpal 1 of *Plotosaurus* whose metacarpal 1 is broader than longer, whereas in MML-PV1, the width and length of this element are subequal.

Carpal

Only one carpal has been preserved. This element is strongly compressed and roughly hexagonal in outline. Based on its morphology and size (relative to metacarpal 1), the element is presumed to be a distal carpal element. Because no evidence of the relative position of this element with the other bones of the limb is preserved, the carpal to which the element corresponds cannot be determined.

3.1.4. Remarks

Although MML-PV1 is incomplete, several diagnostic features have been preserved. Thus, MML-PV1 is referred to the Mosasaurinae on the basis of the short premaxilla predental rostrum, distinctive postglenoid process of the humerus, and absence of cartilaginous epiphyses. Possession of an overhanging anterior crest on metacarpal 1 permits referral of MML-PV1 to the Plotosaurini. This clade includes the genera *Plotosaurus* and *Mosasaurus* (Bell, 1997). Within this clade, MML-PV1 shares with *Mosasaurus* the general morphology and proportions of metacarpal 1, which are different than those of *Plotosaurus*. In the latter genus, one diagnostic character is that the metacarpals are shorter and stouter than in other genera of mosasaurs (Russell, 1967). Thus, in *Plotosaurus*, the metacarpal 1 is broader than longer, whereas in *Mosasaurus*, the length and width of this element are subequal. Another characteristic that permits referral of MML-PV1 to *Mosasaurus* is the morphology of the teeth, with a distinctly U-shaped lingual surface (Russell, 1967).

Within the genus *Mosasaurus*, the MML-PV1 resembles *M. hoffmanni*, in the shape of premaxillary–maxillary suture, and they both have faceted teeth. However, in MML-PV1, the teeth have relatively faint facets on the external faces. The size and robustness of the preserved part of the skull suggests the animal was very large. The estimated skull length of MML-PV1 (approximately 110 cm) enters the range expected for *M. hoffmanni* (Lingham-Soliar, 1995; Bardet and Tunoglu, 2002).

MML-PV1 may represent a new species, because certain characteristics, such as the weak postglenoid process of the humerus, are not shared with other *Mosasaurus*. Nevertheless, the material is fragmentary, so we prefer not to nominate a new taxon until more complete specimens are found. In this context, MML-PV1 is referred to *Mosasaurus* aff. *M. hoffmanni*, following the recommendations in open nomenclature of Bengtson (1988).

Of particular interest is its similarity to a specimen of mosasaurine from the late Maastrichtian of Antarctica, referred to *Mosasaurus* sp. cf. *M. hoffmanni* (Martin, 2006; Martin and Crame, 2006), in terms of its large size and faintly faceted external margins of the teeth.

3.2. Taxon 2

Mosasaurinae Williston, 1897
Plotosaurini Russell, 1967 *sensu* Bell, 1997
Genus and species indet.
Figs. 4b and 6.

3.2.1. Material

MML-PV2. Forty-six vertebrae, two jaw fragments, and three incomplete teeth.

3.2.2. Horizon and locality

Locality C (S39°44′11.9″; W66°40′31.6″). Upper part of the Jagüel Formation (upper Maastrichtian).

3.2.3. Description

Vertebrae. Four cervical vertebrae have been preserved in the MML-PV2. One is complete except for the anterior and dorsal borders of the neural spine (Fig. 6a and b). Thus, only the left anterior zygopophysis is complete. On the lateral surface of the anterior zygopophyses, there are rounded crests. Although the presence of zygophene cannot be determined, a well-developed zygantrum can be observed on this vertebra. The centrum is 80 mm long. The outline of the zynapophysis is roughly rectangular. The condyle is approximately as deep as wide. In the remaining cervical centrae, the same proportion has been observed. Cervical vertebrae are approximately as large as the dorsal vertebrae (Fig. 6c–e). In all 17 dorsal vertebral, the condyles are approximately circular.

