S. subcarinata (Goldfuss, 1826) from the Late Oligocene of Doberg, Germany, differs from this species by its less elongated outline (width is about 88 to 90 % TL), conical profile, its less anterior positioned apical system (about 44 to 50 % TL from the anterior margin), its well developed bourrelets and its more anteriorly positioned peristome (based on the description and figures in Kier, 1962: 218; pl. 41, figs. 6-9 and conspecific material at the NHMW).

Szörényi (1953) described seven species of *Studeria* (under the name *Tristomanthus*, a synonym of *Studeria* according to Kier, 1962) from the Miocene of Pod'yarkov (= Podjarków) in the Ukraine, two of them new. Philippe (1998: 104) suggested, that most of her specimens might belong to *S. meslei*, the descriptions and figures, however, are insufficient and it is necessary to examine the material to judge this. Her two new species "*T.*" *podjarkovi* and "*T.*" *podolicus* are clearly different from the material discussed here, the former differs by its narrower petals, its inframarginal periproct and its different profile with its bluntly pointed posterior end; the latter differs by its less elongated outline, inframarginal periproct and its longer petals, which nearly reach the ambitus. Some of her specimens might belong to *P. vassalli*, the occurrence at Pod'yarkov of which is documented by a specimen in the collection of the NHMW (see above under that species).

The *Pliolampas* species *P. elongatula* (Millet, 1865), *P. gauthieri* (Cotteau, 1880), *P. pioti* Gauthier in Fourtau, 1900, *P. subcarinata* Cotteau, 1895, *P. titanensis* Nelli, 1907 and *P. vassalli* (Wright, 1855) can easily be distinguished from the present species by their pointed posterior end and inframarginal periproct, which is well visible in oral view.

"*Echinanthus*" *marginatus* Mazzetti, 1882a and "*E.*" *angulosus* Mazzetti in Mazzetti & Pantanelli, 1883, as stated above, are based on very poor material hampering comparison, even if the material described and illustrated by Stefanini [1908b: 78-79, pl. 13 (1), figs. 7-9] is taken into account. Stefanini (1908b) referred the two species to *Milletia*, a junior synonym of *Pliolampas* according to Kier (1962).

"*Echinanthus*" *camerinensis* de Loriol, 1882 from Camerino, Italy is a very small sub-globular, slightly elongated form with narrow, open petals and a slightly overhung, marginal periproct. Probable the specimen illustrated by de Loriol is a juvenile. The present species differs by its more elongate test, lower test height and broader petals.

Discussion:
From the known previously described species the Austrian material is most similar to *S. corsica* (Cotteau, 1877) and the extant *S. recens* (Agassiz, 1879). *S. corsica* differs by its slightly narrower posterior end wider anterior end, its wider angle between the posterior paired petals (about 75°; according to the figure in Cotteau, but see below) and its more anterior position of the peristome (about 43 % TL from anterior margin) (compare Cotteau, 1877: 282-284, pl. 11, figs. 1-5). Yet if compared to a specimen from a locality next to or identical with the type locality (NHMW 1857.XV.124, from Monte Balistro, near Bonifacio, Corsica; Pl. 62, Fig. 4a-d), most of these differences (except the more anterior position of the peristome) are not present. It is well known that Cotteau's artist made figures which are nice but often not very accurate [e.g. he almost invariably figured double pores in the phyllodes or the ambulacral plates beyond the petals, regardless of the actual situation in the figured material (Kier, 1962: 197, 1966: U492); likewise the plating patterns of fossil spatangoids and clypeasteroids are often wrongly depicted]. Based on the comparison with the mentioned specimen and the description of Cotteau (1877), the present specimen is tentatively attributed to *S. corsica*. There is also a distinct similarity to *S. ficheuri* (Pomel, 1887) from the Burdigalian of Algeria and Spain [providing the illustration and description in Lambert (1906a: 95-100, pl. 5, fig. 11) corresponds to the type-material].

Studeria subcylindrica (Agassiz in Agassiz & Desor, 1847), likewise, is very similar to the present specimens, judging by the plaster cast figured by Lambert & Jeannet (1928: pl. 1, figs. 1-4). The whereabouts of the holotype of this species is, however, unknown and neither type locality nor type stratum are known. A plaster cast of the holotype with the number P31 is housed at the Musée d'Histoire Naturelle de Neuchâtel. Desor (1858: 298) expressed his doubts about the specimen's provenance and according to Lambert & Jeannet (1928: 154) the specimen is not from the "Calcaire grossier, des environs de Paris" as stated by Agassiz & Desor (1847a: 161), but from an unknown Miocene locality. The original diagnosis of Agassiz (in Agassiz & Desor, 1847a, p. 161: "Espèce renflée, subcylindrique, à ambulacres étroits, à anus proéminent, subrostré [Species reinflated, subcylindric, with narrow ambulacra, prominent anus, subrostrate]" indicates the presence of a rostrum in *S. subcylindrica*, a feature not present in the Austrian specimens. Since its holotype is lost *S. subcylindrica* and the information on the characters of this species in the literature are insufficient, it would be necessary to select a neotype (ICZN 4th ed., 2000, Article 75.1.). Unfortunately that is not possible as the type locality and area is unknown. Thus *S. subcylindrica* is considered as *nomen dubium*.

Gregory (1891: 602) placed *Echinanthus corsicus* Cotteau, 1877 in the synonymy of *Breynella vassalli* (Wright, 1855) [*Breynella* is a junior synonym of *Pliolampas* according to Kier (1962: 195)], an opinion which was subsequently accepted by Cotteau (1895: 38). Yet, as Lambert (1907a: 58) pointed out, the two are clearly different species and can be separated by their different outline (oval to egg-shaped with rounded anterior and posterior ends in *S. corsica* – outline with distinct kinks, distinctly pointed, rostrate posterior end in *P. vassalli*), different posterior paired petals (increasingly widely spaced pores in *S. corsica* – regularly spaced pores in *P. vassalli*), and position of the periproct (marginal, vertical, halfway up the ambitus, not visible in oral view in *S. corsica* – inframarginal, overhanging, well visible in oral view in *P. vassalli*).

