



THE GENUS *AGUAYOASTER* (ECHINOIDEA) IN THE EOCENE OF EUROPE WITH A NEW SPECIES FROM NORTH-EASTERN ITALY

Enrico Borghi¹, Albero Bottazzi², Fabio Caporiondo

¹ Società Reggiana di Scienze Naturali, Reggio Emilia, Italy.

² Museo Civico “Dal Lago”, Valdagno (Vicenza), Italy.

³ Museo Civico “G. Zannato”, Montecchio Maggiore (Vicenza), Italy.

Summary: *Aguayoaster* Sanchez Roig, 1952, a rare echinoid so far known only in the Middle and Upper Eocene of the Caribbean area, has been recognised in the Upper Eocene (Priabonian) of north-eastern Italy, on the basis of two specimens recently collected in a limestone quarry near Orgiano (Vicenza Province). One of them is attributed to *Aguayoaster schickleri* Donovan & Rowe, 2000, a species so far known only from the Middle and Upper Eocene of Jamaica. The other represents the holotype of *Aguayoaster bericus* n. sp. It is characterised by its large size: the test is 89 mm long, a measure more than twice the maximum size so far known for species of *Aguayoaster*. The new taxon is distinguished also by the test shape which is low and elongate in lateral profile, by the lack of a keel in the aboral interambulacrum 5 and the apical system, very close to the anterior test margin. This is the first record of *Aguayoaster* outside the Caribbean area.

Aguayoaster inhabited rather shallow waters (about 50-100 m depth, in the upper Circalittoral), associated with other echinoids such as *Cidaris itala*, *Gitolampas scutella*, *Echinolampas beaumonti* and *Trachypatagus* sp. Based on its morphology, it lived partially burrowed in soft sediments.

Key words: Schizasteridae, *Aguayoaster*, Priabonian, north-eastern Italy.

Riassunto: IL GENERE *AGUAYOASTER* (ECHINOIDEA) NELL’EOCENE EUROPEO, CON UNA NUOVA SPECIE DAL NORD-EST ITALIA (COLLI BERICI, VENETO).

Due esemplari raccolti recentemente nel Priaboniano di Orgiano, nei Colli Berici (Vicenza), vengono attribuiti al genere *Aguayoaster* Sanchez Roig, 1952, un raro echinoide appartenente alla famiglia Schizasteridae Lambert, 1905. *Aguayoaster* era noto sinora solo nell’Eocene medio-superiore dell’area caraibica. Appartiene ad un gruppo di schizasteridi che condividono un aspetto caratteristico: la teca è sub-cilindrica, troncata anteriormente e posteriormente da facce quasi verticali e i petali posteriori sono decisamente rivolti all’indietro. Inoltre, nessun altro schizasteride ha un apparato apicale così spostato in avanti. Questo gruppo informale comprende, oltre ad *Aguayoaster*, anche *Cestobrissus* Lambert, 1912, del Luteziano della Francia, e *Calzadaster* Carrasco, 2005, del Luteziano della Spagna. *Cestobrissus* si distingue dagli esemplari di Orgiano per il disco apicale meno eccentrico in avanti. *Calzadaster* differisce per il solco frontale quasi assente, la parte anteriore della teca più ristretta e i petali che si sviluppano entro solchi molto più stretti, con sezione a forma di “V”. Uno degli esemplari in esame (MCV 22/739) viene attribuito ad *Aguayoaster schickleri* Donovan & Rowe, 2000, una specie sinora nota solamente nell’Eocene medio-superiore della Giamaica. L’esemplare più grande (MCV 23/001) costituisce l’olotipo di *Aguayoaster bericus* n. sp: la lunghezza della teca è più che doppia rispetto alla misura massima degli esemplari noti attribuiti ad *Aguayoaster*. Altre caratteristiche peculiari sono: il profilo laterale basso e privo di carenatura nell’interambulacro 5 aborale, e il sistema apicale, che è molto vicino al margine anteriore della teca. Nel Priaboniano dei Colli Berici *Aguayoaster* viveva in un ambiente ben ossigenato e ricco di vita, nel Circalitorale superiore a circa 50-100 m di profondità, associato ad altri echinoidi come *Cidaris itala*, *Gitolampas scutella*, *Echinolampas beaumonti* e *Trachypatagus* sp.

In base alle caratteristiche morfologiche rilevate, come la presenza di fasciole aborali, la densa tuberculazione secondaria aborale e l’ambulacro frontale dotato solo di pori molto piccoli e non specializzati, *Aguayoaster* viveva parzialmente infossato in un sedimento a grana fine.

Parole chiave: Schizasteridae, *Aguayoaster*, Priaboniano, Veneto (Italia).



Introduction

A group of small-sized schizasterids with a characteristic shape, developed in the Caribbean area and in western Europe during the Eocene. They share a sub-cylindrical test, anteriorly and posteriorly truncated by almost vertical faces; in addition, no other schizasterid has such an anterior apical disc and backwardly directed posterior petals (Zitt, 1981). This informal group consists of three genera: *Cestobrissus* Lambert, 1912, from the Lutetian of Blaye (western France), *Aguayoaster* Sanchez Roig, 1952, from the Middle to Upper Eocene of the Caribbean area, and *Calzadaster* Carrasco, 2005, Upper Lutetian of Barcelona (Spain). The relationships among these schizasterids are still rather uncertain, due to the small number of well preserved specimens so far described.

Two specimens recently collected in the Priabonian of Orgiano, in the Berici Hills (north-eastern Italy), share the characteristic test shape with these taxa. The aim of this paper is to compare the new material available for study with the other schizasterids belonging to this group.

