

Echinoids from the Danian (Lower Paleocene) Bruderndorf Formation of Austria

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Abstract: The echinoid fauna of the Danian (Paleocene) Bruderndorf Formation is described in detail, based on a large collection of more than 1200 specimens, housed at the Natural History Museum of Vienna and the Institute of Palaeontology, University of Vienna. Nineteen taxa are recognised, and most of them are described and figured for the first time from Austrian sediments. Additionally, all former reports of echinoids from these strata have been revised on the basis of the original material, resulting in the withdrawal of several synonymous species. The echinoid fauna generally confirms the Danian age of the Bruderndorf Fm.

This fauna shows affinities to the North and Southwest European echinoid faunas, as well as to the faunas of the Caucasus and the Transcaspien Region. This distribution supports the theory of a major faunal reorganisation following the K/Pg-event, which resulted in a rather homogeneous and widely distributed echinoid fauna during the Danian.

Zusammenfassung: Die Echinidenfauna der Bruderndorf-Formation (Danium, Paleozän) wird anhand einer sehr großen Sammlung von über 1200 Echiniden des Naturhistorischen Museums Wien und des Instituts für Paläontologie der Universität Wien untersucht. Neunzehn Arten, die im Detail beschrieben und abgebildet sind, wurden in dem untersuchten Material festgestellt. Weiters wurden alle bisherigen Arbeiten über diese Echinidenfauna anhand des Originalmaterials revidiert, woraufhin einige Arten als synonym betrachtet werden. Das Danium-Alter der Bruderndorf-Formation wird durch die untersuchte Echinidenfauna bestätigt.

Diese Fauna zeigt sowohl Beziehungen zu den nordeuropäischen und südwesteuropäischen Echinidenfaunen, als auch zu den Faunen des Kaukasus und der Transkaspischen Region. Dies unterstützt die Theorie einer großen Faunenreorganisation nach dem K/Pg-Event, die zur homogenen, weitverbreiteten Echinidenfauna im Danium führte.

Keywords: Echinoidea, Echinodermata, Systematics, Danian, Paleocene, Austria

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1. INTRODUCTION

The present paper is concerned with the echinoid fauna of the Bruderndorf Formation of Lower Austria, which consists of shallow marine sediments of the Late Danian (Paleocene) age. These strata were discovered during field studies by GLAESSNER in 1926 (KÜHN, 1928) and their fauna was subsequently studied by KÜHN (1930).

Geologically, the Bruderndorf Fm. belongs to the Waschberg Zone, an incomplete sedimentary succession ranging from the Late Jurassic to the Early Miocene. This zone has been split tectonically into many small portions. The Waschberg Zone is situated in the northern part of Lower Austria and stretches as a narrow belt from the Danube in the southeast towards Mikulov (Czech Republic) in the northeast (Fig. 1). In the east, this zone is bordered by sediments of the Flysch Zone and Miocene sediments of the Vienna basin. In the west it is bordered by the Molasse Zone. Reference is made to THENIUS (1974) for a more detailed description of the Waschberg Zone.

The Danian age of the Bruderndorf Fm. was inferred by KÜHN (1930) on the basis of its faunal content, in part on the occurrence of the nautilid *Hercoglossa danica* (SCHLOT-HEIM). This age assignment has later been substantiated by studies of the foraminiferan fauna (SCHMID, 1962) and calcareous nannoplankton (STRADNER, 1961, 1962). According to PERCH-NIELSEN (1979), the nannoplankton assemblage indicates a Late Danian age (NP 3/4) (compare STÜRMER in STÜRMER et al., 1991). A list of the macrofossil and selected foraminiferan taxa known from the Bruderndorf Fm. can be found in KÜHN (1960b).

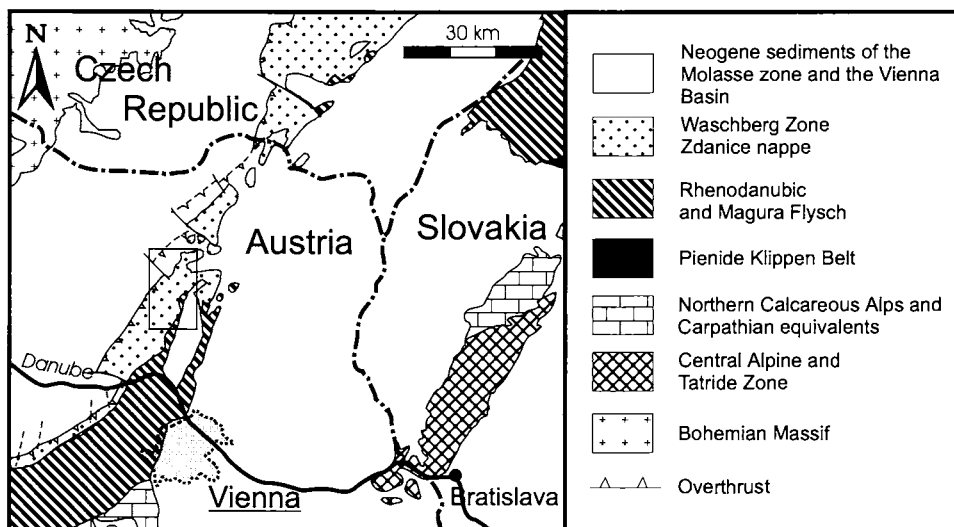


Fig. 1: Geological overview of the Austria-Czech Republik-Slovakia border region (redrawn and modified from FUCHS, 1981). The small rectangle marks the area shown in Fig. 2.

Till now, early Paleogene echinoids from Austria have only been studied in detail by KÜHN (1930, 1960b), who erected three new species: *Echinocorys schafferi*, *Garumnaster lamberti* and *Brissopneustes vindobonensis*. These species have not been considered in subsequent papers (e.g., KIER & LAWSON, 1978; SMITH & JEFFERY, 2000). This material is revised on basis of the holotypes and additional new specimens.

2. STUDY AREA

Due to the nature of the Waschberg Zone, outcrops of the various formations of this zone tend to be small and patchy in distribution. The Bruderndorf Fm. crops out at several localities between Niederfellabrunn in the southwest and Klement in the north-east (GLAESSNER, 1930; BACHMAYER, 1960; Fig. 2). In most cases this formation occurs in the form of pebbles, which can be found on fields and only occasionally is it exposed in small, temporary outcrops. The best site is at Haidhof, west of Ernstbrunn (Fig. 3).

The Bruderndorf Fm. is represented by three different lithologies:

- 1) Sandstone facies: light grey, locally glauconitic or marly, fine- to medium-grained sandstones, which are often well cemented by calcitic cement. The fauna consists mainly of echinoids, moulds of bivalves and gastropods, foraminifers and less commonly of solitary corals, cephalopods and serpulids. Sometimes plant remains and leaves may be found. This facies is the most common facies type of the Bruderndorf Fm.
- 2) Coralline algal limestone facies: light grey to cream coloured sandy, locally glauconitic limestones rich in corallinacea (RASSER & PILLER, 1994). This facies interfingers

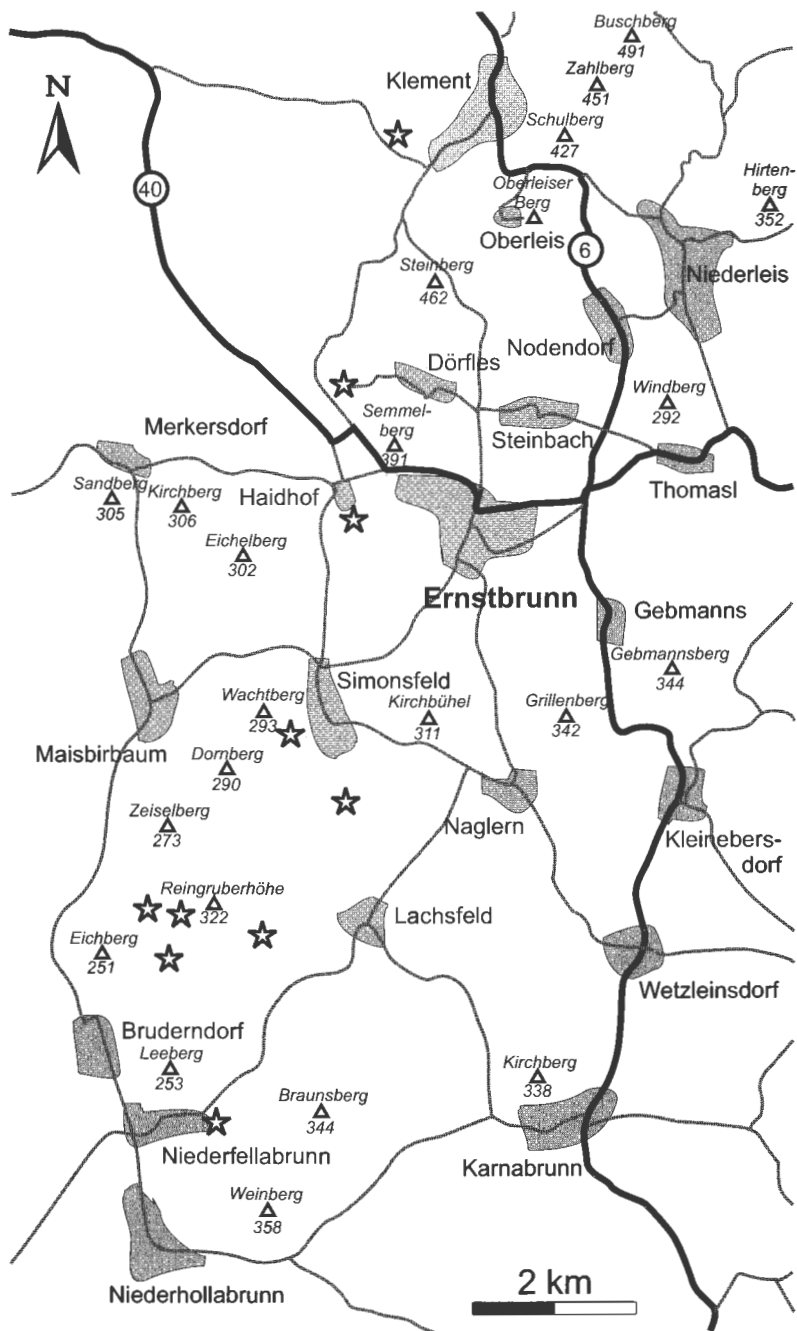


Fig. 2: Regional distribution of the Bruderndorf Formation: asterisks mark known outcrops (modified from GLAESSNER, 1930, with additional data from BACHMAYER, 1960).

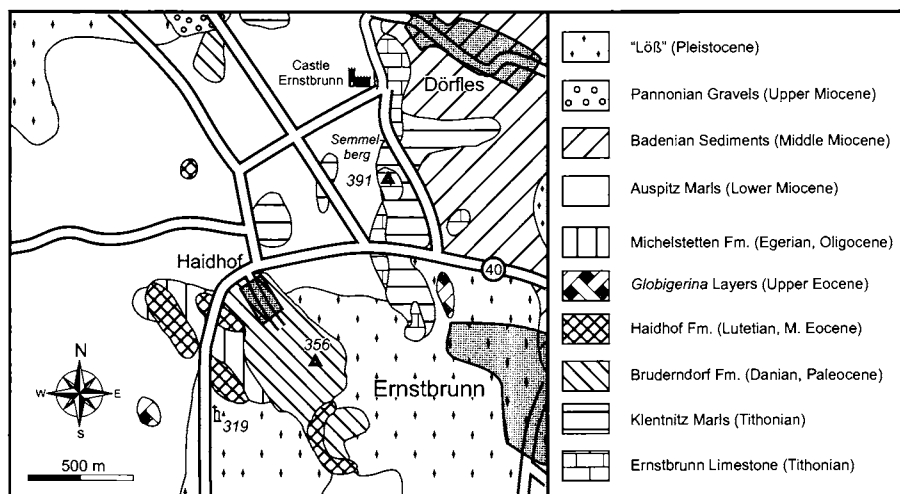


Fig. 3: Distribution of the Bruderndorf Formation at Haidhof (modified from SCHMID, 1962).

laterally with the sandstone facies and varies considerably in colour and composition. The fauna consists mainly of corallinaceae (rhodoliths and broken branches), bryozoans (incrusting and erect forms), foraminifers, corals, and echinoderm fragments (cidaroid spines, asteroid and crinoid ossicles).

- 3) Fine sand facies: brown silty to clayey fine sand rich in foraminifers. This facies has only been found at the locality Haidhof, where it occurs below the sandstone facies (BACHMAYER, 1960; KÜHN, 1960a). According to SCHMID (1962) this sediment was deposited at depths of 100 to 200 metres in a cool sea with a salinity of 30 to 35‰.

3. MATERIAL AND METHODS

For this study, the collections of the Natural History Museum Vienna and the Institute of Palaeontology, University of Vienna were consulted; both include small private collections (CHLUPAC, KÜHN, ORUSZI and ZAPFE at the NHMW; WEINFURTER and RITTER-GULDER at the IPUW). Additionally, material contained in the private collection of Karl WEISS (Vienna) could be studied.

These collections included material from the following localities: Bruderndorf, Haidhof near Ernstbrunn, Klement and Niederfellabrunn. The material from Haidhof makes up more than 90%. Additionally I have collected material at Haidhof for several years, which was deposited at the Natural history Museum of Vienna.

The echinoids were cleaned using a mild detergent and whenever necessary by using an ultrasonic vibrator and a preparation needle. The SEM pictures were taken at the Institute of Palaeontology by the author using a JEOL 6400 SEM. All measurements were made with an electronic digital calliper (mean error: 0.03 mm) and are given in millimetres.

Deviating from the usual habit of giving a left lateral view, the photographs and drawings show the better preserved side of the specimens.

For the description of echinoid coronal pores SMITH's (1978, 1980) nomenclature is used. The numbering of the interambulacra and ambulacra follows the Lovenian system (see MOORE, 1966).

Abbreviations used are:

NHMW	Natural History Museum of Vienna, Burgring 7, A-1040 Vienna, Austria
IPUW	Institute of Palaeontology, University of Vienna, Althanstr. 14, A-1090 Vienna, Austria
TL	test length
TW	test width
TH	test height

4. RESULTS – SYSTEMATIC DESCRIPTIONS

Class Echinoidea LESKE, 1778

Order Cidaroida CLAUS, 1880

Family Cidaridae GRAY, 1825

Cidaridae indet.

Pl. 1, Figs. 1–4

Material: 4 spine fragments (NHMW 2000z0096/0054) and 6 isolated interambulacral plates (NHMW 2000z0096/55).

Description: Interambulacral plates (Pl. 1, Figs. 3–4): Small plates bearing a large perforate, crenulate primary tubercle with globular mamelon, undercut neck and a large areole. The scrobicular tubercles are small, forming a continuous but narrow scrobicular ring.

Spines (Pl. 1, Figs. 1–2): The spine fragments bear coarse thorns with fine granulation between them. The thorns are arranged in 11 uniserial rows. The thorns within a row are connected, forming longitudinal ridges. The collar, as well as the milled ring, are smooth and the acetabulum seems to have a crenulate margin.

Remarks: These fragments cannot be identified more specifically on account of their poor preservation. KÜHN (1930, 1960b) mentioned *Typocidaris* cf. *rosenkrantzi* RAVN from Haidhof, but his material (1 spine) could not be located in the collection of the Natural History Museum of Vienna. Therefore, it cannot be determined whether or not the present material and KÜHN's are conspecific.

Occurrence: Coralline algal limestone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria).

Cohort Echinacea CLAUS, 1876
 Order Calycina GREGORY, 1900
 Family Saleniidae AGASSIZ, 1838
 Subfamily Hyposaleniinae MORTENSEN, 1934
 Genus *Hyposalenia* DESOR, 1856

Diagnosis: Saleniid with bigeminate ambulacral plates; Apical disc ornamented with conspicuous striations or sutural depressions; Periproct lying along the anterior-posterior axis; genital plate 5 not in contact with the suranal plate.