Occurrence:

Austria: Early Badenian (Langhian)
Vienna Basin: Stotzing (sandpit Mayer), Bgld ([coll. Wanzenböck])
Styrian Basin: Retznei (Weissenegg Fm., Lafarge quarry), Styria ([NHMW])

Mediterranean: Late Burdigalian to Early Serravallian
Western Mediterranean: Bonifacio, Corsica, France (Cotteau, 1877); Capo Sant'Elia, Sardinia, Italy (Cotteau, 1895; Lambert, 1907a); Monte Balistro, near Bonifacio, Corsica, France ([NHMW])

Series Atelostomata Zittel, 1879
Order Spatangoida Claus, 1876
Suborder Hemiasterina Fischer, 1966
Family Hemiasteridae Clark, 1917
Genus *Hemiaster* Agassiz in Agassiz & Desor, 1847

Type-species: *Spatangus bufo* Brongniart, 1822; by subsequent designation (Savin, 1903).
Diagnosis: see Fischer (1966)
Distribution: Aptian to Recent – cosmopolitan (Fischer, 1966)

"*Hemiaster*" *kalksburgensis* Laube, 1869

(Fig. 60)

1869a *Hemiaster Kalkburgensis* Laube sp. ined. – Fuchs: 194
* 1869a *Hemiaster Kalksburgensis* Laube. – Laube: 183
1870 *Hemiaster Kalksburgensis* Lbe. – Laube: 314
1871 *Hemiaster Kalksburgensis* Laube. – Laube: 69; pl. 18, fig. 5

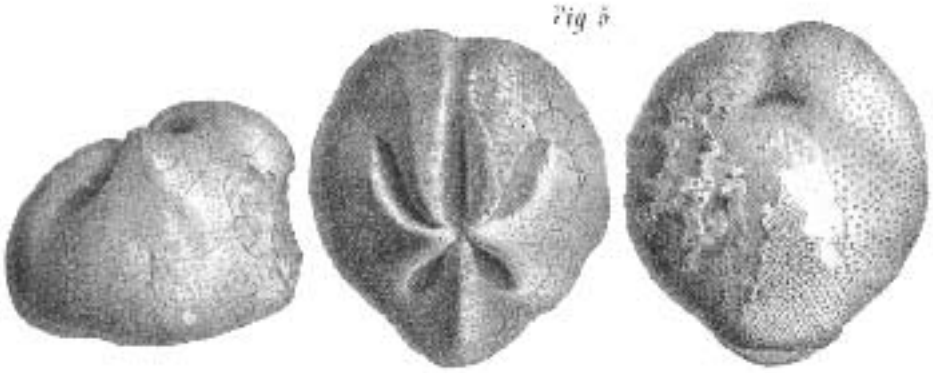

Figure 60: *Hemiaster kalksburgensis* Laube, 1969: reproduction from Laube (1871: pl. 18, fig. 5, specimen from Kalksburg, Vienna); current whereabouts of the specimen unknown; state unclear, probably a misidentified schizasterid (see text).

1877 *Hemiaster Kalksburgensis* Laube – Karrer: 312
1883 [*Opissaster*] *Kalksburgensis* – Pomel: 38
? 1906 *Hemiaster kalksburgensis* Lbe. – Vadász: 333
1913a *S.*[*chizaster*] k*alksburgensis* Laube (*Hemiaster*). – Cottreau: 68
1925 *S.*[*chizaster*] *Kalksburgensis* Laube (*Hemiaster*) – Lambert & Thiéry: 526

Type-material:
Holotype: a single specimen originally housed in the collection of Felix Karrer (Laube, 1871)
Locus-typicus: Kalksburg, Vienna, Austria
Age: Badenian (Langhian-Early Serravallian), Middle Miocene
Remarks: The collection of Felix Karrer was inherited by the Naturhistorisches Museum Wien (Geologische Abteilung) in 1903. Although, the type of *H. kalksburgensis* was registered under the inventory number 1904.VIII.45, the specimen could not be located in the collection.

Discussion:
Based on Laube's (1871) description and illustrations it is difficult to understand why he considered the specimen he had at hand different from his *Schizaster karreri* (he did not compare the two species). In the absence of the type material and lacking sufficient information on the diagnostic characters of this species it has to be considered as *nomen nudum*. It is very likely that it is conspecific with the co-occurring *Schizaster karreri*, but this is an assumption that remains to be verified. At least, the attribution to the genus *Schizaster* seems to be more or less secured and has already been proposed by Lambert & Thiéry (1925).

Occurrence:

Austria: Badenian (Langhian-Early Serravallian)
Vienna Basin: Kalksburg, Vienna (Fuchs, 1869; Laube, 1869a, 1870, 1871; Karrer, 1877)

Paratethys (non-Austrian occurrences): ? Late Badenian (Early Serravallian)
Great Hungarian Basin (Pannonian Basin): ? Budapest-Rákos, Pest, Hungary (Vadász, 1906)

Genus *Ditremaster* Munier-Chalmas, 1885

Type-species: *Hemiaster nux* Desor, 1853; by subsequent designation (Cotteau, 1887: 422)
Diagnosis: Sub-globular with faint frontal sinus. Apical disc ethmolytic with 2 gonopores. Paired ambulacra petaloid. Posterior pair very short, about 0.3 times the length of the anterior ones (modified from Fischer, 1966).
Distribution: Eocene to Pliocene – cosmopolitan (Fischer, 1966)

Ditremaster scillae (Wright, 1855)

(Fig. 61; Pl. 63, Figs. 1a-c)

