

Ordovician Echinoderms of Argentina

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Abstract: *ORDOVICIAN ECHINODERMS OF ARGENTINA.* The record of Ordovician echinoderms in Argentina is restricted to the Pelmatozoans, and has not been deeply studied yet. They commonly appear as fragmentary samples represented by isolated ossicles as thecal plates and columnals with the exception of a single locality with few complete specimens. Among the recognized taxa are: *Macrocystella* sp., *Macrocystella?* *durandi* Aceñolaza and *Lingulocystis* cf. *elongata* Thoral. In addition, a variety of unidentified stem and cup plates from six new localities of the Cordillera Oriental, the Famatina System and the Precordillera are illustrated. An early radiation of the group is inferred from the Central Andean Basin, with a posterior migration to other sectors of Gondwana.

Resumen: *EQUINODERMOS ORDOVÍDICOS DE ARGENTINA.* El registro de equinodermos ordovícicos en la República Argentina está limitado a los pelmatozoos, sin que se haya abordado aún el estudio detallado de los mismos. Los fósiles suelen aparecer fragmentariamente como placas tecaes aisladas y segmentos columnares, siendo escasos los ejemplares completos. Entre los *taxa* reconocidos se cita a *Macrocystella* sp.; *Macrocystella?* *durandi* Aceñolaza y *Lingulocystis* cf. *elongata* Thoral. Complementando al conocimiento de los pelmatozoos ordovícicos, se figura material de algunas nuevas localidades fosilíferas de la Cordillera Oriental, así como del Sistema de Famatina y la Precordillera. En base a su registro cronoestratigráfico desde el Cámbrico Superior en las plataformas de la Cuenca Central Andina, se plantea una posible radiación temprana del grupo en la región, con una posterior migración hacia otros sectores en el margen Gondwánico.

Key words: Echinodermata. Rhombifera. Eocrinoidea. Pelmatozoans. Ordovician. Argentina.

Palabras clave: Equinodermos. Rhombifera. Eocrinoidea. Plematozoos. Ordovícico. Argentina.

Introduction

Echinoderm evolution started during Cambrian times, becoming the pelmatozoans common elements in mid to high latitude Ordovician seas (Sprinkle, 1995). Platforms covering the western margin of Gondwana were no exception to the early referred trend, so fossils are found generally

as fragmentary samples within siliciclastic rocks (sandstones and shales) and limestones.

It is well known the large outcrops of Ordovician sedimentary rocks in Argentina, as well as its abundant fossiliferous content. We must highlight the thick Cambro-Ordovician clastic sequences, of over 9.000 meters, outcropping in the Cordillera Oriental of NW Argentina, and the Cambro-Ordovician limestone sequences that characterize the Precordillera of Western Argentina (Bordonaro, 1992; Aceñolaza, 1992; Astini *et al.*, 1995; Aceñolaza and Toselli, 1999; Aceñolaza *et al.*, 1999; Peralta, 2000 with references).

Although echinoderm debris are common in the above mentioned strata, only one locality yielded so far complete echinoderm specimens, coming from Arenig strata in the Cordillera Oriental of northern Argentina (Gutiérrez-Marco and Aceñolaza, 1999) (Fig. 1 C, 2 G-I).

A variety of stem fragments with distinctive columnal or pluricolumnal morphology tell us about an extensive echinoderm fauna that inhabited the South American margin of Gondwana during the Ordovician. Due to the fragility of their morphological elements, most commonly highly disarticulated, and to the fact that they have been regularly considered as “complementary fauna”, the knowledge of the Argentine Ordovician echinoderms is scarce but promising.

History of research

Kayser (1876; Spanish version of 1925) is the first author who mentions the occurrence of “cylindrical articulations of a few millimeters of thickness” in the “Lower Silurian” limestones (“calizas infrasilurianas”) of Huaco, Precordillera of San Juan. The figured specimens lack any diagnostic elements and are unrecognizable/undeterminable. Harrington (1937, 1938) presents the first description with figures of stem fragments from different Tremadocian and Arenig localities from the Cordillera Oriental of Northwestern Argentina (San Bernardo Hill in the province of Salta, and Coquena and Chalala creeks in the provinces of Jujuy). In both publications, Harrington identified these echinoderms remains in open nomenclature, describing them as “Cystoidea gen. sp. indet.”.