Hyposalenia heliophora (AGASSIZ & DESOR, 1846)

Fig. 4; Pl. 1, Figs. 5–7

- 1846 *Salenia heliophora*. – AGASSIZ & DESOR: 342
- 1856 *Hyposalenia heliophora* AGASSIZ. – DESOR: 148
- 1864 *Peltastes heliophorus* DESOR. – COTTEAU: 122; pl. 1029, figs. 1–7
- 1912 *Peltastes heliophorus* AGASSIZ & DESOR. – LAMBERT & THIÉRY: 209
- 1928 *Peltastes ultimus*. – RAVN: 39; pl. 4, fig. 39
- 1965 *Hyposalenia heliophora* (DESOR). – MEIJER: 27; fig. 1
- 1966 *Hyposalenia heliophora* (AGASSIZ & DESOR). – FELL & PAWSON: U379; fig. 277-1j
- 1979 *Hyposalenia heliophora* (DESOR). – GEYS: 320
- 1982 *Hyposalenia heliophora* (AGASSIZ & DESOR). – GEYS: 269; pl. 29, figs. 5–8; text-fig. 7b
- 1987 *Hyposalenia heliophora* (DESOR). – VAN DER HAM et al.: 22; pl. 2, fig. 5
- 1988 *Hyposalenia heliophora* (DESOR). – VAN DER HAM: 140; pl. 3; figs. 13–16
- 2000 *Hyposalenia heliophora* (AGASSIZ & DESOR). – SMITH & JEFFERY: 48; text-fig. 16D-E

Material: A single specimen (NHMW 2000z0096/0049).

Description: Size and shape: Test small, low arched with circular outline. The oral surface is concave around the peristome.

Apical disc: The apical disc is situated in the centre of the aboral side, it is large (more than 50% of test diameter), has a conical profile and a pentagonal outline, and consists of eleven plates, which are ornamented by small ridges and grooves radiating from the centre of each plate. These ridges and grooves cross the sutures and continue on neighbouring plates within the apical system. The genital plates are hexagonal and each bear a large, round gonopore in their centre, except on the madreporite, where the gonopore lies near the abapical margin. The ocular plates are trigonal to pentagonal in outline and bear a small rounded ocular pore near their abapical margin. The central suranal plate has a pentagonal outline (Fig. 4 a). **Ambulacra:** The ambulacra are slightly undulating in width and are about one quarter of the interambulacra at the ambitus. They consist of small bigeminate plates bearing one small imperforate, crenulate marginal tubercle and several smaller inner tubercles. The two pore pairs are oblique P2 isopores (SMITH, 1978).

Interambulacra: One large, crenulate, imperforate primary tubercle with an undercut globular mamelon and prominent boss on each plate. The primary tubercles take up most of the space on the interambulacral plates, therefore the scrobicular rings are discontinuous. On the oral surface, the primary tubercles are less prominent.

Peristome: The peristome is subcircular in shape, 5.2 mm wide in the investigated specimen (= 34.4% of test diameter) and the area around it is depressed. The gill slits are broad but shallow and surrounded by a low rim.

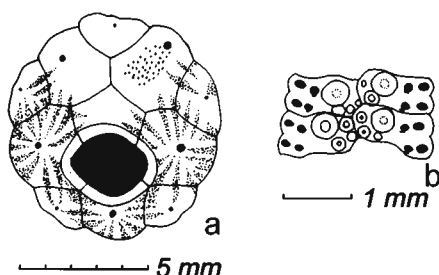


Fig. 4: *Hyposalenia heliophora* (AGASSIZ & DESOR, 1846); a–b: NHMW 2000z0096/0049 from Haidhof, Lower Austria. a: apical disc, b: ambital ambulacrum.

Periproct: The periproct lies slightly eccentric within the apical system on the aboral side of the test. It is situated between the apex and genital plate 5. It is rather large (3.5 mm wide), has an oval to rounded triangular outline and is surrounded by a distinct rim.

Dimensions:	Diameter	TH
NHMW 2000z0096/0049	15.1 mm	8.0 mm

Remarks: The present specimen corresponds fairly well to the description of *Hyposalenia heliophora* given by GEYS (1982). The only difference to GEYS's specimens is that the apical disc has a smaller diameter relative to the overall test diameter. This can be explained by the fact, that the latter were distinctly smaller (test diameter ranging between 1.7 and 12 mm). GEYS observed a tendency for the test to become flatter and the relative size of the apical disc to reduce with age. This species is easily recognised by its ornamented apical disc and the bigeminate ambulacral plating.

Occurrence: Coralline algal limestone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria). Danian Tuffaceous Chalk at Ciply, Hainaut, Belgium (AGASSIZ & DESOR, 1846); Siwak Formation, Early – Middle Danian, Gora Pulawska, Poland (KONGIEL, 1939); Danian Geulhem Chalk, Houthem Formation near Maastricht, The Netherlands (GEYS, 1982; VAN DER HAM, 1988; JAGT, 2000); Late Danian to Thanetian of Mangyshlak, Kazakhstan and Tadzikistan (SMITH & JEFFERY, 2000).

Cohort Irregularia LATREILLE, 1825

Order Holoctypoida DUNCAN, 1889

Family Conulidae LAMBERT, 1911

Genus *Adelopneustes* GAUTHIER, 1889

Diagnosis: Conulids with pyrinoid ambulacral plating orally and simple plating adorally. Periproct inframarginal and subcircular to oval in shape; Peristome oblique, elongated along the 2-V axis.

Adelopneustes boehmi (NIETSCHE, 1921)

Figs. 5, 6; Pl. 2; Figs. 1–2

1921 *Globator böhmi*. – NIETSCHE: 44; pl. 10, figs. 14–15, 17a–c

1926 *Globator ravni*. – BRÜNNICH NIELSEN: 13, fig. 6

- 1927 *Globator ravni* BRÜNNICH NIELSEN. – RAVN: 322; fig. 3; pl. 1, figs. 8 a–c
 1935 *Pygorrhynchus ovalis* RAVN. – SMISER: 47; pl. 4, figs. 7 a–d
 1935 *Pygorrhynchus conicus*. – SMISER: 48; pl. 4, figs. 9 a–d
 1935 *Pygorrhynchus houzeaui* COTTEAU. – SMISER: 48; pl. 4, figs. 8 a–d
 1960b *Globaster ravni* BRÜNNICH NIELSEN. – KÜHN: 164
 1980b *Neoglobator insolitus*. – ENDELMAN: 97; pl. 1, fig. 4; text-fig. 2 a–d
 1987 '*Pygopyrina*' *ovalis* (SMISER). – VAN DER HAM et al.: 27; pl. 8, fig. 9
 1988 '*Pygopyrina*' *ovalis* (SMISER). – VAN DER HAM: 150; pl. 7, figs. 5–8
 2000 *Adelopneustes boehmi* (NIETSCH). – SMITH & JEFFERY: 150; figs. 63 D–E, 64 C

Material: 2 specimens (NHMW 2000z0096/0046, 2000z0096/0047).

Description: Size and shape: Test small, 26.8 and 28.8 mm TL in the investigated material, outline subcircular with a rounded anterior margin, posterior margin rounded to bluntly pointed. The maximum width lies subcentrally. In profile, the test is high, globular with a tumid ambitus. Both aboral and oral surface are strongly convex. The maximum height lies subcentrally. Test length and width nearly equal, the test height is 58 to 66% of TL.

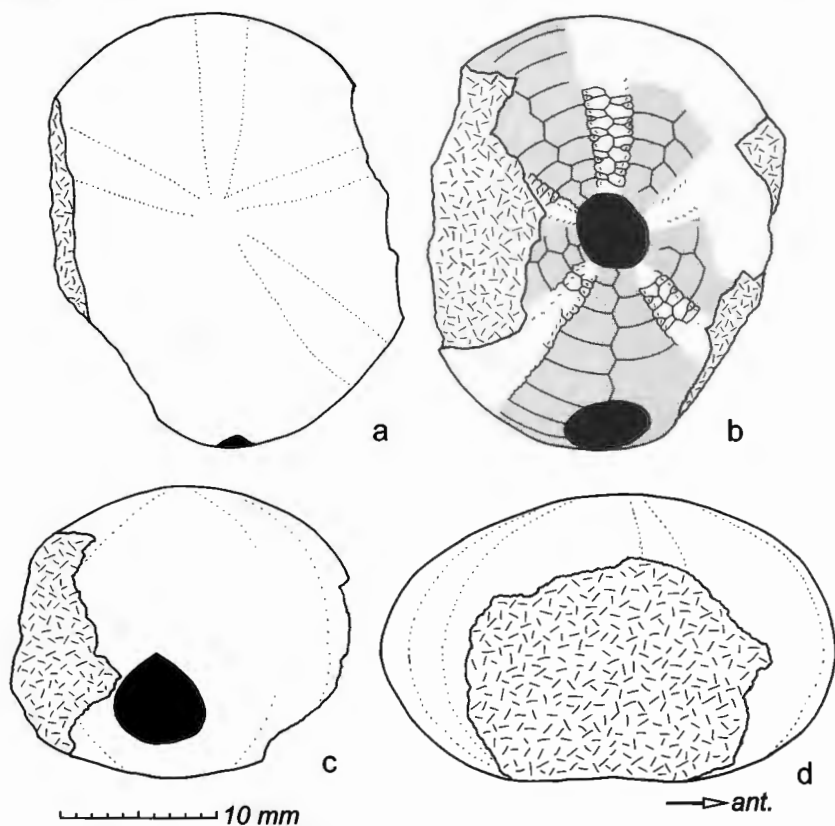


Fig. 5: *Adelopneustes boehmi* (NIETSCH, 1921); a–d: NHMW 2000z0096/0046 from Brudern-dorf, Lower Austria. a: aboral view, b: oral view, interambulacra shaded, c: view of posterior end, d: right lateral view.

Apical disc: The apical disc lies subcentrally to slightly anterior of the centre. It is not well preserved in either of the specimens studied.

Ambulacra: The ambulacra are nonpetaloid on the aboral side of the test. They consist of two straight rows of small partitioned isopores with an axially positioned neural canal. The poriferous zones are slightly depressed. The interporiferous zones are up to 8 times as wide as a single poriferous zone, slightly inflated and covered with primary and secondary tubercles similar to those on the interambulacra. Adorally the ambulacra are very slightly depressed around the peristome, no phyllodes are present. The ambulacral plating is simple on the aboral side of the test, at the ambitus it changes to a triad pattern (Fig. 6).

Interambulacra: The interambulacra are more or less flush with the interporiferous zones of the ambulacra on the aboral side. On the oral side they are slightly inflated between the ambulacra. The interambulacra are loosely covered by perforate, crenulate primary tubercles with slightly sunken areoles. Secondary and miliary tuberculation are relatively dense.

Peristome: The peristome is situated centrally on the oral side of the test and has an oblique oval shape, elongated along the 2-V axis. It is relative large with a mean diameter of about 4 mm in the specimens studied.

Periproct: The periproct lies inframarginally to marginally in interambulacrum 5 (Figs. 5 b-c). Its shape is subcircular to oval with a pointed adapical margin. It is larger than the peristome and has a mean diameter of about 5 mm.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0046	26.8 mm	–	17.9 mm
NHMW 2000z0096/0047	28.8 mm	>26 mm	~16.7 mm

Remarks: The studied specimens are not very well preserved. Nevertheless they show all features necessary to identify them with *Adelopneustes boehmi*. This species differs from *A. montainvillensis* by its more rounded, higher profile and the slightly more posterior position

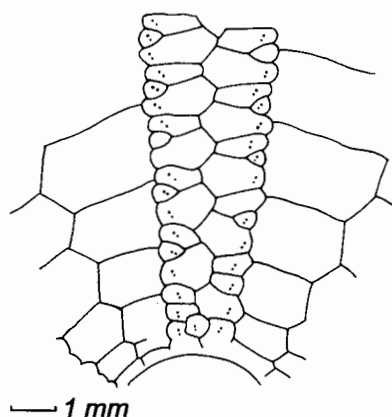


Fig. 6: *Adelopneustes boehmi* (NIETSCH, 1921); Detail of the adoral part of ambulacrum III of NHMW 2000z0096/0046 from Bruderndorf, Lower Austria; note the pyrinid plating.

of the periproct, which is, however, still subambital and visible from beneath. This species was placed into the genus by SMITH & JEFFERY (2000), who concluded, after a revision, that *Globator* is characterised by pyrinoid ambulacral plating from the apex to the peristome and peristome obliquity along the 3-I axis, whereas *Adelopneustes* shows simple ambulacral plating adapically and peristome obliquity along the 2-V axis. Furthermore, the genus *Neoglobator* ENDELMAN (1980a) was placed into the synonymy of *Adelopneustes* by them.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof and Bruderndorf (Lower Austria). Late Maastrichtian of Grimme, northern Germany (NIETSCH, 1921); Middle Danian of Saltholm, Aashøj and Faxe, Denmark (RAVN, 1927); "Poudigue de la-Malonge", Early Danian of Ciply, Belgium (SMISER, 1935); "Montian" (Late Danian – Selandian) of Mangyshlak, Kazakhstan (ENDELMAN, 1980a); Geulhem Chalk, Early Danian of the Maastricht area, The Netherlands and Belgium (VAN DER HAM, 1988; JAGT, 2000).

Adelopneustes montainvillensis (SORIGNET, 1850)

Figs. 7, 8; Pl. 2; Figs. 3–7

- 1850 *Pyrina montainvillensis*. – SORIGNET: 40
1857 *Pyrina montainvillensis* SORIGNET. – DESOR: 191
1875 *Pyrina houzeau*. – COTTEAU: 64; pl. 19, figs. 8–12
1889 *Adelopneustes lamberti*. – THOMAS & GAUTHIER in GAUTHIER: 53; pl. 3, figs. 19–24
1927 *Pseudopyrina subovalis*. – RAVN: 319; pl. 1, figs. 4 a–d; text-fig. 1
1927 *Pseudopyrina subcircularis*. – RAVN: 321; pl. 1, figs. 5 a–c, 6a–c; text-fig. 2
1960b *Pseudopyrina subovalis* Ravn. – KÜHN: 164
1965 *Pygopyrina houzeau* (COTTEAU). – MEIJER: 24; fig. 1
1980a *Neoglobator panteleevi*. – ENDELMAN: 97; pl. 1, figs. 1–6
1980b *Neoglobator danicus*. – ENDELMAN: 93; pl. 1, figs. 1–3; text-fig. 1a
1988 '*Pygopyrina*' *houzeau* (COTTEAU). – VAN DER HAM: 150; pl. 7, figs. 1–4
2000 *Adelopneustes montainvillensis* (SORIGNET). – SMITH & JEFFERY: 149; figs. 63 A–B, 64 A–B, D

Material: 5 specimens: 3 in the Zapfe coll. (NHMW 1997z0178/0411a–b, 1997z0178/0409) and 2 in the NHMW coll. (NHMW 2000z0096/0051, 2000z0096/0052).

Description: Size and shape: Test small, ranging from 20.4 to 26.0 mm TL in the investigated material, outline of the test is oval, anteroposteriorly elongated. Anterior margin rounded, posterior margin rounded to slightly bluntly pointed. The maximum width lies subcentrally. In profile the test is low domed and has a tumid ambitus. The oral surface is moderately convex, only around the peristome is it slightly concave. Test width about 93 to 94% of TL, test height about 54 to 60%.

Apical disc: The apical disc lies subcentrally, is tetrabasal with 4 large gonopores and 5 small ocular pores (Fig. 8a). The madreporite bears relatively few pores.

