

LATE JURASSIC FISHES FROM LONGING GAP, ANTARCTIC PENINSULA

GLORIA ARRATIA¹, ROBERTO A. SCASSO², and WOLFGANG KIESSLING¹

¹Museum für Naturkunde, Institut für Paläontologie, Invalidenstr. 43, D-10115 Berlin, Germany, gloria.ariatia@rz.hu-berlin.de;

²Dpto. de Cs. Geológicas, Universidad de Buenos Aires, Ciudad Universitaria, Pab. 2-1428 Buenos Aires, Argentina

ABSTRACT—Few records of Late Jurassic fishes have been reported previously from Antarctica. They include an indeterminate teleost from the Ameghino (Nordenskjöld) Formation at Longing Gap and two incomplete aspidorhynchiforms from James Ross Island, all of presumed Late Jurassic age. New fish material recently recovered in the Upper Jurassic of Longing Gap is described. The new material consists of one piece of body squamation, which, based on the structure of the scales, corresponds to a new genus and species (*Ameghinichthys antarcticus* gen. et sp. nov.) of an indeterminate actinopterygian family; one aspidorhynchiform identified as *Vinctifer* sp. due to the structure and distribution of the scales; and numerous specimens of a new ichthyodectiform, *Antarctithrissops seymouri* gen. et sp. nov. This new genus differs from European ichthyodectiforms in the shape of the preopercle, the presence of long sensory preopercular branches almost reaching the posterior margin of the bone, and the uncommon structure of the scales, with a fine layer of bone obscuring the circuli.

The presence of *Vinctifer* in the Antarctic is consistent with its other Gondwanan records. The Ichthyodectiformes, previously known from four European genera, extends the distribution of the group to the southernmost part of the Southern Hemisphere during the Late Jurassic. In contrast to most non-teleostean fishes, the known Late Jurassic teleosts apparently are species endemic to restricted areas in the Southern Hemisphere.

INTRODUCTION

Fossil fish remains from the Antarctic were first reported by Woodward (1908) from Cretaceous-Tertiary deposits of Seymour and Snow Hill Islands, near the northeastern tip of the Antarctic Peninsula. Woodward's (1908) material consisted of indeterminate and poorly preserved scales, teeth, and a selachian vertebral centrum (referred to *Ptychodus* sp.). Later, new discoveries of different ages enriched the knowledge of the fish fauna and have been reported in several publications. For instance, Woodward (1921) described a Middle-Late Devonian fish fauna from Victoria Land. Doumani et al. (1965) reported an even older Devonian fauna, and Schaeffer (1972) and Dzie-wa (1980) described Mesozoic occurrences. For a complete list of fishes up to the end of the 1980s see Young (1991).

The original discoveries on Snow Hill and Seymour Islands have been supplemented by the findings of new localities of Jurassic, Cretaceous, and Tertiary age. Collections from Seymour Island include abundant 'holostean' remains, shark teeth, a jaw, and vertebrae (Chatterjee and Zinsmeister, 1982), a well-preserved shark tooth belonging to the family Lamnidae (Grande and Eastman, 1986), hexanchiform shark teeth (Grande and Chatterjee, 1987), and a beryciform teleost (Grande and Chatterjee, 1987). Siluriform and gadiform teleost remains and elasmobranchs and holocephalans have been recovered from Tertiary marine deposits (see for instance Woodward, 1908; del Valle et al., 1976; Cione et al., 1977; Elliot et al., 1977; Welton and Zinsmeister, 1980; Grande and Eastman, 1986; Eastman and Grande, 1989, 1991).

In general, Jurassic Antarctic fish occurrences are scarce. Finds of Early Jurassic fishes consist of several complete individuals of the 'pholidophoriform' *Oreochima ellioti* in the Transantarctic Mountains, Victoria Land (Schaeffer, 1972). All other species of the family Archaeomaenidae are confined to Australia. Discovery of a Middle Jurassic *Hybodus* tooth in Graham Land was communicated by Fleming et al. (1938) and Stephenson and Fleming (1940).

Upper Jurassic fishes have been reported from James Ross Island and Longing Gap on the northeastern coast of Graham Land. An indeterminate teleost was illustrated by Farquharson

(1983:fig. 11) from the Ameghino (Nordenskjöld) Formation at Longing Gap. More recently, the teleostomorph *Aspidorhynchus* was described by Richter and Thomson (1989) from James Ross Island (but see comments on *Vinctifer* sp. below). Doyle and Whitham (1991) reported a complete but unidentified fish from the Ameghino Formation at Longing Gap.

Here we describe new fish material of Late Jurassic age from Longing Gap. The material includes the oldest teleost recovered from the Antarctic continent. Biogeographic affinities of the fish fauna are discussed and the results are compared to the biogeographic patterns of invertebrates.

LOCALITIES, GEOLOGICAL SETTING, AND AGE

All material is derived from the well-exposed Ameghino Formation at Longing Gap, a 4 × 1.5 km outcrop in northeastern Graham Land, Antarctic Peninsula (Fig. 1). The Ameghino Formation (=Nordenskjöld Fm.) comprises an Upper Jurassic sequence of radiolarian-rich mudstones and tuffs deposited in a relatively deep (several hundred meters), oxygen-deficient marine basin (Whitham and Doyle, 1989). The laminated or structureless, black mudstones represented the background sedimentation. They contain a rich assemblage of ammonites, bivalves, and radiolarians. In addition, silicified or phosphatized wood and rare brachiopods were observed. The tuffs are the result of ash falls and pyroclastic turbidite flows (Scasso and del Valle, 1989; Whitham, 1993).

At Longing Gap, the base of the succession is dominated by mudstones, while tuffs become increasingly important higher in the section. Intense silicification is frequent and early diagenetic processes favoured formation of phosphatic concretions and the preservation of phosphatic remains (Scasso and Kiessling, 2001). Mudstones as well as tuff beds are laterally continuous. Indications of bioturbation and bottom currents are rare and no influence of (storm) wave activity is evident. Slumps are very rare and small. Anoxic conditions prevailed especially in the lower part of the sequence (Longing Member), as indicated by the virtually absent bioturbation and rare horizons with bentonic fossils. In the upper part of the sequence ("Ameghino" Member), moderately intense bioturbation (*Zoophycos*, *Chon-*

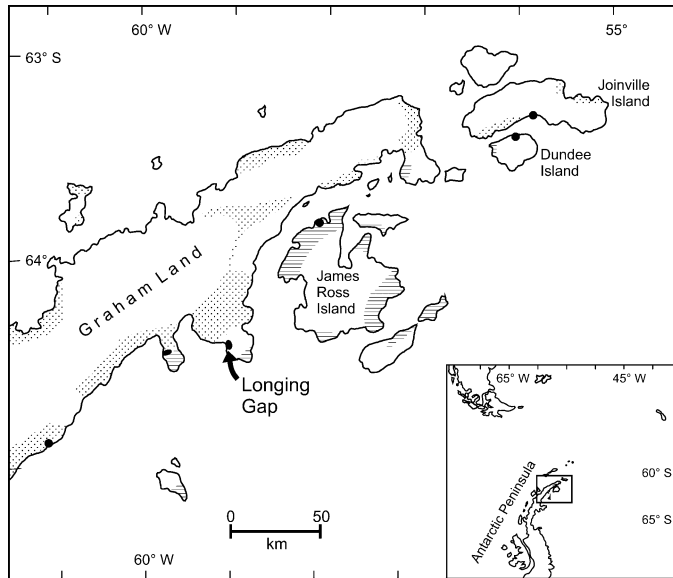


FIGURE 1. Geological sketch map of the northeastern Antarctic Peninsula (Graham Land) with occurrences of the Upper Jurassic Ameghino Formation (black spots). **Dotted**: Upper Jurassic-Cretaceous arc magmatics; **hatched**: Lower Cretaceous-Tertiary back-arc sediments. Our fish material stems from Longing Gap (Fig. 2).

drites, *Planolites*) and a consequent destruction of lamination indicate dysaerobic conditions. Doyle and Whitham (1991) attribute this environmental change to an uplift of the depositional environment above a permanent pycnocline. The submarine relief was very low and a simple hemipelagic sedimentation was dominant.

Our fish material stems from three horizons in the Longing Member (Fig. 2), which according to new biostratigraphic data can be assigned to the upper Kimmeridgian and lower Tithonian, respectively (Kiessling et al., 1999). Rare and scattered fish remains (scales) occur in tuff beds of the lower horizon. In the two upper horizons, complete and incomplete fish skeletons occur in abundance. Fish skeletons are confined to mudstone beds overlain by tuff layers. Fishes were collected from outcrops and scree.

MATERIAL AND METHODS

Comparative Materials

For taxonomic comparisons the following fossils were examined:

†**Acrolepidae**—*Acrolepis* sp. FMNH PF 3829 from the Lower Permian of Baylor County, Texas.

†**Aspidorhynchidae**—*Aspidorhynchus acutirostris*, MB. f. 3517 and 3522 from the Tithonian (Upper Jurassic) of the Solnhofen area, Germany. *Belonostomus muensteri* MB. f. 3544 from the lower Tithonian of the Solnhofen area, Germany. *Vinctifer comptoni*, FMNH PF 10267a, b, 10755a,b, 10762a, b, 10757a, b; MB. f. 3547, 3583, and 3591(1–2) from the Santana Formation (Lower Cretaceous), Ceará, Brazil.

†**Ichthyodectiformes**—*Ascalabothrissops voelkli*, JM SCH 30a, b, from the upper Kimmeridgian (Upper Jurassic) of Schamhaupten, Germany. *Allothrissops mesogaster*, JM SOS1941/17a, FMNH UC 2001 and FMNH UC 2082, SMNH P976, SMNH P2925, SMNH P685, and SMNH P7733 and *Allothrissops* sp. MB. f. 2822, 2823, 2842 (1–2), from the lower Tithonian of the Solnhofen area, Germany. *Pachythrissops propterus*, JM SOS 2526 (=specimen III in Nybelin, 1964),

24-11, 2412, and 741 (=specimen I in Nybelin, 1964), and MB. f. 3505, lower Tithonian of the Solnhofen area, Germany. *Thrissops formosus*, FMNH UC 2023, MB. f. 1590, and MB. f. uncatalogued; *Thrissops* cf. *T. formosus*, JM SOS3024. *Thrissops salmoneus*, FMNH P 25080. *Thrissops subovatus*, JM SOS 1953/14a, from the lower Tithonian of the Solnhofen area, Germany.

†**Ophiopsidae**—*Furo microlepidotus*, MB. f. 1562 (1–13) and 1570 and *Furo* sp., MB. f. 4950, from the Tithonian of the Solnhofen area, Germany.

†**Ptycholepididae**—*Boreosomus gillioti*, FMNH 4523 from the Lower Triassic of Madagascar. *Ptycholepis bollensis*, FMNH P 25157 and 25066 from the Lower Jurassic of Holzmaden, Württemberg, Germany. *Ptycholepis marshi*, from the Newark Group of Massachusetts, Connecticut, New Jersey and Virginia (Upper Triassic-?Liassic).

Methods

Most specimens were slightly mechanically prepared. Latex peels were produced from some of the fossils preserved as imprints and were coated with NH_4Cl . The material has been examined and drawn under a Wild MZ8 dissecting microscope with drawing attachment.

Abbreviations

Anatomical—**b.cl**, broken cleithrum; **b.mx**, broken maxilla; **b.op**, broken opercle; **b.pop**, broken preopercle; **b.qu**, broken quadrate; **bry**, branchiostegal ray; **b.scl**, broken supracleithrum; **b.smx1**, broken supramaxilla 1; **b.sop**, broken subopercle; **cl**, cleithrum; **b.cor**, broken coracoid; **de**, dentary; **io**, infraorbital bone; **iop**, interopercle; **loj**, lower jaw; **mx**, maxilla; **op**, opercle; **pa**[=fr], parietal bone (frontal of traditional terminology); **par**, parasphenoid; **pcl1-2**, postcleithrum 1-2; **pe.axp**, pectoral axillary process; **pec.f**, pectoral fin; **pel.f**, pelvic fin; **pe.ry**, pectoral rays; **pop**, preopercle; **rad**, radii; **l.loj**, left lower jaw; **r.loj**, right lower jaw; **scl**, supracleithrum; **smx2**, supramaxilla 2; **sop**, subopercle, ?**vo**,? vomer.

Institutional—**CABA**, Cátedra de Paleontología (Vertebrados), Facultad de Ciencias Exactas, Universidad de Buenos Aires; **FMNH**, Department of Geology, Field Museum of Natural History, Chicago, Illinois; **JM**, Jura Museum, Naturwissenschaftliche Sammlungen Eichstätt; **MB**, Institut für Paläontologie, Museum für Naturkunde, Berlin; **SMNS**, Staatliches Museum für Naturkunde, Stuttgart.