* 1855 *Hemiaster Scillæ*, Wright, n.sp. – Wright: 191-193; pl. 7, figs. 1a-f
1858 [*Hemiaster*] *Scillae* Wright – Desor: 375
1864 *Hemiaster Scillæ*, Wright. – Wright: 483-484
v. 1869a *Hemiaster rotundus* Laube. – Laube: 183
v. 1870 *Hemiaster rotundus* Lbe. – Laube: 314
v. 1871 *Hemiaster rotundus* Laube. – Laube: 68-69; pl. 18, fig. 6
v. 1883 [*Trachyaster*] *rotundus* – Pomel: 38
1883 [*Opissaster*] *Scillæ* – Pomel: 38
. 1891 *Hemiaster scillæ*, Wright, 1855. – Gregory: 611
? 1905a *Hemiaster ovatus* (Sism.) Air. – Airaghi: 216 [fide Lambert (1907a)]
non 1907a *Opissaster Scillæ* Wright (*Hemiaster*) – Lambert: pl. 3, fig. 12-13 [according to Lambert (1909: 98) this is a *Brissopsis consobrinus*]
1908a *Opissaster Scillae* (Wright). – Stefanini: 470-471; pl. 17, fig. 7
? 1909 *Opissaster Scillæ* Wright (*Hemiaster*) – Lambert: 80-81
1909 *Opissaster Scillæ* Wright (*Hemiaster*) – Lambert: 135
. 1911 *Hemiaster scillæ*, Wright, 1855. – Gregory: 673
. 1913a *Opissaster Scillæ* Wright (*Hemiaster*) – Cottreau: 70
? v 1915 *Schizaster sardiniensis* Cott. – Vadász: 223-224; text-fig. 113; pl. 10 (4), fig. 9
1924 *Trachyaster* (*Opissaster*) *Scillæ* Wright (*Hemiaster*) – Lambert & Thiéry: 509
v. 1924 *Trachyaster* (*Opissaster*) *rotundus* Laube (*Hemiaster*) – Lambert & Thiéry: 509
v. 1925 *Rotundaster rotundus* Laube (*Hemiaster*) – Lambert & Thiéry: 527
1974a *Hemiaster scillae* – Rose: 345, fig. 3 [table]
. 1974b *Hemiaster scillae* – Rose: 351, fig. 3 [table]
. 1975 *Hemiaster scillae* Wright – Rose: 79, tab. 12
v. 1975 *Hemiaster rotundus* Laube, 1871 – Stojaspal: A192
. 1979 *Ditremaster scillae* (Wright) – Challis: 255
. 1979a *Opissaster scilla* (Wright) 1855 – Menesini: 60

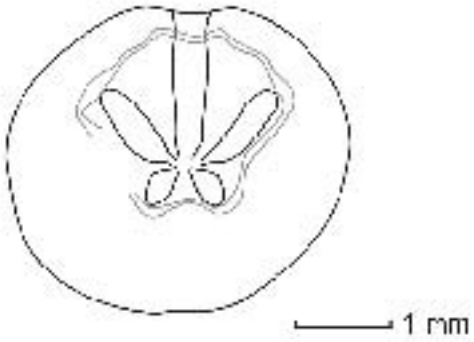

Figure 61: *Ditremaster scillae* (Wright, 1855): outline of the peripetalous fasciole (grey) (Badenian, Sievering, Vienna, GBA 1871/3/1). Note that the test outline is deformed due to compaction, originally the specimen was subcircular.

. 1979b *Opissaster scilla* (Wright) 1855 – Menesini: 802, 804
. 1984 *Ditremaster scillae* – Boggild & Rose: 64; fig. 3
. 1990 *Opissaster scillae* (Wright) – Ragaini: 1-13; figs. 1-10
1994 *Ditremaster scillae* – Néraudeau: 329, tab. 4

Type-material:
Hemiaster scillae Wright, 1855:
Syntypes: the material on which Wright's description is based (formerly in the collection of the Earl of Ducie) is housed at the Bristol Museum, UK under the numbers Cb 4624 – 4630 (Challis, 1980)
Locus typicus: Malta
Stratum typicum: *Globigerina* Limestone (Bed 4 of Wright, 1855)
Age: Aquitanian to Langhian, Miocene

Hemiaster rotundus Laube, 1869:
Holotype (Pl. 63, Figs. 1a-c): specimen figured by Laube (1871: pl. 18, fig. 6); Geological Survey Austria, Type collection, specimen no. 1871/3/1
Locus typicus: Sievering, Vienna, Austria
Age: Badenian (Langhian-Early Serravallian), Middle Miocene

Material:
Badenian (Langhian-Early Serravallian) – Sievering, Vienna, Austria
GBA: 1 specimen in the type collection (holotype of *Hemiaster rotundus* Laube, 1869)
? Late Badenian (Early Serravallian) – Gârbova de Sus (= Felsö-Orbó), Romania
MAFI: 1 specimen [MAFI Ech 306 (figured specimen of *Schizaster sardiniensis* in Vadász, 1915)]

Dimensions (in mm)**:**

Inv. No.	TL	TW	TH
GBA 1871/3/1 (anterior part deformed)	> 33	36.2	25.3

Description:
Size and shape: Test of small size with subcircular outline. The anterior margin is rounded with a faint frontal notch. The posterior margin is rounded to very bluntly pointed. The maximum width lies halfway along the test. In profile the test is high and slightly wedge-shaped. The maximum height lies just posterior of the apical disc in interambulacrum 5.
Apical disc: The apical disc is not preserved in the specimen studied (in Maltese specimens it is ethmolytic with 2 gonopores). The apical disc lies posterior of the centre, approximately two third of TL from the anterior margin.
Ambulacra: Adapically the ambulacra form moderately deep petals. Ambulacrum III is shallower than the paired petals and forms a very shallow frontal sinus. It closes slightly distally, where the poriferous zones end. The pores (oblique partitioned isopores with an axially positioned neural canal) are arranged in two straight rows. The interporiferous zone is very broad and bears few tubercles (no primaries).

The paired petals are relatively short and straight. The posterior paired petals are very short, nearly half as long as the posterior ones. The anterior paired petals form an angle of nearly 90°, while the posterior petals diverge less strongly, forming an angle of about 80°. The poriferous zones of the paired petals consist of very narrow, slit-like elongate isopores. The interporiferous zones are about half as wide as a single poriferous zone and bear only secondary tubercles.

Outside the peripetalous fasciole, the ambulacral pores are minute unipores. The adoral part of the ambulacra is not well preserved, so nothing can be said about the phyllodes. On the oral surface ambulacra I and V form long narrow peri-plastronal areas lacking primary tubercles.

The tuberculation of the ambulacra is rather sparse and conspicuous naked zones running from the tips of the petals down the ambitus are present.
Interambulacra: The interambulacra are strongly inflated adapically, forming high keels along the sunken petals, except in interambulacrum 5, where only a low rounded keel is present. The aboral tuberculation of the interambulacra is heterogeneous. It is very dense with small tubercles within the peripetalous fasciole, except along the sunken part of ambulacrum III, where the tubercles are large. At the ambitus the tubercles are rather large and widely spaced. On the oral side the tuberculation becomes even more sparse. Only on the plastron a regular fan-shaped pattern is observed. The nature of the tubercles is difficult to assess due to abrasion, but most of them seem to be perforate, crenulate tubercles. The plastron is moderately large and mesamphisternous. The labrum is partly missing, but seems to have been about twice its width in length. There are two distinct ridges along the midline of each half-interambulacrum running from the apex to the margin of the oral side, they are most prominent in the interambulacra 1 and 4.
Peristome: The peristome is very poorly preserved in the present specimen. It is situated approximately 20 to 30 % TL from the anterior margin.
Periproct: The periproct is situated marginally, high on the vertical posterior face of the test. Below the peristome there is a large flattened, vertical area with few tubercles in its centre. The shape of the periproct seems to have been subcircular.
Fascioles: Only a peripetalous fasciole, with a broad fasciole band is present. It is widest at the tips of the petals, narrowing in the interambulacra. The peripetalous fasciole is indented in the interambulacra 1 and 4 and crosses the remaining interambulacra more or less straight (Fig. 61).