Ambulacra: The ambulacra are nonpetaloid on the aboral side of the test. They consist of two straight rows of small, oblique partitioned isopores with an axially positioned neural canal. The pores are very small and well visible only in intensely weathered specimens (Fig. 7). The interporiferous zones are up to 8 times as wide as a single poriferous zone, slightly inflated and covered with primary and secondary tubercles similar to those on the interambulacra. Adorally the ambulacra are very slightly depressed around the peristome, no phylloides are present. The ambulacral plating is simple on

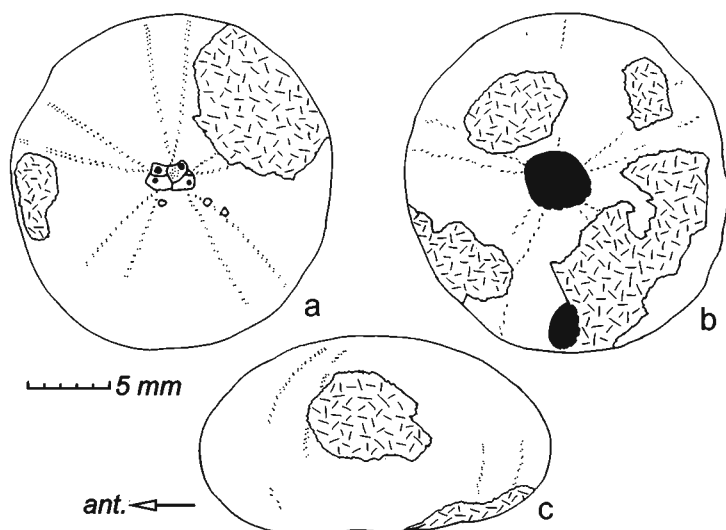


Fig. 7: *Adelopneustes montainvillensis* (SORIGNET, 1850); a–c: NHMW 1997z0178/0411b from Haidhof, Lower Austria. a: aboral view, b: oral view (peristome and periproct not fully preserved, where the outline is reconstructed, it is hatched), c: left lateral view.

the aboral side of the test, at the ambitus it changes to a triad pattern (Fig. 8b). Interambulacra: The interambulacra are more or the less flush with the ambulacra on the aboral side. On the oral side they are slightly inflated between the ambulacra. The interambulacra are loosely covered by perforate, crenulate primary tubercles with slightly sunken areoles on the aboral side. Secondary and miliary tuberculation are relatively dense. On the oral side the primary tubercles are slightly larger and more closely spaced. Peristome: The peristome is slightly sunken and situated centrally. It has an oblique oval shape, elongated along the 2-V axis and its largest diameter ranges from 3.2 to 5 mm in the material studied.

Periproct: The periproct lies inframarginally in interambulacrum 5 and has a an oval, vertically elongated shape. It is slightly larger than the peristome.

Dimensions:	TL	TW	TH
NHMW 1997z0178/0411a	21.1 mm	19.7 mm	12.2 mm
NHMW 1997z0178/0411b	20.4 mm	19.0 mm	11.6 mm
NHMW 1997z0178/0409	26.0 mm	24.5 mm	15.6 mm
NHMW 2000z0096/0051	23.6 mm	21.9 mm	12.8 mm
NHMW 2000z0096/0052	24.0 mm	22.6 mm	11.5 mm

Remarks: The described specimens belong to the species *Adelopneustes montainvillensis*, they correspond fairly well to the description and figures given by Ravn (1927) for *Pseudopyrina subovalis*. SMITH & JEFFERY (2000) revised *P. subovalis* and placed it, along with several other species, in the synonymy of *A. montainvillensis*.

This species differs from other species of *Adelopneustes* by its flatter base and more

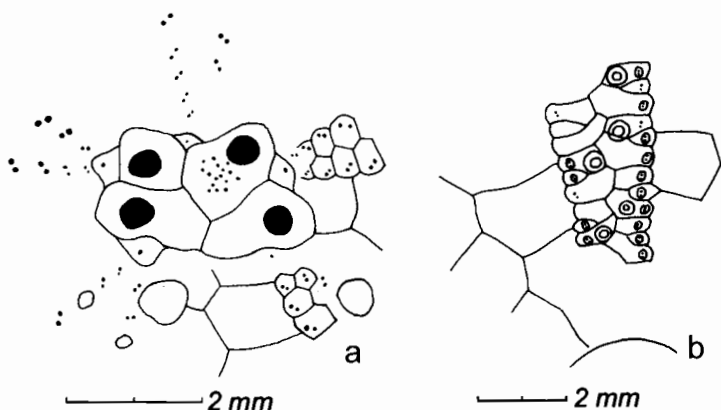


Fig. 8: *Adelopneustes montainvillensis* (SORIGNET, 1850); a: apical disc of NHMW 1997z0178/0411b; b: adoral plating of ambulacrum III of NHMW 2000z0096/0051; both from Haidhof, Lower Austria.

circular peristome. It can, further, be distinguished from *A. boehmi* by its lower profile and slightly less posterior position of the periproct.

The present species is similar to the species *Adelopneustes ernsti* SMITH & GALLEMÍ, 1999 (in SMITH et al., 1999) from the Late Thanetian of Navarra, Spain, which differs from this species by its rudimentary ambulacral pores and a much more sunken peristome.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria); Uppermost Senonian, Guelaat es snam, Tunisia (GAUTHIER, 1889); Late Danian of Aggersborggaard, Denmark (RAVN, 1927); Early and Late Danian of Mangyshlak, Kazakhstan, the Crimea peninsula and the southern Caucasus (ENDELMAN, 1980a, b); Middle Danian, Calcaire de Meudon, Paris Basin, France (ROMAN, 1989); Danian Geulhem Chalk of the Maastricht area, The Netherlands and Belgium (VAN DER HAM, 1988; JAGT, 2000).

Adelopneustes aff. *akkajensis* (ENDELMAN, 1980)

Figs. 9–11; Pl. 3, Figs. 1–3

?1980b *Neoglobator akkajensis*. – ENDELMAN: 99; pl.1, figs. 5 a–d, 6; text-fig. 1b, 3 a–c

Material: 2 specimens: 1 in the NHMW coll. (NHMW 2000z0096/0048) and 1 in the K. Weiss coll., Vienna (no registration no.).

Description: Size and shape: Test small, between 13.4 and 16.2 mm TL in the investigated material, with a subcircular, slightly anteroposteriorly elongated outline, a rounded anterior and a bluntly pointed posterior margin. The maximum width lies subcentrally. In profile the test is hemispherical to slightly domed with a tumid ambitus, which is situated low on the test. The posterior end is obliquely truncated (Figs. 9 c, 10 d). The oral surface is flattened. Test width is 95 to 96% and the test height 58 to 61% TL in the specimens studied.

Apical disc: The apical disc lies slightly anterior of the centre, about 45% of test length away from the anterior margin. It is tetrabasal with 4 large gonopores and very small ocular pores (Figs. 9 d, 11 b).

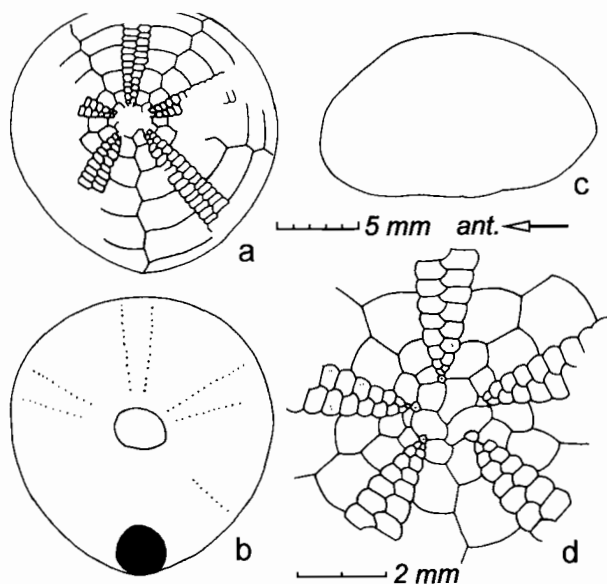


Fig. 9: *Adelopneustes* aff. *akkajensis* (ENDELMAN, 1980).; a-d: NHMW 2000z0096/0048 from Haidhof, Lower Austria. a: aboral view, b: oral view, c: left lateral view, d: apical disc.

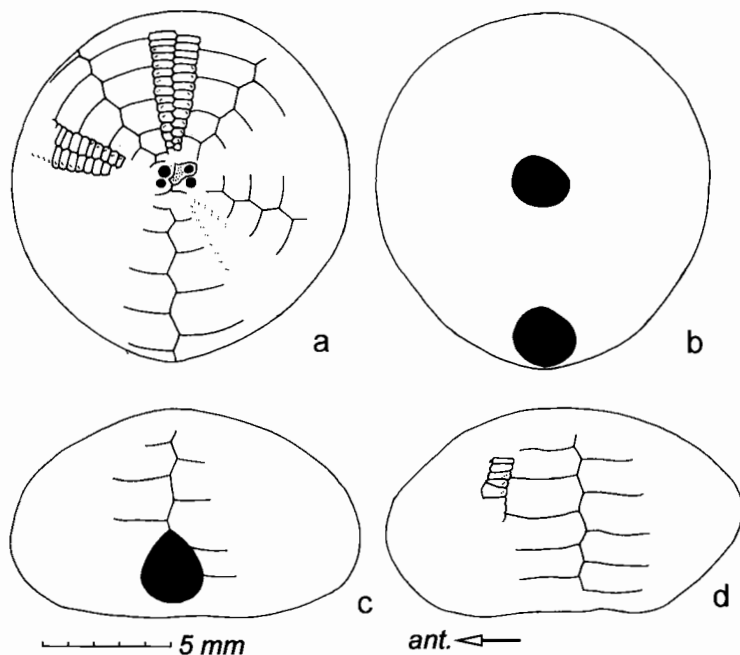


Fig. 10: *Adelopneustes* aff. *akkajensis* (ENDELMAN, 1980); a-d: specimen in the K. Weiss colln. (Vienna), from Haidhof, Lower Austria. a: aboral view, b: oral view, c: view of the posterior end, d: left lateral view.

Ambulacra: On the aboral side the ambulacra are nonpetaloid, pores are very small, oblique and double pores (partitioned isopores?) running in uniserial series from the apex to the peristome. The obliqueness of the ambulacral pores increases from the apex towards the peristome, where they are nearly parallel to the axis of the ambulacra. On the oral side of the test, the ambulacra are very slightly depressed around the peristome. No phyllodes are present. The ambulacral plating is simple on the aboral side, whereas on the oral side the ambulacral plating is partly pyrinoid (below the ambitus) and simple again near the peristome (Fig. 11a).

Interambulacra: The interambulacra are smooth and flush with the ambulacra on the aboral side of the test. They are sparsely covered with crenulate, perforate primary tubercles, which are slightly denser on the oral side. Secondary and miliary tubercles were not observed, maybe on account of the weathering of the specimens.

Peristome: The peristome lies subcentrally and has an oblique oval shape, elongated along the 2-V axis. Its largest diameter is about 2 mm in the specimen of K. Weiss.

Periproct: The periproct lies inframarginally in interambulacrum 5. It is teardrop-shaped with tapering upper margin. It is larger than the peristome (3.9 mm long and 2.8 mm wide in specimen NHMW 2000z0096/0048).

Dimensions:	TL	TW	TH
NHMW 2000z0096/0048	16.2 mm	15.6 mm	9.4 mm
Specimen of K. WEISS	13.4 mm	12.7 mm	8.2 mm

Remarks: The present specimens are similar to *A. akkajensis* (ENDELMAN, 1980b) from the Early Eocene of the Crimea. They differ, however, from this species by their more circular outline, lower profile; their ambitus, which lies slightly higher on the test and the rounded ends of their peristome. Unfortunately the intraspecific variation of *A. akkajen-*

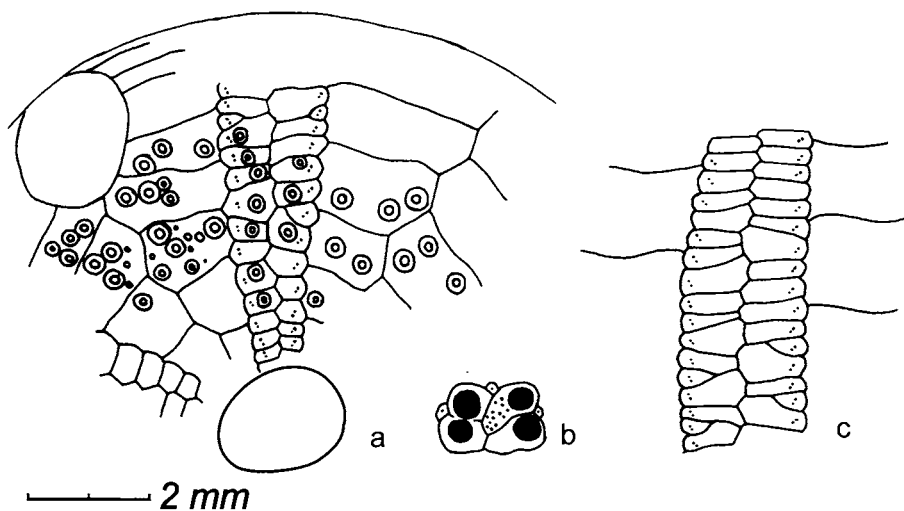


Fig. 11: *Adelopneustes* aff. *akkajensis* (ENDELMAN, 1980); a–c: specimen in the K. Weiss colln. (Vienna), from Haidhof, Lower Austria. a: adoral plating of ambulacrum I, b: apical disc, c: ambital ambulacrum IV.

sis is not known since the description of ENDELMAN (1980b) is based on 2 well preserved and a few poorly preserved specimens only.

This species differs from the other two species of *Adelopneustes* considered here by its flattened oral side, its obliquely truncated posterior end and its ambitus, which lies low on the test.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria).

Order Cassiduloida CLAUS, 1880

Family Pygaulidae LAMBERT, 1905

Genus *Plagiochasma* POMEL, 1883

Diagnosis: Small anteroposteriorly elongated test; semipetaloid ambulacra; large tear-drop-shaped supramarginal periproct; oblique peristome.

Plagiochasma cruciferum (MORTON, 1830)

Figs. 12–14; Pl. 3, Figs. 4–8

- 1830 *Ananchytes cruciferus*. – MORTON: 245
1834 *Nucleolites crucifer* (MORTON). – MORTON: 75; pl. 3, fig. 15
1855 *Trematopygus analis*. – D'ORBIGNY: 383; pl. 952, figs. 1–10
1857 *Nucleolites analis* AGASSIZ. – DESOR: 262
1857 *Nucleolites crucifer* (MORTON). – DESOR: 262
1875 *Nucleolites analis* DESOR. – COTTEAU: 651; pl. 20, figs. 1–5
1898 *Lychnidius scrobiculatus* (GOLDFUSS). – LAMBERT: 162; pl. 5, figs. 17–22
1898 *Lychnidius analis* AGASSIZ. – LAMBERT: 164
1915 *Trematopygus cruciferus* (MORTON). – CLARK in CLARK & TWITCHELL: 71; pl. 27, figs. 3 a–c; pl. 28, figs. 1 a–f
1926 *Pyrina freuchenii* DESOR. – BRÜNNICH NIELSEN: 13
1927 *Pseudopyrina freuchenii* (DESOR). – RAVN: 318–319; pl. 1, fig. 1–3
1935 *Trematopygus analis* AGASSIZ. – SMISER: 45; pl. 4, figs. 5 a–g
1959 *Rhopostoma cruciferum* (MORTON). – COOKE: 26; pl. 7, figs. 1–4
1965 *Plagiochasma analis* (AGASSIZ). – MEIJER: fig. 1
1987 *Plagiochasma analis* (DESOR). – VAN DER HAM et al.: 29; pl. 10, fig. 5
1988 *Plagiochasma analis* (DESOR). – VAN DER HAM: 154; pl. 8, figs. 1–3
1989 *Rhopostoma cruciferum* (MORTON). – MCKINNEY & OYEN: 14
2000 *Plagiochasma cruciferum* (MORTON). – SMITH & JEFFERY: 163; fig. 66 D–H

Material: 5 specimens: 1 in the Zapfe coll. (NHMW 1997z0178/0412), 2 in the NHMW coll. (2000z0096/0044, 2000z0096/0045) and 2 in the Karl Weiss coll., Vienna (no registration nos.).