In a same manner, Loss (1951) mentions the existence of small fragments of cylindrical stem of five elements that belong to “Cistoidea gen. et sp. ind.” (*sic*), from sandstones and shales outcropping in the locality of Portezuelo, south of San Bernardo Hill (Salta). Later, Turco Greco and Zardini (1984) describe from the waxes and shales of the Don Polo Formation, an isolated thecal plate without precise taxonomic attribution. The first paper focusing specifically on Argentine Ordovician Echinoderms is due to F.G. Aceñolaza (1986) who described and figured different thecal plates and stem fragments assigned to the genus *Macrocystella*, an early rhombiferan coming from three localities in the Cordillera Oriental (Alto de la Sierra and Santa Victoria in Salta and Sapagua in Jujuy). Recently, G.F. Aceñolaza (1999) introduces the new species *M.? durandi* Aceñolaza from Tremadocian rocks of the Jujuy province, summarizing the record of the genus in Argentina and presenting new localities from the Cordillera Oriental.

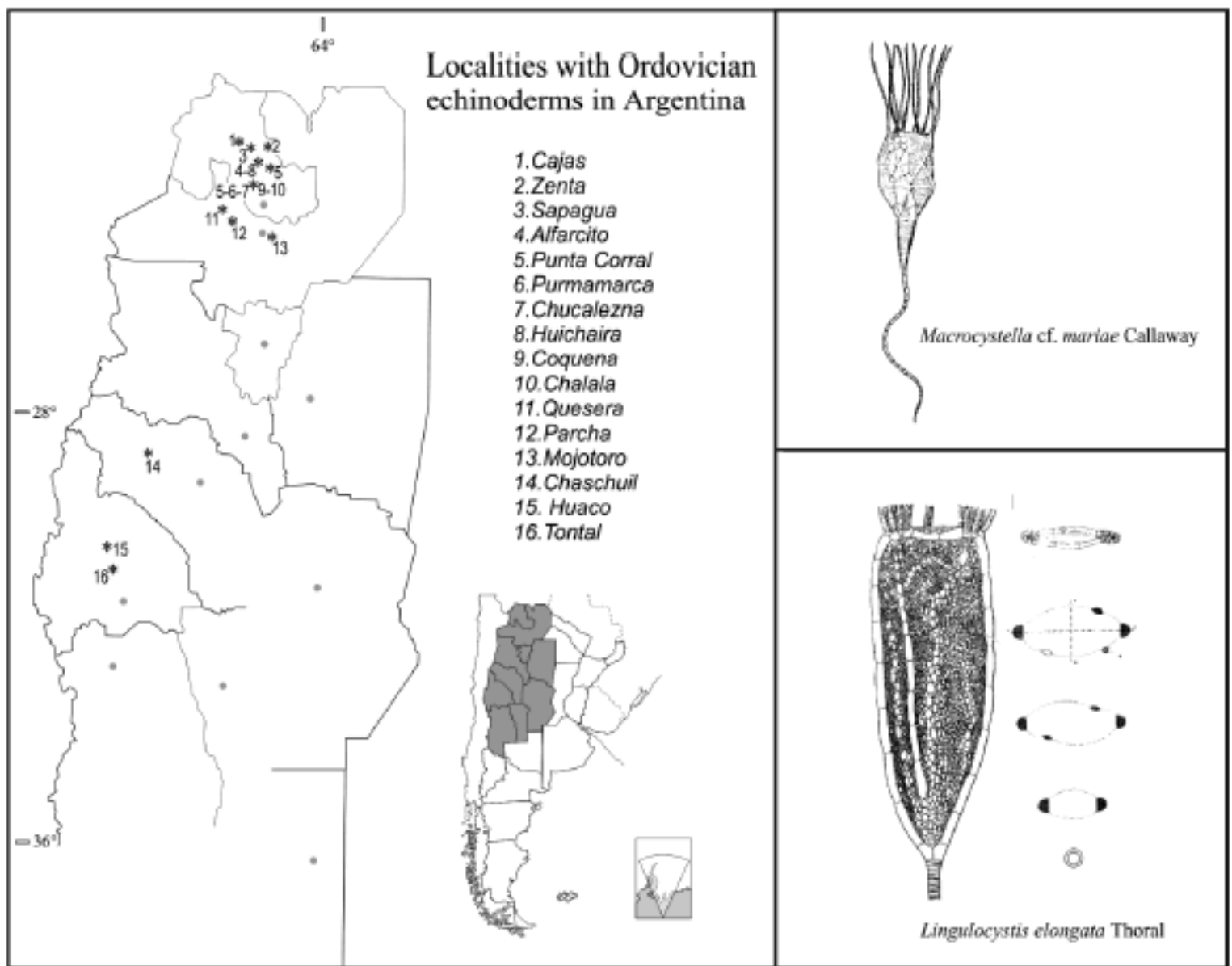
Localities, material and biostratigraphical framework