Differential diagnosis:
This species differs from *Aliaster cotteauii* (Wright, 1855) by its small size, faint frontal sinus, sparse adoral tuberculation, slit-like respiratory pores and most importantly by the shape of the peripetalous fasciole.

Schizasterids present in the Neogene of Austria differ by the presence of a latero-anal fasciole, longer flexed petals, and a heart-shaped outline.

There are no other species with which the present taxon could be confused in the Central Paratethys and few in the Miocene of the Mediterranean. Among these *Hemiaster* ? *vadosus* Gregory, 1891 from the Maltese Islands, which has a similar size, outline and peripetalous fasciole can be distinguished by its ethmophract apical disc with 4 gonopores and more wedge-shaped profile. Nearly the same is valid for

Trachyaster globosus Pomel, 1869 from the Pliocene of Algeria only that the latter has an ethmolytic apical disc. *Opissaster cotteri* de Loriol, 1896 (referred by Néraudeau, 1994 to *Ditremaster*) from the Miocene (?) of Portugal is much larger, has longer, slightly outwards flexed petals, a deeply sunken ambulacrum III with overhanging walls aborally and a very different peripetalous fasciole. *Opissaster polygonalis* Pomel, 1883 and *O. declivis* Pomel, 1887 differ by their lower profile, elongated outline, and presence of a latero-anal fasciole. *Opissaster ? bleicheri* Peron & Gauthier in Cotteau et al., 1891 and *Aliaster jourdyi* (Péron & Gauthier in Cotteau et al., 1891) both from the Miocene of Algeria differ also rather well from *D. scillae*. The former has a strongly wedge shaped profile and less diverging petals, the latter a different peripetalous fasciole.

Discussion:

Laube's (1871: pl. 18, fig. 6) figure of the type of *Hemiaster rotundus* is relatively poor. It evokes the impression that the specimen is more wide than long but that is an artefact of the deformation of the anterior part of the corona. Furthermore, he illustrates a well preserved peristome, while the type is badly damaged in that area and the peristome poorly visible due to the deformation of the anterior part of the corona.

Based on a re-examination of the holotype of *H. rotundus* Laube, 1869 (the only specimen of this nominal species) and comparison with specimens of *Ditremaster scillae* (Wright, 1855) from the Aquitanian to Langhian *Globigerina* Limestone of the Maltese Islands *H. rotundus* is considered as junior synonym of *D. scillae*. In fact, Laube (1871: 69) pointed out the similarity of these two species already. The features used by him to distinguish between those two species (more rounded posterior end, less anterior peristome and more elongated outline in *D. scillae*) were partly artefacts of the deformation of the Austrian material and partly misinterpretations of the then available figures and descriptions of *D. scillae*. If one compares actual specimens, there is no doubt of their conspecifity. Moreover, the holotype of *H. rotundus* fits very well in the morphological range illustrated for *D. scillae* in a study on the morphometrics of this species by Ragaini (1990; based on material from the Maltese Islands).

Pomel (1883: 38) placed this species in the genus *Opissaster.* An opinion rejected by Gregory (1891: 611), who stated that his specimen of *H. scillae* had 3(?) or 4 genital pores and an ethmophract apical disc, although poorly preserved. Therefore he argued that *H. scillae* should be "allowed to remain in *Hemiaster*". The type species of *Opissaster*, *O. polygonalis* Pomel, 1883, however, has only two gonopores and Pomel (1883: 37) considered that as main feature of the genus. Lambert (1906a: 102) made *Ditremaster* Munier-Chalmas, 1885 a junior subjective synonym of *Opissaster* Pomel, 1883. Lambert (1906a: 102), however, rejected Pomel's inclusion of the species *H. cotteauii* Wright, 1855 and *H. scillae* Wright, 1855 into the genus *Opissaster*.

Despite Gregory's and Lambert's rejection, *H. scillae* was considered as *Opissaster* by subsequent authors (e.g. Stefanini, 1908a, Ragaini, 1990….). In 1907 Lambert himself (Lambert, 1907a: 80), contrary to his former statement placed *H. scillae* in the genus *Opissaster*.

Rose (1975: 78, Tab. 11) suggested that *Hemiaster vadosus* Gregory, 1891 might be a junior synonym of the present species. This, however, is improbable since *H. vadosus* has an ethmophract apical disc with four gonopores (see Gregory, 1891:pl. 2, fig. 6d). Néraudeau (1994: 329, tab. 4), following Lambert & Thiéry (1924:509) placed the latter species in the genus *Ditremaster*, which is also a poor choice considering the structure of the apical disc.

Challis (1980: 194-199) was the first to place *H. scillae* into the genus *Ditremaster* on base of the ethmolytic apical disc with two gonopores and its shallow frontal sinus. Since this work is an unpublished PhD thesis, this was no valid action in sense of the ICZN, but subsequent authors followed it nevertheless (e.g. Néraudeau, 1994: 329, tab. 4).

Néraudeau (1994) considered the two genera *Ditremaster* and *Opissaster* to be distinct, albeit closely related. According to him *Opissaster* is more "schizasteriform" in having a more elongate outline, lower profile and less diverging, slightly flexed anterior petals. Certain species of *Opissaster* acquired, furthermore, a latero-anal fasciole at the end of the Palaeogene.

Néraudeau's (1994: 332) statement that "The *Opissaster* reported in the Miocene of Austria-Hungary by Laube (1871) were in fact *Schizaster* (Lambert & Thiéry, 1909-1925) and only one *H.* (*Trachyaster*) is known in the Miocene of Czechoslovakia (Seneš, 1955)." cannot be accepted. First, Laube (1871) did never report any *Opissaster* species (he reported two species of the genus *Hemiaster*). Second, while *H. kalksburgensis* is most probably a *Schizaster*, *H. rotundus* is certainly a hemiasterid, albeit today placed into the synonymy of *Ditremaster scillae*.