Description: Size and shape: Test small, with TL ranging from 16.5 to 19.2 mm in the investigated material, an oval, anteroposteriorly elongated outline. The maximum width lies subcentrally. Anterior margin rounded, posterior margin rounded to bluntly pointed. In profile the test is low arched and has a tumid ambitus. The maximum height lies halfway between the apical disc and the centre of the test. Test width is about 82 to 86% of TL, test height about 55 to 61%.

Apical disc: The apical disc lies anterior of the centre, about 35% of TL away from the anterior margin. It is tetrabasal, has 4 large gonopores, of which the anterior pair is

slightly smaller, and five small ocular pores. The madreporite is relatively large and separates genital plates 1 and 4, as well as the ocular plates I and V (Fig. 13 b). In some specimens, however, ocular plates I and V remain in contact with each other. Ambulacra: The ambulacra are semipetaloid and consist of straight rows of weakly conjugated isopores. Ambulacra I and V are slightly flexed laterally. Towards the test margin of the test the pore pairs become smaller, increasingly oblique and the interporal area becomes smaller and more depressed. At the ambitus the pore pairs are nearly vertically oriented, rather small and well conjugated with a very short interporal partition. The interporiferous zones are about 2 to 3 times as wide as a single poriferous zone adapically and widen towards the margin. They are covered by tubercles similar to those on the interambulacra. Adorally the ambulacra form weakly developed phyllodes consisting of small, depressed, conjugate isopores (Figs. 13 c, 14 a-c). The ambulacral plating

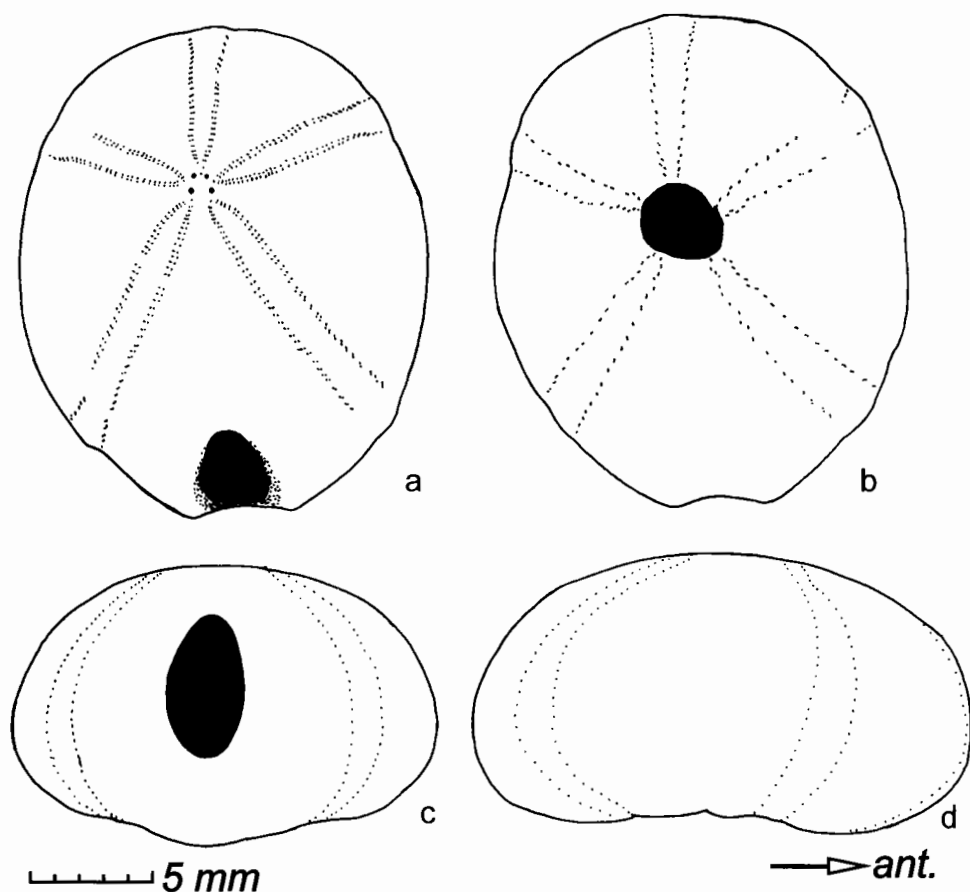


Fig. 12: *Plagiochasma cruciferum* (MORTON, 1830); a-d: NHMW 2000z0096/0044, from Haidhof, Lower Austria. a: aboral view, b: oral view, c: view of the posterior end, d: right lateral view.

on the aboral side is simple, whereas on the oral side, especially near the peristome, a triad pattern is developed (Fig. 13 a).

Interambulacra: On the aboral side the interambulacra are flush with the ambulacra and densely covered with small, perforate, crenulate primary tubercles in sunken areoles. Secondary tubercles are loosely distributed between them. On the oral side the interambulacra are distinctly inflated between the ambulacra.

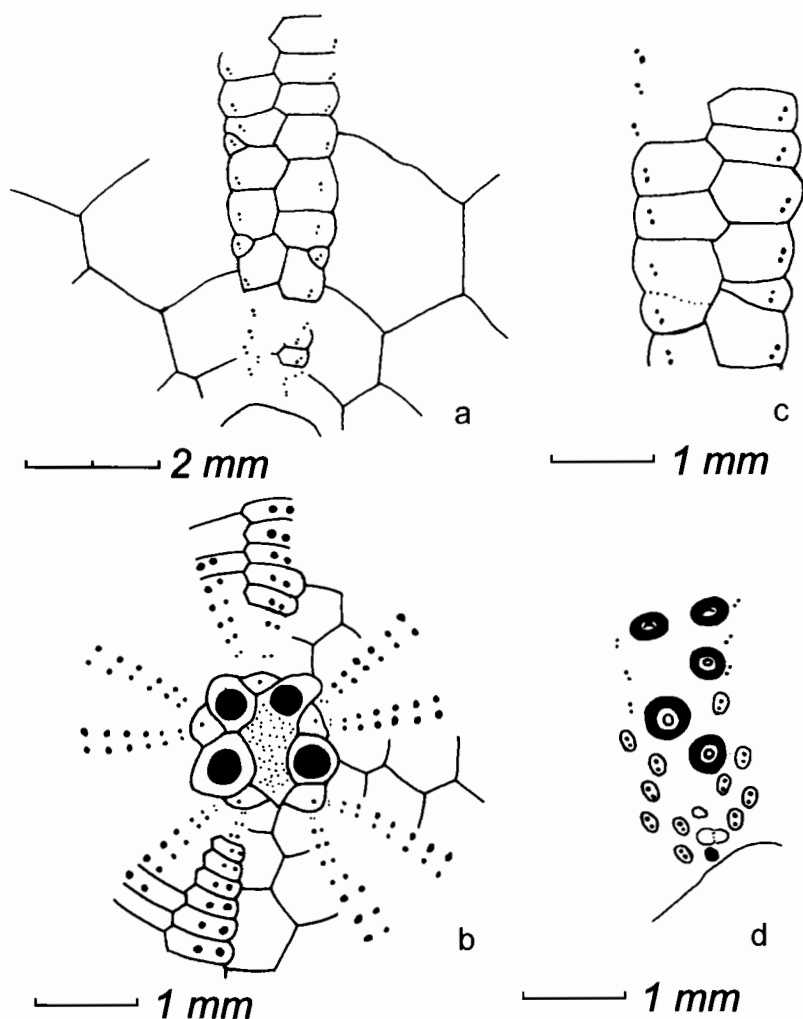


Fig. 13: *Plagiochasma cruciferum* (MORTON, 1830); a–b: NHMW 2000z0096/0044, from Haidhof, Lower Austria. a: adoral ambulacrum V, b: apical disc; c–d: NHMW 1997z0178/0412, from Haidhof, Lower Austria. c: ambital ambulacrum II, d: phyllode of ambulacrum IV.

Peristome: The peristome is situated slightly anterior of the centre. It is irregularly oval to trigonal in outline and deeply sunken. The largest diameter of the peristome ranges from 2.9 to 3.1 mm in the investigated material.

Periproct: The periproct is situated supramarginally in interambulacrum 5 and is clearly visible in aboral view (Figs. 12 a, c). It has a vertically elongated teardrop-shaped outline with its upper end bluntly pointed. It is 5.7 mm long and 2.8 mm wide in NHMW 2000z0096/0044.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0044	19.2 mm	16.0 mm	10.6 mm
NHMW 2000z0096/0045	17.6 mm	15.3 mm	9.9 mm
NHMW 1997z0178/0412	16.5 mm	13.5 mm	10.1 mm

Remarks: The specimens considered here correspond well to the descriptions and figures of *Plagiochasma cruciferum* by SMITH & JEFFERY (2000). Characteristic are the vertically elongated, teardrop-shaped periproct, the oblique peristome and the general shape of the test.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria). Middle Danian of Saltholm and Fakse, Denmark (RAVN, 1927); base of Poudingue de Malogne, Early Danian at Ciply, Belgium (SMISER, 1935); Late Thanetian Vincentown Sands of Timber (New Jersey, USA) (COOKE, 1959); Clayton Formation, Early Danian, Zone NP2 (McKINNEY & OYEN, 1989); Early Danian Geulhem Chalk of The Netherlands (VAN DER HAM et al., 1987; VAN DER HAM, 1988; JAGT, 2000); Danian and "Montian" (?= Selandian) of Kazakhstan (SMITH & JEFFERY, 2000).

Order Holasteroidea DURHAM & MELVILLE, 1957

Family Holasteridae PICTET, 1857

Holasteridae indet.

Fig. 15

Material: 1 specimen in the NHMW coll. (NHMW 2000z0096/0053).

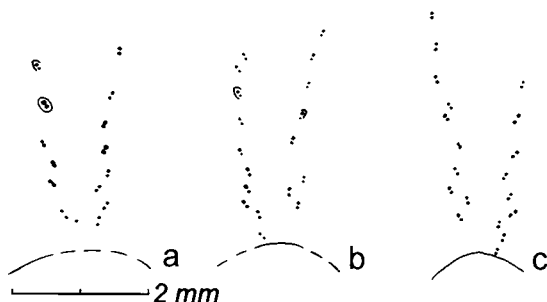


Fig. 14: *Plagiochasma cruciferum* (MORTON, 1830); a–c: NHMW 2000z0096/0044, from Haidhof, Lower Austria. a: phyllode of ambulacrum I, b: phyllode of ambulacrum II, c: phyllode of ambulacrum V.

Description: Size and shape: Test small to medium-sized, heart shaped and slightly elongated anteroposteriorly. The anterior margin is rounded with a shallow, broad frontal sinus. The posterior margin is bluntly pointed. The maximum width lies centrally. In profile the test is rectangular, with a rounded anterior and vertically truncated posterior end. The maximum height lies posterior of the centre along the interradi al suture of interambulacrum 5. Test width is 96.5% and test height 54.6% of TL in the specimen studied.

Ambulacra: The ambulacra seem to have been nonpetaloid on the aboral surface. They are neither sunken, nor inflated. Only ambulacrum III is slightly depressed at the ambitus, forming a broad, shallow frontal sinus. On the oral side ambulacrum III is moderately deep depressed, forming a broad groove between the ambitus and the peristome.

Interambulacra: The interambulacra are flush with the ambulacra on the aboral surface. On the oral surface, they are slightly inflated between the ambulacra. Interambulacrum 5 is slightly raised on the oral side.

Peristome: The peristome is oval and situated about 25% of TL away from the anterior margin.

Periproct: The periproct is situated marginally in interambulacrum 5.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0053	31.5 mm	30.4 mm	17.2 mm

Remarks: Although the specimen is quite weathered and has only faint remains of its original shell, it can be assigned to the family Holasteridae without doubt. An identification to species and genus level, however, is impossible.

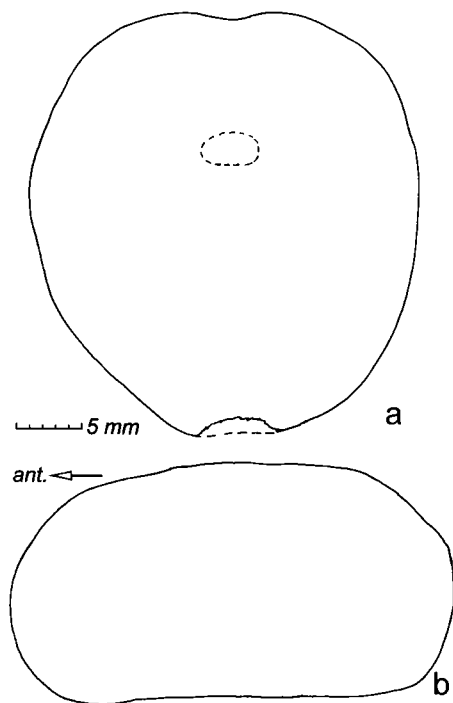


Fig. 15:
Holasteridae indet.; a-b: NHMW
2000z0096/0053 from Haidhof, Lower
Austria. a: oral view, b: left lateral view.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria).

Family Echinocoridae LAMBERT, 1917

Genus *Echinocorys* LESKE, 1778

Diagnosis: Test hemispherical to subconical with flat base; no frontal sinus. Apical system holasterid with 4 gonopores, situated centrally on the aboral side. Ambulacra non-petaloid with a large number of simple partitioned isopores on the aboral side. Periproct inframarginal; peristome oval, slightly sunken, near the anterior margin. Plastron meriosternous. No fascioles.

Remark: A large number of species has been assigned to the genus *Echinocorys*, most of them based on subtle differences in overall shape. Some morphotypes are very distinctive and may be useful in local biostratigraphy. There are, however, many intermediate forms and individual morphotypes occur at various times during the genus's range. Following VAN DER HAM et al. (1987) and SMITH et al. (1999), all forms are here assigned to a single species complex, *Echinocorys scutata* LESKE. The individual morphotypes are recognised as named formae.

Echinocorys scutata (LESKE, 1778)

1778 *Echinocorytes scutata*. – LESKE: 111; pl. 15, figs. a-b

2000 *Echinocorys scutata* (LESKE). – SMITH & JEFFERY: 280; text-fig. 120

Description: Size and shape: Test up to 100 mm in length, with rounded to oval, anteroposteriorly elongated, occasionally even subpentagonal outline. Anterior margin rounded, posterior margin rounded to bluntly pointed. The position of the maximum width varies slightly, most commonly it lies along the line adradial sutures 1/II–IV/4, less commonly along the line interradian sutures 1–4 (Lovenian numbers). The profile varies highly from low arched to highly domed forms, some are even conical. The maximum height lies around the apical system. The oral surface is usually flattened to slightly concave with the posterior portion of the plastron slightly inflated.

Apical disc: Situated centrally, elongated anteroposteriorly, with 4 medium sized gonopores and 5 small ocular pores.