SYSTEMATIC PALEONTOLOGY

Class ACTINOPTERYGII Cope, 1887

Family indeterminate

†**AMEGHINICHTHYS**, gen. nov.

Diagnosis—(based on a combination of features) Thick (2–3 mm) rhombic scales, slightly longer than deep, with two to six longitudinal ganoin ridges that do not reach posterior margin; posterior margin smooth (Fig. 3A–C). Ganoin ridges separated from each other. Dorsally placed scales (Fig. 3B) with ganoin ridges running almost parallel to dorsal margin and covering most of scale surface. Ventrally placed scales (Fig. 3C) with fewer ganoin ridges running obliquely dorsoventrad from anterior part and scales considerably longer than deep. This combination is unique among actinopterygians.

Etymology—The generic name refers to the Ameghino Formation (after the Argentinian paleontologist Florentino Ameghino, 1854–1911) in Longing Gap, where the fish was recovered.

Type Species—*Ameghinichthys antarcticus*, sp. nov.

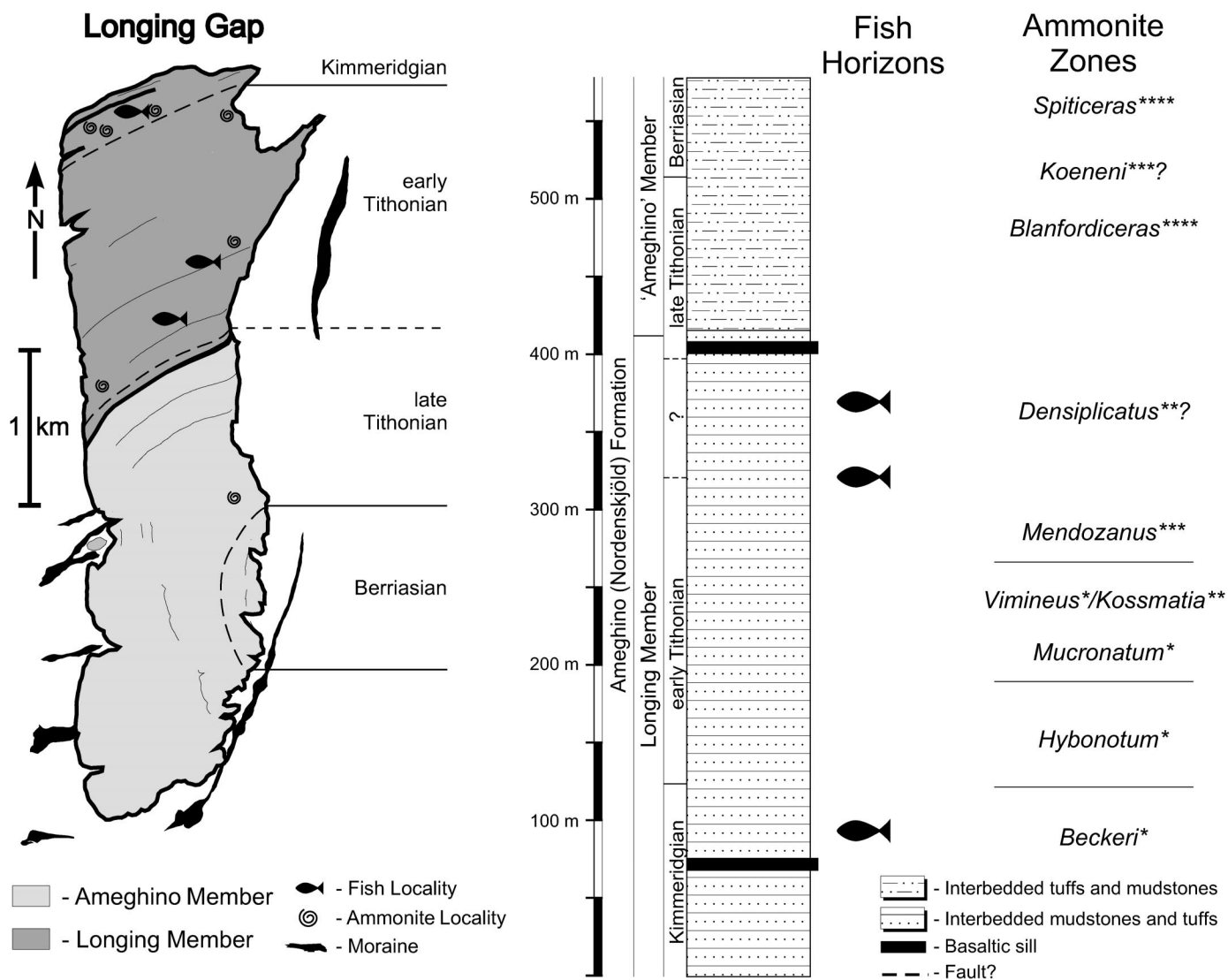


FIGURE 2. Geological map and lithological column of the Ameghino Formation at Longing Gap. Stratigraphy is based on radiolarian and ammonite data. The stratigraphic position of the fish occurrences is indicated. Ammonite zones: * = European standard zone, ** = Himalayan zone, *** = Argentinian zone, **** = Antarctic zone. Modified from Kiessling et al. (1999).

AMEGHINICHTHYS ANTARTICUS, sp. nov.
(Fig. 3)

Diagnosis—As for genus.

Holotype—CPBA-V-14065: piece of body squamation preserved mainly as an imprint. The position of these scales relative to the lateral line is unknown.

Horizon and Locality—The holotype is from the middle fish horizon (level 2) of the Longing Member (Ameghino Formation) at Longing Gap; Lower Tithonian.

Etymology—The specific name refers to the Antarctic continent where the fish was collected.

Description—A few scales are almost completely preserved. These are about 10 mm long and 5 or 6 mm deep. The depth of the scales decreases ventrally; the most ventral scales have only half the depth of the most dorsal ones. The most dorsal scales have most of their free surfaces covered by 5 or 6 elongated, narrow, ganoin ridges with narrow grooves between them. These ridges can have different lengths even on one scale, but commonly they are longer and more numerous than

those of the ventral scales. Ganoin ridges do not appear to extend posteriorly to the free margin; the margin is smooth.

Comments—Comparison with other Late Jurassic fishes shows that no fish with such scales has been reported in the literature. However, somewhat similar scales are found in the Carboniferous-Triassic family Acrolepididae, the Triassic Colobodontidae, the Triassic-Middle Jurassic family Ptycholepididae, and in one Jurassic genus of the family Ophiopsidae.

The scales of acrolepidids have few (ca. 3) ganoin ridges that do not reach the free margin of the scale; the ridges are on the posterior half of the scale and the free margin is smooth. Colobodontid scales can be thin or slightly thickened (e.g., *Crenilepis*) and the exposed surface is densely covered with ganoin ridges that extend posteriorly, giving the free margin a denticulated aspect (Mutter, 2002). The Ptycholepididae include the Triassic genus *Boreosomus*, the Late Triassic-Early Jurassic genus *Ptycholepis*, and the Chinese genera *Yuchoulepis* and *Chungkinichthys*, reported to be of doubtful Middle Jurassic age. The ganoin ridges in *Ptycholepis* are almost parallel to the

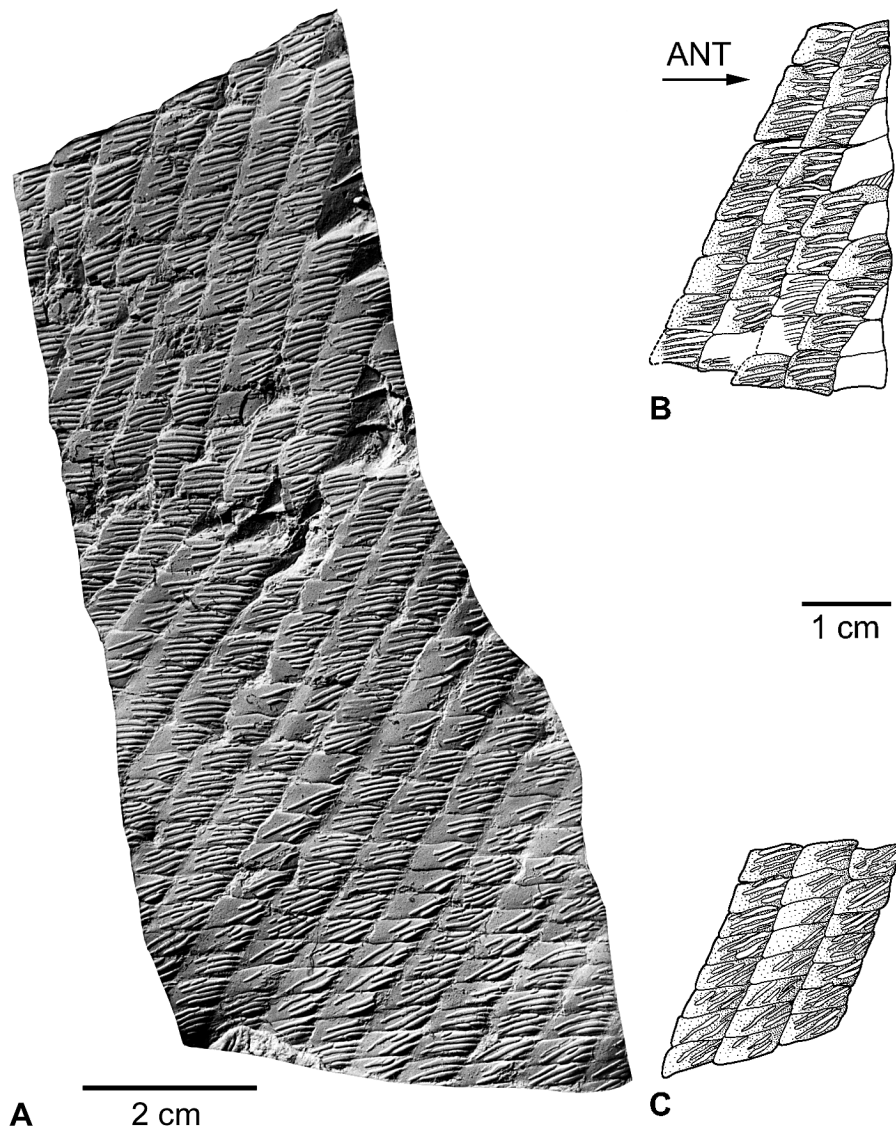


FIGURE 3. Scales of *Ameghinichthys antarcticus*. A, cast of CPBA-V-14065 coated with NH_4Cl . Details of some of the dorsally (B) and of the ventrally placed (C) scales.

dorsal margin; however, in the Chinese genera—as well as in *Acrolepis*—they run obliquely downward and backward from anterior to posterior. The posterior margin of the scales of *Ptycholepis* is notched (Schaeffer et al., 1975) and the ridges usually anastomose near the free edge of the scale. *Boreosomus* has much deeper scales and the free margin of the scale is also notched or denticulated. Flank scales of *Boreosomus*, *Yuchoulepis*, and *Chungkinichthys* are slightly longer than wide (Wenz, 1968; Su, 1974; G.A., pers. obs.), whereas in *Acrolepis* and *Ptycholepis* the flank scales are longer than deep. Ophiopsid scales slightly similar to those of the Antarctic fish described here are known from the genus *Furo* from the Liassic and Upper Jurassic of Germany (Schultze, 1966:fig. 25 and unpublished drawings of *Furo microlepidotes* from Nusplingen by H.-P. Schultze; G.A., pers. obs. of material from the Solnhofen limestones). Most of the surface of the scales is covered by numerous, undulating ganoin ridges of different lengths that extend posteriorly producing a denticulated posterior margin.

In conclusion, the new fish described here cannot be included

in any of the known families because its squamation differs widely from all of them.

Class ACTINOPTERYGII Cope, 1887
 Division TELEOSTEOMORPHA sensu Arratia, 2001
 Family †ASPIDORHYNCHIDAE Nicholson and Lydekker,
 1889

†*VINCTIFER* sp.
 (Fig. 4)

Material—CPBA-V-14066. Body segment showing squamation, pelvic plate and incomplete pelvic, dorsal, and anal fins (Fig. 4). The scales are mainly preserved in internal aspect.