The specimen referred to *Schizaster sardiniensis* by Vadász (1915) was re-examined at the MAFI (Ech 306). It has an ethmolytic apical disc with two gonopores, a very shallow frontal notch, and a small petalodium with very short posterior paired petals. Although the specimen is rather low in profile it is tentatively referred to *D. scillae* here. In Maltese specimens test height varies between 61 and 89 % TL with a mean of 79 % (Ragaini, 1990: tab. 2). In Vadász's specimen the height is around 50 % TL, probably resulting from deformation.

Occurrence:

Austria: Badenian (Langhian-Early Serravallian)
- Vienna Basin: Sievering, Vienna (Laube, 1869a, 1871; Stojaspal, 1975; [GBA])

Paratethys (non-Austrian occurrences): Late Badenian (Early Serravallian)
- Transylvanian Basin: ? Gârbova de Sus (= Felsö-Orbó), Romania (Vadász, 1915; [MAFI])

Mediterranean: Aquitanian – Langhian
- Western Mediterranean: ? Bingia Fargeri (Fangarion), Sardinia, Italy (Lambert, 1907a); ? Valtorta, Sardinia, Italy (Airaghi, 1905a)
- Central Mediterranean: Maltese Islands: Lower Coralline Limestone (Rose, 1975); *Globigerina* Limestone [Mgarr ix-Xini bed (=*Scutella* bed), Lower *Globigerina* Lst. to Upper *Globigerina* Lst., and phosphate conglomerates therein] (Wright, 1855, 1864; Desor, 1858; Gregory, 1891, 1911; Stefanini, 1908a; Lambert, 1909; Cottreau, 1913a; Rose, 1974b, 1975; Challis, 1979, 1980; Menesini, 1979a, b; Boggild & Rose, 1984; Ragaini, 1990; Néraudeau, 1994; [NHMW]); Cyrenaica, Libya: Ain Sciahat (Gregory, 1911); Cyrene and Derna, (Rose, 1974a, b)

Family Pericosmidae Lambert, 1905
Genus *Pericosmus* Agassiz, 1847

Type-species: *Hemiaster* (*Pericosmus*) *latus* Desor in Agassiz & Desor, 1847; by subsequent designation (de Loriol, 1875: 114).

Diagnosis: Apex sub-central to somewhat anterior; petals moderately broad, straight, subequal; anterior sinus moderately deep; peripetalous fasciole passing above the periproct; marginal fasciole generally complete, passing below periproct; apical disc ethmolytic with 3 gonopores. (modified from Fischer, 1966)

Distribution: Eocene to Recent – circumtropical (Fischer, 1966)

Ecology and biogeography: Although ten, possibly twelve, extant species of *Pericosmus* have been described, little is known on the ecology of this genus. Today the genus has an Indo-malayan distribution, ranging south as far as southern

Queensland (Australia) and occur in depth between 18 to 486 metres, most commonly around 200 m (Mortensen, 1951; McNamara, 1984). It is essentially a tropical genus, although its range extends into the northern part southern warm temperate zone east of Australia. Its distribution, however, seems to be limited by winter surface temperatures between 15° and 20° C. *P. porphyrocardius* McNamara, 1984 is the only extant species based on large numbers of specimens. It was trawled from depths between 309 and 420 metres, from muddy sediments and found in association with *Lovenia gregalis* Alcock, 1893, and species of *Stereocidaris* and *Araeosoma* (McNamara, 1984). McNamara & Philip (1984) assumed similar habitats for the other extant species and stated that they are ill-adapted to burrowing in these fine sediments. In contrast, the Oligocene and Miocene *Pericosmus* species of Australia lived in coarse-grained bioclastic calcareous sands, being adapted to relatively shallow-water, high hydrodynamic environments and more effective burrowing (McNamara & Philip, 1984: 355).

Pericosmus latus (Desor in Agassiz & Desor, 1847)

(Fig. 62; Pl. 63, Figs. 2-3)

	1840b	*Micraster latus* Ag. – Agassiz: 2 [*nomen nudum*]
non	1843	*Micraster latus* Ag. – Sismonda: 29-30; pl. 1, fig.13 [a *Micraster* from the Cretaceous of Nice, according to Lambert (1909:83-84)]
*	1847b	*Hemiaster* (*Pericosmus*) *latus* Desor – Agassiz & Desor: 19; pl.16, fig. 1, 1a
.	1855	*Pericosmus latus*, Desor. – Wright: 193-195
	1857	*P.*[*ericosmus*] *latus*, Desor – Pictet: 198
pp	1858	*Pericosmus latus* Agass. – Desor: 396
.	1864	*Pericosmus latus,* Agassiz – Wright: 490
	1873	*Pericosmus latus*, Agass – Manzoni: 10-11, 20
	1877	*Pericosmus latus*, Agassiz, 1847 – Cotteau *in* Locard: 310-312
non	1875a	*Schizaster Grateloupii* Sism. – Hoernes: 385, 389
non	1875b	*Schizaster Grateloupii* Sism. – Hoernes: 211
	1882a	*Pericosmus latus*, Agass, – Mazzetti: 115
pp	1891	*Pericosmus latus* (Agassiz), 1840 – Gregory: 613-615
	1895	*Pericosmus latus*, Agassiz, 1847. – Cotteau: 40
#	1900	*Pericosmus Lyonsi* Gauthier, 1898 – Gauthier *in* Fourtau: 716-717; pl. 4, figs. 10-11
	1902	*Pericosmus latus* Agassiz, 1847 – Fourtau: 108-109
.	1908a	*Pericosmus latus* (Agass.) – Stefanini: 481-482
	1909	*Pericosmus latus* Agassiz, 1847 – Lambert: 83-85; pl. 6, fig. 1-2
.	1913a	*Pericosmus latus* Agassiz. – Cottreau: 71, 120-122; fig. 36; pl. 15, fig. 5, 5a
	1913a	[*Pericosmus latus* Agassiz] variété *minor* – Cottreau: 71, 120-122; pl. 15, fig. 6, 6a
	1915a	*Pericosmus latus* Agassiz, 1847. – Lambert: 171
v.	1915	*Pericosmus latus* Ag. sp. – Vadász: 227; fig. 117
	1920	*Pericosmus latus*, Agassiz 1847 – Fourtau: 73-74
	1924	*P.*[*ericosmus*] *latus* Agassiz (*Micraster*) – Lambert & Thiéry: 512
	1939	*Pericosmus latus* Agassiz – Taviani: 44-45; pl. 3 (5), fig. 5
?	1955	*Periscomus* cf. *latus* Ag. – Seneš: 6
?	1956	*Pericosmus latus* Agassiz – Socin: 14
?	1967	*Pericosmus* cf. *latus* Ag. – Cicha et al.: 93
.	1975	*Pericosmus latus* Desor – Rose: 79, tab. 12
.	1979	*Pericosmus latus* Desor 1840 – Challis: 256
.	1979a	*Pericosmus latus* (Agassiz) 1840 – Menesini: 60
.	1979b	*Pericosmus latus* (Agassiz) 1840 – Menesini: 802
.	1980	*Pericosmus* (*Pericosmus*) *latus* (Agassiz). – Challis: 204-209; pl. 79, figs. A-C; pl. 80, figs. A-C; pl. 81, figs. A-C
.	1984	*Pericosmus latus* – Boggild & Rose: tab. 61, 64; figs. 2-3
	1992	*Pericosmus lyonsi* Gauthier – Blondel & Philippe: 438; pl. 1, figs. 3a-b
.	1998	*Pericosmus latus* (Agassiz, 1840) – Philippe: 169-171; pl. 19, figs. 5a-c
v.	2002	*Pericosmus* sp. – Kazár: 153; fig. 1