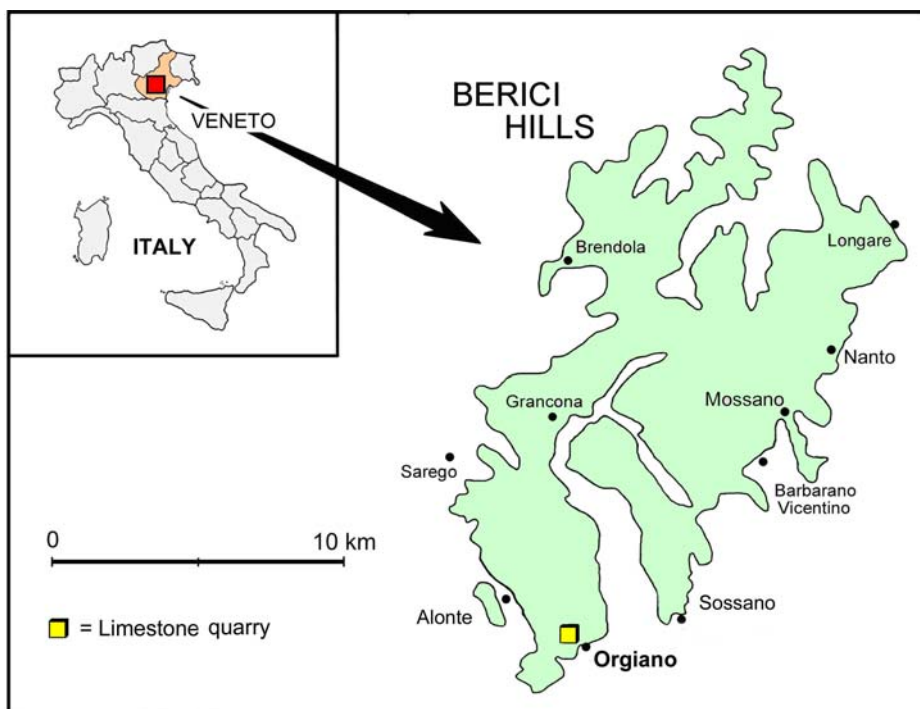


Figure 1 – Location map of the finding locality: the limestone quarry of Orgiano in the Berici Hills (Vicenza Province).

Figura 1 – Mappa con l'ubicazione della località di ritrovamento, la cava inattiva di calcare di Orgiano (Vicenza).

Material and methods

The two specimens under study were collected by one of the authors (F.C.) in the Upper Eocene marly limestones of the San Feliciano quarry of Orgiano, in the Berici Hills (Vicenza Province; Fig. 1). They are at the Museo Civico “Dal Lago” of Valdagno (abbreviation: MCV). The first specimen (MCV 22/739) consists of a middle-sized complete test, with the periproctal area partially deformed; also the point of the labrum is missing. The second (MCV 23/001) is represented by a large, complete test; with the periproct slightly crushed. The fossil material originally utilised by Sanchez Roig (1952) when instituting the genus *Aguayoaster* is housed at the Cuban Academy of Sciences, Havana (Cuba).

The holotype of *Aguayoaster schickleri* Donovan & Rowe, 2000, from the mid Middle to low Upper Eocene Swanswick Formation of Jamaica, is at the Natural History Museum of London (NHM EE6340).



The holotype of *Cestobrissus lorioli* Lambert, 1912, from the Lutetian of Blaye (western France), is stored at the Muséum d'Histoire Naturelle of Paris; illustration of that specimen is provided in Smith & Kroh (2011).

Holotype and paratype of *Calzadaster friasi* Carrasco, 2005, Upper Lutetian of Sant Julià de Vilatorrada (Spain), are hosted at the Museo Geológico del Seminario, Barcelona, Spain (MGSB 67754a, b).

Morphological abbreviations: TL, W, H= respectively length, width and height of the test. Da= distance of the anterior edge of the apical system from the anterior test margin. Dp= distance of the anterior edge of the peristome from the anterior test margin. Ep= episternal plate. La, Lp= length of anterior and posterior paired petals. Lb= labrum. Ps= width of the peristome. St= length of the sternal plates. Wa, Wp= width of anterior and posterior paired petals.

The measure of the angle between the ambulacra II-IV and I-V was taken in a plane projection of the aboral face of the test. Measures with \approx are approximate.

The systematic palaeontology follows Kroh & Mooi (2023).



Figure 2 – Panoramic view of the quarry of Orgiano. In the foreground, the grey marly limestones at the base of the section.

Figura 2 – Panoramica della cava aperta nella collina di San Feliciano, presso Orgiano. In primo piano i calcari marnosi grigi posti alla base della sezione.

Finding locality

The limestone quarry of San Feliciano is close to the village of Orgiano, in the south-western part of the Berici Hills (Fig. 1). Geostratigraphy and paleoenvironments of the Eocene deposits in this area have been studied by Fabiani (1908), Ungaro (1978) and Mietto (1988, 2003).

In the quarry, the limestone deposits belonging to the Upper Eocene marine transgression leading to the burial of the Bartonian volcanic ridge, are well exposed. The stratigraphic unit corresponding to this event is the Priabona Formation (Priabonian). The section, about 30 m thick, is well exposed in the north-western part of the quarry (Fig. 2). At the base there are greyish, well stratified, marly limestones yielding abundant calcareous algae, nummulites, bivalves, rare crustaceans and echinoids. They are overlaid by 6-7 m of yellowish calcarenites rich in calcareous algae, with rare molluscs and crustaceans. At the top of the section there are 7-8 m of marly limestones with nummulites, bryozoans, bivalve molluscs and echinoids (De Angeli, 2016). A study based on calcareous nannofossils (Beccaro, 2003) confirmed an Upper Eocene (Priabonian) age for the whole section exposed in the quarry. Several echinoids have been recognised in this quarry, among them: *Cidaritis itala* Laube, 1868, *Gitolampas scutella* (Lamarck, 1816), *Echinolampas beaumonti* Desor, 1857, and *Trachypatagus* sp.