Description—The preserved fish is a piece of the trunk 25 cm long. The distance between the origins of the pelvic and anal fins is 8.3 cm. Most of the scales are in situ, and consequently, internal vertebral structures and associated elements are not observed with the exception of a few thin ribs between the scales. There is an elongated pelvic bar bearing 8 broad and

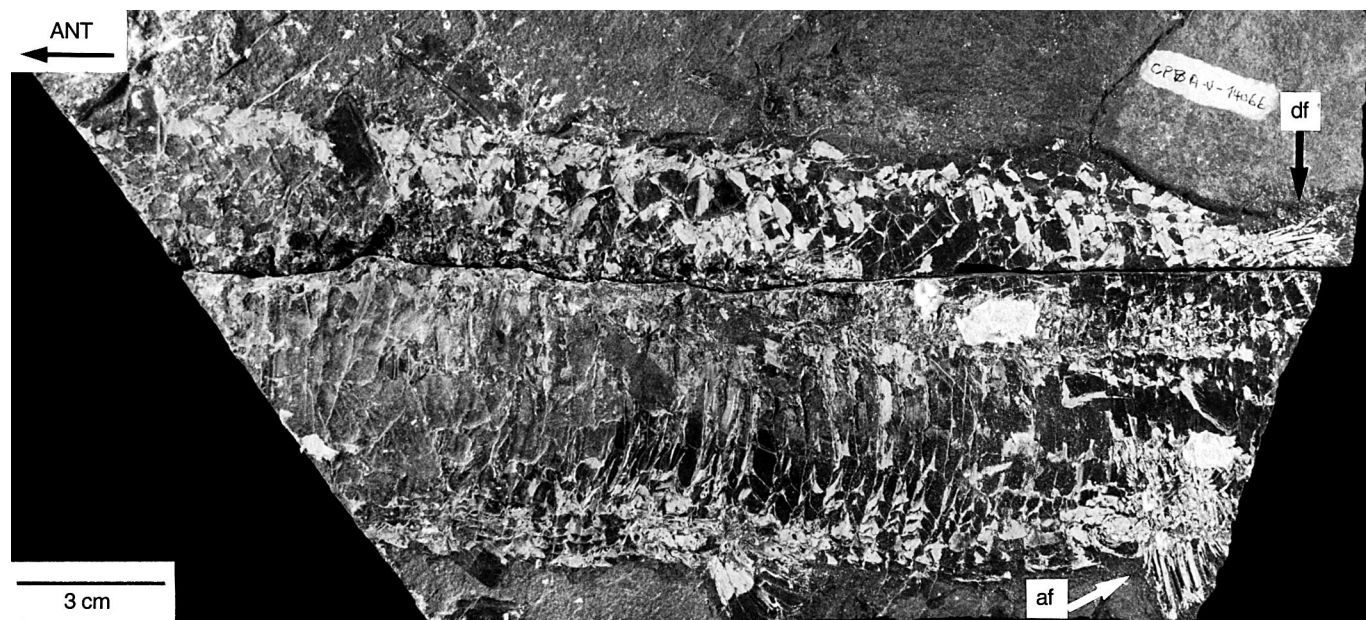


FIGURE 4. Incomplete body in lateral view of *Vincitifer* sp. (CPBA-V-14066) from the Upper Jurassic of Longing Gap.

heavily ossified incomplete rays. Proximally, the pelvic rays have broad, long bases and the rays are branched distally. It is unclear whether the rays were also segmented because the distal tips are not preserved. Remains of the anterior dorsal rays are preserved slightly posterior to the level of origin of the anal fin. There are remains of 10 anal pterygiophores, the first one being thick, long and heavily ossified. A few fringing fulcra are preserved in front of the first anal ray.

The squamation is composed by rows of thick ganoid scales of lepidosteoid-type (sensu Schultz, 1996). Each row (Fig. 4) is formed, from dorsal to ventral, by about 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. The larger scales of the mid-flank have their long, sharp pegs slightly closer to their anterior margin than to the posterior one. However, the smaller scales closer to the body margins have pegs almost in the middle of the dorsal margin. The three larger scales of the mid-flank at the level of the pelvic fin are ca. 7–8, 35–33, and 7–8 mm deep, respectively. Ornamentation has not been observed on the scale surface. Where it can be observed, the posterior margin is smooth.

Comments—The first known Antarctic aspidorhynchiforms are represented by two incomplete specimens that were interpreted as a new species of *Aspidorhynchus* (*A. antarcticus*) and as *Aspidorhynchus* sp. The two aspidorhynchiforms described by Richter and Thomson (1989) are from a reworked boulder of presumed Late Jurassic age in the Lower Cretaceous Whisky Bay Formation on the northwestern coast of James Ross Island. The new species, *A. antarcticus*, essentially was based on the shape of the scales that have smooth surfaces and lack ganoin. Some species of *Aspidorhynchus* lack ganoin, but others have it; consequently Brito and Meunier (2000) interpreted this absence as a secondary loss.

Aspidorhynchus antarcticus was interpreted as having three horizontal rows of scales deeper than long; the scales of the mid-flank row are deeper than those of the dorsal and ventral

scale rows, where they can be observed (most of the dorsal row is incomplete). Consequently, the size and distribution of the scales of *Aspidorhynchus antarcticus* are more similar to those of *Vincitifer* than to *Aspidorhynchus*. However, the ventral lobe of the caudal fin of *A. antarcticus* is longer than the dorsal one, a feature that was suggested to be diagnostic of the genus *Aspidorhynchus*, based largely on *A. acutirostris* (Brito, 1997).

Schultze and Stöhr (1996) revised what was known of the squamation of the three aspidorhynchiform genera (*Aspidorhynchus*, *Belonostomus*, and *Vincitifer*) and included in their study *Aspidorhynchus antarcticus* and *Aspidorhynchus* sp. from Antarctica. They suggested that both *A. antarcticus* and *Aspidorhynchus* sp. from Antarctica are specimens of *Vincitifer*. Brito (1997) agreed that the second specimen studied by Richter and Thomson (1989) belongs to *Vincitifer* but he retained *A. antarcticus* in the genus *Aspidorhynchus*, an assignment that should be reviewed when more specimens from Antarctica become available.

Incomplete preservation renders it difficult to compare the new specimen collected on Seymour Island with other aspidorhynchiforms. Keeping such a limitation in mind, a preliminary comparison is provided here: (1) The pattern of scales of the three horizontal rows of mid-flank scales of *Vincitifer* sp. (CPBA-V-14066) from Seymour Island is similar to that of *Vincitifer* following Schultze and Stöhr (1996) and Brito (1997). A row of deep, large, mid-flank scales that are deeper than the rows of scales placed immediately dorsally and ventrally is a diagnostic feature of the genus *Vincitifer* according to Brito (1997). The patterns of the three horizontal mid-flank scales in *Belonostomus* and *Aspidorhynchus* are different (see Schultze and Stöhr, 1996:fig. 6a–c). (2) The surface of the scales of specimen CPBA-V-14066 is smooth, and probably their posterior margin is also smooth. In contrast, the scales of *V. comptoni* are variably ornamented with tubercles and ridges. (3) The new specimen CPBA-V-14066 possesses five to seven horizontal rows of smaller scales dorsally placed to the three main horizontal rows; in contrast, *V. comptoni* has two or three dorsal rows (Brito, 1997). (4) *Vincitifer* sp. shows 7 or 8 rows of scales placed ventrally to the main horizontal rows of the mid-flank,

whereas *V. comptoni* has five rows ventrally according to Brito (1997). Nevertheless, a review of specimens of *Vinctifer comptoni* reveals fewer ventral rows of small scales than are found in the new Antarctic material. Four or five horizontal rows placed between the pectoral and pelvic fins and three or four horizontal rows of ventral scales between the pelvic and anal fins are found in *V. comptoni*. Larger specimens of *V. comptoni* seem to have five or six rows between the pectoral and pelvic fins. Consequently, the number of horizontal ventral rows of scales of *Vinctifer* sp. from the Upper Jurassic of Antarctica seems to be higher (7–8) than that of other species outside Antarctica. Unfortunately, the dorsal and ventral rows of scales of the specimens described by Richter and Thomson (1989) are incompletely preserved, so that a comparison with the new Antarctic specimen cannot be made.

Class ACTINOPTERYGII Cope, 1887
 Subdivision TELEOSTEI Müller, 1844
 Order †ICHTHYODECTIFORMES
 (Bardack and Sprinkle, 1969)
 Suborder †ALLOTHRISOPOIDEI
 Patterson and Rosen, 1977
 Family †ALLOTHRISOPOIDAE
 Patterson and Rosen, 1977

†ANTARCTITHRISOPOIDS, gen. nov.

Diagnosis—Ichthyodectiform fish with an elongated body as seen in *Occithrissops*, *Allothrissops*, and *Thrissops*; large, broad preopercle with its dorsal and ventral limbs almost of equal size and forming between them an angle of about 90 degrees; the posterior margin lacks a notch usually present in ichthyodectiforms; long preopercular sensory branches reaching the ventral arm of the bone unlike other ichthyodectiform genera; with about 55 or 56 vertebrae; neural and haemal arches fused to well-developed autocentra in the most caudal region; vertebrae sculptured with numerous horizontal ridges and crests; epineural processes reach the first dorsal pterygiophores; the large cycloid scales are oval or slightly rectangular, with circuli at the anterior field and with radii at the anterior and posterior fields; a thin layer of bone covers the whole scale unlike in all other ichthyodectiform genera.

Etymology—The generic name refers to the Antarctic occurrence of the genus and its relationships to *Thrissops*.

Type Species—*Antarctithrissops australis*, sp. nov.

†ANTARCTITHRISOPOIDS AUSTRALIS, sp. nov.
 (Figs. 5–7)

Diagnosis—Same as for genus.

Holotype—CPBA-V-14054, incomplete head missing its anterior portion, and anterior part of body with pectoral girdle and fin preserved (Fig. 5A).

Paratypes—CPBA-V-14055, head preserved as counterpart. CPBA-V-14056, disarticulated skull bones and anterior part of body with abdominal vertebrae and disarticulated scales. CPBA-V-14058, section of the body showing abdominal vertebrae, epineural processes, and ribs. CPBA-V-14059, poorly preserved skull. CPBA-V-14060, skull missing the dorso-posterior part of the cranium, displaced pectoral rays, and a few large scales. CPBA-V-14061, poorly preserved skull and displaced pectoral fin. CPBA-V-14062, poorly preserved skull showing a well preserved opercle. CPBA-V-14063, body with pectoral, pelvic, dorsal, anal, and caudal fins poorly preserved. CPBA-V-14064, part of skull preserved in inner view showing preopercle, supramaxillary bones, and orbit. CPBA-V-14065, partially disarticulated, incomplete skull with sections of the branchial arches showing long, toothed gill-rakers; pectoral girdle and fin and anterior abdominal vertebrae and ribs preserved.

CPBA-V-14067, posterior part of body with vertebrae, incomplete dorsal and anal fins, and squamation. CPBA-V-14091, poorly preserved disarticulated skull bones and fin rays. CPBA-V-14092, section of body showing vertebrae, dorsal and anal fins, and isolated, large cycloid scales. CPBA-V-14093, section of body showing vertebrae, ribs, pelvic plate and fin, incomplete dorsal and anal fins, and large cycloid scales in situ.

Horizon and Locality—The holotype is from the upper fish horizon (level 3) of the Longing Member (Ameghino Formation) at Longing Gap; Tithonian. Paratypes are from the middle (level 2) and upper fish horizons. The holotype and paratypes were collected by R. Scasso and W. Kiessling in 1994.

Etymology—The name refers to the Southern Hemisphere, which appears to be the habitat of the new species.

Description—Although the material of *Antarctithrissops* does not permit a complete morphological description, the species will be described as far as the preservation permits, and mainly by comparison with species of *Occithrissops* (Schaeffer and Patterson, 1984), *Ascalabothrissops* (Arratia, 2000), *Allothrissops* (Nybelin, 1964; Taverne, 1975; Patterson and Rosen, 1977; G.A., pers. obs.), *Pachythrissops* (Arratia, 1997), and Jurassic species of *Thrissops* (Nybelin, 1964; Taverne, 1977; G.A., pers. obs.).

Because most specimens are disarticulated, the total length of the new species is unknown. However, specimen CPBA-V-14063 (Fig. 6A) showing an elongated complete body may have reached about 19 cm in length. Other specimens (e.g., CPBA-V-14054, 14056) have a larger body than CPBA-V-14063, and consequently, it is assumed that the fishes could have reached close to 30 cm in length, which is not an unusual length for Late Jurassic species of *Pachythrissops*, *Allothrissops*, and *Thrissops*. The shape of the elongated body of *Antarctithrissops* resembles more closely that of *Occithrissops* and *Allothrissops* than that of *Ascalabothrissops* and *Pachythrissops*, which have more oblong bodies (Arratia, 1997:fig. 22A, B; 2000:figs. 2A, B, 3). Anal and dorsal fins (Fig. 6A, B) are posteriorly placed and the dorsal fin is shorter than the anal as in other ichthyodectiforms. Due to incomplete preservation it is not possible to establish the shape of the fins.

