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Article

First record of the rare genus *Arachniopleurus* (Echinoidea) in the Eocene of Italy

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Keywords

- Echinoidea
- *Arachniopleurus*
- Upper Eocene
- Italy

Summary

A small regular echinoid recently collected from the Priabonian of Sossano near Vicenza (North-eastern Italy) is here attributed to *Arachniopleurus istrianus* Degli Innocenti, 1924. This species was so far known only by the holotype, an incomplete specimen from the Eocene of Butoniga (Croatia), and it was not cited again after its institution. The preservation of the specimen under study enables to confirm the validity of this rare species, that was still under discussion. *A. istrianus* is distinguished from the other species attributed to this genus above all by its highly sculpted test: the scrobicular rings are large and increase quickly in size towards the ambitus, the space between the scrobicular ridges is small, consequently the oblique ridges forming the reticulate ornamentation are very short. The value of the ratio between the width of the ambulacral and interambulacral area at the ambitus is smaller than in the other known species attributed to *Arachniopleurus*.

Parole chiave

- Echinoidea
- Arachniopleurus
- Eocene superiore
- Italia

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Riassunto

Un piccolo echinoide regolare recentemente raccolto nel Priaboniano (Eocene superiore) di Sossano, nei Colli Berici (Vicenza), viene attribuito ad *Arachniopleurus istrianus* Degli Innocenti, 1924. L'olotipo è irrintracciabile. Il nuovo esemplare consente di completare la descrizione morfologica di questa specie. *Arachniopleurus* Duncan & Sladen, 1882 appartiene alla famiglia Glyphocyphidae Duncan, 1889. Le caratteristiche morfologiche che è stato possibile rilevare nell'esemplare di Sossano corrispondono a quelle di *Arachniopleurus istrianus*. L'esame di un sintipo (NHMD-89740) di *Arachniopleurus hungaricus* (Thirring, 1936), messo gentilmente a disposizione dal Museo di Storia Naturale Danese, ha consentito di confermare la distinzione di questa specie da *A. istrianus*: in particolare i tubercoli e gli anelli scrobicolari sono sensibilmente più piccoli in proporzione. *Arachniopleurus istrianus* Degli Innocenti, 1924 viene quindi confermata come specie valida.

Introduction

Arachniopleurus Duncan & Sladen, 1882 is a rare extinct genus, belonging to the family Glyphocyphidae Duncan, 1889. This echinoid is known from the Paleocene to the Upper Eocene of Pakistan and Europe (France, Spain, Hungary and Croatia). Four species have been attributed to this genus, all of them based on a few, often badly preserved, specimens.

Arachniopleurus istrianus Degli Innocenti, 1924, from the Eocene of Butoniga, near Pazin (Croatia), was based on a single specimen, the holotype, which is wanting (Mikuz, 2008). This species was not cited again after its institution. On the basis of the original illustration and description (Degli Innocenti, 1924b, , pl. 2, figs. 7-10), the holotype was represented by an incomplete and partially abraded specimen. The validity of this species was still debated, due to the bad preservation of the type; a well preserved specimen available for this study, from the Priabonian (Upper Eocene) of the Berici Hills near Vicenza (North-eastern Italy), enables comparison with the other species attributed to this rare genus.

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Material and methods

The specimen under study is housed at the Museo Civico "Dal Lago" of Valdagno (Vicenza), with the repository number MCV 21/037. It is represented by a complete test, missing the apical disc. The illustration of specimens belonging to the other known species of *Arachniopleurus* have been utilised in the discussion:

- *A. reticulatus* Duncan & Sladen, 1882: the plating scheme of a syntype, housed at the Geological Survey of India (SGI), was provided by Smith & Jeffery (2000); the illustration of two specimens (D= 15 mm and 24 mm respectively) from the Eocene of Huesca (Spain) and one (D= 15 mm) from Alicante (Spain) has been published in Echinologia (2019).

- *A. villanovae* (Cotteau, 1890): the illustration of a specimen at the Muséum d'Histoire Naturelle of Genève (MHNG 26032), from the Eocene (?Lutetian) of Callosa, near Alicante (Spain), has been provided by Smith & Kroh (2011). Two specimens (D= 14 mm and 18 mm, respectively), from the Eocene of Aspe near Alicante (Spain), are reported in Echinologia (2019).

