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Research Article

# Late Mesozoic marine Antarctic fishes: future perspectives based on the newly collections recovered in the Ameghino and López de Bertodano Formations

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**Abstract -** Nowadays, notothenioids are the teleostean group that dominates marine Antarctic waters. However, during the Mesozoic a diverse ichthyofauna inhabited the sea that surrounded Antarctic. We present the preliminary results of the last two Argentinian Antarctic field expedition to the Late Jurassic of Antactic Peninsula (Longing Gape) and Cretaceous-Paleogene of Seymour (=Marambio) Island. The fish material recovered is extremely abundant and their further detailed study may provide significant clues into the taxonomy and paleobiogeography of the mesozoic antactic ichthyofaunas.

**Keywords:** Actinopterygii, Chondrichthyes, Jurassic, Cretaceous, Antarctic Peninsula

## 1. Introduction

Antarctica – the most isolated, coolest, driest, and windiest landmass on Earth – has an extant fish fauna characterized by a low taxonomic diversity and high number of endemic taxa (e.g., Kriwet *et al.*, 2016). Nowadays, notothenioids are the teleostean group that dominate marine Antarctic waters. However, during the Mesozoic a diverse ichthyofauna inhabited the sea that surrounded Antarctica. Remarkably, the knowledge of Antarctic Mesozoic ichthyofauna – especially those Jurassic in age – is scarce. To date, few well–preserved specimens were reported from freshwater early Jurassic units of the Transantarctic Mountains (Schaeffer, 1972). Few Late Jurassic marine fishes were additionally described from James Ross Island (Richter and Thomson, 1989), Longing Cape (Arratia *et al.*, 2004), and Behrendt and Hauberg mountains (Arratia and Hikuroa, 2010). Late Cretaceous fish remains have been mainly reported from Seymour (=Marambio) (*e.g.*, Cione and Medina, 1987; Otero *et al.*, 2013, 2014), Snow Hill (e.g., Otero *et al.*, 2014; Gouiric-Cavalli *et al.*, 2015), James Ross (Kriwet *et al.*, 2006; Cione and Medina, 2009), and Vega islands (Martin and Crame, 2006).

Most of the Jurassic (Arratia *et al.*, 2004; Arratia and Hikuroa, 2010) and almost all the Cretaceous Antarctic fish material were identified at generic or higher taxonomic levels (*e.g.*, Grande and Eastman, 1986; Grande and Chatterjee, 1987; Cione and Medina, 1987; Cione, 1996; Kriwet *et al.*, 2006; Otero *et al.*, 2013, 2014).

During the 2016 and 2017 Argentinian Antarctic field expeditions to the marine Upper Jurassic Ameghino Formation and uppermost Cretaceous–Danian López de Bertodano Formation we recovered several fish material. This contribution highlights the research activity of a work team composed of junior and senior researchers, under-

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graduate students, and technicians. Our research focus on the study, prospection, and exploitation of Jurassic–early Paleogene Antarctic vertebrate fossil-bearing units. Here, we present the newly recovered fish material.

**2. Geological setting**

Material presented here was recovered from the Upper Jurassic Ameghino (=Nordenskjöld) Formation at Larsen Basin, Antarctic Peninsula and from the Upper Cretaceous–Danian levels of the López de Bertodano Formation at James Ross Basin, Seymour (=Marambio) Island (Fig. 1).