(Fig. 1 A 1-16)

Cordillera Oriental:

* *Jujuy province:* Cajas Range, Zenta Range, Sapagua, Alfarcito, Punta Corral, Huichaira, Chucalezna, Purmamarca, Coquena and Chalala creeks: Thecal plates assigned to *Macrocystellids* and undifferentiated stem fragments (columnals and pluricolumnals) in the Lower Ordovician shales and sandstones of the Santa Rosita Formation. Fossils are included in the range of the *Parabolina (N.) frequens argentina*, *Kainella meridionalis* trilobite biozones (Tremadocian) and of the Upper Tremadocian/Arenig *Notopeltis orthometopa* trilobite Biozone (Fig. 1, A 1-10, B; Fig. 2, B-C and E).

* *Salta province:* La Quesera locality, Parcha area and Mojotoro Range: Thecal plates of *Macrocystella* sp. thecal plates, associated to undeterminable columnals and pluricolumnals in all localities (Fig 1, A 11-13; Fig. 2, K, M). *Lingulocystis* cf. *elongata* Thoral was reported by Gutiérrez-Marco and Aceñolaza (1999) from the Mojotoro Range, within the greenish sandstones and shales of the San Bernardo Formation (Harrington *in* Harrington and Leanza, 1957 (Fig. 1, A 13, C; Fig. 2, G-J). *Lingulocystis* is accompanied by a rich graptolite assemblage belonging to the association IX of Moya *et al.* (1994) with *Araneograptus murrayi*, *Clonograptus flexilis*, *Tetragraptus lavalensis*, “*Didymograptus v-fractus*”, “*D. nitidus*” and “*D. vacillans*” among others (Loss, 1951; Harrington and Leanza, 1957; Moya *et al.*, 1994



with references). *Thysanopyge argentina*, *Megalaspidella (Kayseraspis) asaphelloides*, *Megalaspidella (Kayseraspis) brackebuschi*, *Nannopeltis modesta*, *Nanorthis grandis* and *Sanbernardaspis pygacantha* conform the coeval trilobite association, indicative of the *Megalaspidella (K.) asaphelloides* Biozone (Harrington and Leanza, 1957; Aceñolaza, 1973; Moya *et al.*, 1994).

Associated to the above mentioned fossils, an abundant ostracod fauna is also recorded, with *Zygodolba asapha*, *Drepanellina ericksoni*, *Bernardite longisulcus*, *Bernardite asapha*, *Saltite erichseni*, *Saltite saltensis* and *Nortite elongatum* (Harrington, 1938; García and Proserpio, 1976).

Famatina System:

Ordovician echinoderms in the Famatina System have only been mentioned from the province of Catamarca, at the locality of Chaschuil (Sierra de Narváez). Fragmentary plematozoan stems grouped and isolated columnals frequently appear in the middle sector of the Arenig Suri Formation.

No complete specimens or thecal plates have been recorded from the unit. Fossils are recognized

within the *Merlinia megacanta* and *Baltoniodus navis* trilobite and conodont biozones, respectively (Harrington and Leanza, 1957; Aceñolaza and Toselli, 1977; Benedetto, 1994; Albanesi and Vaccari, 1994; Vaccari and Waisfeld, 1994 and Gutiérrez-Marco *et al.*, 2000 with references) (Fig. 1, A 14).

Figure 1. A. Location map of Ordovician Echinoderm occurrences in Argentina. B. Reconstruction of *Macrocystella cf. mariae* Callaway. C. Reconstruction of *Lingulocystis elongata* Thoral (after Ubaghs, 1960).