Type-material:
Syntypes: collection Michelin (Agassiz & Desor, 1847b: 19); a plaster cast ("moulage" M23) of this specimen is housed in the collection of the Museé d'Histoire Naturelle de Neuchâtel (Lambert & Jeannet, 1928: 144, M.23); Challis (1980: pl. 80, figs. A-C) figured two specimens from the collection of the Université de Paris-Sud, Orsay, which are probably syntypes of this species
Locus typicus: Bonifacio, Corsica, France
Age: Burdigalian (Philippe, 1998: 170)

Material:
Early Badenian (Langhian) – Stotzing (sandpit Mayer), Bgld, Austria
NHMW: 6 specimens (NHMW 2004z0093/0001-5, 2004z0093/0023)
Wanzenböck coll.: numerous specimens (no inventory nos.)

Foreign material for comparison:
Early Badenian (Langhian) – Totmárokhazá, Nógrád, Hungary
MAFI: 1 specimen [MAFI Ech 308 (reference material of Vadász, 1915)]
Late Badenian (Early Serravallian) – Gârbova de Sus (= Felsö-Orbó), Romania
MAFI: 2 specimens [MAFI Ech 309 and 310 (reference material of Vadász, 1915)]

Dimensions (in mm)**:**

Inv. No.	TL	TW	TH
NHMW 2004z0093/0001	72.5	74.1	37.3
NHMW 2004z0093/0002	60.6	>58	>24
NHMW 2004z0093/0004	79.5	75.6	~46
NHMW 2004z0093/0005	>74	75.3	>32

Description:
Size and shape: Test of medium to large size with rounded, slightly heart-shaped outline. Test length and width subequal. Anterior margin rounded with moderately deep frontal sinus. Posterior margin bluntly pointed. Maximum width halfway along test length. In profile test high, low arched to domed. Posterior end obliquely truncated. Maximum height coinciding with inflated interambulacra anterior and posterior of apical disc. Test sloping steeply from the apex to the anterior margin and gently to the posterior margin. Ambitus tumid to rounded. Oral surface flat to slightly convex, sloping gently from a central elevation on the plastron to the margin.
Apical disc: Apical disc ethmolytic with three gonopores (no gonopore in genital plate 2; Fig. 62.B) and situated centrally.
Ambulacra: Ambulacrum III straight, open and increasingly depressed towards the anterior margin. The pores are minute, oblique partitioned anisopores, which are arranged in straight rows. Interporiferous zone wide, sparsely tuberculated with small perforated tubercles.

Paired ambulacra petaloid, deeply sunken and closed distally. The anterior pair forms an obtuse angle of about 110° to 120°; the posterior pair an acute angle of approximately 70°. The posterior paired petals flex slightly laterally at their distal ends in some specimens. Anterior paired petals about 14 % to 20 % larger than posterior paired petals. Anterior paired petals extend about two third and posterior pair about half of corresponding test radius. The pores within the paired petals are elongated isopores. Outside the petals only small, slit shaped unipores, situated near the adoral suture of each ambulacral plate are present.

On the oral surface ambulacra I and IV each form broad, nearly naked peri-plastronal areas, with very few irregularly spread secondary tubercles. Each ambulacral plate bears one small unipore near the adoral suture.

Adorally the ambulacra form slightly sunken phyllodes bearing large constricted unipores with extensive periporal area.

Interambulacra: On the apical surface the interambulacra are inflated, forming keels between the petals. Tuberculation is moderately dense. Primary tubercles are small, crenulate, perforate with undercut mamelon, concave platform and inclined areoles. Very small secondary tubercles are spread among them. The largest tubercles are situated inside the peripetalous fasciole, bordering the petals, especially around the apical disc and along ambulacrum III.

On the oral surface the interambulacra are flattened and covered with loosely arranged, large primary tubercles. Secondary tuberculation rather dense. Towards the margin the primary tubercles decrease in size and there are few or no secondary tubercles present near the margin. The primary tubercles are perforate, crenulate, have a raised platform and large areoles which are inclined towards the peristome. The plastron is mesamphisternous and up to one third as wide as the test (Fig. 62.A). The junction between the sternal plates forms an antero-posteriorly elongated keel. The tuberculation is dense and forms a radiating pattern from a central elevation. Very few secondary tubercles are present. Two distinct elevations on each side of a very sparsely tuberculated subanal depression are visible at the posterior end of the plastron.

Peristome: The peristome is situated near the anterior margin, about 20 % of TL from the anterior margin. It is rather small, kidney-shaped, transversely elongated, with a short, bluntly pointed labrum. The anterior margin of the peristome is depressed.

Periproct: The periproct which is situated high on the ambitus, is overhanging and has an oval, transversely elongated shape. A broad, sparsely tuberculated subanal depression is present.

Fascioles: The peripetalous fasciole band is rather narrow. There are distinct indentations of the peripetalous fasciole in interambulacra 1, 4 and 5. In interambulacra 2 and 3 the fasciole is indented several times, forming a stair-shaped pattern. Here it splits in several bands which cross ambulacrum III at several different positions (usually between the apical disc and about halfway between apex and margin). A narrow marginal fasciole band is present. It is situated at or slightly above the ambitus except in ambulacrum III, where it is indistinct and below the periproct where it lies on the oral surface and is somewhat broader.