The specimens of *Aguayoaster* have been collected in a small lens made of marly limestone within the calcarenites and in the marly limestones at the top of the section.



Previous work

Sanchez Roig (1952), when instituting *Aguayoaster*, attributed the new genus to the family Brissidae Gray, 1855. Three species have been assigned to *Aguayoaster*: two of them, *A. aguayoi* Sanchez Roig, 1952, the type species of the genus, and *A. nuevitasensis* (Sanchez Roig, 1952), have been described from the Middle Eocene of Cuba. Zitt (1981) re-examined the type species and transferred it to the family Schizasteridae Lambert, 1905, based on the presence of a latero-anal fasciole.

After Zitt (1981) and Smith & Kroh (2011), *A. nuevitasensis* is a junior synonym of *A. aguayoi*.

The third species is *A. schickleri* Donovan & Rowe, 2000, from the mid Middle to low Upper Eocene, White Limestone Group of the Swanswick Formation of Jamaica. This species was treated by Smith & Kroh (2011) as subjective junior synonym of *A. aguayoi*; however, this taxon is currently accepted in Kroh & Mooi (2023).

Cestobrius Lambert, 1912, Lutetian of Blaye (western France), is close to *Aguayoaster* and after Smith & Kroh (2011) it could represent a senior synonym. However, it is represented by a few poorly preserved specimens and it is not completely known in its morphology. In particular, the plate architecture and the fasciole pattern are unknown in *C. lorioli* Lambert, 1912, the type species of this genus. According to Lambert (1912), a single marginal fasciole is present passing beneath the ambitus around the anterior, a few plates below the ends of the paired anterior petals and then beneath the periproct. According to Smith & Kroh (2011), it is not even certain that this taxon belongs to the same family.

Calzadaster Carrasco, 2005, was instituted on the basis of two specimens attributed to *C. friasi* Carrasco, 2005, the type species, from the Upper Lutetian of Sant Julià de Vilatorrada, near Barcelona (Spain). It is currently considered as junior synonym of *Aguayoaster* (Smith & Kroh, 2011; Kroh & Mooi, 2023).

The relationships among these schizasterids are still partially uncertain due to the limited amount of well preserved material available to study.

Systematics

Order Spatangoida Claus, 1876
Suborder Paleopneustina Markov & Solovjev, 2001
Family Schizasteridae Lambert, 1905
Genus *Aguayoaster* Sanchez Roig, 1952

Type species: *Aguayoaster aguayoi*, Sanchez Roig, 1952, by original designation.

Description (partially emended from Smith & Kroh, 2011):

- Medium to large-sized test, sub-cylindrical with ovate outline and shallow anterior sulcus; oral face flattened with ambitus at about mid-height.
- Apical portion of test slightly extended.
- Apical disc ethmolytic with 4 gonopores; close to the anterior test margin.
- Anterior ambulacrum mostly vertical; weakly depressed from apex to peristome; pore-pairs small and uniserial.
- Petals sunken, parallel-sided and more or less straight. Anterior petals angled at slightly more than 180° and extending to the ambitus. Posterior petals less diverging, slightly longer and not reaching the ambitus.
- Peristome large and D-shaped; facing downward.
- Labral plate short and wide; sternal plates large and triangular; episternal plates biserially offset.
- Periproct large, towards top of steeply inclined posterior face.
- Peripetalous and latero-anal fascioles present; the combined fasciole passing inframarginally around the anterior face.

Species included:

- *Aguayoaster aguayoi* Sánchez Roig, 1952, Middle to Upper Eocene, Cuba.
- *Aguayoaster schickleri* Donovan & Rowe, 2000, Middle to Upper Eocene, Jamaica; Upper Eocene, north-eastern Italy (this paper).



- *Aguayoaster bericus* n. sp., Upper Eocene, north-eastern Italy (this paper).

Remarks: The specimens from Orgiano share the characteristic shape with *Aguayoaster* Sanchez Roig, 1952, *Cestobrissus* Lambert, 1912, and *Calzadaster* Carrasco, 2005: the test is sub-cylindrical, truncated anteriorly and posteriorly by almost vertical faces, the apical disc is very eccentric anteriorly, the posterior aboral ambulacra strongly face backwards. Also the other morphological features observed in the specimens from the Berici Hills correspond to those in *Aguayoaster*.

Calzadaster differs by its almost flush frontal ambulacrum, the more restricted anterior part of the test and narrower petals. Additionally, the angle between petals II-IV is 230° (180-200° in *Aguayoaster*).

Cestobrissus has almost flush frontal ambulacrum, shorter petals (Table 1) and the peripetalous fasciole passes rather far from the tips of the petals II and IV.

Aguayoaster, *Cestobrissus* and *Calzadaster* are closely related genera. After Smith & Kroh (2011), *Cestobrissus* could represent a senior synonym of *Aguayoaster*. However, this taxon is poorly known: the plate architecture and the fasciole pattern in *C. lorioli* Lambert, 1912, the type species, are unknown and only a marginal fasciole was described by Lambert (1912). A modern description of *Cestobrissus* is needed to clear its relationships with similar genera. *Calzadaster* is considered by Smith & Kroh (2011) a subjective junior synonym of *Aguayoaster*; however, the two look like well differentiated on the basis of the distinctive characters described by Carrasco (2005), in particular the more restricted anterior outline and the narrower paired petals in *C. friasi*.

Among the schizasterids recorded from the Eocene of north-eastern Italy, *Prenaster* Desor, 1853 is the most similar to the specimens under study. However, *Prenaster* differs by its rounded anterior face, flush ambulacrum III, shorter paired petals and the peripetalous fasciole passes farther from the tips of the anterior paired petals.