- *A. istrianus* Degli Innocenti, 1924, from the Eocene of Pazin (Croatia): the illustration of the holotype and a plating scheme have been provided by Degli Innocenti (1924b, pl. 2, figs. 7-10).

- *A. hungaricus* (Thirring, 1936), Upper Eocene (Priabonian) of Sürü-Berger, near Bakony (Hungary): the photography of a syntype has been kindly provided by the Natural History Museum of Denmark (NHMD-89740).

Morphological abbreviations (Table 1): D= test diameter; Da, Dp, Ds= respectively, diameter of apical disc, peristome and subcircular ridges surrounding the interambulacral primary tubercles at the ambitus; WA/WIA= ratio between the width of an ambulacral and an interambulacral area at the ambitus; nA and nIA= number of the plates in each ambulacral and interambulacral columns, respectively; Wp/Hp = ratio between the width and the height of an interambulacral plate, measured at the ambitus. Some biometric data have been taken from figures and drawings, although they do not represent exact measures they are deemed to be useful for the discussion.

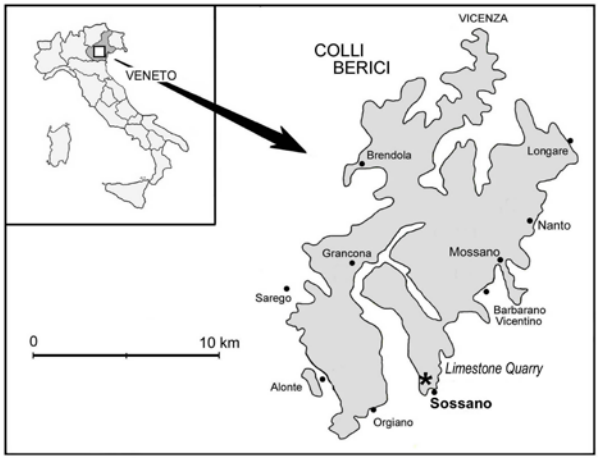

Fig. 1 *- Location map of the finding locality, the inactive limestone quarry near Sossano in the Berici Hills (North-eastern Italy). / Mappa con l'ubicazione della località di ritrovamento, la cava di Sossano nei Colli Berici (Veneto).*

Finding locality

The specimen under study was collected in the limestone quarry of Sossano, located in the south-eastern part of the Berici Hills (Fig. 1). The geo-stratigraphy of the Berici Hills has been studied above all by Fabiani (1908) and Mietto (1988, 2003). Although the quarry is inactive and has recently undergone an intensive process of environmental restoration, the middle Eocene calcarenite deposits, about 50 m thick, are still well visible. At the top of the exposed section there are Upper Eocene (Priabonian) marly limestones, grey on the fresh fracture and yellowish after prolonged exposure to the weather agents. The limestones are well stratified and rich in macrofossils, mainly consisting of nummulites, bryozoans and less frequent bivalves, crustaceans and fish teeth. The echinoids are mainly represented by *Schizaster and Clypeaster* (De Angeli & Caporiondo, 2009). Also the specimen under study originated from the Priabonian marly siltstones.

Systematic palaeontology

The systematic follows Kroh & Smith (2010) and Kroh & Mooi (2020).

Order Camarodonta Jackson, 1912
Infraorder Temnopleuridea Kroh & Smith, 2010
Family Glyphocyphidae Duncan, 1889
Genus *Arachniopleurus* Duncan & Sladen, 1882

[= *Radiocyphus* Cotteau, 1890, p. 98, type-species *Radiocyphus villanovae* Cotteau, 1890]

Type species: *Arachniopleurus reticulatus* Duncan & Sladen, 1882, p. 43, by original designation.

Diagnosis (from Smith & Kroh, 2011)
Arachniopleurus is distinguished from the other glyphocyphids by its highly sculpted test and the poligeminate compounding in the ambulacral plates. In particular, a strong radial ornament consisting of thin ridges surrounds the primary tubercles; the ambulacral plates are made of three elements united by the primary tubercle alternating with one or two simple elements, all of them reaching the perradius, the lowest element is the largest. The other diagnostic features are:
- Test depressed, flattened above and below.
- Ambulacral and interambulacral plates with a large, centrally placed primary tubercle.
- Primary tubercles perforate and crenulate.
- Peristome small and deeply sunken, with deep buccal notches.
- The apical disc, lantern and spines are unknown.