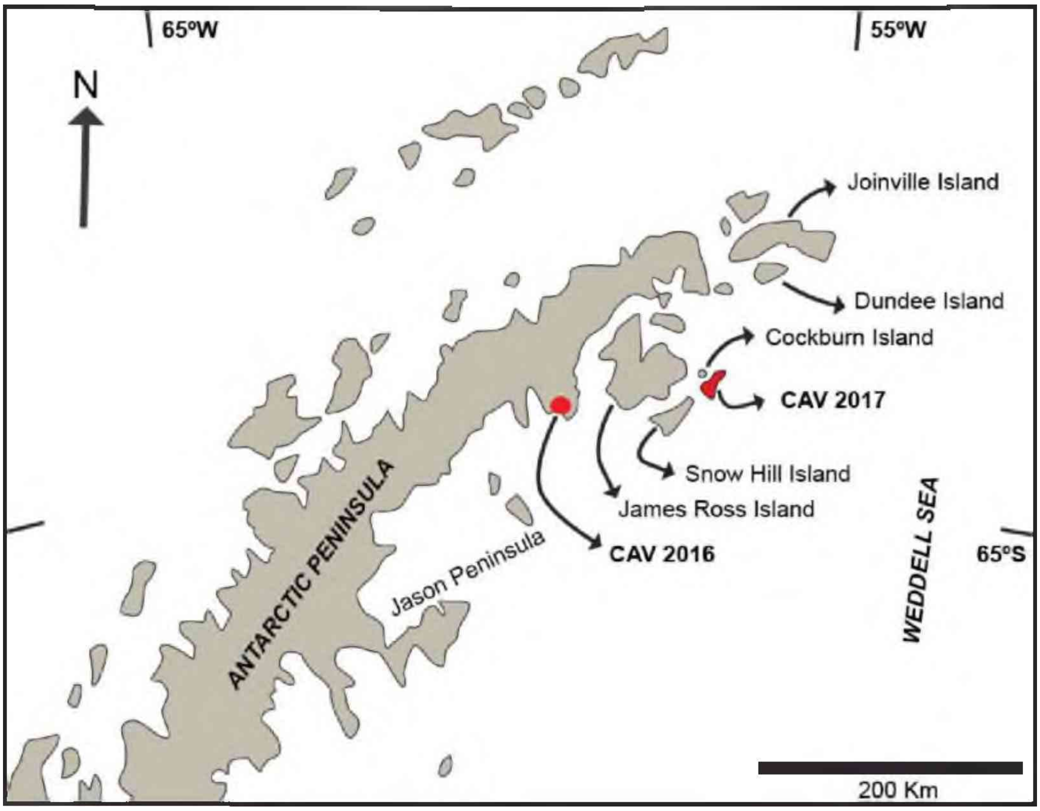


**Figure 1.** Localities prospected. CAV 2016 is for Ameghino Formation at Longing Cape, CAV 2017 is for López de Bertodano Formation at Seymour Island.

**2.1 Ameghino (=Nordenskjöld) Formation**

This Kimmeridgian–Berriasian unit has two members: the lower Longing Member (Kimmeridgian–lower–most upper Tithonian) and the upper Ameghino Member (upper Tithonian–Berriasian) (e.g., Medina and Ramos, 1982; Farquharson, 1982, Kiessling *et al.* 1999). The Ameghino Formation consists of laminated and/or massive mudstones and tuffs with abundant concretions; tuff beds increase at the Ameghino Member (Whitham and Doyle, 1989, Kiessling *et al.*, 1999). Paleoenvironmental settings of the Ameghino Formation correspond to marine pelagic and hemipelagic deposits (*e.g.*, Whitham, 1993; Scasso, 2001). Anoxic conditions prevailed in the Longing Member and dysoxic conditions in the Ameghino Member (Doyle and Whitham, 1991).

Paleontology of the Ameghino Formation includes a rich invertebrate fauna composed of ammonoids, bivalves (*e.g.*, Medina and Ramos, 1982; Kiessling *et al.*, 1999), and radiolarians (Kiessling and Scasso, 1996; Kiessling *et al.*, 1999). Vertebrates are mainly represented by osteichthyans (Richter and Thomson, 1989; Arratia *et al.*, 2004; Gouiric–Cavalli *et al.*, 2016).