***Aguayoaster schickleri* Donovan & Rowe, 2000**

(Fig. 3A-G; Fig. 4A, D-F; Tab. 1)

Type material: holotype (NHM EE6340), TL= 26 mm,

Type locality: Pimento Hill, Jamaica; Middle-Upper Eocene, White Limestone Group, Swanswick Formation, Pimento Hill, Beecher Town, Jamaica,

Material examined: an almost complete specimen (MCV 22/739), Priabonian. Orgiano.

Description: The specimen under study is middle-sized. The maximum test height is located behind the apical system. In the aboral interambulacrum 5 there is a pronounced keel (Fig. 3C-D, 3G). The frontal ambulacrum is almost flush adapically and slightly sunken at the ambitus (Fig. 3A-C); it has oblique pairs of small pores disposed in simple series. Aborally, the paired petals are deeply sunken (Fig. 3A, 3G). The anteriors form an angle of about 200°. The posteriors are much less diverging and face backwards; they are slightly longer than the anteriors but do not reach the margin. In the petals, the pores are roundish in the inner series, oval in the outer series. The interporiferous zone is narrow: it is almost half as wide as the corresponding poriferous one (Fig. 3E). The sternal plates are very long (St \approx 51% TL), sub-triangular and bordered by narrow and elongate ambulacral plates. The oral ambulacrum III is slightly sunken on the oral face, from the margin to the peristome (Fig. 3B). The peristome is rather close to the anterior test margin (Dp \approx 17% TL). Poriferous widened areas (phyllodes) are well developed near the peristome in the oral ambulacra I-II-III. The periproct is supramarginal, located high in the almost vertical posterior face. The tubercles are perforated and crenulate; the largest ones are located in the aboral interambulacra 2 and 3, flanking the frontal ambulacrum (Fig. 3F). In the oral face there are well developed tubercles in the peri-peristomial zone. The remaining part of the test surface is covered by a dense and homogeneous secondary tuberculation that is present also in the labral plate and the plastron, leaving only the ambulacral areas almost naked. The peripetalous fasciole develops inframarginally in the anterior part of the test, passes close to the tip of the anterior petals, forms a sharp indentation just behind these petals, then passes close to the tips of the posterior petals (Fig. 4A-E). The latero-anal fasciole separates from the peripetalous behind the ambulacra II and IV developing inframarginally, then it descends below the periproct (Fig. 4D, 4F).



Remarks: Smith & Kroh (2011) considered *A. schickleri* as subjective junior synonym of the type species, although Donovan & Rowe (2000) underlined that *A. schickleri*, “has a more elongate test” than *A. aguayoi*. Here we follow Kroh & Mooi (2023), who accept *A. schickleri* as valid species.

On the whole, the morphological features in the specimen from Orgiano correspond to those in *A. schickleri*, with the only exception of the larger test size (TL= 57 mm).

Aguayoaster aguayoi differs by the position of the maximum test height, which corresponds to the apex, not behind it, by the lack of a keel in the aboral interambulacrum 5, and the tuberculation, which is homogeneous on both faces, whereas larger tubercles flank the frontal ambulacrum in the specimen under study. Additionally, in the type species of *Aguayoaster* the posterior petals are narrower and almost superficial and the anterior petals are longer than the posteriors.

Distribution: Middle to Upper Eocene of Jamaica (Donovan & Rowe, 2000); Upper Eocene of north-eastern Italy (this paper).