Remarks
The type species of *Radiocyphus* Cotteau, 1890 was R. *villanovae* Cotteau, 1890. Soon after the institution of this genus, Cotteau himself (1893) proposed to synonymize it with the pre-existing *Arachniopleurus*. Two additional species have been subsequently included in *Radiocyphus: R. arenatus* (D'Archiac, 1847), from the Upper Eocene of France, by Lambert & Thiéry (1911), and *R. hungaricus* Thirring, 1936, from the Eocene of Hungary. The genus *Radiocyphus* is currently considered as synonymous of *Arachniopleurus* by Smith & Kroh (2011) and Kroh & Mooi (2020).

Species included:
A. arenatus (D'Archiac, 1847), Upper Eocene, France
A. reticulatus Duncan & Sladen, 1882; latest Paleocene-Lower Eocene, Pakistan and Spain
A. villanovae (Cotteau, 1890), Middle Eocene, Spain
A. istrianus Degli Innocenti, 1924; Eocene, Croatia, Italy (present paper).
A. hungaricus (Thirring, 1936), Eocene of Hungary.

DISTRIBUTION: Upper Paleocene-Eocene of Pakistan, Croatia, France, Spain, Hungary and Italy.

Arachniopleurus istrianus Degli Innocenti, 1924
Figs 2a-c, 3a-b

1924a *Arachniopleurus* sp. n. – Degli Innocenti: p. 298
1924b *Arachniopleurus istrianus* Degli Innocenti – Degli Innocenti: p. 43, pl. 2, figs. 7-10
1925 *Arachniopleurus istrianus* Degli Innocenti – Degli Innocenti: pp. 22-23, fig. 2
2008 *Arachniopleurus istrianus* Degli Innocenti – Mikuz: 14-15, pl.

1, figs. 6, 8a-c, 9a-b.
Type material: the holotype, from the Middle Eocene of Butoniga, near Pazin (Croatia), is untraceable (*fide* Mikuz, 2008).
Material studied: a whole specimen (Museo Civico "Dal Lago" MCV 21/037), Priabonian of Sossano, near Vicenza (North-eastern Italy).

DIMENSIONS: D= 16 mm.

DESCRIPTION:
Test depressed, flattened above and below (Fig. 2b).
The apical opening is subpentagonal (Fig. 2a) and larger than the peristome (Tab. 1).
The ambulacral areas are narrow: the mean value of the WA/WIA ratio at the ambitus is 0.42, just as in the holotype (compare Degli Innocenti, 1925, fig. 2). The ambulacral plates are poligeminate, commonly with 4 couples of pores (there are only 3 of them adapically and near the peristome). Three elements are overlapped by the primary tubercle and alternate with a simple element; all of them reach the perradius. The pore-pairs are uniserial throughout (Fig. 3b); there are no phyllodes.
The interambulacral plates are wider than tall at the ambitus (mean Hp/Wp= 0.58), with a centrally placed primary tubercle. Adapically, the interambulacra tend to widen instead of shrinking and have a median notch in the upper edge, indicating the presence of protruding genital plates in the apical disc, as in other glyphocyphids (Smith & Kroh, 2011).
There are two rows of primary tubercles in each ambulacral and interambulacral area, those in the ambulacra are smaller. All the primary tubercles are perforate and finely crenulate; they are larger near the ambitus.
The test surface is strongly sculpted. The primary tubercles, both in the ambulacral and in the interambulacral areas, are surrounded by a radiating ornamentation consisting of 8-12 costae bounded by a subcircular ridge (Figs. 3 a-b) bearing large military tubercles.
In the interambulacra, the scrobicular rings are much larger and increase quickly in size approaching the ambitus, getting up to Ds= 58% Wp. On both sides of the primary tubercle there is a reticulate ornamentation made of low ridges connecting the scrobicular rings, bearing knobs or miliary tubercles. Since the scrobicular rings are very large, these ridges are shorter than in the other species of *Arachniopleurus*. In the oral interambulacra, each primary tubercle is connected laterally by two couples of ridges with two tubercles located in the adjacent interambulacral column.
Peristome rather small (Dp= 33% D) and sunken, with large and shallow buccal notches (Fig. 3a).

