



## Presence of the elasmosaurid plesiosaur *Mauisaurus* in the Maastrichtian (Late Cretaceous) of central Chile

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**The revision by Hiller et al. (2005) of the species *Mauisaurus haasti* Hector (Plesiosauroidea, Elasmosauridae) from the Late Cretaceous of New Zealand, has provided reliable postcranial characters that permit recognition of this taxon as distinct among Late Cretaceous elasmosaurid plesiosaurs from both the Northern and Southern hemispheres. Particularly, in adult specimens, the femur displays a large, hemispherical capitulum that seems to be autapomorphic. This unique morphology is present in at least two specimens recovered from Late Cretaceous (Maastrichtian) beds in central Chile, which these fossils may be referred to the same taxon with confidence. The Chilean fossils are considerably larger than those from New Zealand, suggesting either difference in ontogenetic age or interspecific variation. The studied material constitutes the second accurate generic identification of elasmosaurid plesiosaurs from the eastern margin of the Pacific Ocean, thus complementing the known south-gondwanic paleodistribution of *Mauisaurus* during the Late Cretaceous.**

### Introduction

Elasmosaurid plesiosaurs have been reported from Chile since the first half of the 19<sup>th</sup> century, though identifications have been based mainly on partial and/or undiagnostic specimens, with still unresolved affinities. Gay (1848) studied the first remains of plesiosaurs from Chile, and based on these materials, he erected the species *Plesiosaurus chilensis* Gay, 1848. Steinmann et al. (1895) reassigned the species to *Pliosaurus chilensis*, and referred other remains to a second species, *Cimoliasaurus andium* Deecke, 1895. Several subsequent studies repeated these identifications until Colbert (1949) commented on the unsatisfactory status of these genera and species, and finally considered the type material of Gay (1848) as a pliosaur (*sensu lato*) and the rest as elasmosaurid plesiosaurs. Cecioni (1955) mentioned an articulated limb from the Magallanes Region, southernmost Chile, identifying it as *Coelospondylus (Plesiosaurus) chilensis* (Gay, 1848); nevertheless, the material is not diagnostic enough to assign it even at family level, and the referred species was previously questioned by Colbert (1949). The first valid generic identification of plesiosaurs in Chile is that of Casamiquela (1969), who recognized the presence of *Aristonectes*, previously reported in Argentina (Cabrera 1941). A second remarkable cranial specimen, also referred to

*Aristonectes*, was recovered from Campanian–Maastrichtian beds in central Chile (Suárez and Fritis 2002). These specimens of *Aristonectes* are, to date, the only fossils of plesiosaurs from the eastern margin of the Pacific Ocean that are reliably identified to the genus level.

The present study recognizes a second genus present in central Chile during the Late Cretaceous. *Mauisaurus* (Plesiosauroidea, Elasmosauridae) is one of the few elasmosaurids that can be identified based on partial postcranial material, particularly femoral morphology.

*Institutional abbreviations.*—CM, Canterbury Museum, Christchurch, New Zealand; DM, Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand; SGO.PV, Museo Nacional de Historia Natural, Santiago, Chile.

### Geological setting

The studied remains were recovered from Las Tablas Bay, on Quiriquina Island (73°03'19''S; 36°36'41''W), Biobío Region, central Chile (Fig. 1). The host unit is the Quiriquina Formation (Biró-Bagóczy 1982), which consists of a basal conglomerate, cross-bedded yellow sandstones with conglomerate lenses, coquinaceous horizons and green sandstones at top that include concretionary nodules. The coquina and the concretions include abundant fossils of invertebrates and vertebrates, together with scarce wood and leaf prints. The age of the formation was originally assigned to the Campanian–Maastrichtian based on the presence of a diverse assemblage of ammonoids (Biró-Bagóczy 1982), and later reassigned exclusively to the Maastrichtian (Stinnesbeck 1986; Salazar et al. 2003). The studied materials are two left femora, one complete and other preserving only the proximal portion, including part of the diaphysis, the trochanter and the capitulum.