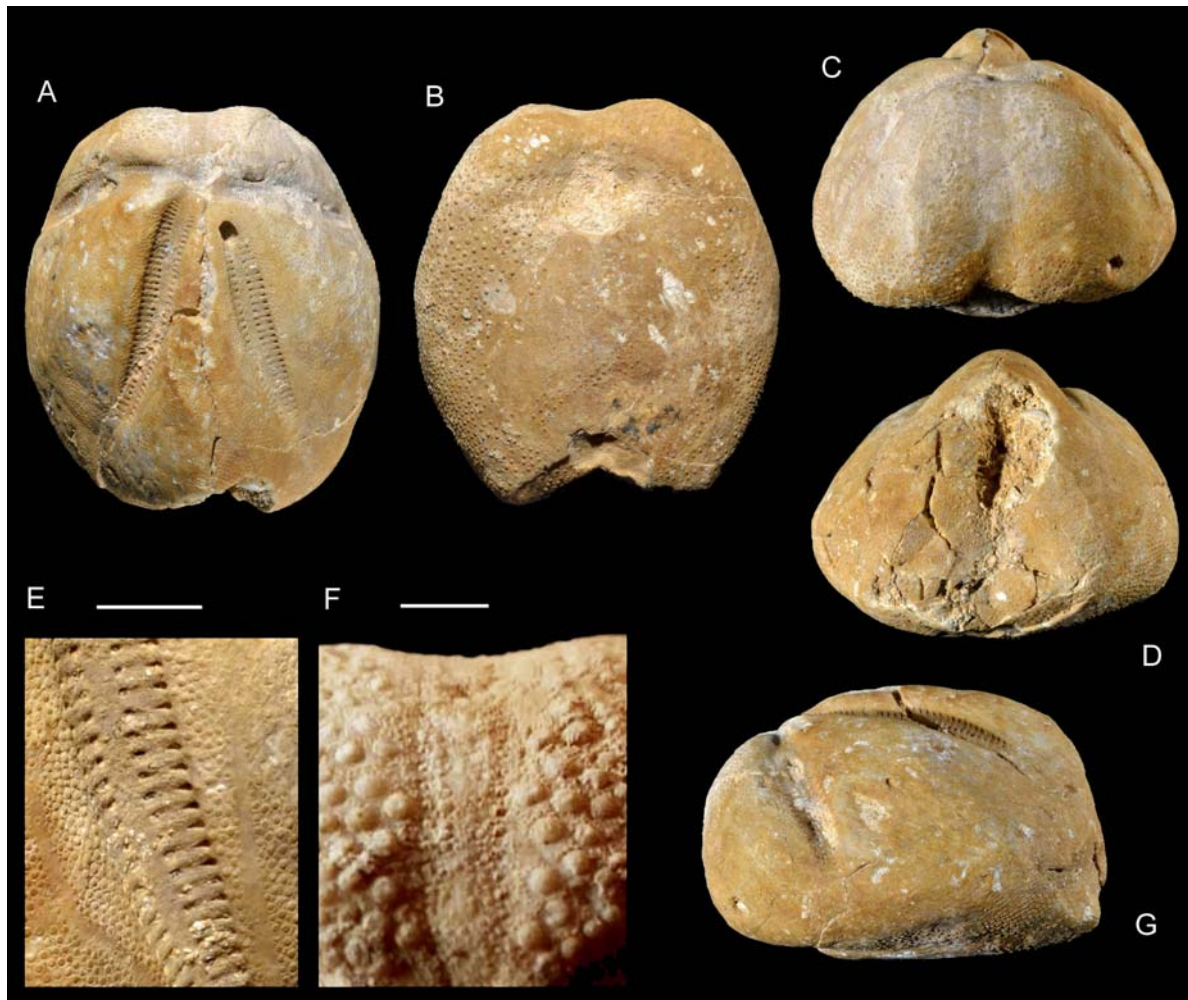


Figure 3 – *Aguayoaster schickleri* Donovan & Rowe, 2000, Priabonian of Orgiano (MCV 22/739), TL= 57 mm: aboral (A), oral (B), frontal (C) and rear (D) views, detail of the ambulacrum I (E), close up of the adapical frontal ambulacrum (F), lateral view (G). The scale bars equal 5 mm in figures E-F.

Figura 3 – *Aguayoaster schickleri* Donovan & Rowe, 2000, Priaboniano di Orgiano (MCV 22/739), TL= 57 mm: vista aborale (A), orale (B), frontale (C) e posteriore (D), dettaglio dell'ambulacro I (E), dettaglio della parte adapicale dell'ambulacro frontale (F), vista laterale (G). La barretta indica 5 mm nelle figure E-F.

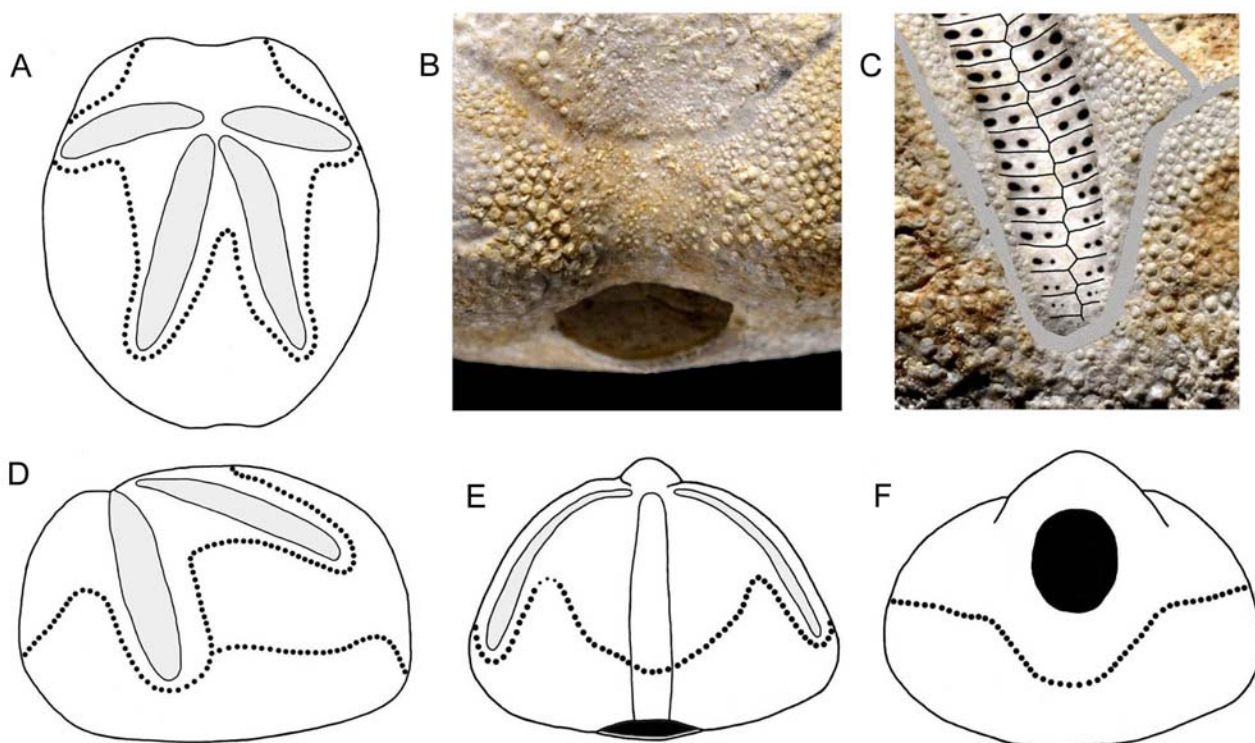


Figure 4 – Fascioles pathways in *Aguayoaster* Sanchez Roig (1952), Priabonian of Orgiano. *Aguayoaster schickleri* Donovan & Rowe, 2000, (MCV 22/739: A, D, E) peripetalous fasciole, D, F) latero-anal. *Aguayoaster bericus* n. sp. holotype: B) detail of the peripetalous in the anterior face, C) peripetalous passing close to the tips of petal IV.