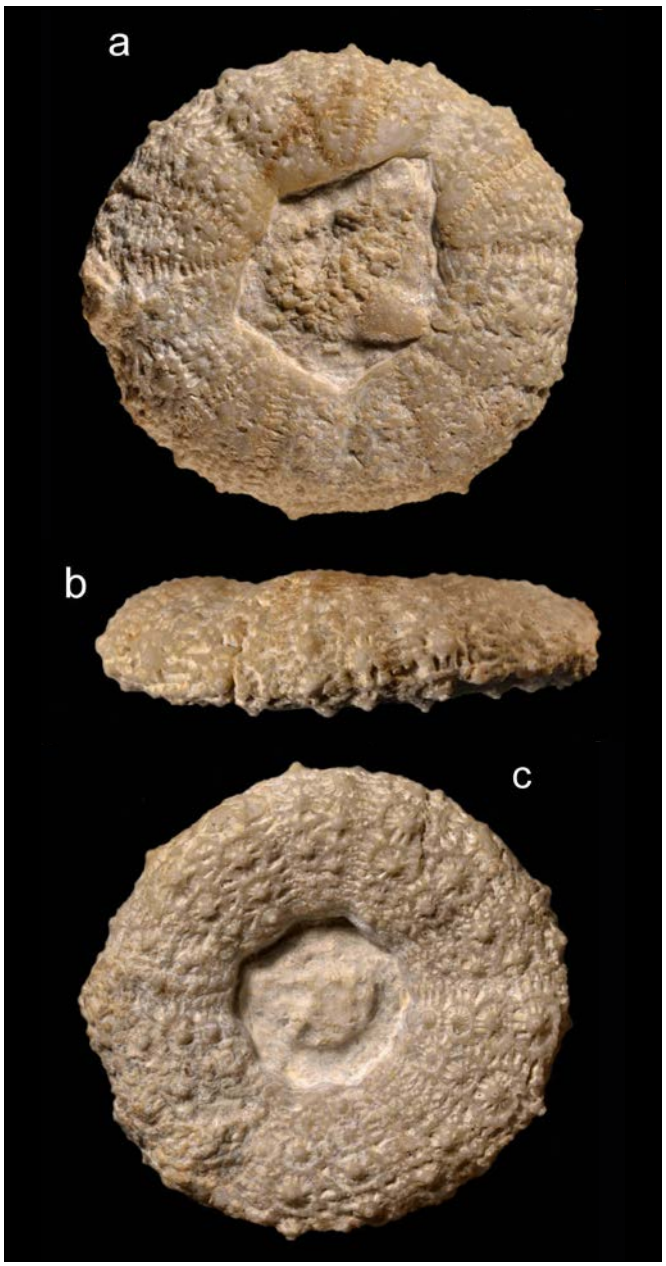

Fig. 2 - Arachniopleurus istrianus *Degli Innocenti, 1924, Priabonian of Sossano, D= 16 mm: a) aboral view, b) lateral view, c) oral view. /* Arachniopleurus istrianus *Degli Innocenti, 1924, Priaboniano di Sossano, D= 16 mm: a) vista aborale, b) vista laterale, c) lato orale.*