Ambulacra: On the aboral side the ambulacra are nonpetaloid, straight and open, sometimes slightly inflated. The pores are partitioned isopores consisting of two round to oval pores in each pair, which have their long axis slightly tilted away from each other. Near the apex the pore pairs lie in the adoral-adradial edge of the ambulacral plates. Here they are small and have rounded pores. Towards the ambitus the pore pairs become larger, slightly oblique and have oval pores. Additionally, their position on the ambulacral plate changes, first they proceed towards the midpoint of the adoral suture and afterwards adapically until they reach the centre of the ambulacral plates. The interporiferous zones are up to 8 times as wide as a single poriferous zones and are sparsely covered with small perforate, crenulate primary tubercles and many miliary tubercles between them. The number of primary tubercles per ambulacral plate usually ranges from 0 to 4, no special arrangement or pattern could be observed. On the oral side the ambulacra I and V are slightly depressed and form broad periplastral areas, bearing miliary and secondary tubercles only. The ambulacral pores on the aboral side (excluding the phylloides) are very small partitioned

anisopores with interporal partitions in the form of a raised, rounded knob. Adorally the ambulacra form small phyllodes consisting of large, sunken partitioned anisopores with axially positioned neural canal. The adoral pore in each pair is larger than the aboral one. The interporal partition has the form of a highly raised wall, lying transverse to the axis of the pore pair. The number of pores in the phyllodes varies individually and with test size, but rarely exceeds four in each poriferous zone.

Interambulacra: The interambulacra are usually smooth and flush with the ambulacra. In some forms a moderately sharp keel is developed aborally in interambulacrum 5. On the aboral side the interambulacra are sparsely covered with small, perforate, crenulate primary tubercles, even on the large plates near the ambitus no more than 8 primary tubercles are often present. Many miliary tubercles are distributed between the primary tubercles. In contrast to those of the aboral side, the primary tubercles of the oral side are larger and much more densely crowded. Between them dense secondary and miliary tubercles are found. The labrum is short; the plastron is long, slightly inflated and meridosternous in structure.

Peristome: The peristome lies close to the anterior margin on the oral side of the test. It is strongly sunken with sloping walls around it and has a rounded to oval, transversely elongated shape.

Periproct: The periproct lies inframarginally near the posterior margin on the oral side of the test in interambulacrum 5. It is subcircular to oval, transversely elongate and usually as large as the peristome.

Remarks: The following four morphotypes are recognised in the material studied: forma *ovata* LESKE, 1778; forma *pyrenaica* SEUNES, 1888; forma A; forma B.

Echinocorys scutata forma *ovata* (LESKE, 1778)

Figs. 16, 17, 20 q-r; Pl. 4, Figs. 1-3; Pl. 5, Figs. 1-3

1778 *Echinocorytes ovatus*. – LESKE: 178, pl. 53, fig. 3

1930 *Echinocorys schafferi*. – KÜHN: 551; pl. 1, fig. 3

1930 *Echinocorys* nov. spec. – KÜHN: 551; fig. 15

1974 *Echinocorys sulcatus* (GOLDFUSS). – THENIUS: 57, fig. 12, nos. 12-13

1991 *Echinocorys schafferi*. – STÜRMER in STÜRMER et al.: 155

1991 *Echinocorys sulcatus*. – STÜRMER in STÜRMER et al.: 155

1998 *Echinocorys sulcatus* (D'ORBIGNY). – SCHULTZ: 44; p. 14, fig. 2

1999 *Echinocorys scutata* forma *ovata* LESKE. – SMITH et al.: 108; text-fig. 17a

Material: 89 specimens: 3 in the Ritter-Gulder coll. (no registration nos.), 4 in the Weinfurter coll. (IPUW 1992/3, 1992/23, 1992/26, 1992/35), 4 in the Zapfe coll. (NHMW 1997z0178/0405-0408), 2 in the Kühn coll. (NHMW 1930V7 and 1930V11), 10 registered specimens (NHMW 2000z0096/0056-58, 2000z0096/0062-68) and 66 additional, unregistered ones in the NHMW coll.

Description: Large form of up to 94 mm TL with an ovate outline, subconical in profile and varying from flat-topped to distinctly pointed. Test width ranges from 78.2 to 92.3% of TL (Mean: 85.3%) and test height ranges from 64.4 to 80.3% of TL (Mean: 72.2%). The ambitus is very low and rounded. A distinct, rounded keel is developed in aboral interambulacrum 5 of some specimens. Ambulacra simple with small pore pairs, which are rather dense adapically. In some specimens the ambulacra are inflated adapi-

cally. Oral surface flattened and slightly concave. Plastron slightly inflated posteriorly. A distinct rostrum is developed and the periproct lies entirely on the oral side.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0063	80.7 mm	67.6 mm	61.7 mm
NMHW 2000z0096/0064	94.3 mm	81.0 mm	62.7 mm
NHMW 1997z0178/0405	80.1 mm	62.8 mm	57.8 mm
NHMW 1997z0178/0406	79.0 mm	68.0 mm	55.7 mm

Remarks: Some of the specimens have inflated ambulacra adapically and their outline is thus slightly subpentagonal. They are also less distinctly ovate in outline. In this respect the specimens resemble *Echinocorys darderi* LAMBERT, 1935 from the Maastrichtian of Sierra de Bernia (Alicante, Spain), but the outline of LAMBERT's specimen is even more pentagonal.

The holotype of *Echinocorys schafferi* KÜHN, 1930 (NHMW 1930V11; Fig. 16 a-b), was also studied and no significant difference to the other specimens considered in this study and ascribed to *E. scutata* forma *ovata* could be detected. It does, however, belong to the group, that shows inflated ambulacra adapically. *Echinocorys* nov. spec. (NHMW 1930V7) mentioned by KÜHN (1930) is just a fragment of an *E. scutata* forma *ovata* (only the base being preserved).

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof, Klement and Bruderndorf (Lower Austria). Late Campanian to Early Maastrichtian of The Netherlands (VAN DER HAM et al., 1987); Maastrichtian of Bulgaria (TZANKOV,

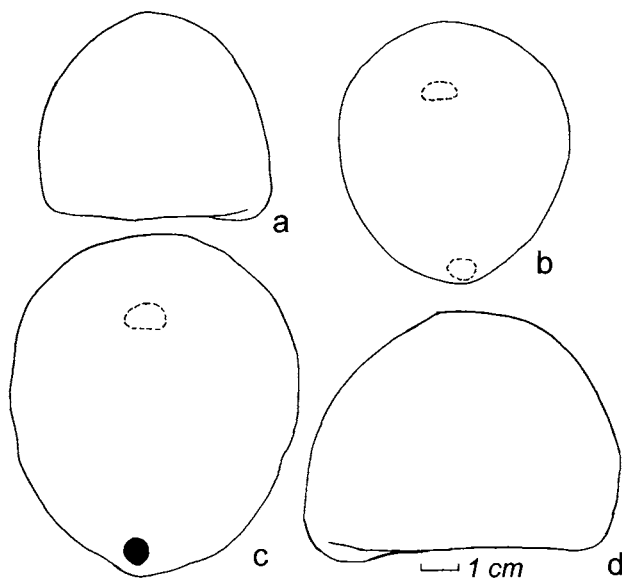


Fig. 16: *Echinocorys scutata* forma *ovata* (LESKE, 1778); a-b: NHMW 1930V11 (holotype of *Echinocorys schafferi* KÜHN, 1930a); a: left lateral view, b: oral view. c-d: NHMW 2000z0096/0062; c: oral view, d: right lateral view.

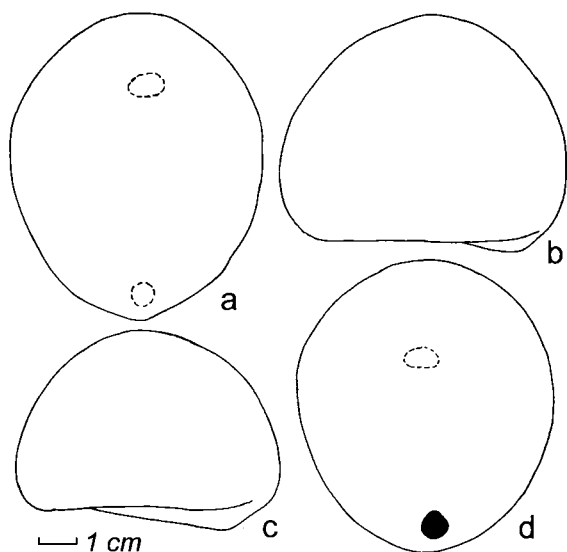


Fig. 17: *Echinocorys scutata* forma *ovata* (LESKE, 1778); a–b: NHMW 2000z0096/0057; a: oral view, b: left lateral view. c–d: NHMW 2000z0096/0056; c: left lateral view, d: oral view.

1982); Late Maastrichtian of Mangyshlak, Kazakhstan (JEFFERY, 1997); Maastrichtian of Santander, Cantabria and Sarasate, Navarra in Spain (SMITH et al., 1999).

Echinocorys scutata forma *pyrenaica* SEUNES, 1888
Figs. 18, 19, 20 a–j; Pl. 6, Figs. 1–5; Pl. 7, Figs. 1–5

- 1888 *Echinocorys pyrenaicus*. – SEUNES: 814; pl. 30, fig. 5; pl. 31, figs. 2 a–c
1927 *Echinocorys obliquus* [NIELSSON, MS]. – RAVN: 336; pl. 4, fig. 2 a–c; pl. 5; 2 a–c
1930 *Echinocorys sulcatus* (GOLDFUSS). – KÜHN: 549; pl. 1, fig. 2
1930 *Echinocorys* cf. *obliquus* (NIELSSON). – KÜHN: 549; pl. 1, fig. 4
1930 *Garumnaster lamberti*. – KÜHN: 552; pl. 1, figs. 6–7
1949 *Echinocorys obliquus* (NIELSSON). – KONGIEL: 18–20; pl. 5, fig. 7; pl. 6, figs. 4, 7–9; pl. 7, fig. 1–12; pl. 8, figs. 1–11; pl. 9, figs. 6–12; pl. 11, figs. 6–12; pl. 12, figs. 1–9
1960b *Garumnaster lamberti* KÜHN. – KÜHN: 164
1999 *Echinocorys scutata* f. *pyrenaica* SEUNES. – SMITH et al.: 109; fig. 17d

Material: 148 specimens: 4 in the Ritter-Gulder coll. (no registration nos.), 9 in the Weinfurter coll. (IPUW 1992/4, 1992/6, 1992/7, 1992/8), 11 in the Zapfe coll. (NHMW 1997z0178/0416), 3 from the Kühn coll. (NHMW 1930V6, 1930V9–10), 5 registered specimens (NHMW 2000z0096/0005, 2000z0096/0060, 2000z0096/0069–71) and 116 additional, unregistered ones in the NHMW coll.

Description: Small form of up to 54 mm (most commonly between 20 and 45 mm) TL with a rounded anterior margin and bluntly pointed posterior margin. The test is moderately arched to trigonal in profile. Test width ranges from 85.3 to 98.7% of TL (Mean: 91.5%) and test height ranges from 52.7 to 70.4% of TL (Mean: 62.1%). The

ambitus is situated low and is rounded. Ambulacra simple with small pore pairs, which are rather dense adapically. Oral surface flattened and slightly concave. Plastron distinctly inflated posteriorly. A distinct rostrum is developed and the periproct is inframarginal in position, but entirely on the oral side in almost all specimens.

Dimensions:	TL	TW	TH
NHMW 1997z0178/0416a	31.9 mm	27.2 mm	16.8 mm
NHMW 1997z0178/0416b	34.6 mm	31.8 mm	23.5 mm
NHMW 1997z0178/0416c	36.8 mm	32.7 mm	22.8 mm
NHMW 1997z0178/0416d	33.4 mm	30.2 mm	20.2 mm
NHMW 1997z0178/0416e	34.2 mm	32.2 mm	22.9 mm

Remarks: The specimens considered here are very similar to *Echinocorys pyrenaica* SEUNES, 1888, with the exception that their ambitus is slightly more rounded. The holotype of *Garumnaster lamberti* KÜHN, 1930 (NHMW 1930V9; Pl. 7, Figs. 4–5) also belongs to the genus *Echinocorys* and to the morphotype considered here. KÜHN (1930) placed his new species in the genus *Garumnaster* on account of a supramarginal periproct above a rostrum, nonconjugate pores, the lack of fascioles and the lack of a frontal sinus. His statement that the periproct lies supramarginally in his specimens is simply not true. A re-examination of the holotype (the only specimen of the four specimens he had at hand, which could be found in the NHMW) shows the periproct to be entirely on the oral side of the test (although it must be said that the specimen is not very well preserved). In fact, the specimen shows all the characteristic features of the genus *Echinocorys*, including the elongated apical system, which KÜHN (1930) stated to be only partially preserved and which in reality was only covered by a thin layer of sediment on its crushed posterior portion (Fig. 19 a). The specimens of *Echinocorys* cf. *obliqua* (NILSSON) (NHMW 1930V10) and *Echinocorys sulcata* (GOLDFUSS) (NHMW 1930V6) KÜHN (1930) reported from Bruderndorf, also belong to the morphotype considered here.

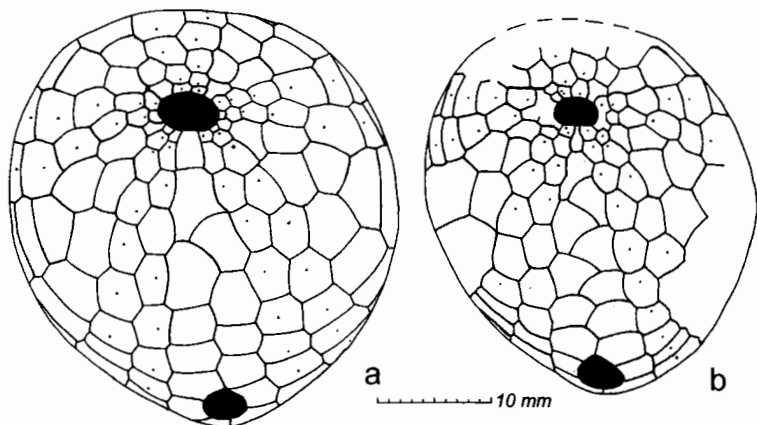


Fig. 18: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888: a–b: oral plating of specimen a: NHMW 2000z0096/0005 and b: NHMW 1997z0178/0416a; interambulacra shaded.

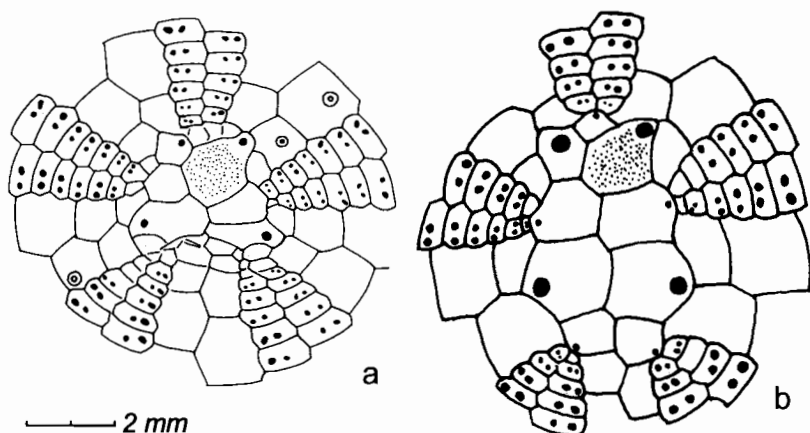


Fig. 19: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888; a: apical disc of NHMW 1930V9 (holotype of "*Garumnaster lamberti*" Kühn, 1930a; note the deformed posterior region); b: apical disc of NHMW 1997z0178/0416b (not deformed).

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof, Klement, Niederfellabrunn and Bruderndorf (Lower Austria). Danian at various localities in Denmark (RAVN, 1927); Danian of Erice, Navarra and Alfàs del Pi, Alicante, Spain (SMITH et al., 1999).