The head (Figs. 5A, B, 7) of *Antarctithrissops* is slightly deeper than the head of *Allothrissops mesogaster*. In this respect, it resembles more closely that of *Pachythrissops propeteris*. A prominent supraoccipital crest, like that found in *Thrissops*, is absent. The mouth (Fig. 7) is short; the articulation of the lower jaw with quadrate is below the posterior half of the orbit. A moderately short mouth is also present in *Ascalabothrissops* and in *Allothrissops mesogaster*. The lower jaw is comparatively shorter in *Pachythrissops*, where the articulation with the quadrate lies in front of the anterior half of the orbit. The ratio of the ventral limb of the preopercle to the dorsal limb is about 1.0 in *Antarctithrissops*, unlike other Late Jurassic forms (e.g., ~1.3 in *Occithrissops*; ~1.5 in *Allothrissops*; ~2 in *Ascalabothrissops* and *Thrissops formosus* and *T. cirinensis* according to Schaeffer and Patterson, 1984; Arratia, 2000:fig. 3; Taverne, 1977:figs. 5, 6, 8). The narrow subopercle corresponds to 1/7 or 1/8 the depth of the opercle. In contrast, the subopercle is not as deep in *Ascalabothrissops* (~3.0), *Allothrissops* (~3–3.5), and *Thrissops formosus* (~4.0).

All the skull bones are poorly preserved because the bones split easily. In most cases the cranial bones are preserved in their inner view or as a natural mold of the outer surface. There are sections of the broad parietal (=frontal of conventional terminology) preserved as well as the mesethmoid that is vaguely triangularly-shaped anteriorly, with elongated lateral processes.

Generally the circumorbital bones (Figs. 5A, 7) are damaged. However an elongated supraorbital bone and a comma-shaped antorbital (not carrying the antorbital section of the infraorbital canal) are observed in CPBA-V-14060. The infraorbital 1, usu-

ally damaged, is a broad, somewhat triangular bone, similar in shape to that of *Allothrissops mesogaster*. Infraorbital 2 is comparatively narrower and shorter than infraorbital 1, but is deeper (CPBA-V-14061) than the bone found in *A. mesogaster*. Infraorbitals 3 to 5 cannot be described because of poor preservation, but apparently they are large, thin bones covering the region between the posterior margin of the orbit and anterior margin of the preopercle (Fig. 7). There is no evidence that a suborbital bone is present. The infraorbital sensory canal runs close to the dorsal margin of the infraorbital 1 and ends blindly in this bone. The canal runs deeply in the bone and the number of sensory branches is unknown.

The upper jaw comprises a broad, triangular premaxilla that bears small conical teeth (e.g., CPBA-V-14060), the maxilla, and two supramaxillae. The narrow maxilla is short, slightly shorter than the lower jaw and presents a smooth curvature similar to that in *Allothrissops*; the posterior tip of the bone is rounded. A row of small conical teeth is present on the ventral margin of the maxilla like in most Late Jurassic ichthyodectiforms. In contrast, the maxilla of the Late Jurassic species of *Thrissops* is almost straight and bears large teeth. The broad supramaxillae 1 and 2 (Fig. 5A, B) cover the dorsal margin of the maxilla and they are similar to other ichthyodectiform supramaxillary bones.

The lower jaw (Fig. 7) is moderately long and the dentary has a high coronoid process (Fig. 7) of leptolepid type. The mandibular symphysis is deep, and more similar to that in *Pachythrissops* (Arratia, 1997:figs. 22, 23A) than that of *Allothrissops*. It is unclear whether a 'leptolepid' notch is present in the ascending dorsal portion of the anterior margin of the dentary. Posteriorly there is a well developed, elongated postarticular process. The preservation of the lower jaw does not permit the description of its dentition and of the bones forming its posterior part. The posterior opening of the mandibular sensory canal seems to be medial.

The quadrate (Figs. 5A, B, 7) is a deep triangular bone with a well developed, heavily ossified posteroventral process (e.g., CPBA-V-14054, -14060). Other bones of the palatoquadrate series are damaged, with the exception of a boomerang-shaped ectopterygoid preserved in CPBA-V-14093. The ectopterygoid seems to be edentulous. However, part of the region occupied by the entopterygoid is covered by a tiny dentition.

The opercular apparatus comprises the preopercle, interopercle, opercle, and subopercle. A suprapreopercle is absent. The preopercle (Figs. 5A, B, 7) is preserved in numerous specimens; both limbs are long, almost equal in length and forming an angle of 90 degrees. The posteroventral angle of the bone projects slightly. The hind margin continues smoothly dorsally producing a somewhat convex posterior margin. A notch is absent at the posterior margin of the preopercle, while it is present in *Allothrissops* and *Thrissops*. There are more than 11 long sensory canal branches in the ventral limb and a few more in the dorsal limb. Most ichthyodectiforms are characterized by the presence of short preopercular branches. The interopercle (Figs. 5A, B, 7) is as long as the ventral limb of the preopercle. The opercle (Figs. 5A, B, 7) is a large, deep, more or less rectangular bone whose dorsoanterior corner is inclined slightly anteriorly. The subopercle (Figs. 6A, B) is a small, narrow bone, comparatively narrower than in other Jurassic ichthyodectiforms.

Remains of the long posterior branchiostegal rays are preserved in different specimens, but their total number is unknown.

The vertebral column (Fig. 6) is almost straight, though the last caudal vertebrae are inclined upward. The vertebral column is formed by 56 or 57 vertebrae in the only specimen showing the complete column (CPBA-V-14063). The number falls in the range given for other Jurassic ichthyodectiforms, e.g., *Occhith-*

rissops (58), *Allothrissops* (57–61), and *Thrissops* (57–59) (Taverne, 1977; Schaeffer and Patterson, 1984). An exception is *Ascalabothrissops* with 41 vertebrae (Arratia, 2000). All autocentra are heavily ossified and ornamented with fine longitudinal grooves and crests. All the anterior abdominal centra have autogenous neural arches. Fusion of the neural arch to the autocentrum occurs caudally though it is unclear how far back fusion begins. The anterior abdominal vertebrae have unfused halves of the neural arch; these form a single spine posteriorly. However, it is unclear where a single neural spine is present in the only specimen available. There are more abdominal (more than 30) than caudal vertebrae (22 or 23). The long, narrow supraneural bones are badly preserved and it is unclear whether they extend below the first dorsal pterygiophores. The long, thin epineural processes become progressively inclined toward the horizontal caudally; the tips of the last processes reach the first vertebra below the dorsal fin. There are no epipleural bones as is typical for most ichthyodectiforms. However, *Pachythrissops* apparently has epipleural bones (Arratia, 1997). The ribs are long, almost reaching the ventral margin of the body.

The pectoral girdles are incompletely preserved. The cleithrum (Figs. 5A, B, 8) is a broad, short bone, but it narrows at its dorsal and anteroventral portions. There is a comparatively large, massive coracoid, typical of ichthyodectiforms; it is incompletely preserved in the holotype. The total number of postcleithra is unknown but specimen CPBA-V-14054 presents two elongated bony elements. These additional ventrally placed postcleithra form an axillary process (Fig. 5B). The first pectoral fin-rays are stout and segmented only toward the tip, whereas the other rays are finely branched and segmented distally; the most anterior rays are the longest and the length of the rays decreases rapidly in the innermost rays. There are about 14 pectoral rays. The pelvic plate and fin do not show any remarkable character; about 7 rays are preserved in CPBA-V-14093.

As in most ichthyodectiforms, the dorsal and anal fins are closer to the caudal fin than to half of the standard length, with the exception of *Pachythrissops*. The dorsal fin has 10 pterygiophores and about 14 rays and the anal fin about 20. Due to poor preservation the shape of the fins cannot be determined.

The caudal skeleton is poorly preserved in the only specimen we are certain belongs to an ichthyodectiform (CPBA-V-14063). (Among the material, there are a few isolated, poorly preserved tails that can be assigned to some indeterminate teleost). The tail is homocercal and not deeply forked.

The body is completely covered with strongly imbricated, large, cycloid scales. The large scales are ovate or subrectangular in shape (Fig. 9A). For instance, in specimen CPBA-V-14092, with vertebrae about 3 mm in length, the scales are about 6 mm long \times 6 mm width. When a scale has its surface preserved, a thin bony layer covers it and no circuli are observed. However, in those scales where the bony layer is partially destroyed it is possible to observe the circuli filling the anterior field and extending slightly posteriorly. The posterior field does not have circuli and in this feature resembles *Thrissops* (Schultze, 1966:fig. 2a, b). While the scales of *Allothrissops*, *Thrissops* (Fig. 9C), and *Pachythrissops* are deeper than long, and with a small focus displaced posteriorly, the scales of *Antarctithrissops* are slightly longer than deep and with a large focus almost at the center of the scale.

Comments—Ichthyodectiformes are known only from the Middle-Late Jurassic and Cretaceous. They have received attention from numerous workers (e.g., Nybelin, 1964; Bardack, 1965; Cavender, 1966; Bardack and Sprinkle, 1969; Nelson, 1973; Taverne, 1973, 1975, 1977, 1986; Patterson and Rosen, 1977; Schaeffer and Patterson, 1984; Maisey, 1991; Arratia, 1997, 2000; Stewart, 1999; Taverne and Chanet, 2000) and there is an extensive literature concerning the group. The ich-

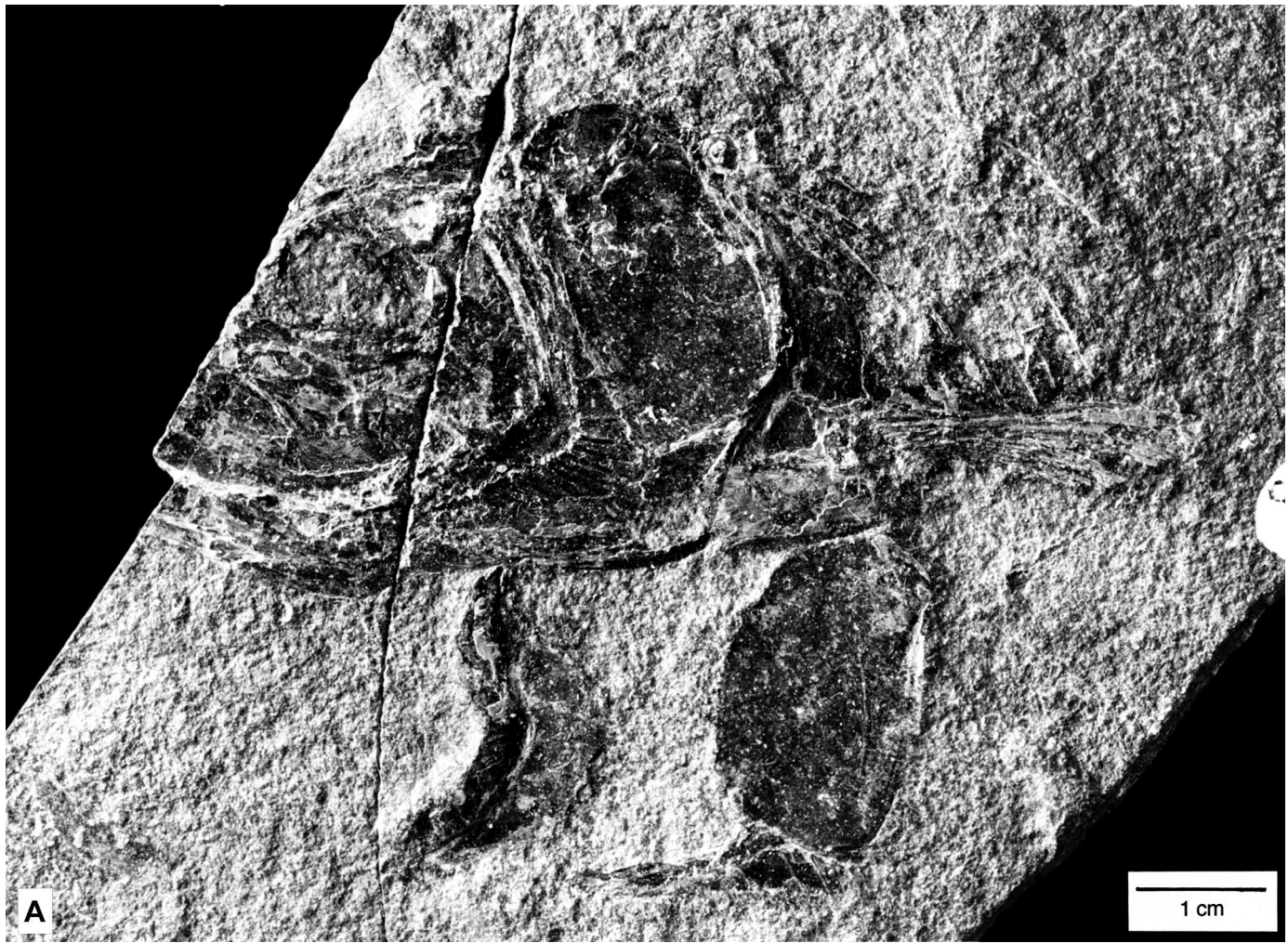


FIGURE 5. *Antarctithrissops australis* (CPBA-V-14054; holotype) from the Upper Jurassic of Longing Gap. **A**, photograph of anterior part of body in lateral view. **B**, identification of the structures in A.

thyodectiforms are considered a monophyletic group that is characterized by a series of synapomorphies listed in Patterson and Rosen (1977:115). Of these, *Antarctithrissops* shares three (teeth in a single series in the jaws, coracoid enlarged and meeting its fellow in a midventral symphysis, and long anal fin opposed by a short dorsal fin) with the ichthyodectiforms. Two characters (floor of nasal capsule with an ethmopalatine ossification that articulates with the palatine, and six or seven uro-neurals with the first three or four extending anteroventrally to cover the sides of the first to third preural centra) are unknown because of poor preservation. Although some of the characters are homoplastic, there are, however, numerous resemblances to *Occithrissops*, *Allothrissops*, *Pachythrissops*, and *Thrissops* that provide evidence that *Antarctithrissops* is an ichthyodectiform.