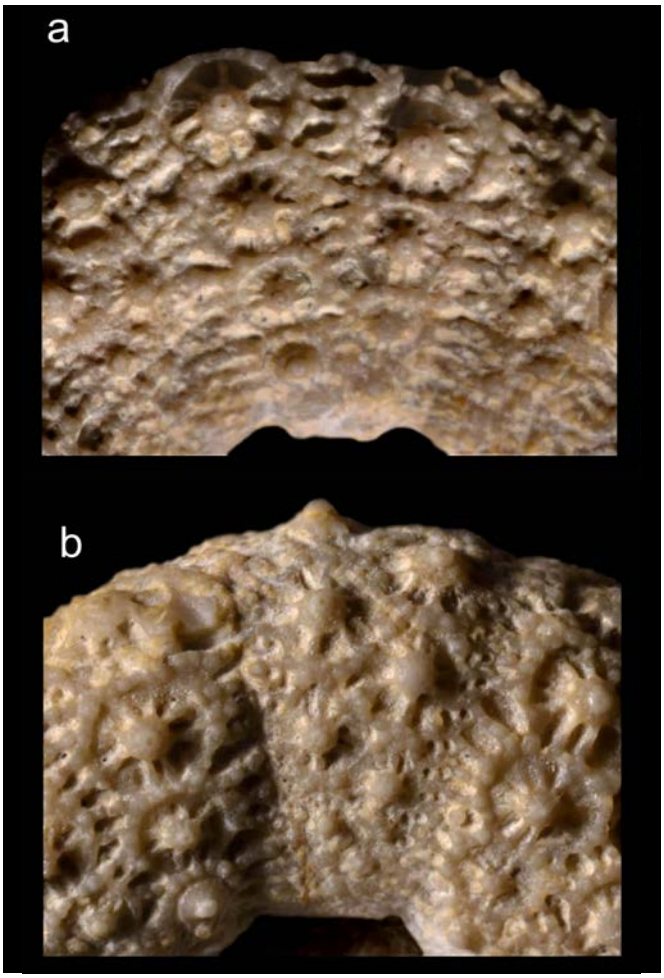

Fig. 3 - *Close up oral views of test sculpture in* Arachniopleurus istrianus *Degli Innocenti, 1924, Priabonian of Sossano: a) interambulacral area, b) ambulacral area. / Dettaglio dell'ornamentazione in* Arachniopleurus istrianus *Degli Innocenti, 1924, Priaboniano di Sossano: a) area interambulacrale, b) area ambulacrale.*

Differential diagnosis

The specimen under study shares the morphological features of the holotype of *A. istrianus* Degli Innocenti, 1924. In particular: the scrobicular rings increase quickly in size towards the ambitus (about Ds= 57% Wp in the holotype of *A. istrianus*). The space between the scrobicular ridges is narrow, above all at the ambitus, and the oblique ridges forming the reticulate ornamentation are short. The mean value of the ratio between the width of the ambulacral and the interambulacral areas at the ambitus is smaller in proportion (WA/WIA= 0.42 in the studied specimen and in the holotype of *A. istrianus*) than in the other species attributed to this genus. The buccal notches are rather wide but shallow.

A. arenatus (D'Archiac, 1847), from the Upper Eocene of France, has a finer ornamentation: in the median interambulacral areas the ridges connecting the primary tubercles are thinner, more numerous and almost parallel, leaving a narrow empty space between them (Cotteau, 1893, pl. 344, figs. 2, 5). The scrobicular rings are made of fine ridges; they are smaller than those in *A. istrianus* and increase more progressively in size towards the ambitus. The test is larger, with a more elevate and less depressed lateral profile.

A. reticulatus Duncan et Sladen, 1882, the type-species of the genus, has much smaller tubercles and scrobicular rings (mean Ds/Wp= 0.21), the ambulacra are larger in proportion, in the interambulacral columns the plates are more numerous and much wider than tall (mean Hp/Wp= 0.45, instead of 0.58). The ridges connecting the scrobicular circles form arches leaving relatively large empty spaces; in *A. istrianus* the ridges are almost straight.

In *A. vilanovae* (Cotteau, 1890) the test is higher, the apical disc is smaller (Da= 31% D) with almost the same size as the peristome. The ambulacra are larger in proportion (WA/WIA= 0.56), The ridges radiating from the primary tubercles are more numerous, almost twice the number of those present in the specimen from Sossano (Cotteau, 1890, pl. 15, fig. 17). The number of the interambulacral plates in each column is higher than in the other species of *Arachniopleurus*, consequently the plates are much wider than tall (Hp/Wp= 0.36). The buccal notches are deeper.

A. hungaricus (Thirring, 1936), from the Upper Eocene (Priabonian) of Sürü-Berger (Hungary), is represented by five specimens, with D ranging from 15.5 to 22 mm. The availability of a syntype enables to confirm that this species is different from the specimen from Sossano: in particular, the primary tubercles and the scrobicular rings surrounding them are much smaller (Ds/Wp is about 0.36 at the ambitus), the ambulacra are larger in proportion, the buccal notches are deeper (Fig. 4b). Since the original illustration of the type in Thirring (1936, pl. 2, fig. 15) shows only the oral face, the photography of a syntype is provided here (Figs. 4a-b).

On the basis of all these observations, the specimen from the Berici Hills is assigned to *Arachniopleurus istrianus* Degli Innocenti, 1924 and the validity of this species is confirmed.

Distribution: Middle Eocene (Lutezian) of Butoniga, Croatia (Degli Innocenti, 1924a-b, Mikuz, 2008), Upper Eocene (Priabonian) of Sossano, Italy (present paper).

