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# First record of a fossil selenariid bryozoan in South America

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Selenariidae Busk 1854 (Bryozoa) is considered endemic to Australia and New Zealand. Here we describe a new species of *Selenaria* Busk 1854 from the lower Miocene Monte León Formation (Patagonia, Argentina). *Selenaria lyrulata* sp. nov. is characterized by autozooids with a lyrula-like, anvil-shaped cryptocystal denticle, opesiular indentations and lateral condyles, as well as avicularia with a shield of fused costae. This is the first record of a selenariid bryozoan in South America.

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LUNULITIFORM bryozoans are characterized by convergently evolved, free-living, cup-shaped colonies adapted for life in sandy or muddy sediments (Lagaaij 1963, Cadée 1975, among others). They belong to several phylogenetically unrelated genera and families. Among them, Selenariidae is presently monogeneric, including only *Selenaria* Busk, 1854, with 27 Cenozoic species, almost exclusively confined to Australia, and one species, *S. concinna* Tenison Woods 1880, also occurring in New Zealand (Bock & Cook 1999, Conroy *et al.* 2001). Other genera formerly classified within Selenariidae were later transferred to Lunulitidae and Otionellidae (Cook & Chimonides 1986, Bock & Cook 1998), or are presently regarded as *incertae sedis* [e.g., *Discovibracella* Voigt 1964, see Voigt (1964), P. Bock, D. Gordon, personal communication].

The diagnostic characters of *Selenaria* are: zooids budded radially; colonies partitioned into concentric astogenetic zones of zooids with different functions; avicularia large and isolated, usually placed at the bifurcation of radial autozooidal rows, with a well-developed condyle system and frontal areas covered by a porous cryptocyst (Cook & Chimonides 1987, Bock & Cook 1999). It has been shown that at least one species, *Selenaria maculata* Busk 1852, is capable of locomotion (Cook & Chimonides 1978). Selenariidae shares with the related Otionellidae the possession of free-living, lunulitiform colonies. The latter family differs in having avicularia with paired, often fused condyles (Bock & Cook 1998).

The fossil species described herein comes from the shell-beds at the top of the Punta Entrada Member of the Monte León Formation, which outcrops along the coastal cliffs of the Monte León National Park (Fig. 1). The siliciclastic section at the locality known as ‘Cabeza de León’ is ca 47 m thick and consists of bioturbated muddy siltstone and fine sandstone with abundant bivalves, gastropods, bryozoans, brachiopods, echinoids, cirripedians, polyplacophorans and scaphopods (Parras *et al.* 2012). The age of this sequence is ca 18 Ma, as proposed by Parras *et al.* (2012), based on  $^{87}\text{Sr}/^{86}\text{Sr}$  age dates.

The aim of this study is to describe a new species of *Selenaria*, the first recorded outside Australasia, based on specimens found in the lower Miocene deposits of the Monte León Formation, Argentine Patagonia.

## Material and methods

The material was collected by G. Pastorino and M. Griffin in 1995. It comes from ‘Cabeza de León’ (50°21′32″S–68°52′58″W), Monte León Formation, Santa Cruz Province, Argentina (Fig. 1). Fragments of *Selenaria lyrulata* sp. nov. were recovered by sieving the loose sediment and then picking the material under a binocular microscope. They were coated with gold/palladium and digital images were obtained using a SEM (Phillips XL-30) at the Museo Argentino de Ciencias Naturales (MACN). Specimens are housed in the collection of the División Paleozoología Invertebrados—Museo de La Plata (MLP).



Fig. 1. Map of the study area.

## Systematic palaeontology

Family SELENARIIDAE Busk, 1854

*Selenaria* Busk, 1854

*Type species:* *Lunulites maculata* Busk 1852, by monotypy.

*Selenaria lyrulata* sp. nov. (Fig. 2A–D)

*Types.* Holotype: MLP 35534, ‘Cabeza de León’, Monte León Formation (lower Miocene), Santa Cruz Province, Argentina. Paratype: MLP 35535, same locality as holotype.

*Description.* Colony unattached, lunulitiform. Basal surface with extrazoooidal calcification, tuberculated, radially grooved (Fig. 2D). Autozooids ordered quincuncially, subhexagonal, with distinct zooidal boundaries; proximal and distal zooidal margins concave and convex, respectively (Fig. 2A). Cryptocyst well developed proximally, tapering laterally, sunken, its whole surface coarsely tuberculated (Fig. 2B). Opesia somewhat trifoliate, rounded distally, constrained by a pair of robust, pointed condyles projecting proximally (Fig. 2B). Opesiular indentations reniform, defined by the condyles and a large, anvil-shaped, lyrula-like denticle (Fig. 2B). Avicularia vicarious, longer than autozooids, asymmetrical, with a wedge-shaped proximal margin, placed at the bifurcation of radial autozooidal

rows (Fig. 2A, C). Avicularian cryptocyst tuberculated, composed of 10–12 costae, fused medially (Fig. 2A–C). Condyle smooth, on the left-hand side, asymmetric, robust, projecting distally and upwards (Fig. 2A, B). Peripheral zooids, ancestrula and early astogeny not seen.