Two localities have been recognized. a) Huaco, a classical Ordovician locality in western Argentina from where Kayser (1876) mentioned “cylindrical articulations of a few millimeters of thickness” within grey and whitish limestones. Material from Huaco has never been studied in detail and there is no record of complete samples from the locality (Fig. 1, A 15; Fig. 2, L). b) Quebrada del Carrizalito, where Turco Grecco and Zardini (1984) described an isolated thecal plate from the Don Polo Formation cropping out in the northeastern sector of the Sierra del Tontal (vicinity of Calingasta Village). In a general sense the plate resembles a rhombiferan low relief *Macrocystella* type. The absence of a repository for the described material did not allow the revision of the original specimen (Fig. 1, A 16; Fig. 2, F). No other fossils have been recorded from Don Polo Formation, which has been interpreted to be partially equivalent to metamorphosed facies of the Llanvirn-Caradoc Alcaparrosa Formation (Bordonaro, 1999).

Description of material

Repository. Material described herein is housed in the invertebrate paleontological collection of the Facultad de Ciencias Naturales and Instituto Miguel Lillo, Universidad Nacional de Tucumán under a designated PIL (Paleontología Invertebrados Lillo).

Phylum Echinodermata Klein, 1734

Class Rhombifera Zittel, 1879

Order Dichoporita Jaekel, 1899

Family Macrocystellidae Bather, 1899; enmend. Jaekel, 1918

Genus *Macrocystella* Callaway, 1877

Type species: *Macrocystella mariae* Callaway, 1877

Macrocystella sp.

Fig. 2 B, C, E

v.1986 *Macrocystella* sp. - Aceñolaza, F.G. pág. 134, lám. 1, fig. A-F.

v.1996 *Macrocystella* sp. - Aceñolaza, G.F. pág 203, lám. 11, fig. A-D

Material. 16 moulds of internal and 8 external lateral plates. 2 moulds of internal infralateral plates, 1 mould of a internal probably marginal periproctal plate. Several isolated and connected stem segments. Complete thecae were not recovered. Samples from different sections of the provinces of Salta and Jujuy. PIL 14.475, PIL 14.476, PIL 14.477, PIL14.521, PIL 14.522, and PIL 14.523.

Description. Hexagonal thecal plates, with vaulted profile. Length varies from 5,8 to 7,3 and width from 4,9 to 7,5 mm. Umbo defined by a structure raised 1,3-2,1 mm above the plate. Straight and well delimited main folds. Secondary folds of a variable number, from 3 to 4, subtriangular outline, parallel to main folds without contact between both.

Isolated and grouped stem fragments, with a variable length (1,8 to 12,2 mm and composed of up to 10 columnals), circular to sub-circular cross section, thick walled segments with small central lumen are the most common. No radially structures or ornamented surfaces were observed within the crenularium or areola.