Echinocorys scutata forma A

Figs. 20 o–p; Pl. 8, Figs. 1–3

Material: One specimen in the Zapfe coll. (NHMW 1997z0178/0408).

Description: Medium-sized form with low arched profile, gently sloping anteriorly and posteriorly, and inflated ambitus. Test width about 93 % of TL, the test is nearly circular, but slightly anteroposteriorly elongated. Test height is about 53 % of TL. A slight keel is developed in aboral interambulacrum 5. Ambulacra simple with small pore pairs, which are rather dense adapically. Oral surface flattened, slightly convex (!). Plastron slightly inflated. Periproct not preserved.

Dimensions:	TL	TW	TH
NHMW 1997z0178/0408	63.4 mm	58.9 mm	37.1 mm

Remarks: The sole specimen shows sublethal predation scars in the posterior left side, probably caused by fishes. Since no *Echinocorys* species known to the author has such a low profile, and only a single specimen is available, it is left in open nomenclature.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria).

Echinocorys scutata forma B

Fig. 20 k–n

Material: Two specimens in the NHMW coll. (2000z0096/0059, 2000z0096/0061).

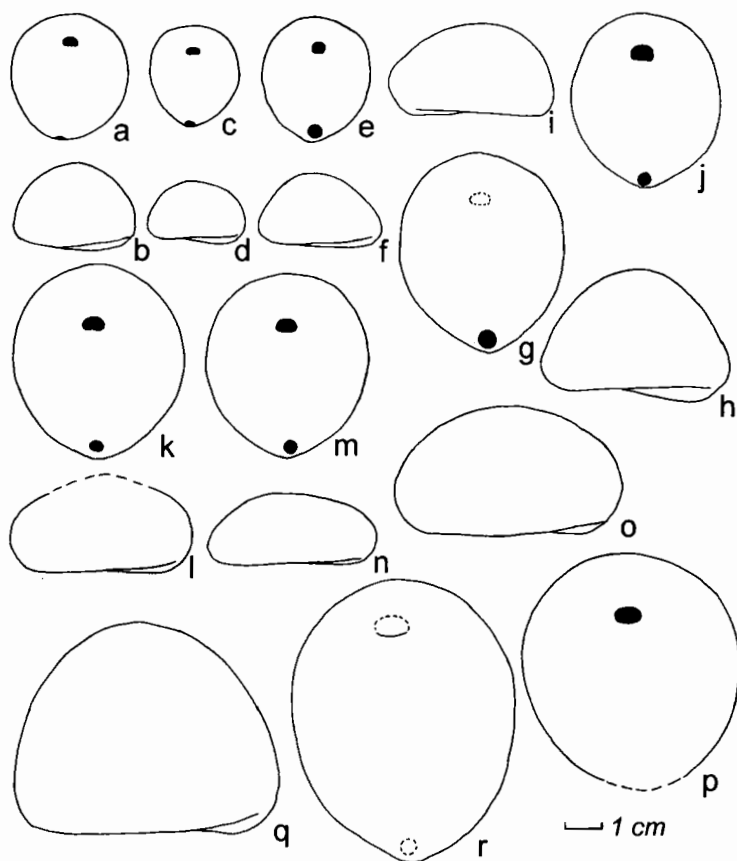


Fig. 20: Profiles and oral views of various *Echinocorys* morphotypes: a-j: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888 (a-b: NHMW 1997z0178/0416e, c-d: NHMW 1997z0178/0416f, e-f: NHMW 1997z0178/0416h, g-h: NHMW 1930V6, i-j: NHMW 2000z0096/60), k-n: *Echinocorys scutata* forma B (k-l: NHMW 2000z0096/0059, m-n: NHMW 2000z0096/0061), o-p: *Echinocorys scutata* forma A (NHMW 1997z0178/0408), q-r: *Echinocorys scutata* forma *ovata* (LESKE, 1778) (NHMW 2000z0096/0058).

Description: Medium-sized form of about 50 mm test length with an oval anteroposteriorly elongated outline and a low arched profile. The test width is about 90% of TL and test height ranges from about 40 to 50% of TL. The ambitus is rounded. Ambulacra simple with small pore pairs, which are rather dense adapically. Oral surface flattened and concave, with the peristome further removed from the anterior margin than in the other morphotypes of *Echinocorys*. Plastron slightly inflated posteriorly. Periproct entirely on the oral side.

Dimensions:

	TL	TW	TH
NHMW 2000z0096/0059	51.8 mm	47.1 mm	25.4 mm
NHMW 2000z0096/0061	49.6 mm	44.6 mm	19.8 mm

Remarks: The two specimens considered here are distinctly different from the other *Echinocorys* in the study area. They are flatter, their oral surface is more concave and their peristome is further removed from the anterior margin.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria).

Order Spatangoida CLAUS, 1876

Family Micrasteridae LAMBERT, 1920

Genus *Cyclaster* COTTEAU in LEYMERIE & COTTEAU, 1856

Diagnosis: Oval to coffin shaped outline, with or without frontal sinus. Apical disc ethmophract with 3 gonopores (madreporite without gonopore); sexual dimorphism of gonopore size common. Ambulacra petaloid; petals usually rather short and slightly sunken. Periproct marginal, rounded to vertically elongated; peristome near anterior margin, oval to kidney shaped, usually weakly labiate. Bilobed subanal fasciole present; complete or partial peripetalous fasciole present in most species, but may be absent altogether.

Cyclaster aturicus (SEUNES, 1888)

Figs. 21–23; Pl. 9, Figs. 1–6; Pl. 10, Figs. 1–4

1888 *Isopneustes aturicus*. – SEUNES: 797; pl. 28, figs. 3 a–b

1930 *Brissopneustes vindobonensis*. – KÜHN: 553; pl. 1, figs. 8–10

1930 *Brissopneustes* sp. – KÜHN: 554

1960b *Brissopneustes vindobonensis* KÜHN. – KÜHN: 164

1974 *Brissopneustes vindobonensis* KÜHN. – THENIUS: 57; fig. 12, no. 11

1991 *Brissopneustes vindobonensis*. – STÜRMER in STÜRMER et al.: 155

1998 *Cyclaster aturicus* (SEUNES). – JEFFERY: 150; figs. 2 d–f

1998 *Brissopneustes vindobonensis* KÜHN. – SCHULTZ: 44; pl. 14, fig. 5

1999 *Cyclaster aturicus* (SEUNES). – SMITH et al.: 124; figs. 31 c + 32 a–b; pl. 9, figs. 15–17

2000 *Cyclaster aturicus* (SEUNES). – SMITH & JEFFERY: 312; text-figs.: 130A–C

Material: 612 specimens: 39 from the Ritter-Gulder coll. (no registration nos.), 12 from the Weinfurter coll. (1992/2, 1992/5, 1992/13 and 1992/34), 45 in the Zapfe coll. (NHMW 1997z0178/0420, NHMW 1997z0178/0419), 3 in the Kühn coll. (holotype of *Brissopneustes vindobonensis* and 2 paratypes NHMW 1930V8), 10 registered specimens (NHMW 2000z0096/0003, 2000z0096/0042–43, 2000z0096/50 and 1985/80/1–6) and 507 additional, unregistered ones in the NHMW coll.

Description: Size and shape: Test of small to medium size, commonly between 22 and 34 mm long. It is coffin-shaped, elongated anteroposteriorly and with oval to rectangular outline. Anterior margin rounded to transversely truncated with shallow frontal sinus. Posterior margin bluntly pointed. Maximum width anterior of centre, along the line 1b–4a or 1b/IIa–IVb/4a (Lovenian numbers). In profile anterior part of the test arched, posterior margin vertically truncated. The maximum height lies posterior of the apical disc, centrally or slightly posterior of the centre on keel in interambulacrum 5. Test width is about 82 to 85% of TL, test height about 67 to 70%, in extreme cases up to 74%. Apical disc: The apical disc lies slightly anterior of the centre, is ethmophract and has 3 large gonopores (Fig. 23). The madreporite shows rather large pores and bears no

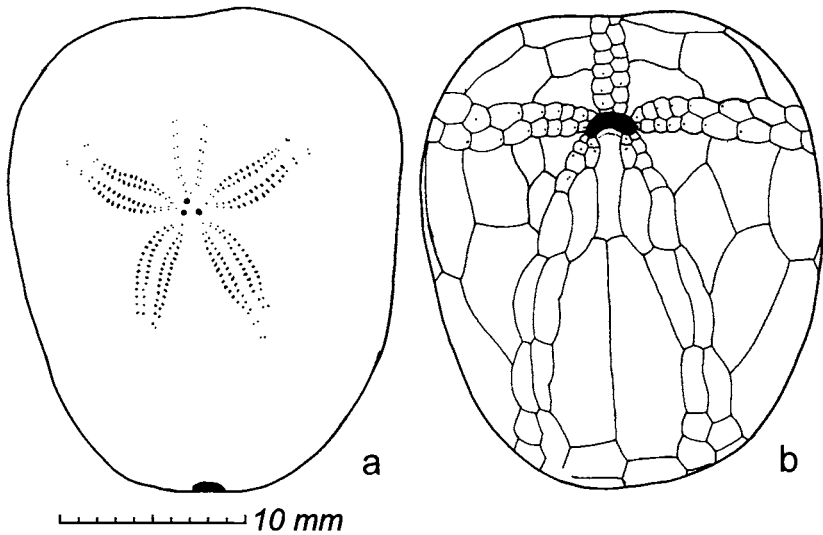


Fig. 21: *Cyclaster aturicus* (SEUNES, 1888); a–b: NHMW 2000z0096/0043 from Haidhof, Lower Austria. a: aboral side, b: oral side, interambulacra shaded.

gonopore. A distinct sexual dimorphism expressed in gonopore size can be observed in this species, as can be in many other species of this genus (HENDERSON, 1975; JAGT & MICHELS, 1990; JEFFERY, 1998; JAGT, 2000).

Ambulacra: Adapically all ambulacra are petaloid; the petals are depressed. The anterior paired petals are as long as, or slightly shorter, than the posterior ones. The anterior paired petals form an obtuse angle of about 120° , whereas the posterior ones form an acute angle of about 50° . The frontal petal is straight, slightly closing distally and compromised of oblique, partitioned isopores. The pore pairs consist of two rounded pores, subequal in size, which are separated by a small interporal partition in form of a rounded knob. Outside the petals the pores become smaller and less closely spaced. The interporiferous zone of the frontal petal is covered by secondary tubercles only and is up to five times as wide as a single poriferous zone. The paired ambulacra are distinctly petaloid, moderately closed distally and consist of closely spaced elongate isopores (SMITH, 1980). The pores in the adapical part of the anterior pore zones of petals II and IV are smaller than those of the posterior poriferous zones. Adjacent pore pairs are separated by narrow ridges, which bear a single row of a few secondary tubercles. The interporiferous zone is sparsely covered with secondary tubercles and up to two thirds, the width of a single poriferous zone. The paired petals are slightly flexed, the anterior pair anteriorly and the posterior pair posteriorly.

Adorally the ambulacra form small phyllodes consisting of oblique, large, sunken, partitioned isopores with axially positioned neural canal (at the perradial pore). The pores in each pair are roughly subequal in size and rounded. The interporal partition is a high ridge, which lies transverse to the axis of the pore pair. Around the pores a distinct sunken attachment zone is present. The interporiferous zones of the phyllodes are

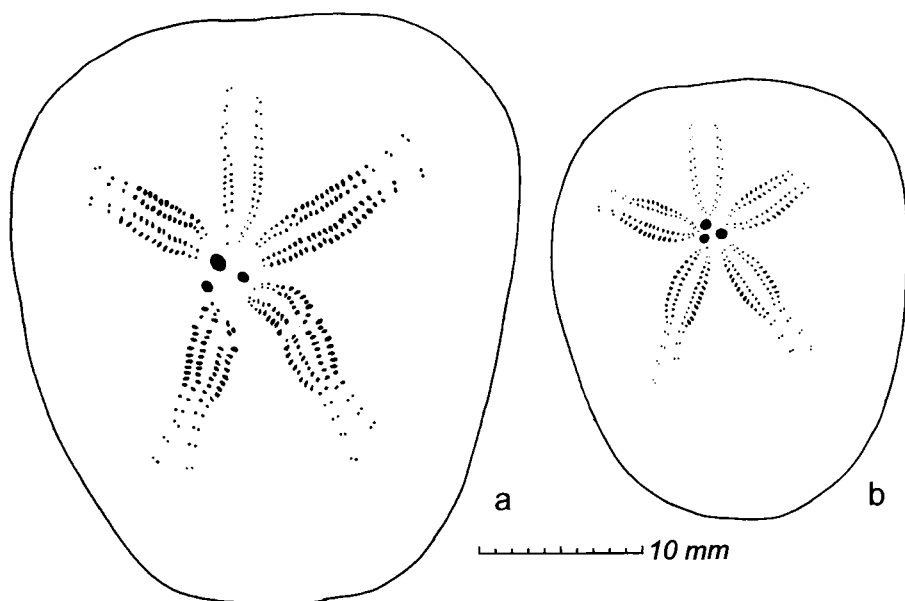


Fig. 22: *Cyclaster aturicus* (SEUNES, 1888); a: aboral view of NHMW 1985/80/3 from Haidhof, Lower Austria. a: aboral side, (note the abnormal development of the petals and the apical system caused by an injury of the posterior petals) b: aboral view of NHMW 2000z0096/0042 from Haidhof, Lower Austria.

covered by small secondary and miliary tubercles. Along the plastron ambulacra I and V form narrow periplastron areas, which are sparsely tuberculated with secondary and miliary tubercles and which bear very small slit-like unipores. Inside the subanal fasciole three to four large, oblique, partitioned isopores with axially positioned neural canal are present in ambulacra I and V. The interporal partition of these pores has the form of a large rounded knob.

Interambulacra: The interambulacra are slightly inflated between the petals. Interambulacrum 5 forms a distinct but not very sharp keel on the aboral side. The crenulate, perforate primary tubercles are widely spaced and have small, inclined areoles. The secondary tuberculation is very dense. The largest primary tubercles are found orally at the anterior margin, inside the subanal fasciole and on the plastron, where they form a

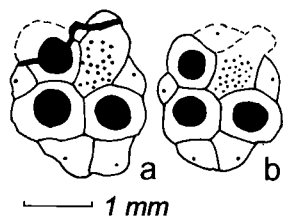


Fig. 23: *Cyclaster aturicus* (SEUNES, 1888); a: apical disc of IPUW 1992/2-1 (the thick dark line represents a fracture, which runs through the apical area of this specimen); b: apical disc of IPUW 1992/34-2, both from Haidhof, Lower Austria.

fan-shaped pattern radiating from the posterior end of the plastron. The labrum is long and slender and projects slightly over the peristome. The plastron is long and mesamphisternous.

Peristome: The peristome is situated near the anterior margin and lies about 18 to 21% of TL away from it. The peristome is oval, transversely elongated, surrounded by a small rim and usually 2.5 to 3.5 mm wide.

Periproct: The periproct is situated marginally in interambulacrum 5, circular to oval, vertically elongate and usually 2.5 to 3 mm in diameter.

Fascioles: The subanal fasciole has a bilobed shape and is an orthofasciole (sensu NÉRAUDEAU et al., 1998). The fasciole is moderately wide and well separated from the tuberculation of the remaining surface.

A peripetalous fasciole is usually absent; when present, it is incomplete, consisting of short fasciole bands running along the posterior paired petals. These small fasciole parts belong to the parafasciole type sensu NÉRAUDEAU et al. (1998).

Dimensions:	TL	TW	TH
NHMW 2000z0096/0003	34 mm	27.1 mm	24.8 mm
NHMW 2000z0096/0042	33.4 mm	28.3 mm	24.8 mm
NHMW 2000z0096/0043	24.1 mm	20.6 mm	17.6 mm

Remarks: The material is fairly uniform, only a few specimens being slightly different, in being higher, wider or longer than usual. However, since there are intermediate specimens, these forms are simply extreme morphotypes of this species. Additionally, a single specimen showing an abnormal development of the petals obviously caused by a injury of ambulacrum I (Fig. 22 a; Pl. 10, Fig. 4) was found among the studied material.