Within the Ichthyodectiformes Patterson and Rosen (1977) established two suborders, the Allothrissopoidei and the Ichthyodectoidae. *Antarctithrissops* shares with the first suborder the absence of a suborbital bone, the infraorbital canal ending blindly in the first infraorbital without reaching the antorbital bone, and the haemal arches fused with the centra in most of the caudal region. Consequently, and because of additional morphological similarities with *Allothrissops*, *Antarctithrissops*, gen. nov. is included within the Allothrissopoidei.

Jurassic ichthyodectiforms comprise at least six genera: *Oc-cithrissops*, the oldest, from the Middle Jurassic (Bathonian);

Ascalabothrissops from the Kimmeridgian; and *Allothrissops*, *Antarctithrissops*, *Pachythrissops*, and *Thrissops* from the Tithonian. The combination of characters of *Antarctithrissops* separates it from all other ichthyodectiforms. In addition, *Antarctithrissops* differs from other ichthyodectiforms in the presence of (1) a preopercular bone with both limbs of almost the same length and forming an angle of 90 degrees between them, lacking a notch at its posterior margin and with long preopercular branches reaching the ventral and posterior margins of the preopercle; and (2) large, cycloid scales with a superficial bony layer obscuring the circuli.

Antarctithrissops represents the oldest record of the Teleostei from Antarctica. (We note that the unidentified fish illustrated in Doyle and Whitham, 1991:fig. 10F is an ichthyodectiform that we suppose belongs to the same genus and species described here.) Younger records of teleosts include the beryci-form *Antarcticberyx seymori* from the Upper Cretaceous of Seymour Island (Grande and Chatterjee, 1987); a siluriform pectoral spine (Grande and Eastman, 1986), and gadiform vertebrae and skulls (Jerzemska, 1988; Eastman and Grande, 1991) have been recovered in the upper Eocene–Oligocene La Meseta Formation. Additionally, the presence of possible clupeiforms has been mentioned by Doktor et al. (1988) and numerous undescribed specimens are deposited at the Department of Geology, Field Museum of Natural History.

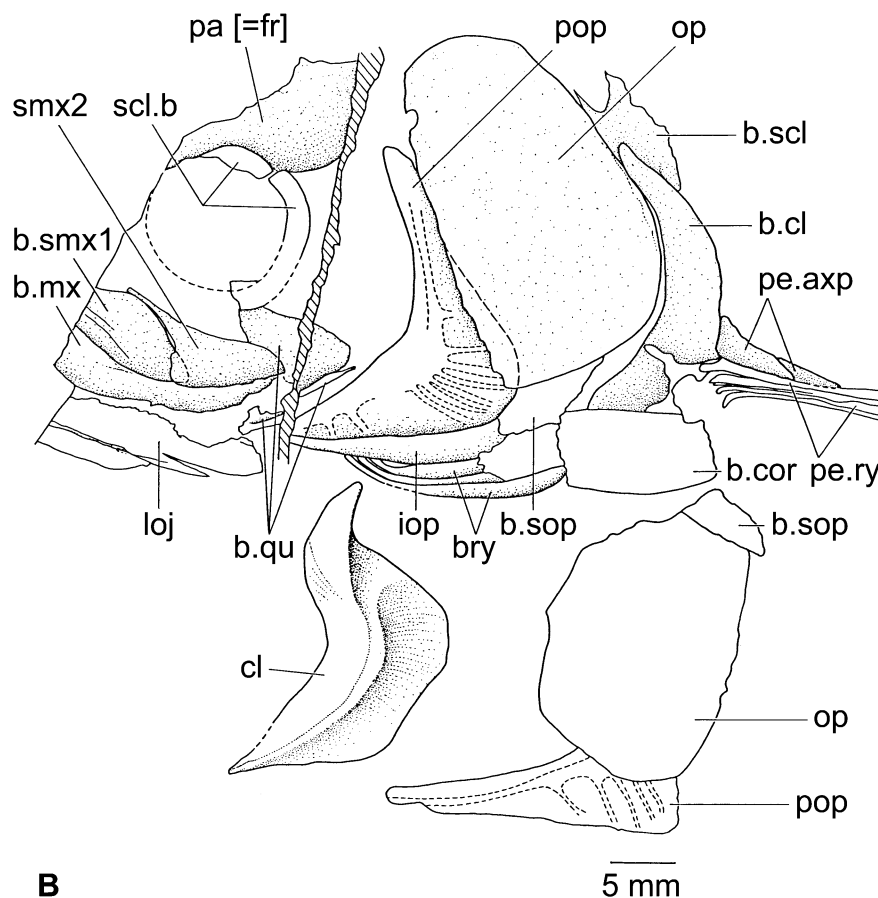


FIGURE 5. Continued.

GEOGRAPHICAL DISTRIBUTION AND ENDEMISM DURING THE LATE JURASSIC

Geographical Distribution

Aspidorhynchiformes—Aspidorhynchiforms were broadly distributed (Fig. 10) in the Late Jurassic. Members of the genus *Aspidorhynchus* have been reported from numerous localities in Europe (e.g., Ain, France; Nusplingen and different localities near Solnhofen, Germany; Cambridgeshire, Dorsetshire, and Oxfordshire, England), Central America (e.g., Pinar del Río, Cuba), and Antarctica (Richter and Thomson, 1989; see above about the problems concerning generic identification). Late Jurassic members of the genus *Belonostomus* were reported from several localities in Europe (e.g., Solnhofen, Germany; Dorsetshire, England) and they are currently unknown from other continents in the Late Jurassic. Incomplete Late Jurassic specimens preliminarily assigned, because of their squamation, to the genus *Vinctifer*, are known only from Antarctica.

The oldest known aspidorhynchiforms are *Aspidorhynchus crassus* and *A. euodus*, which are known from the Bathonian and Callovian of England, respectively (Brito, 1997). According to Brito (1997:fig. 58) *Aspidorhynchus* had a Pangean distribution with a Middle Jurassic minimal age. *Belonostomus* had a Laurasian distribution with a Late Jurassic minimal age, and *Vinctifer* had a Gondwanan distribution with a Late Jurassic minimal age. According to Brito (1997), the historical biogeographic analysis of the aspidorhynchiforms indicates a Pangean-type relationship, dating back to the Early Jurassic. Late Jurassic aspidorhynchiform distribution emphasizes Tethyan connections (Schultze and Stöhr, 1996). Tethyan connections already

have been cladistically demonstrated for some European, Central American (Cuba), and South American (Chile) teleosts (Arratia, 1994, 1996). Arratia (1994, 1996) has shown that the Late Jurassic locality El Profeta in northern Chile is the sister-area of Pinar del Río in Cuba, and both are the sister-areas of some localities in the Solnhofen area in Germany. These sister-area relationships are based on cladograms showing the phylogenetic relationships of *Ascalabos* and the family Varasichthyidae that include members from Cuba and Chile.

Ichthyodectiformes—Until now Jurassic ichthyodectiforms were only known from localities in the Northern Hemisphere, mostly Europe (Fig. 10). The new record from Antarctica is the oldest from the Southern Hemisphere. Although *Thrissops* was mentioned by Biese (1961) as present in the Kimmeridgian of Cerritos Bayos in northern Chile, this was a misidentification. Ichthyodectiforms have not yet been found in the Middle-Upper Jurassic of Chile (Arratia 1987, 1994; Arratia and Schultze 1999). However, the new finding from Antarctica raises the possibility that other Jurassic ichthyodectiforms were present in the Southern Hemisphere but have not been discovered.

The oldest ichthyodectiform, *Occithrissops willsoni*, was recovered from the lower part of the upper Bathonian Sundance Formation in Wyoming. The absence of other Middle Jurassic ichthyodectiform records may be due to the scarcity of Middle Jurassic fish-bearing localities and their incomplete exploration. In contrast, Upper Jurassic localities in Europe have been intensively explored and have produced an interesting and diverse ichthyodectiform fauna. From the best known localities in southern Germany are known *Ascalabothrissops* (the oldest one, from the Kimmeridgian; Arratia, 2000), *Allotrissops*,

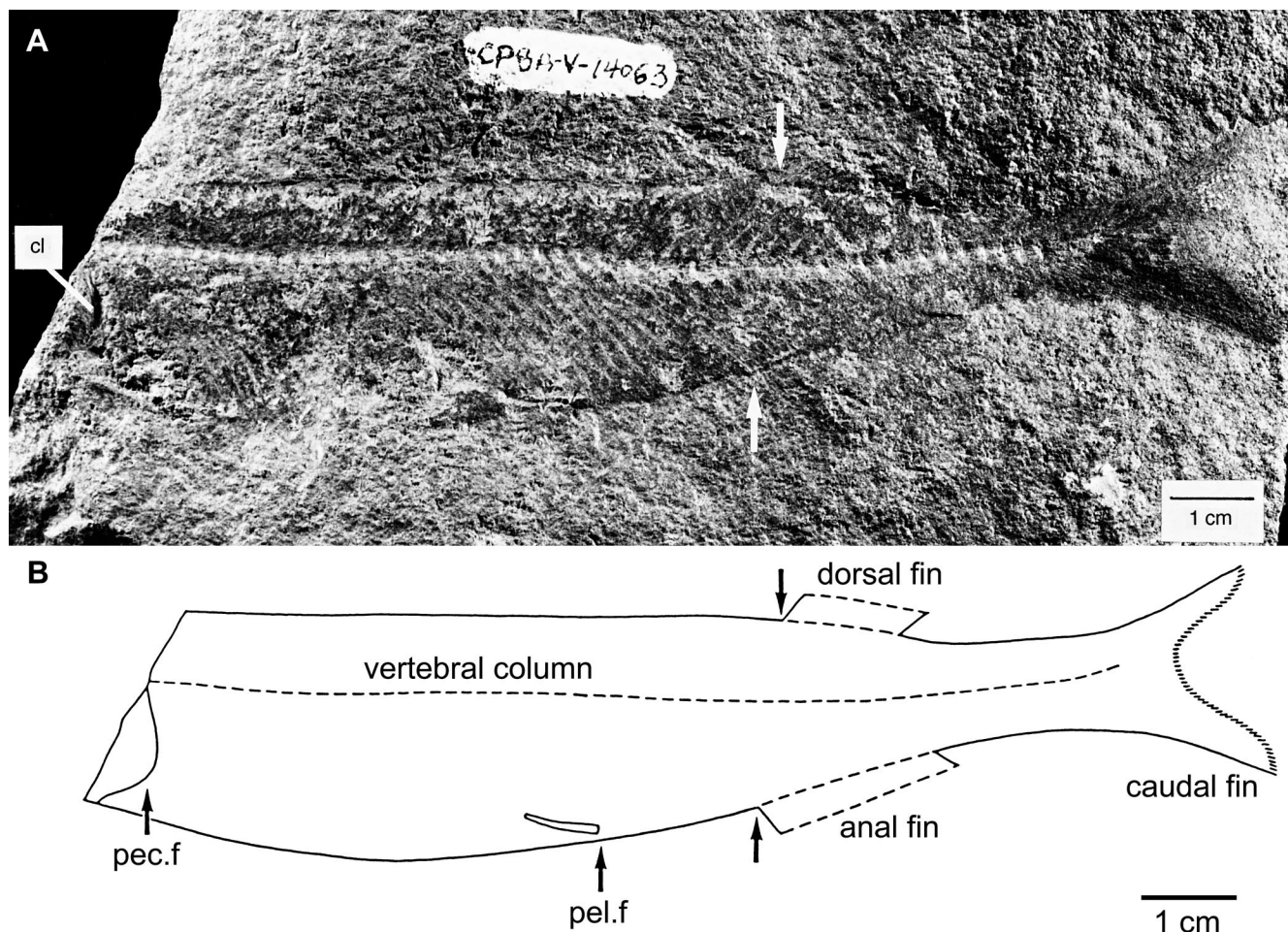


FIGURE 6. **A**, *Antarctithrissops australis* (CPBA-V-14063) in lateral view. Arrows point to the origin of the dorsal and anal fins. **B**, diagram showing the position of the vertebral column and the fins.