Tab. 1 - Arachniopleurus istrianus *Degli Innocenti, 1924, main biometric values of the specimen under study. The data regarding the other species are taken from illustrations. Da and Dp are expressed as % of D. /* Arachniopleurus istrianus *Degli Innocenti, 1924: dati morfometrici principali dell'esemplare studiato. I dati relativi alle altre specie sono desunti da illustrazioni. Da e Dp sono espressi come % di D.*

	Da	Dp	Ds/Wp	Hp/Wp	WA/WIA	nA	nIA
A. istrianus *(MCV 21/037, from Sossano)*	38	33	0.58	0.58	0.42	11-12	10
A. istrianus *(holotype)*	-	-	0.57	0.57	0.42	-	11
A. arenatus *(Cotteau, 1893, pl. 342, figs. 3-6)*	35	35	0.43	0.44	0.58	11-12	10
A. reticulatus *(syntype, SGI)*	-	-	0.38	0.45	0.50	-	13
A. vilanovae *(MHNG.26032)*	30	31	0.34	0.33	0.56	18-19	17
A. hungaricus *(syntype, NHMD-89740)*	-	-	0.36	0.40	0.58	-	-

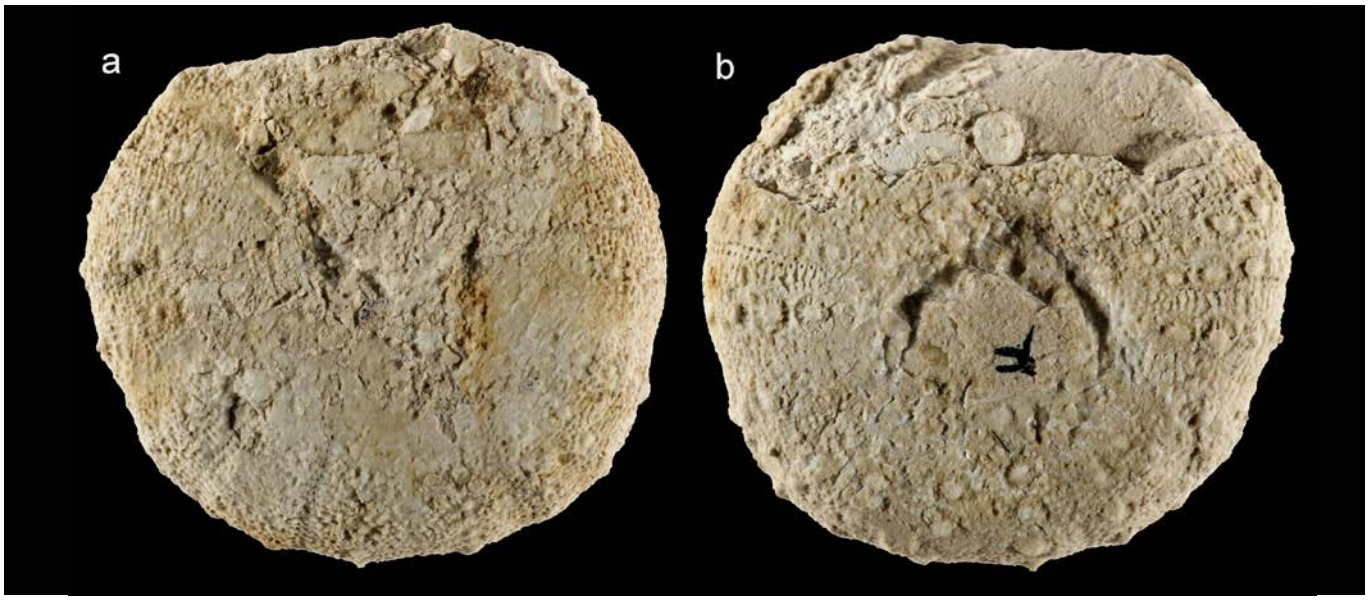

Fig. 4 - Arachniopleurus hungaricus *(Thirring, 1936), syntype (NHMD-89740), D= 26 mm, Eocene of Bakony (Hungary): a) aboral view, b) oral view; (copyright of the Natural History Museum of Denmark). /* Arachniopleurus hungaricus *(Thirring, 1936), sintipo (NHMD-89740), D= 26 mm, Eocene di Bakony (Ungheria): a) vista aborale, b) vista orale; (Copyright Museo di Storia Naturale della Danimarca).*

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