The material considered in this study corresponds fairly well to the description and figures given by SEUNES (1888) for *Isopneustes aturicus*. This species has later been placed in the genus *Cyclaster* by JEFFERY (1998), because *Isopneustes* POMEL, 1883, has 4 gonopores. *Cyclaster aturicus* (SEUNES) is characterised by its well defined petals; shallow but distinct frontal sinus; lack of a peripetalous fasciole in most of the specimens; keel in interambulacrum 5; the large divergence between the anterior paired petals and petals which are similar in length. These features separate *C. aturicus* from other species of *Cyclaster*.

The holotype and paratypes of *Brissopneustes vindobonensis* KÜHN, 1930 (NHMW 1930V8) are rather poorly preserved (KÜHN, 1930, Pl. 1, Fig. 8–10) but correspond very well to the description and figures of *Cyclaster aturicus* given by SEUNES (1888). Even a detailed examination of the type material of *B. vindobonensis*, as well as all the other specimens originating from the *locus-typicus* Bruderndorf (Lower Austria) did not reveal any specific difference to *C. aturicus*. Therefore, the species *Brissopneustes vindobonensis* KÜHN, 1930, is considered here a junior synonym of *Cyclaster aturicus*. The genus *Brissopneustes* COTTEAU, 1886, was placed in synonymy with the genus *Cyclaster* by JEFFERY (1998), since the distinction between these two genera was based on the presence/absence of a peripetalous fasciole, a feature which JEFFERY (1998) found to be not constant even within single species of these genera.

Cyclaster aturicus differs from *C. integer* (SEUNES, 1888) (= *C. danicus* (SCHLÜTER, 1897), compare SMITH & JEFFERY, 2000), a well known Danian form of Northern Europe by its longer petals, stronger divergence of the anterior paired petals, and the absent or incomplete peripetalous fasciole.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof, Klement, Niederfellabrunn and Bruderndorf (Lower Austria). Danian of the French and Spanish Pyrenees; Middle to Late Danian of the northern Caucasus and the Transcasian region; Danian of Georgia (COTTEAU, 1886; JEFFERY, 1998; SMITH et al. 1999).

Genus *Isaster* DESOR, 1858

Diagnosis: Test ovate, without frontal sinus, orally slightly flattened. Apical disc ethmophract with 3 gonopores (madreporite without gonopore). Ambulacra petaloid; petals only slightly sunken, with similar pores in all 5 petals. Periproct inframarginal; periproct oval, slightly labiate. No fascioles.

Isaster aquitanicus (GRATELOUP, 1836)

Fig. 24, Pl. 11, Figs. 1–4

- 1836 *Spatangus aquitanicus*. – GRATELOUP: 176; pl. 2, fig. 17
1853 *Epiaster aquitanicus* D'ORBIGNY. – D'ORBIGNY: 199; pl. 863, figs. 1–8
1856 *Epiaster aquitanicus* D'ORBIGNY. – LEYMERIE & COTTEAU: 347
1927 *Ismidaster toulai*. – BÖHM: 194; pl. 11, fig. 3
1960b *Isaster* nov. spec. – KÜHN: 164
1966 *Isaster aquitanicus* (GRATELOUP). – FISCHER: U554; figs. 438-1 a–e
1966 *Ismidaster toulai* BÖHM. – WAGNER & DURHAM: U530
1986 *Isaster aquitanicus* (GRATELOUP). – STOKES: 172, text-fig. 1–2
1996 *Isaster* sp. – WILMSEN et al.: fig. 7
1999 *Isaster aquitanicus* (GRATELOUP). – SMITH et al.: 124; figs. 33–34; pl. 9, figs. 18–21
2000 *Isaster aquitanicus* (GRATELOUP). – SMITH & JEFFERY: 317; text-fig. 132

Material: 8 specimens: 6 in the NHMW coll. (2000z0096/0032–37), 1 in the Weinfurter coll. (IPUW 1992/11) and 1 in the K. Weiss coll. (no registration no.).

Description: Size and shape: Test of medium to large size, ranging from 47.5 to 66.2 mm TL in the investigated material. Oval outline with rounded anterior and bluntly pointed posterior margin. No frontal sinus present. The maximum width lies anterior of the centre along line 1b–4a. In profile the test is domed to subconical. The maximum height lies slightly anterior of centre, around the apical disc. Test width is about 80 to 87% and test height about 62 to 63% of TL.

Apical disc: The apical disc lies anterior of the centre, about 40% of TL away from the anterior test margin. It is slightly sunken, ethmophract and has 3 large gonopores and 5 small ocular pores (Fig. 24 a). The madreporite shows many small pores and lacks a gonopore.

Ambulacra: Apically the ambulacra are petaloid, straight and only slightly closed distally. The petals are slightly depressed and extend about half of the corresponding test radius. The frontal petal is the shortest, the posterior paired petals are longest. The anterior paired petals form an obtuse angle of about 130–135°, whereas the posterior paired petals form an acute angle of about 55–60°. The pores within the petals are elongate anisopores, adjacent pairs are separated by broad ridges bearing secondary tubercles. The perradial pore in each pore pair is smaller, subcircular to oval, transversely elongated, whereas the adradial pore is larger, teardrop-shaped and tapers towards the perradial pore. The pores in each pair are connected by a shallow narrow groove. The

interporiferous zones are $\frac{3}{4}$ to 1 times the width of a single poriferous zone and bear few primary and secondary tubercles. Outside the petals the pores are less closely spaced, smaller partitioned isopores with axially oriented neural canal.

Adorally the ambulacra form phyllodes consisting of large partitioned isopores surrounded by a depressed, ring-shaped attachment zone. The phyllodes lack primary tubercles, only secondary tubercles are present. Ambulacra I and V form broad periplastral areas, which are densely covered by fairly large miliary tubercles on the oral side of the test, very similar to the tubercles present in the fasciole bands of other spatangoids (Fig. 24 b).

Interambulacra: Interambulacra slightly inflated between the petals. A weak median keel is developed in interambulacrum 5 on the aboral side. The crenulate, perforate primary tubercles with small, slightly sunken areoles are widely spaced. The secondary tuberculation is fairly dense. On the oral side the primary tubercles are larger than on the aboral side, they are largest near the anterior margin and on the plastron. The labrum is long and relatively slender, the plastron is long and mesamphisternous.

Peristome: The peristome lies about 20% of TL away from the anterior margin. It is oval, transversely elongate to kidney-shaped, 6 to 7 mm wide in the investigated material and surrounded by a distinct rim. The posterior margin of the peristome is raised.

Periproct: The periproct lies inframarginally in interambulacrum 5. It has a subcircular outline and a diameter ranging from 4.8 to 5.6 mm in the material studied.

Fascioles: No fascioles, although, below the periproct, near the posterior end of the plastron short portions of a fasciole band (orthofasciole type) are visible in one specimen (Fig. 24 b).

Dimensions:	TL	TW	TH
NHMW 2000z0096/0032	66.2 mm	>54 mm	>42 mm
NHMW 2000z0096/0033	63.4 mm	~56 mm	~43 mm
NHMW 2000z0096/0035	63.9 mm	~51 mm	40.7 mm

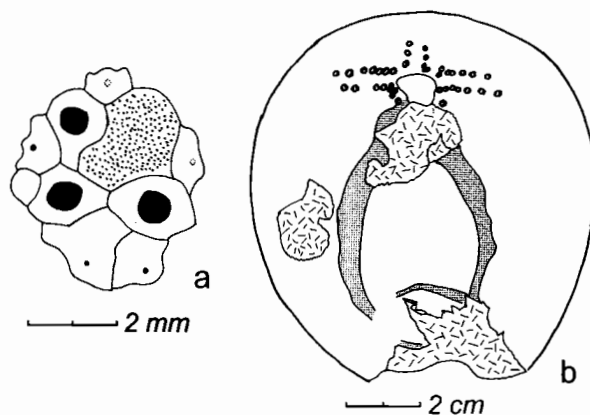


Fig. 24: *Isaster aquitanicus* (GRATELOUP, 1836); a: apical disc of NHMW 2000z0096/0035, b: oral side of IPUW 1992/11 (the shaded areas represent areas of fine fasciole-like-tuberculation, see text).

Remarks: The specimens considered here show all the characteristic features of *Isaster aquitanicus* (GRATELOUP): ethmophract apical system with 3 gonopores; no fascioles; overall shape; petaloid ambulacrum III and similar pores in all five petals. The material corresponds very well to the descriptions and figures given in D'ORBIGNY (1853–55) and SMITH et al. (1999). *Ismidaster toulai* BÖHM, 1927 (the type species of the genus *Ismidaster*) is a junior synonym of *Isaster aquitanicus* (STOKES, 1986).

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria). "Senonian" of Laplante-Montfort and Tercis (Landes) (D'ORBIGNY, 1853–55); Danian of Turkey (BÖHM, 1927; STOKES, 1986); Late Danian to Thanetian of the Crimea and the Mangyshlak Peninsula of Kazakhstan (POSILAVSKAYA & MOSKVIN, 1960; SMITH & JEFFERY, 2000), Maastrichtian, Cabo de Lata Section, Santander, Cantabria, Spain (WILMSEN et al., 1996), Late Thanetian (*P. pseudomenardii* Zone) of Casas de Oraien, Navarra, Spain (SMITH et al. 1999), Maastrichtian of Alicante, Spain (SMITH & JEFFERY, 2000).

Family Hemiasteridae CLARK, 1917

Genus *Hemiaster* AGASSIZ in AGASSIZ & DESOR, 1847

Diagnosis: Test circular to slightly heart-shaped in outline, with or without frontal sinus. Apical system usually ethmophract (except subgenus *Trachyaster*), with 4 large gonopores. Ambulacrum III non- or semipetaloid; paired ambulacra petaloid. Posterior paired petals relatively short.

Hemiaster stella (MORTON, 1830)

Figs. 25, 26; Pl. 12, Figs. 1–8

- 1830 *Spatangus stella*. – MORTON: 245; pl. 3, fig. 11
- 1834 *Spatangus stella* MORTON. – MORTON: 78; pl. 3, fig. 18
- 1856 *Hemiaster punctatus* D'ORBIGNY. – LEYMERIE & COTTEAU: 342
- 1957 *Hemiaster stella* MORTON. – DESOR: 373
- 1877 *Hemiaster nasutulus* SORIGNET. – COTTEAU: 65; pl. 6, figs. 19–20
- ? 1897 *Hemiaster tamulicus*. – KOSSMAT: 61, 96; pl. 10, figs. 5 a–d
- ? 1899 *Hemiaster(?) aquisgranensis*. – SCHLÜTER: 123; pl. 10, figs. 1–2
- 1906 *Hemiaster punctatus* var. *garumnica*. – LAMBERT: 721 (*nomen nudum*)
- 1906 *Hemiaster punctatus* var. *arizensis*. – LAMBERT: 721 (*nomen nudum*)
- 1906 *Hemiaster punctatus* var. *spissa*. – LAMBERT: 721 (*nomen nudum*)
- 1908 *Hemiaster* (*Leucaster*) *lamberti*. – COTTEAU: 173; pl. 5, figs. 3, 3a; text-fig. 15
- ? 1911 *Hemiaster rutoti*. – LAMBERT: 52; pl. 3, figs. 3–5
- 1915 *Hemiaster stella* (MORTON). – CLARK in CLARK & TWITCHELL: 93; pl. 48, fig. 2
- 1922 *Hemiaster madagascariensis* forme A. – COTTEAU: 10; pl. 2, figs. 1, 1 a–c, 2, 2 a–c, 3, 3 a–c, 6, 6 a–b
- 1924 *Hemiaster* (*Integraster*) *garumnica* LAMBERT. – LAMBERT & THIÉRY: 504
- 1924 *Trachyaster spissus* LAMBERT. – LAMBERT & THIÉRY: 507
- ? 1925 *Hemiaster* aff. *garumnica* LAMBERT. – KÜHN: 178, 186
- ? 1925 *Hemiaster* aff. *punctatus* D'ORBIGNY. – KÜHN: 178, 186
- 1930 *Hemiaster madagascariensis* COTTEAU. – BESAIÉRIE: 573; pl. 26, fig. 12
- 1930 *Hemiaster* sp. – KÜHN: 60–61; pl. 1, fig. 5
- 1933 *Hemiaster hawkinsi*. – LAMBERT: 22; pl. 4, figs. 19
- 1936 *Hemiaster garumnica* LAMBERT. – LAMBERT: 91; pl. 1; figs. 8–13

- 1959 *Hemiaster stella* (MORTON). – COOKE: 67; pl. 28, figs. 10–14
 1960b *Hemiaster garumnicus* LAMBERT. – KÜHN: 164
 1962 *Hemiaster garumnicus* LAMBERT. – VILLATTE: 168; pl. 4, figs. 11–15
 1975 *Hemiaster garumnicus* LAMBERT. – PLAZIAT et al.: 643; fig. 10
 1979 *Hemiaster (Bolbaster) hawkinsi* LAMBERT. – TANAKA et al.: 32; pl. 1, figs. 4 a–d; text-figs. 5–8
 1999 *Hemiaster stella* (MORTON). – SMITH et al.: 126; pl. 9, figs. 8–10
 2000 *Hemiaster stella* (MORTON). – SMITH & JEFFERY: 323; text-figs. 134A–B, F

Material: 82 specimens: 1 in the Ritter-Gulder coll. (IPUW, no registration nos.), 1 in the Weinfurter coll. (IPUW 1992/14), 4 in the Zapfe coll. (NHMW 1997z0178/0414), and 5 in the Kühn coll. (NHMW, 1933X49), 5 registered (NHMW 2000z0096/0038–41 and 2000z0099/0001) and 66 unregistered specimens in the NHMW coll.

Description: Size and shape: Test small, TL ranging from 15.8 to 28.5 mm in the material studied, with circular to slightly rectangular outline. No frontal sinus, anterior and posterior margin are both rounded. The maximum width lies centrally. In profile the test is wedge shaped with the maximum height near the posterior margin on the median keel of interambulacrum 5. Test width is about 95 to 97% and test height about 69 to 73% of TL.

Apical disc: The apical disc lies posterior of the centre, about 60% TL away from the anterior margin and is depressed. It is ethmophract and has 4 large gonopores, of which the posterior pair is slightly larger, and 5 indistinct ocular pores (Fig. 26 c).

Ambulacra: Adapically ambulacra are petaloid and slightly depressed. The frontal ambulacrum is the longest, the posterior paired petals are shortest. The frontal ambulacrum is straight, moderately closed distally and consists of two straight to slightly curved rows of oblique partitioned isopores with shallow, lateral neural canal. The interporal partition is highly raised, wall-like and lies transverse to the axis of the pore pair. The interporiferous zone is up to 4 times as wide as a single poriferous zone and bears mainly secondary tubercles and only occasionally primary tubercles. The paired petals show elongate isopores (compare SMITH, 1980) and are closed distally. The interporiferous zones are 1 to 1½ times as wide as a single poriferous zone and bear miliary tubercles only. The uppermost 10 pore pairs of the anterior poriferous zones of the anterior paired petals (IIb and IVa) are distinctly smaller. The anterior paired petals are slightly flexed anteriorly, their tips are flexed laterally. The anterior paired petals form an obtuse angle of about 90–105°, in smaller specimens the angle is larger, whereas in larger specimens the angle is smaller. The posterior paired petals form an acute angle of about 60–70°.