From the caudal vertebral column, 21 centrae have been preserved: 15 pygals, 1 from the intermediate region and 7 from the terminal region (Fig. 6f and g). On the ventral surfaces, the scars of haemal arches suggest the arches were fused to the vertebra centra (Fig. 6g).

Marginal dentition

Three tooth bases and the lower part of their crowns are preserved. They are compressed, the anterior carine is delicate, and the limit between buccal and lingual surface cannot be clearly traced. The posterior carina is well defined and sharp. Both lingual and buccal surfaces are subequal and slightly faceted (Fig. 4b). Their surfaces are without striations.

3.2.4. Remarks

Assignment of MML-PV2 to the Mosasaurinae is based on the vertebral condyles being approximately circular, elongated dorsal vertebrae, and fused haemal arches. Although generic and though specific assignments are uncertain, MML-PV2 cannot be assigned to the same taxon as MML-PV1 because their tooth morphologies clearly differ. MML-PV2 also differs from the other Gondwanan Mosasaurinae, *Moanasaurus*, because the cervical vertebrae are not dorso-ventrally compressed. The tooth crowns are not clearly divided into lingual and buccal sur-

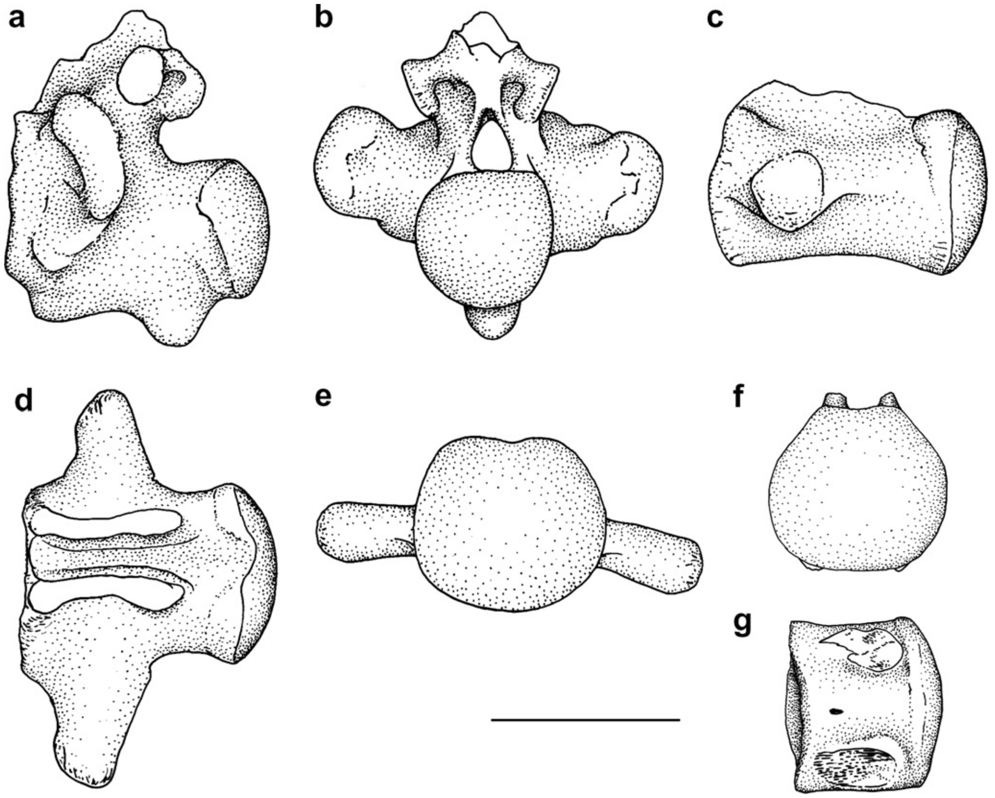

Fig. 6. MML-PV2: Mosasaurinae, genus and species indet. (a and b) Cervical vertebra in lateral and posterior views; (c–e) dorsal vertebra in lateral, dorsal, and posterior views; (f and g) caudal vertebra in posterior and ventral views. Scale bars equal to 5 cm.

faces by a longitudinal carina, and the enamel has no striations.