Differential diagnosis:

Pericosmus orbignyi Cotteau, 1877 from the Miocene of Corsica can be distinguished from this species by its slightly lower test profile, its stronger inflated interambulacra between the petals, its flatter oral surface, its larger petals and its peripetalous fasciole, which is not or only slightly indented.

P. peroni Cotteau, 1877 another species from Corsica can be held apart from the species considered here by its oval, transversely elongated outline (width > length), its high, angular test profile, the stronger diverging anterior petals and its transversely truncated posterior margin.

P. agassizi (Sismonda, 1841) from the Late Oligocene of the Colli Torinesi and Sardinia differs from *P. latus* by its more angular outline, more strongly diverging anterior petals, its different profile (with vertically truncated posterior end) and different outline of the peripetalous fasciole (compare Lambert, 1909: 85-86; pl. 7, figs. 6-7).

P. lovisatoi Lambert, 1909 and *P. petasatus* Lambert, 1909, both from the Late Oligocene of Sardinia, differ from *P. latus* by their longer and more strongly flexed petals (compare Lambert, 1909: 87-88; pl. 6, figs. 3-4; pl. 9, fig. 1)

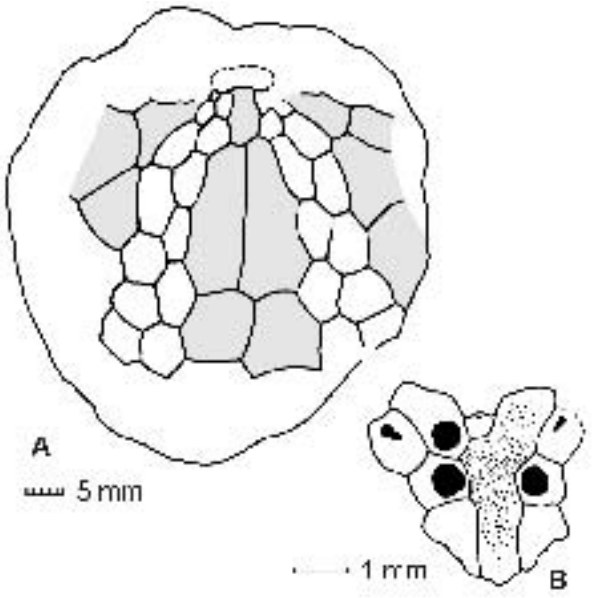

Figure 62: *Pericosmus latus* (Desor in Agassiz & Desor, 1847b): oral plating (A) and apical disc (B) (Early Badenian, Stotzing, Bgld, NHMW 2004z0093/0002).

Discussion:

The Austrian specimens clearly belong to the well known and widely distributed species *Pericosmus latus* (Desor in Agassiz & Desor, 1847). The species *Pericosmus lyonsi* Gauthier was placed into the synonymy of *P. latus* (Desor, 1847) by Cottreau (1913a), Fourtau (1920), and Philippe (1998) because they considered the type species as an aberrant morphotype of this species, a fact which was already noted by Gauthier himself according to Cottreau (1913a). Philippe (1998; 169-171) also placed *P. pasqualii* Gauthier in Fourtau, 1900 into the synonymy of *P. latus*, which would extend the range of this species down to the Eocene.

The correct authorship of the species *P. latus* has been subject to some confusion in the past, resulting in quite surprising combinations as e.g. *Pericosmus latus* Desor, 1840 (Challis, 1979). The name *Micraster latus* Agassiz, 1840b is a *nomen nudum* according to the ICZN rules (ICZN 4th ed., 2000, Article 12.1.). The next author who published a description for this name is Sismonda (1843: 29-30; pl. 1, fig.13), which is thus the valid author for *M. latus* (ICZN 4th ed., Articles 11. and 12.). Sismonda's description, however, is based on Cretaceous specimens from Nice (Lambert, 1909) which are micrasterids not related to the species discussed here. In 1847 Desor (in Agassiz & Desor, 1847b: 19), validly established the taxon *"Hemiaster (Pericosmus) latus"* using Agassiz's (1840b) material as type. The correct authorship for the present taxon is thus *Pericosmus latus* (Desor in Agassiz & Desor, 1847) and this species should not be confused with the valid species *Micraster latus* Sismonda, 1843.

Until now *P. latus* was not recorded form the Neogene of Austria, although its presence in the Central Paratethys was documented by Vadász (1915) already. Laube (1869a) established the species *Pericosmus affinis* on base of a single specimen from Sievering, Vienna (now lost) and it seems possible that this specimen was a misidentified *P. latus*. A detailed comparison of Laube's (1871) description and illustration of *P. latus* specimens from the Central Paratethys and the Mediterranean, however, reveals many discrepancies and it seems more likely that *P. affinis* belongs into the synonymy of *Aliaster cotteauii* (see below under that species for details).

Philippe (1998: 169) placed Hoernes' (1875a, b) record of *Schizaster grateloupi* Sismonda in the synonymy of *P. latus*.

Based on a re-examination of the specimen on which HOERNES' record is based (GBA 1875/01/77) it is placed into *Linthia* ? *hlinnensis* (SENEŠ, 1955) (see below under that species).

Occurrence:

Austria: Early Badenian (Langhian)
Vienna Basin: Stotzing (sandpit Mayer), Bgld (KAZÁR, 2002; [NHMW])

Paratethys (non-Austrian occurrences): ? Karpatian (Late Burdigalian), Early to Late Badenian (Langhian-Early Serravallian)
Great Hungarian Basin (Pannonian Basin): Tótmarokháza, Nógrád (VADÁSZ, 1915; [MAFI])
Transcarpathian Basin: ? Hlinné, eastern Slovakia (SENEŠ, 1955; CICHA et al., 1967)
Transylvanian Basin: Gârbova de Sus (= Felsö-Orbó), Romania (VADÁSZ, 1915; [MAFI])