*Measurements.* Autozooid length, 0.23–0.27 mm (n: 5); autozooid width, 0.21–0.26 mm (n: 5); opesia length, 0.14–0.15 mm (n: 5); opesia width, 0.11–0.12 mm (n: 5); avicularium length, 0.33–0.35 mm (n: 2); avicularium width, 0.14–0.17 mm (n: 2).

*Remarks.* The material consists of two small fragments representative of the zone of autozooids and avicularia. The central primary zone and the subperipheral and peripheral zones were missing. The position of the vicarious avicularia at the bifurcation of zooidal rows as well as the structure of the avicularian condyle and cryptocyst are, however, typical of *Selenaria*.

Although most species of *Selenaria* have subcircular opesia which lack condyles, opesiular indentations, or a proximal denticle, these structures are present in some Australasian representatives of the genus. In *S. maculata* (Busk 1852) and *S. watersi* Cook & Chimonides 1985a, the opesia may be laterally constricted and divided centrally by a proximal tongue of cryptocyst (Cook & Chimonides 1985a 1987), but the avicularian cryptocyst is finely punctate. *Selenaria hexagonalis*



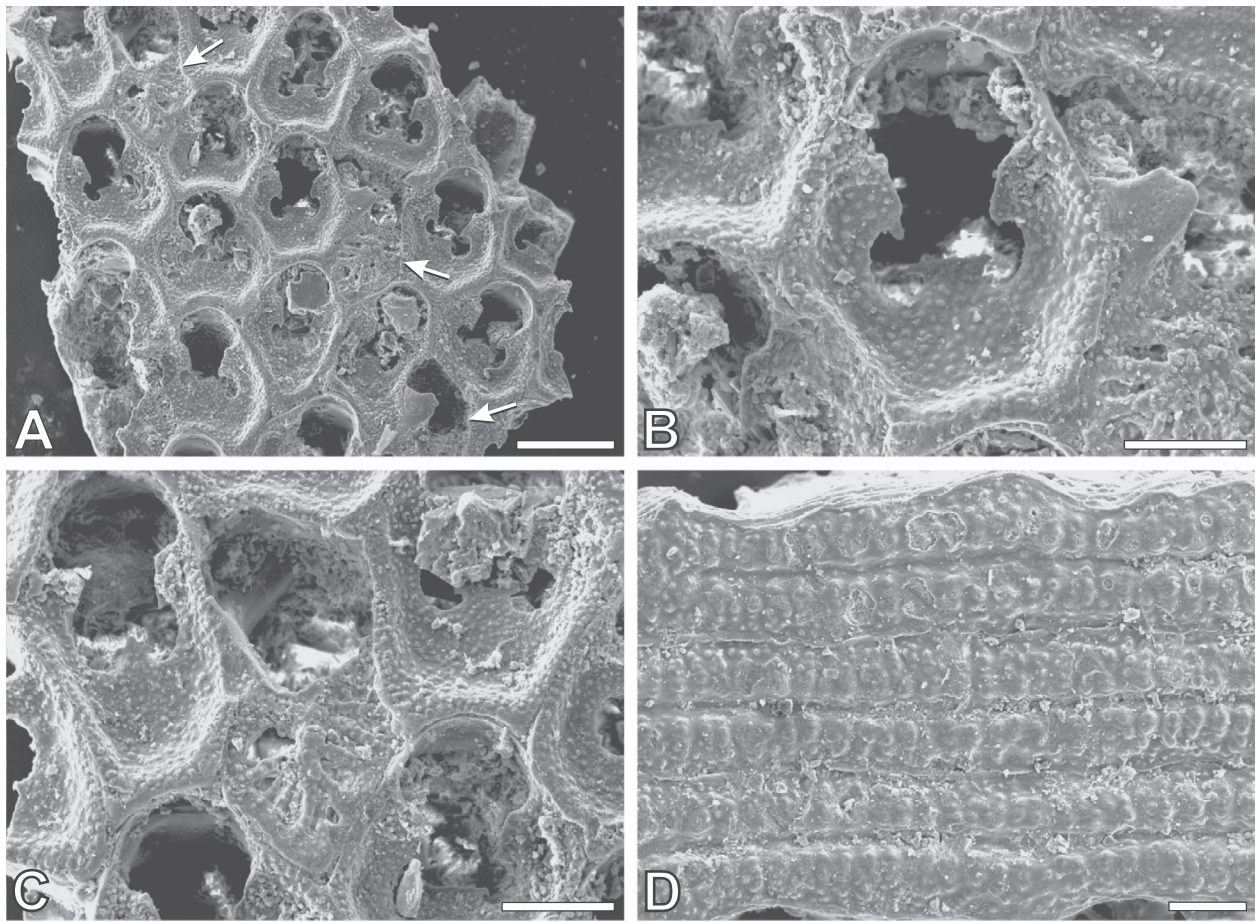


Fig. 2. Holotype (MLP 35534): **A**, general aspect of the colony surface. Arrows show three vicarious avicularia (scale bar = 200  $\mu$ m); **B**, detail of autozoooid, showing the lyrula-like denticle, opesiular indentations and condyles. An avicularian condyle and cryptocystal costae can be seen on the right side (scale bar = 80  $\mu$ m); **C**, avicularium showing a detail of the fused cryptocystal costae (scale bar = 100  $\mu$ m); the condyle is broken. Paratype (MLP 35535): **D**, lower surface of the colony (scale bar = 100  $\mu$ m).

Maplestone, 1904, shares with *S. lyrulata* the fused costae of the avicularian cryptocyst, but the autozoooidal opesia are subcircular and devoid of any other morphological structure (Cook & Chimonides 1987).

Some otionellids also share certain morphological features with *S. lyrulata* sp. nov. *Petasosella alata* (Tenison Woods 1880), from the Australian Miocene, has a trifoliate opesium but lacks the median proximal denticle. In addition, its avicularia have paired condyles and lack the shield of cryptocystal fused costae (see Cook & Chimonides 1985b, Bock & Cook 1998).

*Selenaria lyrulata* sp. nov. adds to other lunulitiform bryozoans already recorded from the Paleogene and Neogene of Argentina, such as the otionellids *Petasosella bioculata* (Canu 1904) and *Otionella parvula* (Canu 1904), and the cupuladriids *Discoporella depressa* (Conrad, 1841) (Canu 1904, as *Cupularia punctata*, see Cook 1965) and *Cupuladria* sp. (Pérez *et al.* 2013). *Petasosella bioculata*, from the late Oligocene of Patagonia (San Julián Formation), differs from the new species in having opesiulate autozooids and vicarious avicularia lacking the shield of cryptocystal costae. Living lunulitiform bryozoans are absent from the Magellanic Region (López Gappa 2000) and only