### Systematic paleontology

Diapsida Osborn, 1903

Sauropterygia Owen, 1860

Plesiosauria de Blainville, 1835

Plesiosauroidea (Gray, 1925) *sensu Welles* 1943

Elasmosauridae Cope, 1869

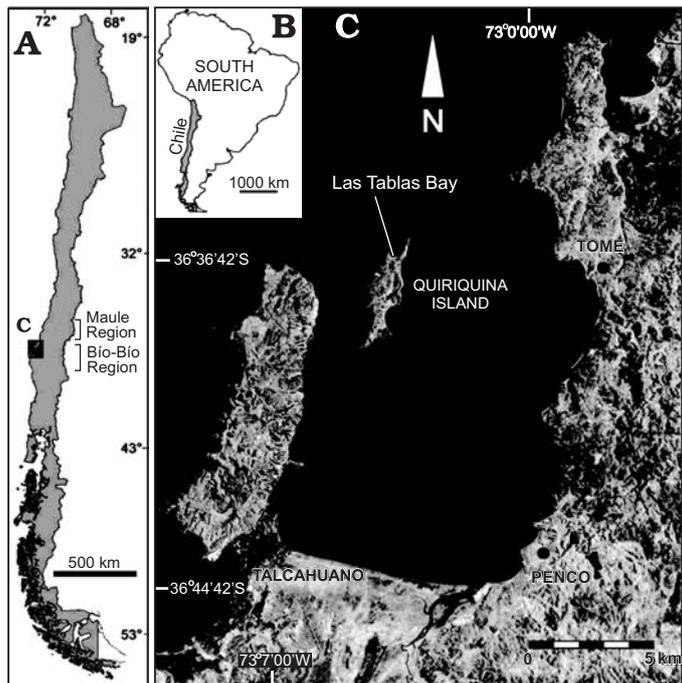


Fig. 1. **A.** Location of Maule and Biobío regions, where crops out most of the Maastrichtian beds with plesiosaur remains in Chile. **B.** Relation of the Chilean frontiers with South America. **C.** Map indicating Las Tablas Bay, on the northern part of Quiriquina Island, central Chile, where the studied materials were collected.

### *Mauisaurus* Hector, 1874

Type species: *Mauisaurus haasti* Hector, 1874.

### *Mauisaurus* sp.

Fig. 2.

**Material.**—SGO.PV.135: Left femur (Fig. 2A). SGO.PV.169: Proximal portion of left femur (Fig. 2B).

**Description.**—SGO.PV.135: Almost complete femur, originally recovered in three sections, with some loss of bony material at the attached portions. The femur has a gracile shape with its breadth approximately 2/3 of its total length (Table 1). The distal end has a medial thickness similar to the shaft, becoming narrower to the anterior and posterior margins, of which the poste-

Table 1. Measurements [in mm] of the studied specimens. The dorso-ventral distance between trochanter and capitulum on SGO.PV.169 is omitted because the trochanter of this specimen is worn.

	SGO.PV.135	SGO.PV.169
distal, antero-posterior length	253.0	—
distal, dorso-ventral thickness	99.0	—
total length	400.0	—
minimum thickness at diaphysis	105.4	107.7
capitulum maximum thickness	144.2	166.5
dorso-ventral distance between trochanter and capitulum	163.7	—
dorsal constriction between trochanter and capitulum	95.2	—

rior margin is the most slender. The articular facets are asymmetrical, with the anterior being shorter and narrower. Distally, the concave angle between facets is close to 210°. The capitulum is remarkably differentiated from the diaphysis and has a hemispheric shape with a sub-circular contour in proximal view, slightly compressed dorso-ventrally. The trochanter is large and developed diagonally with respect to the axis of the diaphysis, having a constriction that segregates it from the capitulum. This constriction is more excavated along the posterior margin than on the anterior. On the ventral face and near the midpoint of the shaft, a prominent callosity is preserved.

SGO.PV.169 is a proximal portion of a left femur that preserves the capitulum and part of the trochanter. The conserved part of the diaphysis shows a gracile shaft. The capitulum has a hemispheric shape very similar to that of SGO.PV.135, also with a sub-circular contour in proximal view. The trochanter is poorly preserved, but retains part of the constriction between itself and the capitulum. Morphologically, it closely resembles SGO.PV.135, but is larger.

## Discussion

The original description by Hector (1874) of the type materials of *Mauisaurus haasti* considered them as a scapular girdle and front paddles that correspond to an articulated portion of the pelvis and hind limbs. Despite this, the author noted the unique shape of the bone identified as the humerus (actually, the femur). Due to the lack of a formalized holotype material, Welles (1962) nominated a lectotype for the species. More recently, Hiller et al. (2005) described the most complete specimen referable to *Mauisaurus haasti*, permitting a more detailed description and a revised diagnosis that notes its uniquely hemispheric capitulum of the femur. As these authors indicate, the femoral morphology is unusual among elasmosaurids and it is considered as diagnostic for the taxon. Based on this feature, the femora from central Chile can be generically identified. Specific affinities of the Chilean fossils cannot be established, however, because they differ significantly in size from the lectotype material. The referred specimens described by Hiller et al. (2005) include a femur of an adult individual (CM Zfr 95), another femur (CM Zfr 115) regarded as a young adult, and a third femur, the lectotype, (DM R1529), with a capitulum slightly different but still hemispheric in shape. All these figured materials have a total length of the bone ranging between 300 to 350 mm, while the only complete femur from Chile (SGO.PV.135) has a total length of 400 mm. In addition, the fragmentary femur SGO.PV.169 was part of a femur that was apparently larger than SGO.PV.135. This could indicate that the referred specimens from New Zealand represent sub-adult individuals; however, the well-developed capitulum and trochanter seen at least in CM Zfr 95 and CM Zfr 115 are proportionally coincident with the Chilean fossils. Another possible interpretation is that the New Zealand materials and the Chilean femora belong to two different species of the genus *Mauisaurus*. Owing to this uncertainty, species-level identification for the Chilean specimens is presently unwarranted.

