Shallow-water late middle Eocene crinoids from Tierra del Fuego: a new southern record of a retrograde community structure*

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SUMMARY: One of the very few crinoid records in Patagonia is that of the abundant columnals of the genus Isselicrinus found in several localities in shallow marine, glauconitic sandstones of the Leticia Formation (upper middle Eocene of Tierra del Fuego Island). Some of them, up to 10 cm long, are preserved in a position almost perpendicular to the stratification, which is attributed to episodes of high sedimentation rate. The Isselicrinus remains occur either almost alone or associated with solitary corals, gastropods, bivalves, rare nautilids, shark teeth, penguin bones and well-preserved specimens of Ophiura elegantoides. The associated microfossils, mainly Foraminifera, are characterised by the anomalous abundance and dominance of large Nodosariacea. These records reflect a peculiar success of a retrograde, dense, suspension-feeding crinoid population as a regional extension of previously described distribution in the Antarctic upper Eocene.

Keywords: Tierra del Fuego, Eocene, Leticia Formation, shallow-marine, crinoids, Isselicrinus, Nodosariacea, retrograde community structure.

INTRODUCTION

The Mesozoic marine biotic revolution is thought to have caused irreversible changes in the life habits of many invertebrates. This is exemplified by the stalked isocrinid crinoids, which today are only known in deep-water environments. When they appeared in the Triassic, isocrinids were mostly restricted to shallow waters but, with few exceptions, during the Late Cretaceous they migrated to deep-water settings (Bottjer and Jablonski, 1988). Crinoids from Tierra del Fuego have been known...
since the beginning (Doello-Jurado, 1922) and middle of the last century (Furque and Camacho, 1949) in the La Despedida and Leticia beds, originally dated as Cretaceous-Early Cenozoic and Late Cretaceous respectively. However, Codignotto and Malumián (1981) and Olivero and Malumián (1999, and unpublished results) indicate that fossil crinoids from the Argentinean portion of the Tierra del Fuego Island are all isocrinids restricted to the shallow-water Leticia Formation of late middle Eocene age (Fig. 1). The palaeoecologic and stratigraphic implications of these anomalous, shallow-marine isocrinids are addressed and compared with similar records, mainly from Antarctica.

DISTRIBUTION AND RECORD OF ISOCRINID CRINOIDS IN TIERRA DEL FUEGO

Short segments of the column of stalked crinoids, sometimes preserved almost perpendicular to the stratification (Fig. 2), are common to abundant in certain fine, glauconitic, sandstone beds of the Leticia Formation in different localities of the central and coastal parts of Tierra del Fuego Island (Fig. 1). Segments of the column, occasionally up to 10 cm long, are the only preserved parts; isolated cups or partial broken arms were not recorded. The section of the column is pentagonal or less frequently cylindrical and the nodals bear three small, subcircular cirrus sockets (Fig. 3). Based on these features the material is assigned to *Isselicrinus* sp.

In the coastal localities, *Isselicrinus* sp. is associated with an abundant megafauna, which comprises solitary corals, gastropods, bivalves, rare nautilids, shark teeth (Olivero and Malumián, 1999), penguin bones (Clarke et al., 2003), and in particular well-preserved specimens of *Ophiura elegantoides*.
(Furque and Camacho, 1949). In the central localities, the megafauna is poorly represented, but the associated Foraminifera are characterised by the great abundance of large Nodosariacea, which commonly reach up to 4 mm in length and are the largest calcareous Foraminifera found in Argentina (Malumíán, 1990). The sedimentology, ichnology, and foraminiferal assemblages all indicate shallow marine to marginal marine settings, including estuarine and subtidal channel environments, for the crinoid-bearing Leticia Formation (Olivero and Malumián, 1999). The record of the first appearance datum of the planktonic foraminiferan *Globigerinathéka index* (Finlay), just below the crinoid horizons, indicates a late middle Eocene age for the Leticia Formation (not older than 42.9 Ma, cf. Berggren et al., 1995).

Recent studies in Tierra del Fuego recognised a rather complete Upper Cretaceous-Middle Miocene stratigraphic column. The Upper Cretaceous, part of the Palaeocene, and the Lower Eocene are relatively deep-marine deposits; the Oligocene-Lower Miocene are deep-marine deposits; and parts of the Palaeocene and Eocene, and the Middle Miocene are shallow-marine deposits (Olivero et al., 2002, 2003). Isocrinid crinoids and ophiuroids are only known from the Leticia Formation and are apparently absent from the rest of the stratigraphic column in Tierra del Fuego. With the only exception of some scarce columnals records from the Danian (Fig. 4) that do not belong to the genus *Isselicrinus*, crinoids are also apparently absent in the rest of the shallow marine Patagonian Cenozoic deposits. In the Chilean portion of the Austral Basin, there is only a mention of *Balanocrinus*, in the Chorrillo Chico Formation (Charrier and Lahsen, 1969), recently assigned to a post-Danian Palaeocene age (Quatrocchio and Sarjeant, 2003).