*Discoporella depressa* occurs today in the warm-temperate zone of the Argentine Sea off Buenos Aires Province (Silén 1942, Buge 1975, López Gappa & Lichtschein 1990).

The denticle of *S. lyrulata* sp. nov. is a distal projection of the cryptocyst, i.e., it is located under the frontal membrane of the zooid. Although its morphology is strikingly similar to lyrula in ascophoran cheilostomes, the two structures can not be regarded as homologous. As recently discussed by Berning *et al.* (2014), the distal margin of a true lyrula fulfils the function of stopping the operculum in a vertical position during opening. We infer that the function of this denticle is to protect the bryozoan from predators trying to gain access to the polypide. The lateral pointed corners of this structure also set the limits of the opesiular indentations, a space traversed by muscles depressing the frontal membrane of the zooid.

Opesiulate selenariids (see species descriptions in Cook & Chimonides 1985a) may have originated from taxa with trifoliate opesia, such as *S. lyrulata* sp. nov. Opesiules may eventually be produced by the closing of opesiular indentations, after the median denticle meets and fuses with the lateral condyles that constrict the

opesia. This trend is suggested in the lateral extensions of the median cryptocystal denticle of *S. lyrulata* sp. nov., and is fully expressed, for instance, in the sexual dimorphism between male (opesiulate) and female zooids (trifoliate) of *S. watersi* Cook & Chimonides, 1985a. A trifoliate opesia with notches at the proximo-lateral corners to accommodate the parietal muscles has also been interpreted as a primitive evolutionary state in the Pyrisinellidae (Di Martino & Taylor 2012).

This constitutes the first record of a selenariid bryozoan in the South American continent. The occurrence of *Selenaria* in lower Miocene deposits of Patagonia is a further confirmation of the strong palaeobiogeographic links that probably existed between the southern tip of South America and the Australasian region at the beginning of the Neogene, as has been discussed by previous authors (Casadio *et al.* 2010, Pérez *et al.* 2015, and references therein).

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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