**2.2 López de Bertodano Formation**

This unit ranges from the Maastrichtian to the Danian. It was subdivided into ten units based on lithology, fauna, and physiography (Macellari, 1988). The López de Bertodano Formation consists of massive mudstones and silty, fine–grained sandstones interbedded with glauconitic fine sandstone beds and concretionary horizons (Olivero, 2012). At Seymour Island the Cretaceous/Paleogene boundary is present within the López de Bertodano Formation (Marenssi *et al.*, 2012).

Paleoenvironmental setting of the López de Bertodano Formation was interpreted as estuarine and shallow marine transgressive deposits in the lowest part followed by transgressive shelf deposits, and overlaid by near-shore marine deposits in the uppermost part of the López de Bertodano Formation (*e.g.*, Olivero, 2012).

The López de Bertodano Formation is of interest particularly, for its implications on the extinction pattern of many fossil groups, including ammonites (Macellari, 1986), bivalves (Zinsmeister and Macellari, 1988), foraminifera (Huber, 1988), palynomorphs (Askin, 1988), diatoms, and silicoflagellates (Harwood, 1988). The vertebrate distribution in the López de Bertodano Formation include sharks (Cione and Medina, 1987; Kriwet *et al.*, 2006; Otero *et al.*, 2013, 2014), teleosts (Kriwet *et al.*, 2006), mosasaurs (Martin, 2006), plesiosaurs (O´Gorman *et al.*, 2013), and a bird (Acosta Hospitaleche and Gelfo, 2015).

## 3. Material and methods

The newly Jurassic material reported here was collected during the summer (January–February) 2016 field trip to Longing Cape. The Cretaceous–Danian material reported here was recovered in February 2017 on Seymour Island. The specimens are housed at the Repositorio Antártico de Colecciones Paleontológicas y Geológicas of the Instituto Antártico Argentino (IAA).

## 4. Results

### 4.1Fishes from the Ameghino Formation

Most of the specimens were collected in the lower Tithonian Longing Member and additional few fragmentary material recovered from the upper Tithonian Ameghino Member.

The preliminary field study of the material allowed to identify holosteans, teleosteomorphs, teleosts, and many indeterminate actinopterygians. *Ameghinichthys antarcticus* – previously known only by impression of its scales (Arratia *et al.*, 2004) – now include fin rays and scales. Aspidorhynchids, previously known by three incomplete specimens (Richter and Thomson, 1989; Arratia *et al.*, 2004) are now represented by several almost complete specimens (juveniles and adults). The new Antarctic material might be assigned to *Vinctifer* based on the presence of a row of deep, large, mid–flank scales that are deeper than the rows of scales placed immediately dorsally and ventrally (see Brito, 1997). However, the newly material show variations in some of the scale characters compared with those previously described by Arratia *et al.*, (2004) *i.e.*, it has thin ganoid scales (vs. thick ganoid scales); the three rows of flank scales near the pelvic area are 15 mm, 25–30 mm, 15 mm respectively (vs. 7–8, 35–33, and 7–8 mm); each scales row are composed of five dorsal rhombic scales, three row of large flank scales, and 6 or 7 rectangular and narrow ventral scales (vs. five to seven nearly square or rectangular scales followed by one nearly square scale, larger than the dorsal ones, then an elongated scale, deeper than long, that covers the mid–flank; below the large scale is a smaller rectangular one that is followed by 7 or 8 narrower rectangular scales that are longer than deep); dorsal scales are strongly ornamented with concentric ganoine ridges (vs. smooth scales surface). Pachycormids are represented by badly preserved fragmentary skull bones and branchial arches. Teleosts are represented by the previously known, *Antarctithrissops*, and a dissimilar morphotype currently under study (Fig. 2c). We also collected several coprolites with actinopterygians remains. To date, at least three different morphotypes were recognized. The coprolites are of dissimilar size and their infill is represented by scales, vertebrae, fin rays, and bones that show a variable state of grinding and mineral replacement (Fig. 3).