3.3. Taxon 3

Plioplatecarpinae Williston, 1897
Plioplatecarpini Russell, 1967
Plioplatecarpus sp. Dollo, 1882
Figs. 4c and 7.

3.3.1. Material

MML-PV7. Two cervical, ten dorsal, and twelve caudal vertebrae, one tooth and fragments of a mandible.

3.3.2. Horizon and locality

Locality B (39°46′12,6″; 66°40′55.1″). Upper part of the Jagüel Formation (upper Maastrichtian).

3.3.3. Description

Vertebrae. All preserved centrae are relatively short in lateral view (Fig. 7). Two cervical vertebrae have been preserved in the MML-PV7. Although incomplete, they are fairly well preserved. In dorsal view, the scars of the neural arches occupy almost all the length of the dorsal surface of the centrum. The synapophyses are vertically compressed. In one vertebra (Fig. 7a and b), the hypapophyseal peduncle has been preserved on the posterior ventral surface of the centrum. The peduncle is subcircular in cross-section. The articulating surfaces of the centrum are wider than deep (width 1.3 × depth), with a slight emargination on the dorsal border of the condyle.

The articulating surfaces of the dorsal vertebral centrae (Fig. 7c) are, as in the cervical centrae, dorso-ventrally compressed. The emargination on the dorsal border of the condyle is better defined than in the cervicals (Fig. 7e). The synapophyses are vertically compressed, and their articulating surfaces for the ribs are remarkably rugose.

From the caudal series, 11 centrae correspond to the basal region bearing only transverse processes. As in the dorsal centrae, these processes are distinctly vertically compressed. The outline of the condyles is roughly hexagonal. The remaining caudal vertebrae correspond to the intermediate region. Their transverse processes are vertically compressed. One centrum corresponds to the intermediate region of the caudal vertebral column (Fig. 7f and g). This centrum has the complete right transverse process. Although the haemal arch is lost, the haemal peduncles indicate the presence of unfused haemal arch (Fig. 7g).

Marginal dentition

One tooth has been preserved with the complete crown (Fig. 4c). The tooth base and crown are compressed and subcircular in cross-section. The crown bears delicate striations and is abruptly posteriorly recurved from about the midpoint of the crown.

3.3.4. Remarks

MML-PV7, though incomplete, displays diagnostic features. Thus, delicate teeth, strongly and abruptly posteriorly