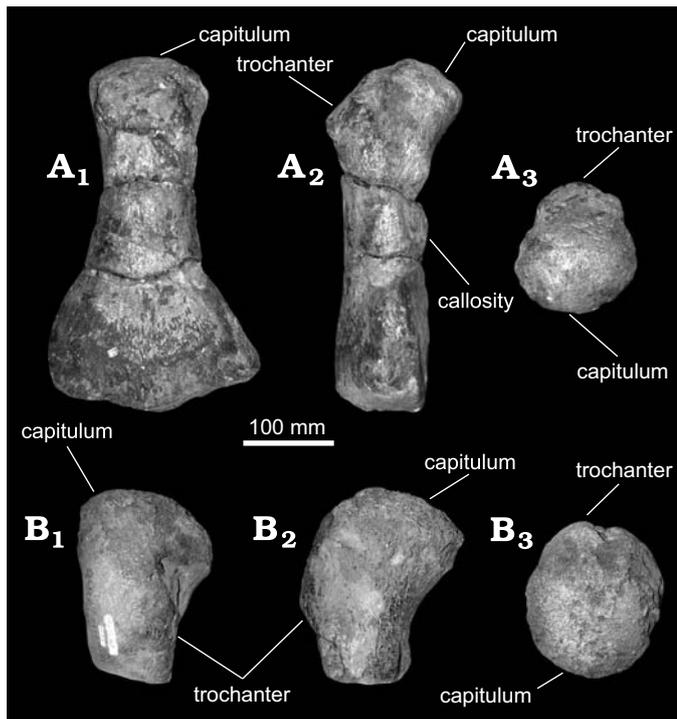


Fig. 2. Elasmosaurid plesiosaur *Mauisaurus* sp. from Las Tablas Bay, Quiriquina Island, Chile, Quiriquina Formation, Maastrichtian (Late Cretaceous). **A.** SGO.PV.135, left femur in dorsal (A<sub>1</sub>), posterior (A<sub>2</sub>), and proximal (A<sub>3</sub>) views. **B.** SGO.PV.169, proximal portion of left femur in dorsal (B<sub>1</sub>), posterior (B<sub>2</sub>) and proximal (B<sub>3</sub>) views.

The previous known paleodistribution of *Mauisaurus* includes cranial and postcranial materials from New Zealand (Hiller et al. 2005) and a hind limb from Seymour Island in Antarctica (Gasparini et al. 1984; Hiller et al. 2005). Additionally, an articulated postcranial skeleton of a juvenile individual was reported from Vega Island, Antarctica (Martin et al. 2007). Other remains from Río Negro Province, Argentina, were referred to cf. *Mauisaurus* sp. (Gasparini et al. 2003), and later reconsidered as Elasmosauridae indet. (Gasparini et al. 2007). The presence of this genus in Chile was previously suggested by Gasparini et al. (2007) based on fossils figured by Broili (1930), who originally assigned them to *Cimoliasaurus andium* Deecke, 1895 (nomen vanum). These authors also suggest that specimens of the paleontological collection of the Museo Nacional de Historia Natural of Santiago, Chile, particularly SGO.PV.91, SGO.PV.118, and SGO.PV.135, and several fossils of the paleontological collection of Museum Lajos Biró (University of Concepción, Chile), could eventually provide new information about the systematics of the elasmosaurids of the Southern Hemisphere. This is the case of SGO.PV.135, herein referred as *Mauisaurus* sp., while SGO.PV.91 is still considered as Elasmosauridae indet. due the close resemblance of the dorsal vertebrae with another unpublished specimen (SGO.PV.260, an articulated postcranial skeleton under study by the authors). Additionally, an articulated hind paddle collected at Faro Carranza, Maule Region, and figured by Tavera (1987) closely resembles *Mauisaurus*. Unfortunately, however, the specimen is apparently lost.

## Conclusions

This study verifies the presence of the genus *Mauisaurus* Hector, 1874 in the Maastrichtian of Chile, being the second valid genus identified in the country, together with *Aristonectes* Cabrera, 1941. The unique femoral morphology diagnosed for the species *Mauisaurus haasti* is recognized for two specimens from Chile. The Chilean fossils are considerably larger than the lectotype material. This could suggest that the femoral type material, so far considered as adult individual, is actually sub-adult. A second interpretation suggests that the larger Chilean femora belong to another species of the genus. The presence of *Mauisaurus* sp. in the eastern margin of the Pacific Ocean extends its known paleodistribution, previously verified in New Zealand and Antarctica, confirming its broad distribution along the Weddellian Province during the uppermost Late Cretaceous.

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