Figura 4 – Percorso delle fasciole in *Aguayoaster* Sanchez Roig (1952), Priaboniano di Orgiano. *Aguayoaster schickleri* Donovan & Rowe, 2000, (MCV 22/739): A, D, E) fasciola peripetalica, D, F) latero-anale. *Aguayoaster bericus* n. sp. olotipo: B) dettaglio della peripetalica sulla faccia anteriore, C) peripetalica passante molto vicina all'estremità del petalo IV.

***Aguayoaster bericus* n. sp.**

(Fig. 4B-C, Fig. 5A-E, Fig. 6; Tab. 1)

Type material: the holotype, a complete specimen (MCV 23/001), TL= 89 mm.

Type locality: San Feliciano quarry, near Orgiano (Vicenza Province).

Type stratum: Priabona Formation, Upper Eocene (Priabonian).

Origin of name: from the Colli Berici, the hills near Orgiano.

Diagnosis: a large-sized species of *Aguayoaster* with low lateral profile and missing the keel in the aboral posterior interambulacrum 5; the apical system is very close to the anterior test margin.

Description: test large-sized (Tab. 1), elongate and relatively low in lateral view (Fig. 5E); the aboral interambulacrum 5 is not keeled (Fig. 5C-E). The apical system is ethmolytic, very eccentric anteriorly (Da = 14% TL); it has four gonopores, the anteriors are smaller and closer than the posterior ones. The frontal ambulacrum is slightly sunken adapically and deepens towards the test margin, with a maximum depth of 6 mm (Fig. 5A-C). The paired petals are almost straight, slightly flexed distally (Fig. 5A). The anterior petals are angled at about 200° and extend to the ambitus; posterior petals less diverging, slightly longer than the anteriors and not reaching the ambitus (Fig. 5A). The maximum petal width is 8 mm (9% TL), the interporiferous zone is

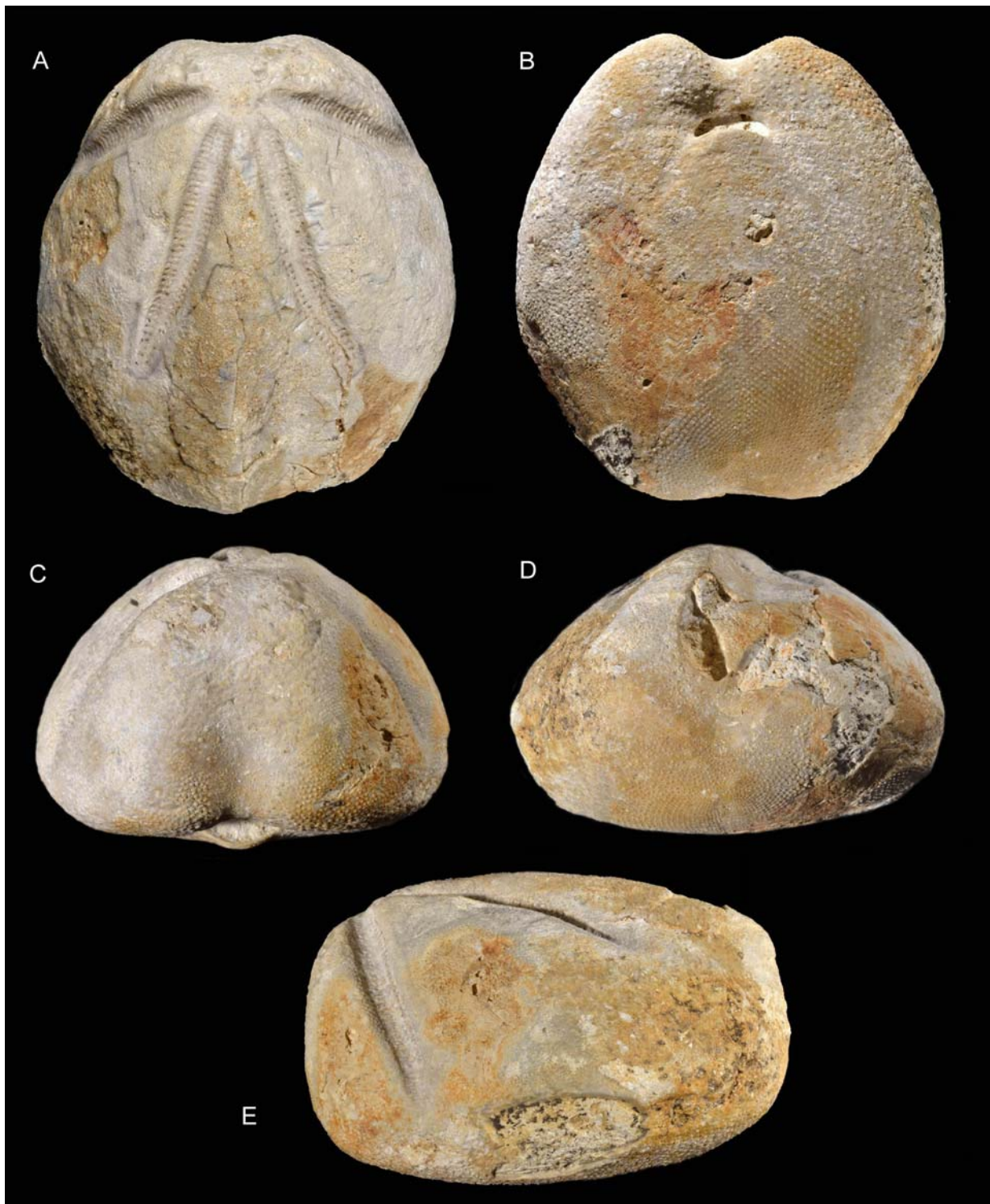


Figure 5 – *Aguayoaster bericus* n. sp., Priabonian of Orgiano, holotype (MCV 23/001), TL= 89 mm: aboral (A), oral (B), frontal (C), rear (D) and lateral (E) views.