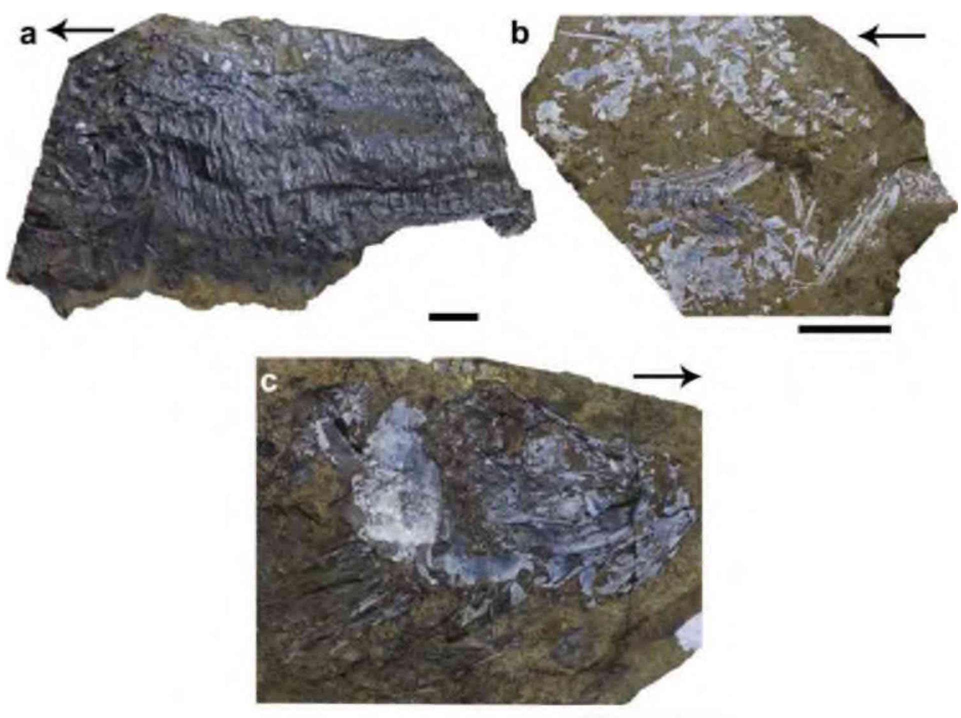


**Figure 2.** Some of the material recovered in the latest Antarctic field expeditions. (a–c) Material collected at Ameghino Formation. (a) IAA-Pv 424 Aspidorhynchiformes cf. *Vinctifer*, incomplete specimen in lateral view (b) IAA-Pv 324 Aspidorhynchiformes caudal endoskeleton, bones, and scales, (c) IAA-Pv 368 Teleostei indet. photograph of the head and pectoral fin, Scale bar= 20 mm. Arrow point anteriorly.