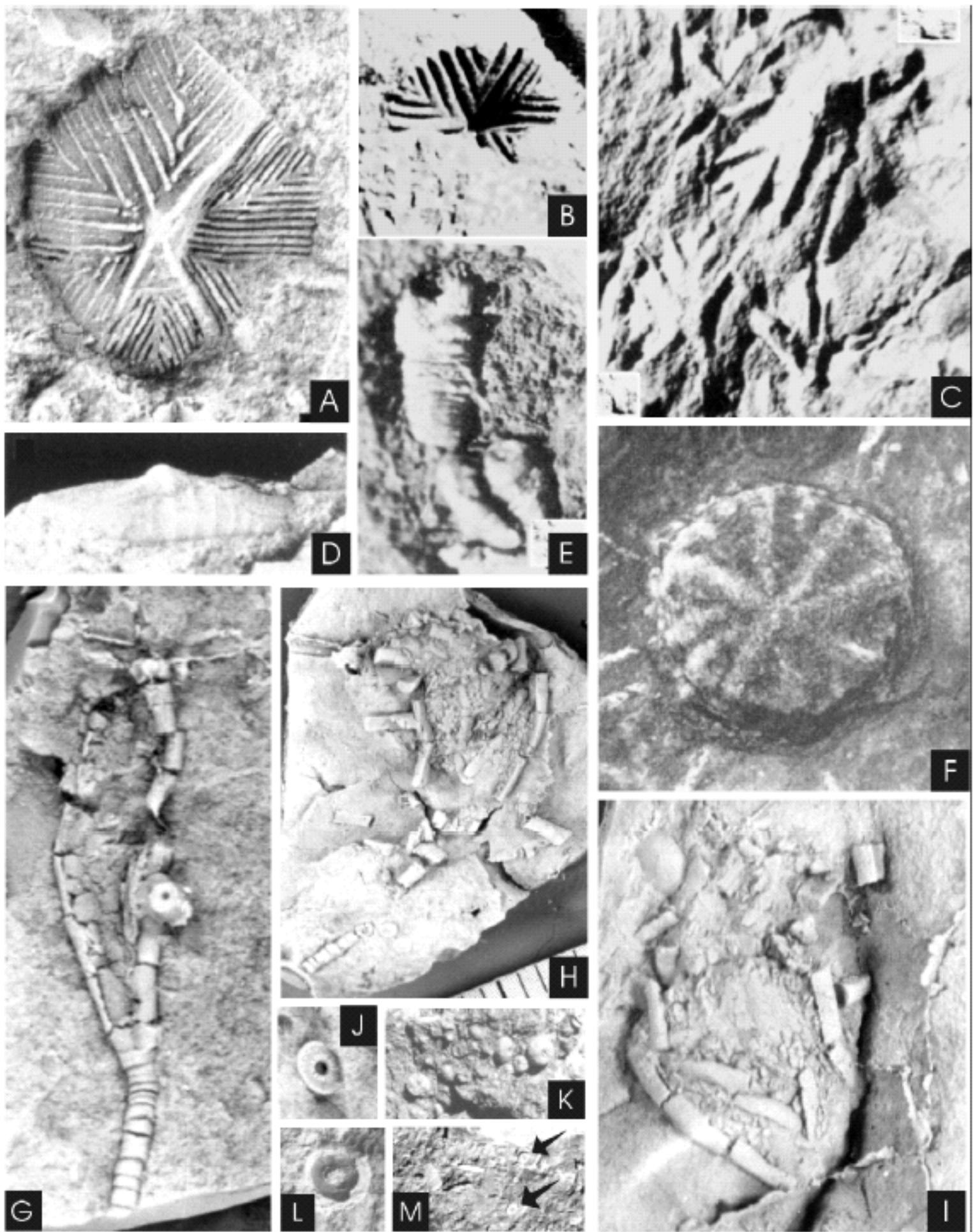


Figure 2. Ordovician echinoderms of Argentina. A, D. *Macrocytella? durandi* (x5) Aceñolaza from

Cerro Ronqui, Jujuy, Cordillera Oriental Argentina. B-C-E - *Macrocytella* sp. from Salta and Jujuy provinces (B x 2,5; C x 3,5; E x 4). F- Isolated plate from the Don Polo Fm., Argentine Precordillera (x 4, Turco Greco and Zardini, 1984). G-I. *Lingulocystis* cf. *elongata* from the Arenig Strata of the Cerro San Bernardo, Salta province (x5). J-M. Diverse columnals from Argentine Ordovician strata.

Remarks. *Macrocytella* Callaway is the only genus of the family Macrocytellidae, characterized by a cylindrical theca with 6 radial plates, a large and flexible periproct with several small plates surrounded by 5 lateral and infralateral plates. Brachioles are restricted to the upper sector of the theca, rising from the ambulacra placed between the oral plates (Paul, 1968, 1984).

On the basis of morphological characters, *Macrocytella* has been assigned by several authors to Eocrinoidea (Moore, 1954; Ubaghs, 1967; Chauvel, 1969; Rosova *et al.*, 1985 and Sprinkle, 1995) or to the Rhombifera (Bather, 1899; Thoral, 1935; Cuénot, 1948; Ubaghs, 1967; Paul, 1968, 1984; Gil Cid *et al.*, 1996; Vizcaïno and Lefebvre, 1998 and Sdzuy *et al.*, 2001). Broadhead (1982) analyzes Eocrinoidea as a group, rising it to a Class category, including Macrocytellidae in a new Order (Ascocystitida). But the genus *Macrocytella* is actually considered as an ancestor of cheirocrinid rhombiferans due to the lack of dichopores.