Figure 5 – *Aguayoaster bericus* n. sp., Priaboniano di Orgiano, olotipo (MCV 23/001), TL= 89 mm: vista aborale (A), orale (B), frontale (C), posteriore (D) e laterale (E).



almost as wide as a poriferous one (Fig. 4C). There are 44-45 couples of pores in the anterior petals, 47-48 in the posteriors.

The structure of the plastron is of the schizasterid type (Fig. 6). The labral plate is short and wide. The sternals are large (St= 63% TL) and triangular, flanked by narrow and elongate ambulacral plates; the episternals are biserially offset. The peristome measures 11.5 x 5 mm (Ps= 14 % TL) and it is rather close to the anterior test margin (Dp= 18% TL). There are well developed phyllodes in the oral ambulacra II-IV close to the peristome. The periproct is located towards the top of the almost vertical posterior face; it is oval, longitudinally elongate and large: its height is about 20% TL. The tubercles are perforated and crenulate; the largest ones are located in the aboral interambulacra 2 and 3, flanking the frontal ambulacrum. The remaining part of the test surface has a dense secondary tuberculation covering also the labrum and the plastron. Only the oral ambulacral areas are almost naked towards the peristome. The pathway of the fascioles corresponds to that in *A. schickleri* (Fig. 4A, D-F): the peripetalous fasciole develops inframarginally in the anterior part of the test (Fig. 4B), passes very close to the tip of the anterior petals (Fig. 4C), forms a sharp indentation behind these petals, then passes close to the tips of the posterior petals. The latero-anal fasciole separates from the peripetalous just behind the anterior paired ambulacra (Fig. 4C-D), develops inframarginally and then descends below the periproct (Fig. 4F). All the fascioles are rather thin (1-1.5 mm) but well marked.

Remarks: The specimen under study shows the diagnostic characters of the genus *Aguayoaster*, but its size is almost twice the maximum so far known for this genus: TL is 44 and 34 mm in the two type-specimens of *A. aguayoi*, TL= 26 mm in *A. schickleri*. Also in the holotype of *Cestobrissus* and the two type-specimens of *Calzadaster* the test is much smaller: TL= 37, 39 and 33 mm, respectively.

The new species differs from *A. aguayoi* and *A. schickleri* also because the test is lower and the keel in the aboral interambulacrum 5 is missing. Additionally, the interporiferous zones in the petals are almost as wide as the poriferous ones, not half as in *A. schickleri*, and the posterior petals are longer than the anteriors, not shorter or subequal as in *A. aguayoi*.

A. bericus n. sp. shares the low and elongate test profile with *Calzadaster*. However, in *C. friasi* the frontal ambulacrum is almost flush above the ambitus, the test outline is more restricted anteriorly and the petals are narrower. Additionally, in the original illustration of *Calzadaster* the distance from the labrum to the anterior margin is about 28-30% TL (Carrasco, 2005), whereas it is only 21% TL in the specimen from Orgiano.

The occurrence at Orgiano of two specimens of *Aguayoaster* may rise doubts about the possibility that the type of the new species could represent a larger specimen of the same species. However, aside the morphological differences described above, three additional specimens of *Aguayoaster* from the same locality have been examined in private collections: a small specimen (TL= 43 mm), almost identical to MCV 22/739, is attributed to *A. schickleri*, whereas two large incomplete specimens (TL \approx 80-85 mm) share all the distinctive characters with *Aguayoaster bericus* n. sp. This additional fossil material confirms that two distinct species of *Aguayoaster* were present at Orgiano.

Palaeoecology

Some morphological features are useful guides when trying to decide whether or not a fossil spatangoid burrowed (Smith, 1984):

- There is a correlation between aboral tubercles density and the grade of sediment inhabited: a dense and uniform development of aboral tubercles, as in the studied specimens from Orgiano, is indicative of an infaunal mode of life in fine-grained sediment.
- The anterior ambulacrum flanked by enlarged interambulacral tubercles (Fig. 3F) is characteristic of echinoids that burrow and construct shafts to the surface.
- Aboral fascioles (peripetalous and lateral fascioles in the case of *Aguayoaster*) are always present in spatangoids that burrow in fine sands and mud.

On the other hand, in *Aguayoaster*.



- There pores in the adapical region of the ambulacrum III are very small; consequently, there were no tube feet specialized in the construction of a shaft up to the surface.
- The ambulacrum III is shallow, it lies almost flush with the rest of the test and has not larger adapical pores; after Smith (1984) in this case the hearth-urchin lived either epifaunally or within coarse grained sediments without constructing a vertical shaft.

On the whole, the morphology of *Aguayoaster* indicates that the excavation activity was limited in this echinoid and that it likely lived only partially burrowing within soft sediments.

The Priabonian deposits in the Berici Hills were characterized by well-oxygenated and rich in life environments located in the upper Circalittoral, at about 50-100 m depth (Bassi, 1995). This is corroborated by the frequent occurrence of other echinoids which are commonly found in rather shallow water environments, such as *Gitolampas*, *Echinolampas* and *Trachypatagus*.