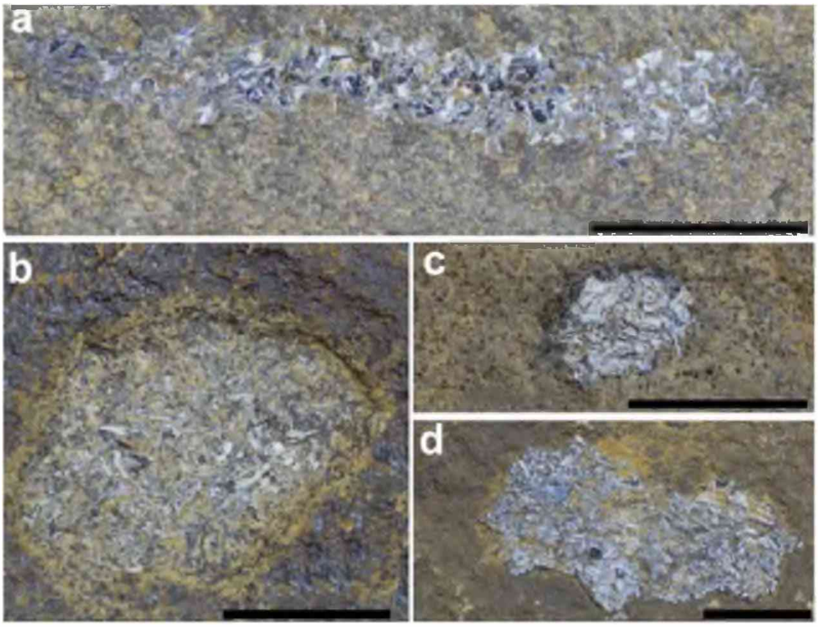

**Figure 3.** Coprolites recovered at Ameghino Formation. (a) IAA-Pv 423 68, Elongated, (b–c) IAA-Pv 423 35 and IAA-Pv 423 14 Rounded, (d) IAA-Pv 423 82 Rectangular. Scale bar= 10 mm.

### 4.2 Fishes from the López de Bertodano Formation

Specimens reported here were recovered from unit 9 and 10 of the López de Bertodano Formation (latest Maastrichthian–earliest Danian) on Seymour Island (Montes *et al.*, 2013). The material corresponds to chondrichthyans (chimaeroids and sharks) and osteichthyans (teleosts). Most of the material are isolated chondrichthyan and actinopterygian teeth and vertebral centra, and chimaeroid tooth plates. The preliminary taxonomic assignment of the chondrichthyan teeth allows the identification of Hexanchiformes (*Notidanodon*) and indeterminate lamniforms. We collected several selachian vertebral centra that correspond to large sharks, probably lamniforms. The fragmentary chimaeroid tooth plates are tentatively assigned to *Callorhynchus* and *Ischyodus*. Actinopterygians are represented by isolated ichthyodectiforms and aulopiforms teeth and several isolated teleostean vertebrae.

The uppermost levels of the López de Bertodano Formation house the extremely interesting fish bone layer associated to the K/Pg boundary and the iridium anomaly. This fish bone layer crops out in a large extension in the Seymour Island. Teleostean fish material–skull bones and vertebrae–are preserved partially disarticulated and highly disarticulated in concretions and associated to a massive sediment containing charcoal and plant debris (ferns, conifers, and angiosperms).

## 5. Remarks

The exploratory study of the Ameghino Formation allows the identification of at least six actinopterygian taxa and the absence of chondrichthyans. Also, highlights the abundance of coprolites with actinopterygians remains in the Longing Member. The newly collection made is –up to date– unique and the most important (in terms of number of specimens, taxa diversity, and preservational quality) marine fish collection of the Jurassic of Antarctica. Although preliminarily, the fishes provide a better knowledge about the taxonomic diversity and morphological disparity of the Ameghino Formation ichthyofauna. The good preservation and completeness of the specimens will provide new information in the near future.

The López de Bertodano Formation is highly fossiliferous being among the most productive sites for fossil remains in the Southern Hemisphere. Most of the vertebrate material recovered are fishes, which mainly encompass isolated chondrichthyans and teleostean teeth, tooth plates, and vertebrae. Here we report at least four chondrichthyan and two actinopterygian taxa. Apparently none of the fish material recently collected is novel for the López de Bertodano Formation. However, it is important to recall the high taxonomic diversity and specimen abundance of material recovered. The fish bone layer associated to the K/Pg boundary is represented by concretions extremely abundant in fish bones, which could be of taxonomic relevance. However, these remains have not yet been studied.

## 6. Further perspectives

We are interested in the evolutionary and taphonomic histories of the Mesozoic Antarctic ichthyofaunas. Thus, SGC started the review and study of the marine late Mesozoic ichthyofaunas of Antarctica. MBO is starting an undergraduate investigation which involves the study of the coprolites recovered at the Ameghino Formation.

Finally, a further detailed study of the – to date – collected fish remains from the Ameghino and López de Bertodano formations, as well as further field work, will ensure to provide new and valuable information on fish taxa diversity, evolution, and paleobiogeographic history of Antarctic ichthyofaunas.

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