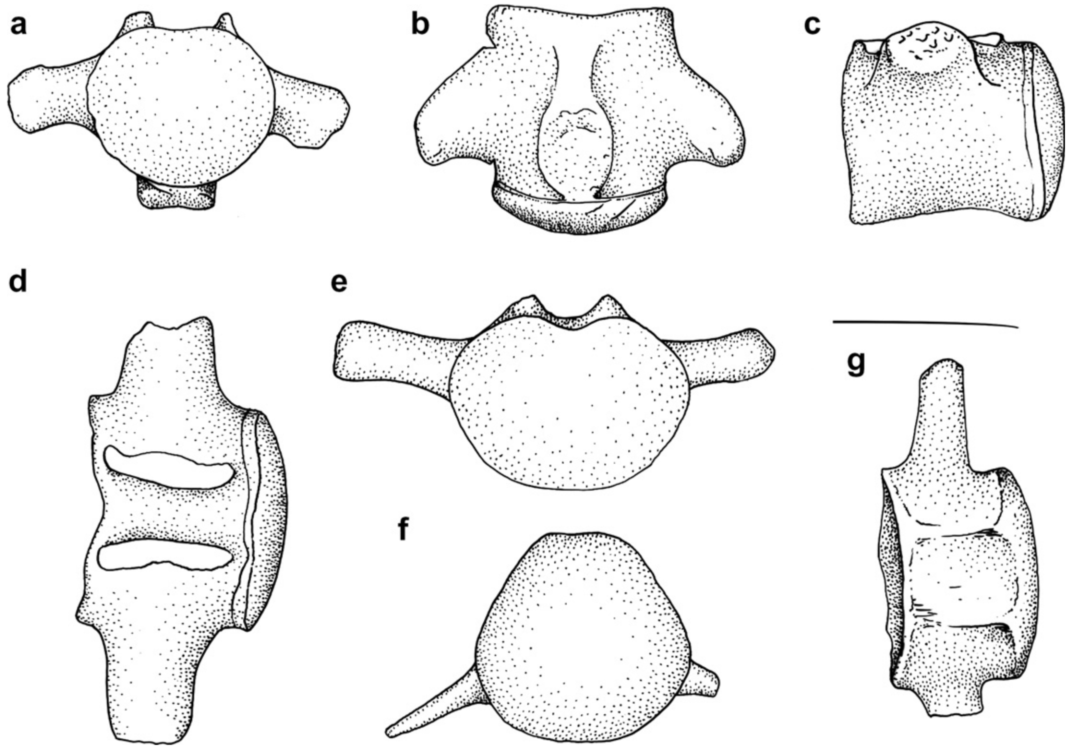

Fig. 7. MML-PV7: *Plioplatecarpus* sp. (a and b) Cervical vertebra in posterior and ventral views; (c–e) dorsal vertebra in lateral, dorsal, and posterior views; (f and g) caudal vertebra in posterior and ventral views. Scale bars equal to 5 cm.

curved and subcircular in cross-section, are diagnostic of the Plioplatecarpini (Lingham-Soliar, 1994). The articulating surface of cervical and anterior dorsal vertebral centra being smoothly elliptical in outline (Lingham-Soliar, 1994, 1995) permits the assignment of MML-PV7 to the genus *Plioplatecarpus*. Tooth morphology in MML-PV7 resembles that of *P. marshi* from the Upper Maastrichtian of Belgium, described and figured by Lingham-Soliar (1994, p. 1987, Figs. 12 and 13), though in MML-PV7, the preserved crown is not as large as that of *P. marshi*.

3.4. Taxon 4

Mosasaurinae Williston, 1897
Globindensini *sensu* Bell, 1997
Prognathodon sp. Dollo, 1889
Fig. 4d.

3.4.1. Material

MML-PV8. A large tooth crown (Fig. 4d).

3.4.2. Description

The tooth is large, stout, pyramidal and not laterally compressed. The distal tip of the crown has not been preserved. The tooth is bicarinate, with the lingual and buccal surfaces subequal in size. No prisms can be identified on its surface, and the enamel is smooth without striations. Although the tip of the crown has not been preserved, the configuration of the crown suggests the tip only slightly recurved posteromedially.

3.4.3. Remarks

MML-PV8 was collected in the area of Bajos de Trapalcó and Santa Rosa. Although its stratigraphic level cannot be determined, MML-PV8 is important because the tooth represents the first occurrence of *Prognathodon* from Patagonia.

4. Discussion

The material described herein represents the first diagnostic material at generic level exhumed from Patagonia and one of the youngest mosasaurs found. Recently, Bardet and Tunoglu (2002) reported the presence of *Mosasaurus hoffmanni* in the Late Maastrichtian of Turkey, 10–15 m below the K/T boundary, and referred to this occurrence as one of the youngest mosasaurs found in the fossil record. MML-PV1 was found 3.4 m below the K/T boundary, and MML-PV2 was found only 1.5 m below it. According to Casadio (1994) sedimentation rate in the environments where mosasaurs were found in northern Patagonia during Maastrichtian was approximately 2 cm/year. Thus, these mosasaurs may have been deposited only 75–170 years before the boundary. Only specimens from Antarctica found within a meter of the boundary occur higher in the section (Martin, 2006), though Welles and Greggs (1971, p. 104) report that the holotype of *Prognathodon waiparaensis* came from 2.5 to 6 m below the boundary.