Pachythrissops, and *Thrissops* (from the Tithonian Malm Z2 and 3; Nybelin, 1964; Arratia, 1997). From the Kimmeridgian locality of Cerin, France, are known *Allothrissops* and *Thrissops* (for the most recent revision see Wenz et al., 1993).

Migration Routes—To explain the distribution of certain marine faunas, a marine corridor (Hispanic or Caribbean Corridor) has been postulated between the western Tethys (European Tethys) and the East Pacific (west of South America) during the Late Jurassic (e.g., Hallam, 1983); however, new corridors arose as a consequence of the separation of Laurasia and Gondwana (e.g., Hallam, 1983; Riccardi, 1991). Late Jurassic marine vertebrates that could have migrated through the Hispanic Corridor include fishes (e.g., aspidorhynchiforms, members of the varasichthyid group, ichthyodectiforms) and crocodiles recently recovered in the Oxfordian of Cuba (Iturrialde-Vinent and Norell, 1996), and in the Upper Jurassic of South America and Europe (e.g., Gasparini, 1992; Gasparini and Fernández, 1997). For some invertebrates the Hispanic Corridor was an efficient gateway for faunal exchange as early as the later Early Jurassic (Aberhan, 2001). For nektonic organisms such as ammonites the faunal exchange through the Hispanic Corridor was more episodic. Although evidence for late Liassic faunal interchange exists (Jakobs, 1995), migration of faunal elements was apparently periodic before the Hispanic Corridor was persistently open in the Late Jurassic (Westermann in Hallam, 1996). However, combining the evidence from ammonites (Enay and Cariou, 1997) and belemnites (Challinor et al.,

1992), it is unlikely that the Antarctic nekton migration through the Hispanic Corridor was more prominent than migration along the eastern margin of Africa (Kiessling et al., 1999) or along the southern Tethys (Enay and Cariou, 1997).

Endemism

Jurassic fishes of the southernmost part of the Southern Hemisphere are known from different localities. For instance, from the Sinemurian of Vaquillas Altas and numerous Upper Jurassic localities of Chile (Arratia and Schultze, 1999); from Mendoza, Neuquén, and Chubut provinces in southern Argentina (Arratia and Cione, 1996); from the ?Upper Jurassic of Talbragar, New South Wales in Australia; and Upper Jurassic localities of Antarctica.

Members of the main fish groups such as chondrichthyans, sarcopterygians, and actinopterygians have been reported in a few Upper Jurassic localities of the Southern Hemisphere. However, their distribution is unknown for all the southern continents. For instance:

1. Until now a Middle Jurassic tooth of *Hybodus* has been recovered from the Jurassic of Antarctica. Late Jurassic chondrichthyans are unknown from the Southern continents with the exception of a ray from the Tithonian of Argentina (Cione, 1999), which is the first Jurassic ray reported outside the European Tethys and the first Jurassic selachian in South America. Hybodonts of possible Late Jurassic age are doc-

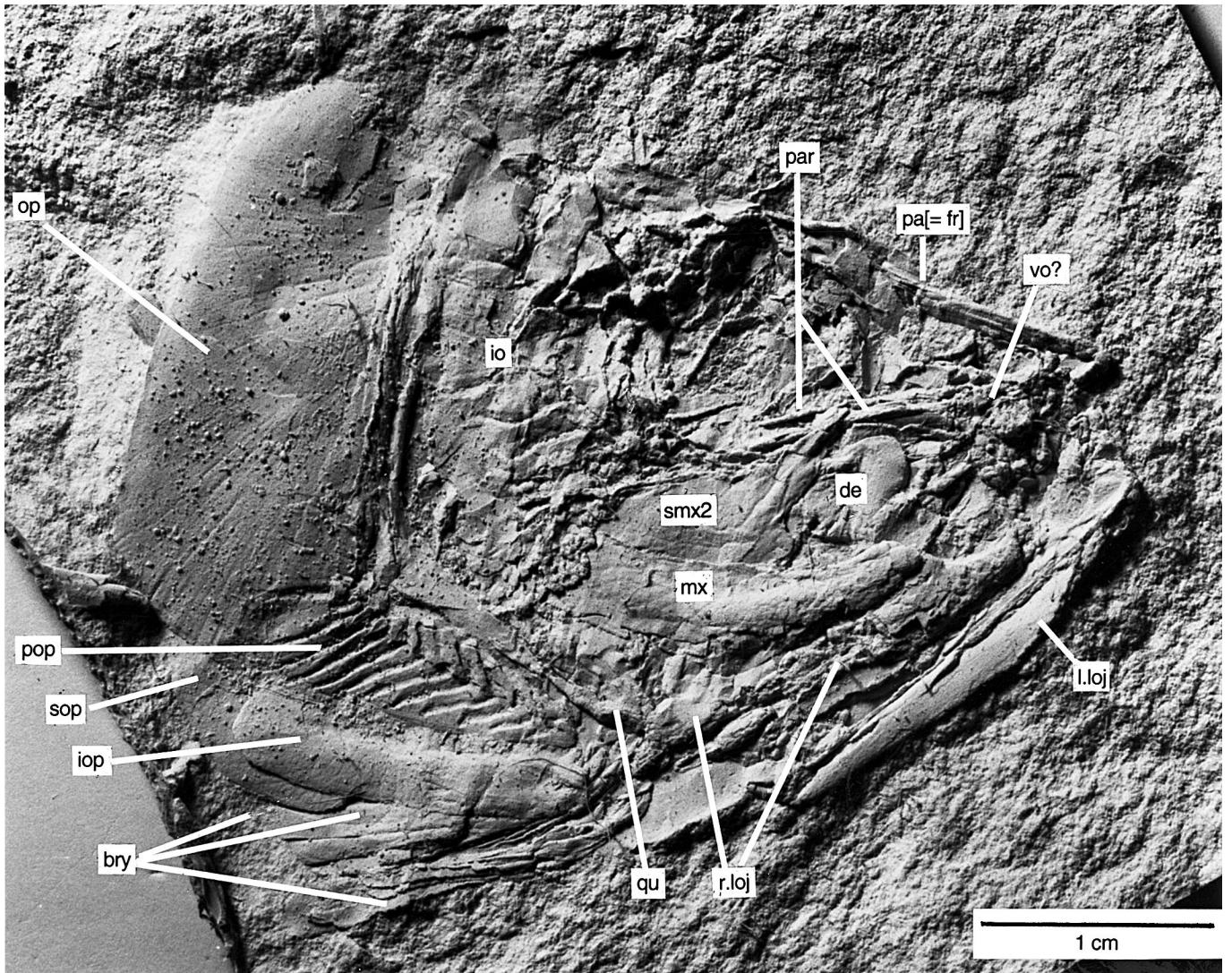


FIGURE 7. Head of *Antarctithriassops australis* (cast of CPBA-V-14095) dusted with NH₄Cl.

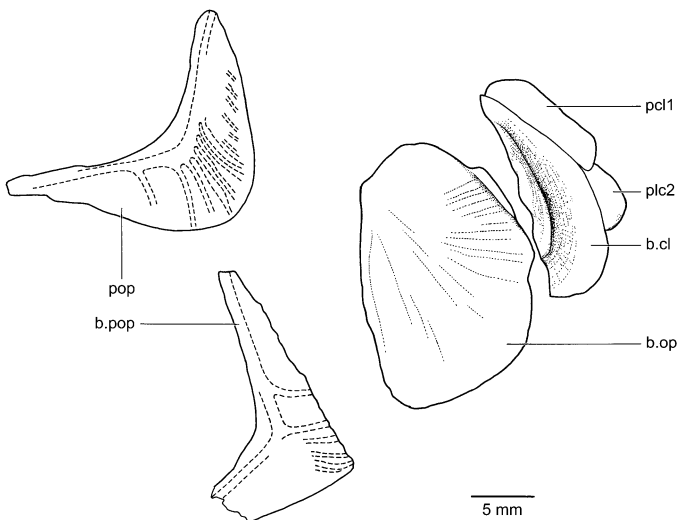


FIGURE 8. *Antarctithriassops australis* (CPBA-V-14056). Displaced opercular bones and cleithrum.

umented in Missão Velha Fm., Araripe Basin (see Maisey, 2000).

2. Among sarcopterygians, Late Jurassic dipnoans and coelacanths are still unknown from Antarctica as well as in most regions of the Southern Hemisphere; however, the oldest coelacanth was recently reported from the Sinemurian of Chile (Arratia and Schultze, 1999) and “*Neoceratodus*” of possible Late Jurassic age was reported from Missão Velha Fm., Brazil (for references concerning age of the formation see Maisey, 2000).
3. Among primitive actinopterygians, Late Jurassic palaeonisciforms are known from Argentina and Australia, but they have not been recovered in Upper Jurassic deposits of Antarctica. Based on a few overall similarities these specimens were assigned to the European genus *Coccolepis*. However, the Argentinian specimens are currently under revision, and apparently, they belong in a new genus.

Semionotiform remains are known from the Late Jurassic of South America and have been assigned to the cosmopolitan genus *Lepidotes*. Semionotiforms are not presently known from Antarctica.

4. Among teleostiomorphs (sensu Arratia, 2001), Late Jurassic aspidorhynchiforms are known from Antarctica, but they

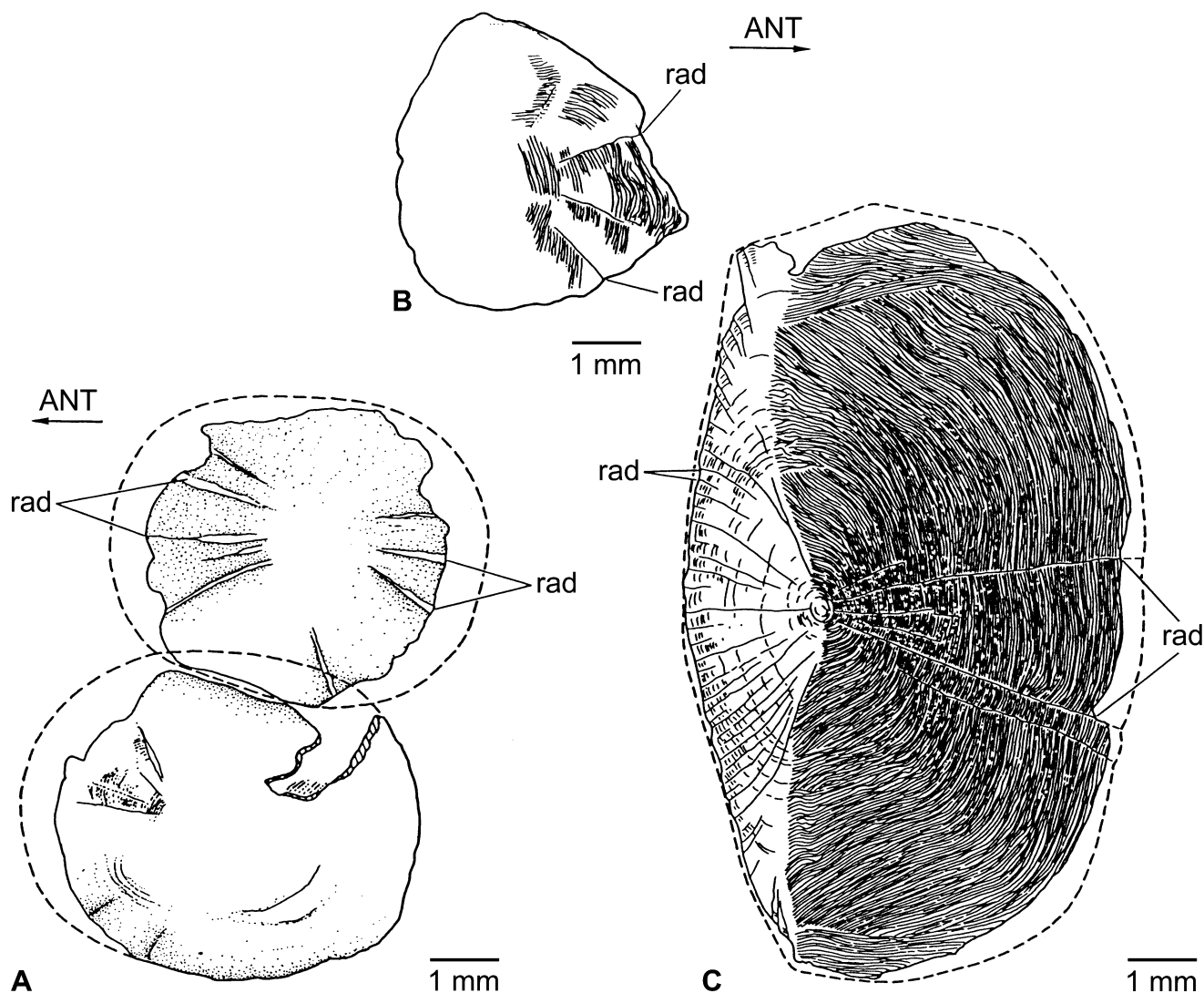


FIGURE 9. Ichthyodectiform scales. **A, B**, *Antarcticthriassops australis* (CPBA-V-14056) in lateral view (**A**). Note that incomplete circuli are seen where the superficial bony layer is broken. **B**, internal view. **C**, *Thriassops formosus* (after Schultz, 1966), in lateral view.

have not been recorded from other southern continents. The few incomplete Antarctic specimens have been controversially assigned to the well known European genus *Aspidorhynchus* and to the Gondwanan genus *Vinctifer*. Other Late Jurassic teleosteomorphs such as pycnodontiforms, pachycormiforms, and *Atacamichthys* have not been reported from Antarctica and Australia.