Cystidea Barrande, *Mimocystites* Barrande (Chauvel, 1966) and *Mimocystis* Barrande (invalid name, Carpenter, 1891, Haeckel, 1896 and Bather, 1900) have been sinonimized to *Macrocytella* Callaway (Cunéot, 1953; Havlicek y Vanek, 1966; Paul, 1967, 1968, 1973, 1984; Chauvel, 1969; Gil Cid *et al.*, 1996; Aceñolaza, 1999).

Seven species are actually assigned to the genus: *M. mariae* Callaway from the Tremadocian of England and Wales, *M. bavarica* (Barrande) and *M. greilingi* Hammann and Sdzuy from the Tremadocian of Bavaria, Germany. *M. bohémica* (Barrande) from the Tremadocian of Bohemia (Czech Republic) and Lower Arenig of Morocco, *M. azaisi* (Thoral) from the Upper Tremadocian of the Montagne Noire (southeast France), *M. tasseftensis* Chauvel from the Lower Arenig of Morocco, *M. pauli* Gil Cid *et al.* from the Lower Caradoc of the Central Iberian Zone (Spain).

The last record of the genus is placed in Lower Caradoc strata in Spain (Gil Cid *et al.*, 1996). The material from the Argentine Cordillera Oriental is all fragmentary and ranges from the Upper Cambrian to the Upper Tremadocian.

The earlier record of *Macrocytella* from the Central Andean Basin could be indicating an initial radiation of macrocytellids from the western margin of Gondwana, with a subsequent eastwards migration to other perigondwanan areas of Europe and North Africa. In a same sense, several other invertebrate groups enhanced this one-way migratory route (Aceñolaza, *et al.*, 1999; Gutiérrez-Marco *et al.*, 1999; Gutiérrez-Marco *et al.*, 2000).

Macrocytella? durandi Aceñolaza

Fig. 2 A, D

1999 *Macrocystella? durandi* sp. nov. - Aceñolaza, G.F., pág. 95-98, fig. 2.1-2.5

Material. Several thecal plates with moulds associated to stem fragments that have been tentatively assigned as belonging to the genus. PIL 14.530, 14.531, 14.532, 14.533 y 14.534. Samples were recovered from the shales and sandstones of the Tremadocian Rupsaca Formation cropping out at the locality of Cerro Ronqui, Jujuy Province.

Description. Hexagonal plates of uneven sized lateral margins, without sutural pores and with radial folds merging from a clearly elevated central umbo (3,1 to 3,5 mm high). Principal folds display rounded borders, from 7,8 to 8,1 mm long. Several and delicate secondary folds characterize this species, they have 6,1 to 6,7 mm long and are arranged on a parallel setting respect to the main folds. Regular shallow rhomboidal figures appear when meeting lateral plates.

Remarks. Analyzed material is referred to thecal plates and moulds, with several diagnostic elements supporting its taxonomic differentiation from other species of *Macrocystella* Callaway (as the presence of probable pectinirhombs). More material is needed in order to ensure the correct assignation of this form to the genus. If general morphological characters stay coherent with samples herein described, this pelmatozoan will probably be assigned to a new genus.

Assignation to *Macrocystella?* is supported by the fact that plates do not show sutural pores, presenting an umbo elevated from the plate and radially arranged folds merging from it. Main thecal folds cut straight to sides of plates, and in a different manner of the late Cambrian *Cambrocrinus*, whose folds reach bifurcated the angles of plates (Dzik y Orłowski, 1993).

M.? durandi Aceñolaza differs from *M. tasseftensis* Chauvel, because main folds reach the umbo in the first situation, while a lack of granulation characterizes the second case (Chauvel, 1969).

M. bohémica (Barrande), *M. mariae* Callaway, *M. pauli* Gil Cid *et al.* and *M. greilingi* Hammann and Sdzuy (*in Sdzuy et al.*, 2001) differs from *M.? durandi* Aceñolaza by the abundant delicated secondary folds that characterize the argentine species (reaching up to 30 folds per plate, compared to the 3 to 5 folds in the other species). *M. azaisi* (Thoral) display distinctive convergent basal secondary folds very different to the material here described.