The mosasaur occurrences of northern Patagonia indicate not only the high fossiliferous potential of the area but also that during the latest Maastrichtian, the seas of northern Patagonia were inhabited by a rich and diverse marine reptile fauna. Thus, though fieldwork has been carried out within a restricted area (Fig. 1), four mosasaur specimens already have been recovered. This material may be referred to three different taxa: three mosasaurines and a plioplatecarpine. Three relatively complete elasmosaurid plesiosaurs recently recovered from the same site (Gasparini et al., 2003) accompany these mosasaur specimens.

The Patagonian mosasaurs are very important biogeographically. The area was part of the Weddellian Province during the Late Cretaceous that probably included Antarctica and New Zealand, and the mosasaur assemblages provide information connecting the relationship of this province to those elsewhere. The question as to the endemism of the mosasaur assemblages can be addressed by the specimens described herein. Martin et al. (2002) note that mosasaurs from Antarctica, which have been identified to generic levels, are relatively cosmopolitan in distribution. However, Martin et al. (2002) note the exception of the possible occurrence of *Moanasaurus*, a genus known otherwise only from New Zealand. These specimens and those described herein reinforce the concept that at a generic level, mosasaurs are relatively cosmopolitan. While Martin et al.'s (2002) paper was in press, Novas et al. (2002) described a new genus *Lakumasaurus* and suggested that Late Cretaceous mosasaurs from Antarctica and New Zealand, such as *Lakumasaurus*, *Taniwhasaurus*, and *Moanasaurus* were part of an unique faunal assemblage that does not conform to the coeval northern paleogeographic pattern. Therefore, at a generic level, a mix of both endemic and cosmopolitan mosasaur genera exists in the Weddellian Province. Recently faunal similarity within the Weddellian Province has been reinforced by the synonymy of *Lakumasaurus* and *Taniwhasaurus* (Martin and Fernández, 2007). Other coeval taxa do not appear widely distributed at a generic level (and when enough morphological information is accumulated, we expect differences of most taxa at a specific level). For example, distribution of Patagonian and Antarctic plesiosaurs (Gasparini et al., 2003) and invertebrate faunas appear restricted. Thus, during the Late Cretaceous, relatively shallow seas separated Australia, New Zealand, Antarctica, and South America (Zinsmeister, 1982), enabling the persistence of a certain degree of similarity in marine faunal composition in these areas. This similarity originated previous to the final breakup of Gondwana during the Paleogene and has been noted by various authors (Freneix, 1981; Zinsmeister, 1982; Woodburne and Zinsmeister, 1984; Macellari, 1987; Griffin, 1991; Pascual et al., 1992; Griffin and Hünicken, 1994; Zinsmeister and Griffin, 1995; Stilwell, 1994, 1997, 1998, 2000, 2003; Henderson et al., 2000; Novas et al., 2002; Casadío et al., 2005). To characterize taxa that appeared in this region prior to the Paleogene, Fleming (1963) proposes the term "palaeoaustral". Later, Kauffman (1973) established the Austral Province based on Cretaceous bivalve distribution. This province includes the southernmost tip of South America and the easterly margin of India, Australia, New Zealand, New Caledonia, and Antarctica and existed until the Paleogene, when breakup took place. In this context, the Late Cretaceous plesiosaurs found in northern Patagonia and Antarctica are closely related to those of the Maastrichtian of Chile, Antarctic Peninsula, and New Zealand, which coincide with the observations of molluscan faunas and reinforce the hypothesis of a southern Gondwanan distribution of pelagic marine reptiles (Novas et al., 2002; Gasparini et al., 2003).

Although mosasaurs from the late Maastrichtian of northern Patagonia do not provide, at this point, definitive empirical support of endemism at a specific level, the presence of *Mosasaurus* sp. aff. *M. hoffmanni*, which may be a new species but is similar to *M. hoffmanni*, suggests that at least one species of *Mosasaurus* could be endemic of a southern Gondwanan fauna.

According to preliminary findings from the El Jagüel Formation in northern Patagonia, more complete mosasaur material might shed light on the affinities of northern and southern faunas and increase our knowledge of the latest episode in the evolutionary history of the group.

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