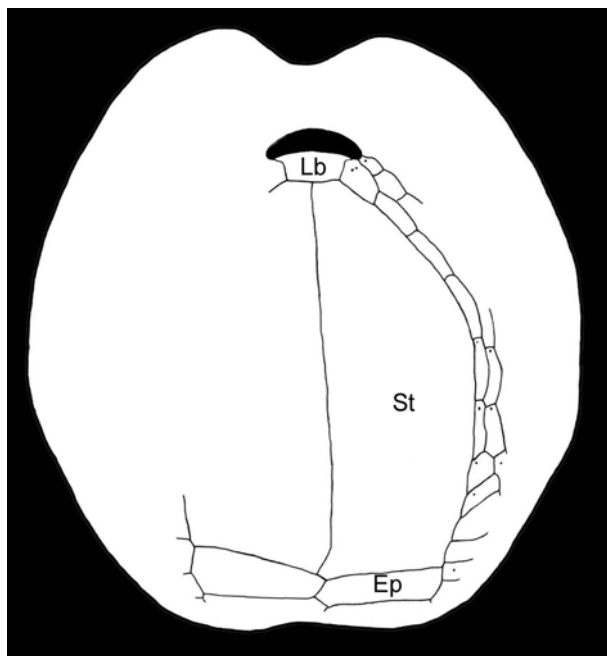


Figure 6 – *Aguayoaster bericus* n. sp., Priabonian of Orgiano, holotype (MCV 23/001), TL= 89 mm: oral plating scheme.

Figura 6 – *Aguayoaster bericus* n. sp., Priaboniano di Orgiano, olotipo (MCV 23/001), TL= 89 mm: schema della struttura del plastron.

Acknowledgements

The authors are grateful to Francisco Carrasco (Museo Geológico del Seminario, Barcelona, Spain), for providing bibliography and improving comments to the first manuscript, and to Bernardetta Pallozzi (Museo Civico “Dal Lago”, Valdagno), for taking charge and providing inventory codes to the studied specimens.

Bibliography

- Bassi D. (1995). Crustose coralline algal pavements from late Eocene Colli Berici of Northern Italy. *Rivista Italiana di Paleontologia e Stratigrafia*, 101(1): 81-92.
- Beccaro L. (2003). Revisioni stratigrafiche nel Paleogene del Veneto occidentale. Dottorato di Ricerca in Scienza della Terra, ciclo XVI°, Università degli Studi di Padova (tesi inedita).



- Carrasco J.F. (2005). *Calzadaster friasi*. Un nuevo género y una nueva especie de Spatangoida (Echinoidea) del Eoceno de Cataluña. *Batalleria*, 12: 1-9.
- De Angeli A. (2016). Nuovi crostacei Cymonomidae (Decapoda: Brachyura) dell'Eocene dei Monti Berici (Vicenza, Italia settentrionale). *Studi Trentini di Scienze Naturali*, 95: 25-32.
- Donovan S.K. & Rowe D.A (2000). Spatangoid echinoids from the Eocene of Jamaica. *Journal of Paleontology* 74(4): 654-661.
- Fabiani R. (1908). Paleontologia dei Colli Berici. *Società Italiana di Scienze Naturali, Memorie*, serie 3, 15: 45-248.
- Kroh A. & Mooi R. (2023). World Echinoidea Database. *Aguayoaster* Sanchez Roig, 1952. World Register of Marine Species: <http://marinespecies.org/aphia.php?p=taxdetails&id=512836> [accessed January 2023].
- Lambert J. (1912). Révision des échinides fossiles du Bordelais. *Actes de la Société Linnéenne de Bordeaux*, 66: 45-120.
- Mietto P. (1988). Aspetti geologici dei Monti Berici. In: *I Colli Berici - Natura e civiltà*. Pubblicazione speciale a cura della Banca Popolare Vicentina, Signum Edizioni, Vicenza: 13-23.
- Mietto P. (2003). Appunti di Geologia in Grotte dei Berici, Aspetti fisici e naturalistici. Club Speleologico Proteo, Vicenza - Museo Naturalistico Archeologico di Vicenza. I: 11-23.
- Sánchez Roig M. (1952). Nuevos generos y especies de equinoideos fosiles cubanos. *Torreia*, 17: 1-18.
- Smith A.B. (1984). Echinoid Palaeobiology. George Allen & Unwin Ltd., London. 190 pp.
- Smith A.B. & Kroh A. (Eds.) (2011). The Echinoid Directory. World Wide Web electronic publication. <http://www.nhm.ac.uk/research-curation/projects/echinoid-directory> [accessed January 2023].
- Ungaro S. (1978). L'Oligocene dei Colli Berici. *Rivista Italiana di Paleontologia*, 84(1): 199-278.
- Zitt J. (1981). *Aguayoaster* Sanchez Roig (Echinoidea) from Cuba. *Casopis pro mineralogii a geologii*, 30: 265-284.

	TL	W (%TL)	H (%TL)	Da (%TL)	La II-III	Lp IV-V	Dp (%TL)	Ps
<i>Aguayoaster schickleri</i> MCV 22/739	57	91	72	19	51	59	17	18
<i>Aguayoaster bericus</i> n. sp. MCV 23/001 holotype	89	91	63	14	52	55.5	18	14
<i>Aguayoaster aguayoi</i> Sanchez Roig, 1952 holotype	44	86	68	25	45.5	38.5	-	-
<i>Aguayoaster schickleri</i> Donovan & Rowe, 2000 (NHM EE6340)	26	82.5	71	19	-	50	17	19
<i>Cestobrissus lorioli</i> Lambert, 1912	37	90	68	25	-	43	-	-
<i>Calzadaster friasi</i> Carrasco, 2005 (MGSB 67754a)	39	82	59	10	51.5	54	-	15.5

Table 1 – Main biometric data of the studied specimens; measures expressed in mm, shape ratios as % of TL. Data regarding *Calzadaster* and *Cestobrissus* were taken from Carrasco (2005), those about *Aguayoaster aguayoi*, from Sanchez Roig (1952).

Tabella 1 – Dati biometrici principali degli esemplari studiati; misure in mm, rapporti di forma espressi come % di TL. I dati relativi a *Calzadaster* e *Cestobrissus* sono stati tratti da Carrasco (2005), quelli di *Aguayoaster aguayoi*, da Sanchez Roig (1952).