Macrocystella? durandi Aceñolaza has been found in a single locality (Cerro Ronqui, Jujuy province) and probably represents an intermediate step on the evolution between *Macrocystella* and *Cheirocrinus*, being the last trend indicated by the presence of incipient pectinirhombs on the marginal sectors of thecal plates (Aceñolaza, 1999).

Class Eocrinoidea Jaekel, 1918

Family Lingulocystidae Ubaghs, 1960

Genus *Lingulocystis* Thoral, 1935

Type specie: *Lingulocystis elongata* Thoral, 1935

Lingulocystis cf. *elongata* Thoral

Fig. 2 G-J

cf. 1935 *Lingulocystis elongata* n. sp. (var. *typica* et var. *lata*) - Thoral, pág. 94-95, lám. 8, fig. 3a-b, 4a-b, 6.

cf. 1960 *Lingulocystis elongata* Thoral - Ubaghs, pág 83-103, fig. 1-9; lám. 1, fig 1-6; lám. 2, fig. 1-4; lám. 3, fig. 1-5.

1999 *Lingulocystis* cf. *elongata* Thoral - Gutiérrez-Marco and Aceñolaza, pág. 351-353, fig. 1a-c.

Material. Four fairly complete samples of theca with fragmentary stem, one of them with attached brachioles and several isolated pieces of theca and stem. The material comes from the shales of the San Bernardo Formation (Arenig) cropping out at the Sierra de San Bernardo, Salta Province, northwestern Argentina. PIL 14.535-38.

Description. The body of *Lingulocystis* Thoral can be divided into three sectors, a long stem, a flattened theca and a number of biserial brachioles raising from the upper margin of the theca. The stem reaches up to 20 cm long, formed by numerous cylindrical crenulated columnals of uneven thickness. No basal segments of the stem has been observed. The theca is 2,2 to 3 cm long and 0,7 to 1,3 cm wide, formed by numerous small irregular plates limited by several thicker marginals.

These do not participate in the internal pavement, except for few ribbon like plates laterally displaced from the middle of the tegument that constituted the longitudinal carina so far characteristic of the species *L. elongata*. Anus is placed laterally in the upper third of flattened theca, covered by numerous small and elongated plates. Brachioles show a biserial organization and are inserted marginally in the framework of the oral face (Fig. 1C).

Remarks. *Lingulocystis elongata* was originally described by Thoral (1935) from Lower Ordovician shales of the Montagne Noire, southeastern France; being carefully reviewed by Ubaghs (1960), who adds new material. Later, Sprinkle (1973a) presents the first occurrence of the genus in South America, with the new species *L. boliviana* that occurs from a single locality placed in the southern Eastern Cordillera of Bolivia (Tarija area). Its type material was first considered to be of "Llanvirn" age (now reviewed as Arenig; Aceñolaza *et al.*, 1999), and consists on the single

specimen previously reported as an unidentified crinoid by Ahlfeld and Branisa (1960) and Branisa (1965). Recently, Ubaghs (1994) adds a second European species to the genus, *L. deani*, also from the Lower Ordovician of the Montagne Noire, France. Finally, Gutiérrez-Marco and Aceñolaza (1999) inform of the probable record of the type species of *Lingulocystis* in South America, being the first occurrence of the genus in Argentina, also considered herein.

Lingulocystis is the only genus of the Family Lingulocystidae Ubaghs, and is characterized by being the only known flattened pelmatozoan with a probably flexible theca covered by small irregular plates. *Lingulocystis* was assigned to different groups such as Carpoidea (Thoral, 1935) and Eocrinoidea (Ubaghs, 1960; Sprinkle, 1973a, 1973b, 1995; Sumrall *et al.*, 2001), as well as to a new class closely allied to Paracrinoidea (Broadhead, 1982). In this paper we follow the analysis done by Sprinkle (1995), considering *Lingulocystis* as an Eocrinoid.

Acknowledgements. We thank D. Ruiz Holgado and E. Gómez (Tucumán) for the line drawings. This paper was finished thanks to the financial support of Fundación Antorchas and the Instituto Superior de Correlación Geológica (CONICET- UNT, Argentina), being also a contribution to the project “Dinámica faunística perigondwánica” of the current Scientific Cooperation Program between Spain and Argentina.

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Recibido: 15 de Septiembre de 2002

Aceptado: 3 de Diciembre de 2002