Mediterranean: Aquitanian to Messinian
Western Mediterranean: Bonifacio, Corsica, France (AGASSIZ & DESOR, 1847b; PICTET, 1857; DESOR, 1858; MANZONI, 1873; COTTEAU in LOCARD, 1877; GREGORY, 1891); Cap Sant'Elia, Cagliari, Sardinia, Italy (LAMBERT, 1909); Emilia, Northern Italy (COTTREAU, 1913a); Isili, Sardinia, Italy (COTTEAU, 1895); Montese, Italy (MAZZETTI, 1882a; GREGORY, 1891); Monte Titano, Italy (MANZONI, 1873; GREGORY, 1891); Saint-Florent, Corsica, France (COTTEAU in LOCARD, 1877; GREGORY, 1891; COTTREAU, 1913a); Ste Colombe, near Vence, Alpes-Maritimes, France (LAMBERT, 1906b, 1915a; COTTREAU, 1913a)
Rhône Basin: Bassin d'Apt, Boillons, Goult, France (PHILIPPE, 1998)
Central Mediterranean: Bologna, Italy (GREGORY, 1891); Jebel Korbous, Tunisia (BLONDEL & PHILIPPE, 1992); Maltese Islands: *Globigerina* Limestone (Lower *Globigerina* Lst. to Upper *Globigerina* Lst., and phospate conglomerates therein) (WRIGHT, 1855, 1864; DESOR, 1858; MANZONI, 1873; GREGORY, 1891; STEFANINI, 1908a; COTTREAU, 1913a; ROSE, 1975; CHALLIS, 1979, 1980; MENESINI, 1979a, b; BOGGILD & ROSE, 1984), records from the Blue Clay are dubious according to CHALLIS (1980) and need to be confirmed
Eastern Mediterranean: Gebel Aouebet, Egypt (GAUTHIER in FOURTAU, 1900; FOURTAU, 1920); Gebel Chebrewet, Eastern Desert, Egypt (FOURTAU, 1902, 1920);Gebel Damasq, Egypt (GAUTHIER in FOURTAU, 1900; FOURTAU, 1920); Gebel Geneffé, Eastern Desert, Egypt (GAUTHIER in FOURTAU, 1900; FOURTAU, 1902, 1920); Umm er Rzem, Cyrenaica, Libya (TAVIANI, 1939)

Atlantic Ocean: ? Miocene
Canary Islands: ? Madeira [GREGORY, 1891 (needs to be confirmed)]

Indian Ocean: ? Early Miocene
Eastern African coast: ? Ehil, Somalia [SOCIN, 1956 (specific identification needs to be confirmed)]

Family Schizasteridae LAMBERT, 1905
Genus *Schizaster* AGASSIZ, 1836

Type-species: *Schizaster studeri* AGASSIZ, 1840, by subsequent designation (ICZN 1954b, opinion 209, p. 385, 8th May 1954).
Diagnosis: Test cordiform with deep anterior sulcus and slightly pointed posterior end; apical disc ethmolytic, with 2, 3 or 4 gonopores (see remarks); ambulacrum III and petaloid paired ambulacra moderately to deeply sunken aborally; anterior petals longer and more flexed than posterior petals; periproct small and marginal, on near-vertical or obliquely truncate posterior face; peristome opening facing anterior; kidney-shaped; labral plate short and wide; not extending beyond the first ambulacral plate; broad between labral and sternal plates; plastron mesamphisternous with large and symmetric sternals and biserially offset episternals; aboral tuberculation fine, uniform and dense; oral tuberculation coarser, but also dense and uniform; peripetalous and latero-anal fascioles well-developed; latero-anal fasciole branches off about one-third up from the ends of the anterior petals (modified from MORTENSEN, 1951; FISCHER, 1966 and SMITH "*The Echinoid Directory*", 07.05. 2004).
Distribution: Eocene to Recent – cosmopolitan (FISCHER, 1966)
Remarks: SMITH ("*The Echinoid Directory*"; 07.05.2004) proposed to restrict the use of the genus *Schizaster* to include only those forms with four genital pores as in the type-species *S. studeri*. For the forms with two genital pores he suggested the use of the genus *Ova* GRAY, 1825 [type species: *Spatangus canaliferus* LAMARCK 1816; by subsequent designation (ICZN op. 209, 1954), non *Ova* POMEL 1887, p. 701; (= *Nina* GRAY, 1855, p. 60)]. Within this genus he recognises two subgenera: one (*Ova*) for forms with pore-pairs of aboral ambulacrum III offset in double column in each half ambulacrum, and the other one (*Aplospatangus* LAMBERT, 1906) for forms with the pores in single series. Although this classification seems to be quite reasonable, there is a problem: in the type species of *Aplospatangus* LAMBERT, 1906 *Schizaster eurynotus* SISMONDA, 1841 (*S. eurynotus* AGASSIZ, 1840 is a *nomen nudum*; see below), as well as in a number of other species, the number of gonopores varies between two (the posterior ones; LAMBERT, 1907a: 68) and four (CHALLIS, 1980: 221). Yet in these cases where four gonopores are present the anterior ones are very small reaching only about 25 % the diameter of the posterior ones (in *S. eurynotus*: CHALLIS, 1980: 221; and pers. comm. M. GATT, Malta, 22.12.2003).

MCNAMARA (1995) documented similar variation in gonopore number in a population of the extant *Schizaster* (*S.*) *compactus* (KOEHLER, 1914) from Western Australia. He found that 55.6 % had four gonopores (n=27), 29.6 % had three and 14.8% had two, with no correlation between gonopore number and test size. Similar to the situation in the fossil *S. eurynotus* the anterior gonopores, where present, are very small in *S.* (*S.*) *compactus* (MCNAMARA, 1995: fig. 3). They range between 10 and 33 % of the posterior ones and in species with three gonopores the odd gonopore may be either the left or the right one. At least two further Australian schizasterids show the same phenomenon (MCNAMARA & PHILIP, 1980a, b; MCNAMARA, 1995). Based on these observations MCNAMARA (1995) proposed an emended diagnosis for the subgenus *Schizaster* (*S.*) and provided differential diagnostic characters to distinguish it from the two other subgenera [*S.* (*Ova*) and *S.* (*Paraster*)] he recognised.

Although the findings of MCNAMARA (1995) do not invalidate the proposed classification of SMITH, they illustrate the potential problems. Here the classification of MCNAMARA (1995) is favoured over that of SMITH as it seems to better reflect the relationship between the taxa on one hand, and provides more stability of the nomenclature on the other (SMITH's concept would necessitate to change the generic attribution of a large number of taxa without providing a better understanding of the relationship within this group).

Subgenus *Schizaster* AGASSIZ, 1836

Diagnosis: Ambulacrum III moderately to deeply sunken aborally, with numerous pore pairs (more than 15 in each poriferous zone), which are arranged in single, regular series and are aligned transversely, or only slightly obliquely (from MCNAMARA, 1995).
Distribution: Eocene to Recent – cosmopolitan (FISCHER, 1966)
Ecology and biogeography: Modern representatives of the subgenus *Schizaster* (*S.*) usually occupy soft bottoms in depths between 4 and 900 metres. Four living species are currently