**DISCUSSION**

Post-late Cretaceous, shallow-water records of fossil isocrinids are exceedingly rare and they are only known in the Southern Hemisphere. A few specimens of isocrinids were recorded in shallow-water deposits from New Zealand (*Metacrinus* sp. in...
Pacific region. Species of the genus widespread in deep-water settings in the Indo-

able known fossil species of a modern isocrinid

Antarctica is particularly significant as the only reli-

Eocene shallow-water, tidally influenced deposits of

bedding preservation of part of the column of

explanation for the isolated, almost perpendicular-to-

very high. This is probably the best taphonomic

chances of parts of the remaining column could be

one year (Oji and Amemiya, 1998), the burial

from a living crinoid in aquaria can survive more than

finding that stalk fragments detached and isolated

rate sedimentation event. Moreover, given the recent

it could remain buried if followed by a sudden, high-

during this time. The excellent

sediments, suggesting the existence of nutrient-rich

1992), have been reworked from late middle Eocene

ods of low sedimentation rates. Recent observations

fossil record of particulate organic matter promoted by increased upwelling in Antarctica

(Aronson and Blake, 1997).

The finding that the isocrinid crinoids from Tier-

ra del Fuego are stratigraphically restricted to the

late middle Eocene has significant palaeoecologic

implications, as it clearly indicates a regional exten-

sion of anomalous, suspension-feeding communities

with abundant stalked crinoids in the late middle and

late Eocene of the southern ocean. The anomalous

success of retrograde, dense, suspension-feeding

echinoid populations in the late Eocene of Antarcti-

can have been explained by the joint combination of

three critical conditions: low predation pressure;

low rates of sediment resuspension; and a high flux

of particulate organic matter. The accelerated cooling

trend during the late Eocene was linked to the dis-

appearance or marked diminution of durophagous

predators and to the high productivity of particulate

organic matter promoted by increased upwelling


Similar outstanding associated characteristics are

inferred for the late middle Eocene of Tierra del

Fuego. Abundant crinoid columns are recorded in

Seymour Island, and this was interpreted as a secondary stalkless condition follow-

autotomy of juvenile stalks during ontogeny

(Meyer and Oji, 1993). On the other hand, only part

of the stalk is preserved in Isselicerinus sp. from Tierr-

a del Fuego. Isocrinids never have a radix and they

are attached to the bottom by distal cirri. However,

during this process, part of the distal column may break off and it could remain buried if followed by a sudden, high-

rate sedimentation event. Moreover, given the recent

finding that stalk fragments detached and isolated

from a living crinoid in aquaria can survive more than

one year (Oji and Amemiya, 1998), the burial

chances of parts of the remaining column could be

very high. This is probably the best taphonomic

explanation for the isolated, almost perpendicular-to-

bedding preservation of part of the column of Isseli-

crinus sp. in the Leticia Formation.

Shallow-water, suspension feeder benthic com-

munities with abundant stalked crinoids were domi-

nant in the Paleozoic and their success was correlat-

ed with the lack of an intensive predation pressure.

The success of bivalves and gastropods with defensive structures as the dominant benthic, shallow-

water communities in the Cenozoic was related to

the Mesozoic marine revolution, characterised by

the increasing dominance of durophagous predators

since the Jurassic, including sharks, teleostean fishes and crustacean decapods. The abundant record of

isocrinids and ophiuroids in localised horizons in the late Eocene from Antarctica was considered as an anomalous and explained as a retrograde community reminiscent of Paleozoic marine and modern deep-sea communities (Aronson et al., 1997, Aronson and Blake, 2001).

Low-predation levels for the late Eocene as in the Paleozoic were interpreted as driven by global cooling and changes in productivity associated with increased upwelling in Antarctica (Aronson and Blake, 1997).

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Similar outstanding associated characteristics are

inferred for the late middle Eocene of Tierra del

Fuego. Abundant crinoid columns are recorded in
glaucic-rich intervals, suggesting localised peri-

ods of low sedimentation rates. Recent observations
demonstrate that the phosphatic concretions, so

common in different late Eocene-Miocene conglom-

erates in Tierra del Fuego (cf. Leanza and Hugo,

1992), have been reworked from late middle Eocene

sediments, suggesting the existence of nutrient-rich

oceanic waters during this time. The excellent

preservation of the Foraminifera associated with

isocrinids at La Despedida section is linked to dis-
aerobic bottom conditions suggestive of a high flux

of particulate organic matter. In addition, a striking

feature is the absolute dominance and diversity of

Nodosariacea in certain horizons. Absolute domi-
nance of this superfamily is typical of the Jurassic and early Cretaceous, with a declining relative

dominance in the Palaeocene, and thus the dominance of

Nodosariacea in the late middle Eocene can also be

considered as a retrograde feature.
Extant isocrinids are stenothermal, living generally within a short range of temperatures and in the deep sea, where their bathymetric distribution is controlled by temperature (Oji, 1996). Fossil isocrinids were probably also stenothermal. Thus, it seems reasonable to assume that the late middle to late Eocene declining temperature of the seawater led to a decline in predation pressure and favoured the preferred range of temperature for different isocrinid groups at slightly different times, allowing the bloom of shallow-water, isocrinid populations in the Southern Ocean.

ACKNOWLEDGEMENTS

This study was partly financed by ANPCYT-FONCYT PICT 07-8675. We thank T. Oji, University of Tokyo, for helping with the systematics of isocrinids and making valuable comments.

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