5. Teleosts are well represented and well diversified in a few Upper Jurassic localities. The best known fish faunas are those from the Oxfordian marine localities of northern Chile from which are known eight basal teleostean species. Most of them are members of a monophyletic group, the family Varasichthyidae, with representatives from Chile (e.g., *Domeykos*, *Protoclupea*, and *Varasichthys*) and Cuba (*Luisichthys*) (Arratia, 1994, 1997). These teleosts constitute endemic genera and species. A similar situation concerns the teleosts from the Argentinian Upper Jurassic of Chubut. They include at least two genera (e.g., '*Tharrias*' and *Luisiella*) that were thought to have lived in freshwater environments. They are currently under revision to clarify their taxonomic position and phylogenetic relationships. The Australian? Late Jurassic teleosts (e.g., archaeomaenid 'pholi-

dophoriforms,' *Cavenderichthys* and '*Leptolepis*') are also endemic forms interpreted as basal teleosts (e.g., *Cavenderichthys*; Arratia, 1997).

The new teleost recovered in Upper Jurassic rocks of Antarctic represents the oldest record of ichthyodectiforms in the Southern Hemisphere. It is apparently endemic to the Antarctic continent, an attribute shared with all Late Jurassic teleosts reported from the southern continents at the species and genus level. Most teleosts have been described from complete specimens. The same is true of *Atacamichthys*. In contrast, other actinopterygians such as aspidorhynchiforms, pycnodontiforms, and semionotiforms, which are known from incomplete specimens, seem to belong to cosmopolitan genera. It is unclear whether their determination is the result of an overall similarity, or whether they are correctly identified.

Among teleosts, the Late Jurassic members from the Southern Hemisphere belong to unknown families, with the exception of *Luisichthys* (Cuba) within the Varasichthyidae and the new Antarctic ichthyodectiform that is tentatively assigned to the Allothrissopidae. Late Jurassic ichthyodectiforms are now known from four European genera and one Antarctic genus

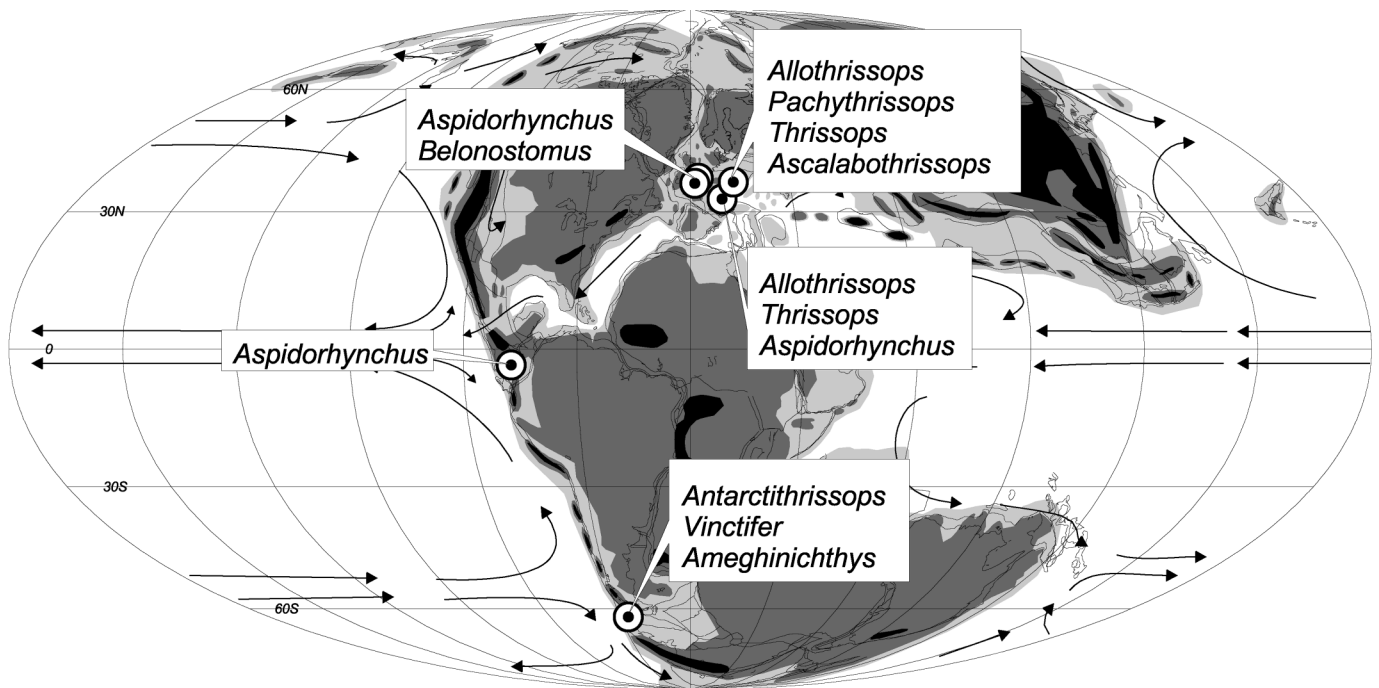


FIGURE 10. Geographical distribution of certain actinopterygians during the Late Jurassic.

revealing a discontinuous distribution with a big geographic gap between Europe and the Antarctic. Consequently, the presence of other ichthyodectiforms is expected along the Tethys seaway.

The high degree of endemism among teleosts of the southern continents contrasts with the relatively cosmopolitan Upper Jurassic invertebrate fauna in Antarctica. However, Antarctic radiolarians also exhibit little similarity with European faunas. Apart from a high number of suspected endemic species, faunal similarities are much greater between Antarctica and the eastern Pacific (Argentina, Mexico, California) than between Antarctica and the Mediterranean Tethys (Kießling, 1999).

CONCLUSIONS

1. The new findings include only actinopterygians: (1) a new genus and species of unknown family placement, (2) an aspidorhynchiform specimen, and (3) a new genus and species of teleost.
2. *Ameghinichthys*, gen. nov., based on scales only, cannot be assigned to family.
3. The Antarctic record of *Vincitifer* extends the distribution of aspidorhynchiforms to the southernmost part of the Southern Hemisphere during the Late Jurassic. Late Jurassic aspidorhynchiforms are known from two European and Cuban genera (*Aspidorhynchus* and *Belonostomus*) and one Antarctic genus (*Vincitifer*). Previous reports of *Aspidorhynchus* and *Vincitifer* from Antarctica should be revised when more material is available.
4. *Antarctithrissops* is the oldest record of a Late Jurassic ichthyodectiform for the Southern Hemisphere. The Jurassic Ichthyodectiformes are now known from one Middle Jurassic genus (*Occithrissops*) and five Late Jurassic genera, four from Europe (*Ascalabothrissops*, *Allothrissops*, *Pachythrissops*, and *Thrissops*) and one from Antarctica (*Antarctithrissops*).
5. All Late Jurassic teleosts reported from the southern continents are endemic to very restricted areas at the species and genus level. In contrast, actinopterygians such as aspidor-

hynchiforms, pycnodontiforms, and semionotiforms seem to belong to cosmopolitan genera.

ACKNOWLEDGMENTS

Thanks are due to the following individuals and institution for permission to study material under their care: Ana María Báez (CPBA), Lance Grande (FMNH), Günter Viohl (JM), and R. Bötcher (SMNS). We are very much indebted to John Chorn, John Maisey, Hans-Peter Schultze, and Louis Taverne for comments and suggestions on the manuscript, to Mr. J.-P. Mendau and Mrs. E. Siebert (MB) for their valuable help with the illustration of the specimens based on the original drawings of G.A., and to Mrs. C. Radke (MB) for preparing the photographs. Logistical support by the Instituto Antártico Argentino (Dirección Nacional del Antártico) is gratefully acknowledged. We also acknowledge W. Bausch, F. Pángano, and M. Santisteban for their collaboration in the field work.

LITERATURE CITED

- Aberhan, M. 2001. Bivalve palaeobiogeography and the Hispanic Corridor: time of opening and effectiveness of a proto-Atlantic seaway. *Palaeogeography, Palaeoclimatology, Palaeoecology* 165:375–394.
- Arratia, G. 1987. Jurassic fishes from Chile and critical comments; pp. 257–286 in W. Volkheimer and E. A. Musacchio (eds.), *Bioestratigrafía de los Sistemas Regionales del Jurásico y Cretácico de América del Sur. Vol. 1. Jurásico anterior a los movimientos intermálmicos*. Comité Sudamericano del Jurásico y Cretácico, Mendoza.
- Arratia, G. 1994. Phylogenetic and paleogeographic relationships of the varasichthyid group (Teleostei) from the Late Jurassic of Central and South America. *Revista Geológica de Chile* 21:119–165.
- Arratia, G. 1996. The Jurassic and the early history of teleosts; pp. 243–259 in G. Arratia and G. Viohl (eds.), *Mesozoic Fishes—Systematics and Paleogeology*. Verlag Dr. F. Pfeil, München.
- Arratia, G. 1997. Basal teleosts and teleostean phylogeny. *Palaeo Ichthyologica* 7:5–168.
- Arratia, G. 2000. Remarkable teleostean fishes from the Late Jurassic of southern Germany and their phylogenetic relationships. *Mitteil-*

- lungen aus dem Museum für Naturkunde in Berlin, Geowissenschaftliche Reihe 4:137–179.
- Arratia, G. 2001. The sister-group of Teleostei: consensus and disagreements. *Journal of Vertebrate Paleontology* 21:767–773.
- Arratia, G., and L. A. Cione. 1996. The record of fossil fishes of southern South America; pp. 9–72 in G. Arratia (ed.), *Contributions of Southern South America to Vertebrate Paleontology*. Münchner Geowissenschaftliche Abhandlungen 30.
- Arratia, G., and H.-P. Schultze. 1999. Mesozoic fishes from Chile; pp. 565–594 in G. Arratia and H.-P. Schultze (eds.), *Mesozoic Fishes 2—Systematics and Fossil Record*. Verlag Dr. F. Pfeil, München.
- Bardack, D. 1965. Anatomy and evolution of chirocentrid fishes. *University of Kansas Paleontological Contributions*, Article 10:1–88.
- Bardack, D., and G. Sprinkle. 1969. Morphology and relationships of saurocephalid fishes. *Fieldiana, Geology* 16:297–340.
- Biese, W. 1961. *El Jurásico de Cerritos Bayos*. Universidad de Chile, Publicación No. 19:1–61.
- Brito, P. M. 1997. Révision des Aspidorhynchidae (Pisces, Actinopterygii) du Mésozoïque: ostéologie, et relations phylogénétiques, données environnementales et biogéographiques. *Geodiversitas* 19(4): 681–772.
- Brito, P. M., and F. J. Meunier. 2000. The morphology and histology of the scales of Aspidorhynchidae (Actinopterygii, Halecostomi). *Geobios* 33:105–111.
- Cavender, T. M. 1966. The caudal skeleton of the Cretaceous teleosts *Xiphactinus*, *Ichthyodectes*, and *Gillicus*, and its bearing on their relationship with *Chirocentrus*. *Museum of Zoology, University of Michigan, Occasional Papers No. 650*:1–15.
- Challinor, A. B., P. Doyle, P. J. Howlett, and T. I. Nal'nyaeva. 1992. Belemnites of the circum-Pacific region; pp. 334–341 in G. E. G. Westermann (ed.), *The Jurassic of the Circum-Pacific*. Cambridge University Press, Cambridge.
- Chatterjee, S., and W. J. Zinsmeister. 1982. Late Cretaceous marine vertebrates from Seymour Island, Antarctic Peninsula. *Antarctic Journal of the United States* 17(5):66.
- Cione, L. 1999. First report of a Jurassic ray outside Europe; pp. 21–28 in G. Arratia and H.-P. Schultze (eds.), *Mesozoic Fishes 2—Systematics and Fossil Record*. Verlag Dr. F. Pfeil, München.
- Cione, L., C. A. del Valle, C. A. Rinaldi, and E. P. Toni. 1977. Nota preliminar sobre los pinguinos y tiburones del Terciario inferior de la Isla Vicecomodoro Marambio, Antártida. *Dirección Nacional del Antártico—Instituto Antártico Argentino, Contribución No. 213*:3–21.
- Cope, E. D. 1887. *Geology and Paleontology*. *American Naturalist* 21: 1014–1019.
- Del Valle, R. A., H. H. Fourcade, and C. A. Rinaldi. 1976. Nota sobre el hallazgo de una nueva especie de nautiloideo del género *Eutrephoceras* Owen, en la Isla Vicecomodoro Marambio, Antártida. *Dirección Nacional del Antártico—Instituto Antártico Argentino, Contribución No. 208*:1–10.
- Doktor, M., A. Gazdzicki, S. A. Marensi, S. J. Porebski, S. N. Santillana, and A. V. Vrba. 1988. Argentine-Polish geological investigations on Seymour (Marambio) Island, Antarctica, 1988. *Polish Polar Research* 9:521–541.
- Doumani, G. A., R. S. Boardman, A. J. Rowell, A. J. Boucot, J. G. Johnson, A. L. McAlester, J. Saul, D. W. Fisher, and R. S. Miles. 1965. Lower Devonian fauna of the Horlick Formation, Ohio Range, Antarctica; pp. 241–281 in J. D. Hadley (ed.), *Geology and Paleontology of the Antarctic*, Antarctic Research series, Vol. 6. American Geophysical Union, Washington, D.C.
- Doyle, P., and A. G. Whitham. 1991. Palaeoenvironments of the Nordenskjöld Formation: an Antarctic Late Jurassic-Early Cretaceous black shale-tuff sequence; pp. 397–414 in R. V. Tyson and T. H. Pearson (eds.), *Modern and Ancient Continental Shelf Anoxia*. Special Publications Geological Society (London), Vol. 58, London.
- Dziewa, T. J. 1980. Note on a dipnoan fish from the Triassic of Antarctica. *Journal of Paleontology* 54:488–490.
- Eastman, J. T., and L. Grande. 1989. Evolution of the Antarctic fish fauna with emphasis on the recent notothenioids; pp. 241–252 in J. A. Crame (ed.), *Origin and Evolution of the Antarctic Biota*. Geological Society of London Special Publication No. 47:241–252.
- Eastman, J. T., and L. Grande. 1991. Late Eocene gadiform (Teleostei) skull from Seymour Island, Antarctic Peninsula. *Antarctic Science* 3:87–95.
- Elliot, D. H., C. Rinaldi, W. J. Zinsmeister, T. A. Trautman, W. A. Bryant, and R. del Valle. 1977. Geological investigations on Seymour Island, Antarctic Peninsula. *Antarctic Journal of the United States* 10:182–186.
- Enay, R., and E. Cariou. 1997. Ammonite faunas and palaeobiogeography of the Himalayan belt during the Jurassic: initiation of a Late Jurassic austral ammonite fauna. *Palaeogeography, Palaeoclimatology, Palaeoecology* 134:1–38.
- Farquharson, G. W. 1983. The Nordenskjöld Formation of the northern Antarctic Peninsula: an Upper Jurassic radiolarian mudstone and tuff sequence. *British Antarctic Survey Bulletin* 60:1–22.
- Fleming, W. L. S., A. Stephenson, B. B. Roberts, and C. G. L. Bertram. 1938. Notes on the scientific work of the British Graham Land Expedition, 1934–1937. *Geographical Journal* 91:508–512.
- Gasparini, Z. 1992. Marine reptiles of the Circum-Pacific region; pp. 361–364 in G. Westerman (ed.), *The Jurassic of the Circum-Pacific*. World and Regional Geology, Vol. 3. Cambridge University Press, Cambridge.
- Gasparini, Z., and M. Fernández. 1997. Tithonian marine reptiles; pp. 435–450 in J. Callaway and E. Nichols (eds.), *Ancient Marine Reptiles*. Academic Press, San Diego.
- Grande, L., and S. Chatterjee. 1987. New Cretaceous fish fossils from Seymour Island, Antarctic Peninsula. *Palaeontology* 30:829–837.
- Grande, L., and J. T. Eastman. 1986. A review of the Antarctic ichthyofauna in the light of new fossil discoveries. *Palaeontology* 29: 113–137.
- Hallam, A. 1983. Early and mid-Jurassic molluscan biogeography and the establishment of the Central Atlantic seaway. *Palaeogeography, Palaeoclimatology, Palaeoecology* 43:181–193.
- Hallam, A. 1996. Major bio-events in the Triassic and Jurassic; pp. 265–283 in O. H. Walliser (ed.), *Global Events and Event Stratigraphy*. Springer, Berlin.
- Iturrualde-Vinent, M. A., and M. Norell. 1996. Synopsis of Late Jurassic marine reptiles from Cuba. *American Museum Novitates* 3164:1–17.
- Jakobs, G. K. 1995. New occurrences of *Leukadiella* and *Paroniceras* (Ammonoidea) from the Toarcian (Lower Jurassic) of the Canadian Cordillera. *Journal of Paleontology* 69:89–98.
- Jermanska, A. 1988. Isolated vertebrae of teleostean fishes from the Paleogene of Antarctica. *Polish Polar Research* 9:421–435.
- Kiessling, W. 1999. Late Jurassic radiolarians from the Antarctic Peninsula. *Micropaleontology* 45, supplement 1:1–96.
- Kiessling, W., R. Scasso, A. Zeiss, A. Riccardi, and F. Medina. 1999. Combined radiolarian-ammonite stratigraphy for the Late Jurassic of the Antarctic Peninsula: implications for radiolarian stratigraphy. *Geodiversitas* 21:687–713.
- Maisey, J. G. 1991. *Cladocyclus* Agassiz, 1841; pp. 190–207 in J. Maisey (ed.), *Santana Fossils. An Illustrated Atlas*. T. F. H. Publications, Neptune City, New Jersey.
- Maisey, J. G. 2000. Continental break up and the distribution of fishes of Western Gondwana during the Early Cretaceous. *Cretaceous Research* 21:281–314.
- Müller, J. 1844. Über den Bau und die Grenzen der Ganoiden, und über das natürliche System der Fische. *Physikalisch-Mathematische Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin* 1845:117–216.
- Mutter, R. 2002. Revision of the Triassic Family Colobodontidae sensu Anderson 1916 (emended) with a tentative assessment of perleidiform interrelationships (Actinopterygii: Perleidiformes). Unpublished Ph.D. dissertation, Universität Zurich, 334 pp.
- Nelson, G. J. 1973. Notes on the structure and relationships of certain Cretaceous and Eocene teleostean fishes. *American Museum Novitates* 2524:1–31.
- Nicholson, H. A., and R. Lydekker. 1889. *A Manual of Paleontology*. 2nd ed. Edinburgh and London, 1624 pp.
- Nybelin, O. 1964. Versuch einer taxonomischen Revision der jurassischen Fischgattung *Thrissops* Agassiz. *Göteborgs kungliga vetenskaps-och vitterhets Samhälle Handlingar* 6, Serie B, 9(4):1–44.
- Patterson, C., and D. E. Rosen. 1977. Review of the ichthyodectiform and other Mesozoic teleost fishes and the theory and practice of classifying fossils. *Bulletin of the American Museum of Natural History* 158:83–172.
- Riccardi, A. 1991. Jurassic and Cretaceous marine connections between the southeast Pacific and Tethys. *Palaeogeography, Palaeoclimatology, Palaeoecology* 87:155–189.

- Richter, M., and M. R. A. Thomson. 1989. First Aspidorhynchidae (Pisces: Teleostei) from Antarctica. *Antarctic Science* 1:57–64.
- Scasso, R. A., and R. A. del Valle. 1989. Nuevas observaciones sobre la Formación Ameghino en la península Sobral, Antártida. *Contribuciones Científicas del Instituto Antártico Argentino* 374:1–43.
- Scasso, R. A., and W. Kiessling. 2001. Diagenesis of Upper Jurassic concretions from the Antarctic Peninsula. *Journal of Sedimentary Research* 71:88–100.
- Schaeffer, B. 1972. A Jurassic fish from Antarctic. *American Museum Novitates* 2495:1–17.
- Schaeffer, B., and C. Patterson. 1984. Jurassic fishes from the western United States, with comments on Jurassic fish distributions. *American Museum Novitates* 2796:1–86.
- Schaeffer, B., D. H. Dunkle, and N. G. McDonald. 1975. *Ptycholepis marshi* Newberry, a chondrosteian fish from the Newark Group of Eastern North America. *Fieldiana, Geology* 33:205–233.
- Schultze, H.-P. 1966. Morphologische und histologische Untersuchungen an den Schuppen mesozoischer Actinopterygier (Übergang von Ganoid- zu Rundschnuppen). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 126:232–314.
- Schultze, H.-P. 1996. The scales of Mesozoic actinopterygians; pp. 83–94 in G. Arratia and G. Viohl (eds.), *Mesozoic Fishes—Systematics and Paleoecology*. Verlag Dr. F. Pfeil, München.
- Schultze, H.-P., and D. Stöhr. 1996. *Vinctifer* (Pisces, Aspidorhynchidae) aus der Unterkreide (oberes Aptium) von Kolumbien. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 199(3): 395–415.
- Stephenson, A., and W. L. S. Fleming. 1940. King George the Sixth Sound. *Geographical Journal* 96:153–164.
- Stewart, J. D. 1999. A new genus of Saurodontidae (Teleostei: Ichthyodectiformes) from the Upper Cretaceous rocks of the Western Interior of North America; pp. 335–360 in G. Arratia and H.-P. Schultze (eds.), *Mesozoic Fishes 2—Systematics and Fossil Record*. Verlag Dr. F. Pfeil, München.
- Su, T.-t. 1974. New Jurassic ptycholepid fishes from Szechuan, S. W. China. *Vertebrata Palasiatica* 12:1–20. (Chinese with English summary).
- Taverne, L. 1973. Les affinités systématiques des téléostéens fossiles de l'ordre des Ichthyodectiformes. *Bulletin de l'Institut Royal des Sciences naturelles de Belgique, Sciences de la Terre*, 49(6):1–11.
- Taverne, L. 1975. Considérations sur la position systématique des genres fossiles *Leptolepis* et *Allothrissops* au sein des téléostéens primitifs et sur l'origine et le polyphylétisme des poissons téléostéens. *Académie royale de Belgique, Bulletin de la Classe des Sciences, série 5*, 6:336–371.
- Taverne, L. 1977. Ostéologie et position systématique du genre *Thrissops* Agassiz (sensu stricto) (Jurassique supérieur de l'Europe occidentale) au sein des téléostéens primitifs. *Geobios* 10:5–33.
- Taverne, L. 1986. Ostéologie et affinités systématiques de *Chirocentrites vexillifer* du Crétacé supérieur de la Mésogée eurafricaine. Considérations sur la phylogénie des Ichthyodectiformes, poissons téléostéens du Jurassique et du Crétacé. *Annales de la Société royale zoologique de Belgique* 116:33–54.
- Taverne, L., and B. Chanet. 2000. *Faugichthys lorgi* n. gen., n. sp. (Teleostei, Ichthyodectiformes) de l'Albien terminal (Crétacé inférieur marin) du Vallon de la Fauge (Ysere, France) et considération sur la phylogénie des Ichthyodectidae. *Geodiversitas* 22:23–34.
- Welton, B. J., and W. J. Zinsmeister. 1980. Eocene neoselachians from the La Meseta Formation, Seymour Island, Antarctic Peninsula. *Contributions to Science of the Natural History Museum, Los Angeles* 329:1–10.
- Wenz, S. 1968. Complément à l'étude des poissons actinoptérygiens du Jurassique français. *Cahiers de Paléontologie* (1967):1–276; Centre National de la Recherche Scientifique, Paris.
- Wenz, S., P. Bernier, G. Barale, J.-P. Bourseau, E. Buffetaut, C. Gaillard, and J.-C. Gall. 1993. L'ichthyofaune des Calcaires lithographiques du Kimméridge supérieur de Cerin (Ain, France). *Geobios, Mémoire Spécial no. 16*:61–70.
- Whitham, A. G. 1993. Facies and depositional processes in an Upper Jurassic to Lower Cretaceous pelagic sedimentary sequence, Antarctica. *Sedimentology* 40:331–349.
- Whitham, A. G., and P. Doyle. 1989. Stratigraphy of the Upper Jurassic–Lower Cretaceous Nordenskjöld Formation of Graham Land, Antarctica. *Journal of South American Earth Sciences* 2:371–384.
- Woodward, A. S. 1908. On fossil fish-remains from Snow Hill and Seymour Islands. *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901–1903*, 3(4):1–6.
- Woodward, A. S. 1921. Fish remains from the Upper Old Red Sandstone of Granite Harbour, Antarctica. *British Antarctic (Terra Nova) Expedition, 1910. British Museum (Natural History), London, Natural History Report, Geology* 1:51–62.
- Young, G. C. 1991. Fossil fishes from Antarctic; pp. 538–567 in R. J. Tingey (ed.), *The Geology of Antarctica*. Clarendon Press, Oxford.

Received 20 September 2002; accepted 30 April 2003.