Adorally the ambulacra form small phylloides consisting of partitioned isopores with axially positioned neural canal, which are surrounded by a large, depressed attachment area. The pores in each pair are subequal in size and rounded. The interporal partitions have a wall-like shape and lie transverse to the axis of the pore pairs. The interporiferous zones of the phylloides are naked. Ambulacra I and V form broad periplastral areas, which are densely covered by secondary and miliary tubercles.

Interambulacra: The interambulacra are slightly inflated between the petals. The crenulate, perforate primary tubercles of the aboral side are small and widely spaced. The secondary tuberculation is fairly dense. On the oral side, the tubercles are larger and more closely spaced. The largest tubercles are found near the anterior margin and on the anterior part of the plastron, where they are arranged in a fan-shaped pattern radiating

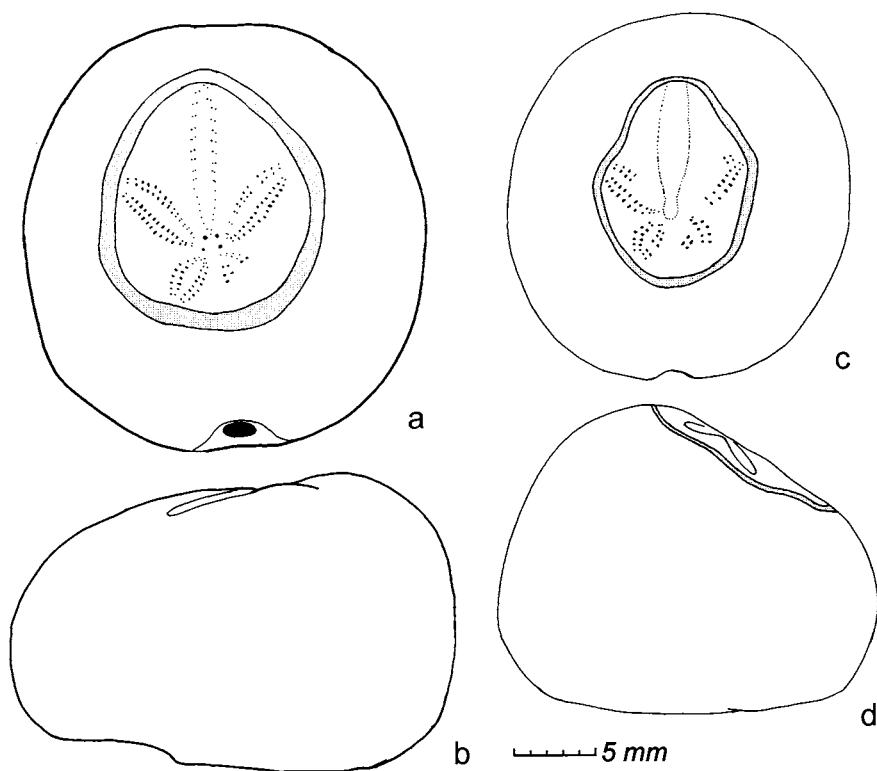


Fig. 25: *Hemiaster stella* (MORTON, 1830); a–b: NHMW 2000z0096/0040 from Haidhof, Lower Austria. a: aboral view, b: left lateral view. c–d: NHMW 2000z0099/0001 from Haidhof, Lower Austria. c: aboral view, d: right lateral view.

from an elevation on the posterior part of the plastron. Few secondary tubercles are found on the plastron. The labrum is long, moderately wide (widest at the margin of the peristome) and projects slightly over the peristome. The plastron is moderately long and mesamphisternous.

Peristome: The peristome is situated about 20 to 25% of TL away from the anterior margin of the test. It is oval to kidney-shaped, commonly 2.5 to 3.5 mm wide and surrounded by a distinct rim. The anterior margin of the peristome is slightly depressed, whereas the posterior margin is raised.

Periproct: The periproct is situated marginally in interambulacrum 5, often the area around it is slightly depressed. It has a circular shape and has a diameter ranging from 1.5 to 2.5 mm in the investigated material.

Fascioles: The peripetalous fasciole is an orthofasciole consisting of a broad fasciole band, which runs completely around the petalodium. The fasciole has an oval, antero-posteriorly elongated shape and is normally not embayed between the petals. In some specimens, however, it may be slightly indented between anterior and posterior petals (Fig. 25 c).

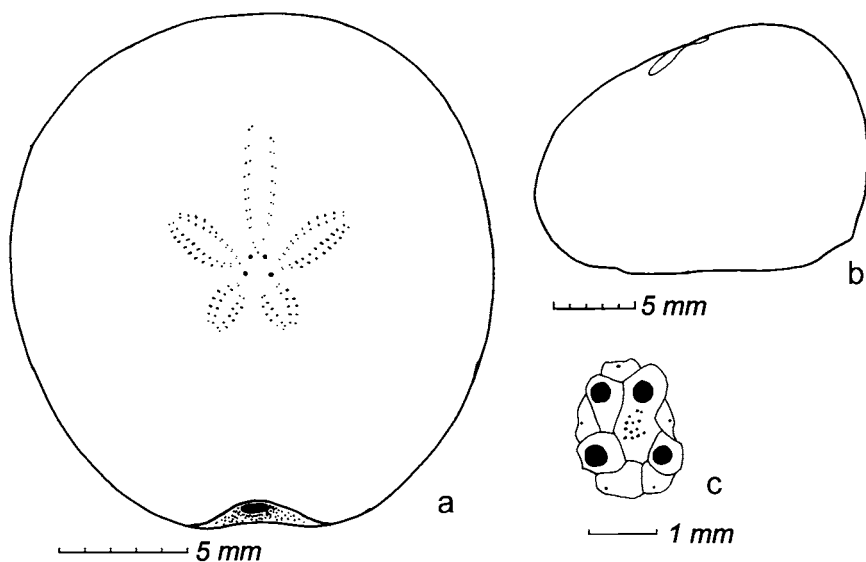


Fig. 26: *Hemiaster stella* (MORTON, 1830); a–b: NHMW 2000z0096/0041 from Haidhof, Lower Austria. a: aboral view, b: left lateral view. c: apical disc of NHMW 2000z0096/0038 from Haidhof, Lower Austria.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0038	25.3 mm	24.8 mm	18.4 mm
NHMW 2000z0096/0039	20.0 mm	19.4 mm	14.6 mm
NHMW 2000z0096/0040	25.2 mm	24.0 mm	17.6 mm
NHMW 2000z0096/0041	19.4 mm	18.6 mm	14.7 mm

Remarks: The present material is assigned to the species *Hemiaster stella* (MORTON, 1830), it corresponds fairly well to the description and figures given in CLARK & TWITCHELL (1915) and COOKE (1959). The specimens are also very similar to the Coniacian to Santonian species *Hemiaster punctatus* D'ORBIGNY (1854), they differ, however, from this species, by the weaker depression and smaller size of their petals and the shape of their peripetalous fasciole. The specimens studied show considerable intrapopulation variation especially in the extent of their wedge-shape. SMITH & JEFFERY (2000) provided an extensive synonymy list of this species and placed several species into the synonymy of *H. stella*, including *Hemiaster*(?) *aquisgranensis* SCHLÜTER, 1899, *Hemiaster rutoti* LAMBERT, 1911, and *Hemiaster tamulicus* KOSSMAT, 1879. I have, however, some doubts, that those three species are really synonyms of *H. stella*.

H. stella can be distinguished from the very similar species *H. prunella* (LAMARCK, 1816) by its distinct wedge shape and the less strong divergence of the anterior paired petals (compare SMISER, 1935; SMITH et al., 1999 or SMITH & JEFFERY, 2000 for a description of *H. prunella*). *Hemiaster koninckanus* D'ORBIGNY, 1855, differs from *H. stella* by its distinctly elongated outline with a length:width relation of roughly 1:0.8, its longer posterior petals and by its more strongly flexed petals (compare SMITH et al., 1999 for a description

of *H. koninckanus*). *Hemiaster brevisculus* D'ORBIGNY, 1854, differs from *H. stella* by its distinct frontal sinus, nonpetaloid ambulacrum III and the anterior paired petals, which are straight, not flexed, and diverge more strongly (D'ORBIGNY, 1853–55).

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof and Bruderndorf (Lower Austria). Late Thanetian Vincentown Sands of New Jersey, USA (COOKE, 1959); "Montian" (= ? Selandian) (VILLATTE, 1962) to mid Thanetian of the French Pyrenees (PLAZIAT et al., 1975); Maastrichtian and Danian of Madagascar (COTTREAU, 1908, 1922; BESAIRE, 1930; TANAKA et al., 1979); Late Danian of Denmark and Paleocene Agatdal Formation of East Greenland (SMITH & JEFFERY, 2000).

Family Corasteridae LAMBERT in LAMBERT & THIÉRY, 1924

Genus *Coraster* COTTEAU, 1886

Diagnosis: Test globular, to ovoid, with shallow frontal groove, or none at all. Apical disc ethmophract with 4 gonopores. Ambulacra nonpetaloid with small pores. Labrum long and slender; plastron mesamphisternous. Peristome situated very close to the anterior margin. Peripetalous fasciole present, passing just close behind the apical system posteriorly and at the ambitus anteriorly.

Coraster vilanovae COTTEAU, 1886

Figs. 27–29; Pl. 14, Figs. 1–6

- 1886 *Coraster vilanovae*. – COTTEAU: 70; pl. 9, figs. 1–4
- 1888 *Coraster marsooi*. – SEUNES: 806; pl. 29, figs. 2 a–d
- 1888 *Coraster sphaericus*. – SEUNES: 807; pl. 29, figs. 3 a–d
- 1888 *Coraster munieri*. – SEUNES: 808; pl. 29, figs. 4 a–c
- 1889 *Coraster vilanovæ*. – COTTEAU: 155
- 1900 *Coraster vilanovae* COTTEAU. – ANTHULA: 61; pl. 2, figs. 5 a–c
- 1927 *Coraster vilanovae* COTTEAU. – BÖHM: 195; pl. 12, figs. 6, 6 a–b
- 1927 *Coraster frechi*. – BÖHM: 195; pl. 12, figs. 5, 5 a–b
- 1960b *Coraster villanovae* nov. subspec. – KÜHN: 164
- 1966 *Coraster vilanovae* COTTEAU. – WAGNER & DURHAM: U542; figs. 425–2 a–b
- 1975 *Coraster vilanovae* COTTEAU. – VILLATTE in PLAZIAT et al.: 637; fig. 9
- 1975 *Coraster* cf. *sphaericus* SEUNES. – VILLATTE in PLAZIAT et al.: 637; pl. 1, fig. 7
- 1982 *Coraster urmaensis*. – MOSKVIN: 106, pl. 10, figs. 4 a–e, 5 a–e; text-figs. 1 j–l
- 1982 *Coraster vilanovae* COTTEAU. – TZANKOV: 106; pl. 46, figs. 5, 5 a–c, 6, 6 a–c
- 1982 *Coraster sphaericus* SEUNES. – TZANKOV: 106; pl. 47, figs. 1, 1 a–b
- 1982 *Coraster frechi* BÖHM. – TZANKOV: 107; pl. 47, figs. 2, 2 a–b, 3, 3a
- 1995 *Coraster vilanovae* COTTEAU. – GALLEMÍ et al.: tab.1
- 1999 *Coraster vilanovae* COTTEAU. – SMITH et al.: 126; fig. 37 a; pl. 11, figs. 4–7
- 1999 *Coraster vilanovae* COTTEAU. – JAGT: 8
- 2000 *Coraster vilanovae* COTTEAU. – SMITH & JEFFERY: 355; text-fig. 146 A–C

Material: 39 specimens: 2 in the Weinfurter coll. (IPUW 1992/27-2, 1992/29); 1 in the Zapfe coll. (NHMW 1997z0178/0413) and 8 registered (NHMW 2000z0096/0001, 2000z0096/0012, 2000z0096/0018 to 19, 2000z0200/0001 to 3 and 2000z0200/0006) and 28 unregistered specimens in the NHMW coll.

Description: Size and shape: Test small, commonly 10–26 mm long, of globular shape with no or only very shallow frontal groove. The outline of the test is subcircular, length

and width are subequal. Anterior margin rounded, posterior margin rounded to bluntly pointed. The maximum width lies centrally to slightly anterior of the centre. In profile the test is high and oval. The maximum height lies centrally and is about 89 to 97% (Mean: 93,9%) of TL.

Apical disc: The apical disc lies anterior of the centre and is slightly depressed in larger specimens. It belongs to the ethmophract type and has 4 large gonopores and 5 small ocular pores (Figs. 27 a–c). In one specimen the gonopores are surrounded by a narrow ring and lie in a shallow depression (Fig. 27 d).

Ambulacra: On the aboral surface the ambulacra are nonpetaloid, straight and open distally. The uppermost 5 to 9 pore pairs in each half ambulacrum are rather closely spaced, further distally, they are less closely spaced. The pore pairs are oblique and lie near the centre of the adoral plate margin. The pores are partitioned isopores with laterally positioned neural canal and narrow attachment area (compare SMITH, 1980). The pores in each pair are separated by a highly raised interporal partition. On the ambulacral plates beside the episternal plates (i. e. in ambulacra I and V) and on the plates near the peristome the pore pairs are slightly larger. The interporiferous zones are about as wide as a single poriferous zone adapically to several times as wide at the ambitus and show the same tuberculation as the interambulacra. Ambulacrum III is very slightly depressed between the apex and the ambitus.

Interambulacra: The interambulacra are slightly inflated. Interambulacrum 5 forms a rounded, weakly developed keel on the aboral side of the test. The tuberculation is fairly dense, consisting of small perforate, crenulate primary tubercles and a high number of miliaries. Within the “peripetalous” fasciole, on the plastron and near the margin of the oral side the tubercles are slightly larger. Adorally interambulacrum 5 consists of a long and slender labrum and a short, mesamphisternous plastron.

Peristome: The peristome lies very close to the anterior margin, facing anteriorly. It is small (commonly between 1.5 and 2.1 mm wide) and circular to slightly oval (transver-

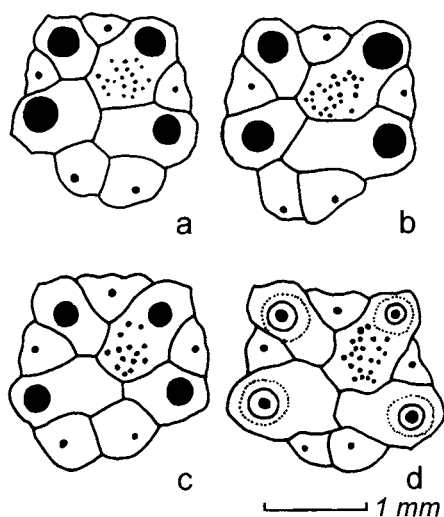


Fig. 27:
Coraster vilanovae COTTEAU, 1886; a: apical disc of NHMW 2000z0200/0006; b: apical disc of NHMW 2000z0096/0001; c: apical disc of IPUW 1992/27-2; d: apical disc of NHMW 1997z0178/0413; all from Haidhof, Lower Austria.

sely elongate). The posterior margin of the peristome is strongly raised and the labrum slightly projects over the peristome.

Periproct: The periproct lies marginally in interambulacrum 5 and has a circular to slightly oval (transversely elongate) shape. It is slightly larger than the peristome, commonly 1.5 to 2.5 mm wide.

Fascioles: "Peripetalous" fasciole present, passing just close behind the apical system posteriorly and at the ambitus anteriorly. Immediately behind the anterior paired ambulacra it shows a distinct kink. The fasciole band is narrow and consists of small miliary tubercles. No primary or secondary tubercles are included and the fasciole band is distinctly differentiated from the aboral tuberculation, thus it belongs to the orthofasciole type sensu NÉRAUDEAU et al. (1998). For the exact position of the peripetalous fasciole see Fig. 28 a–d. No subanal or latero-anal fascioles.

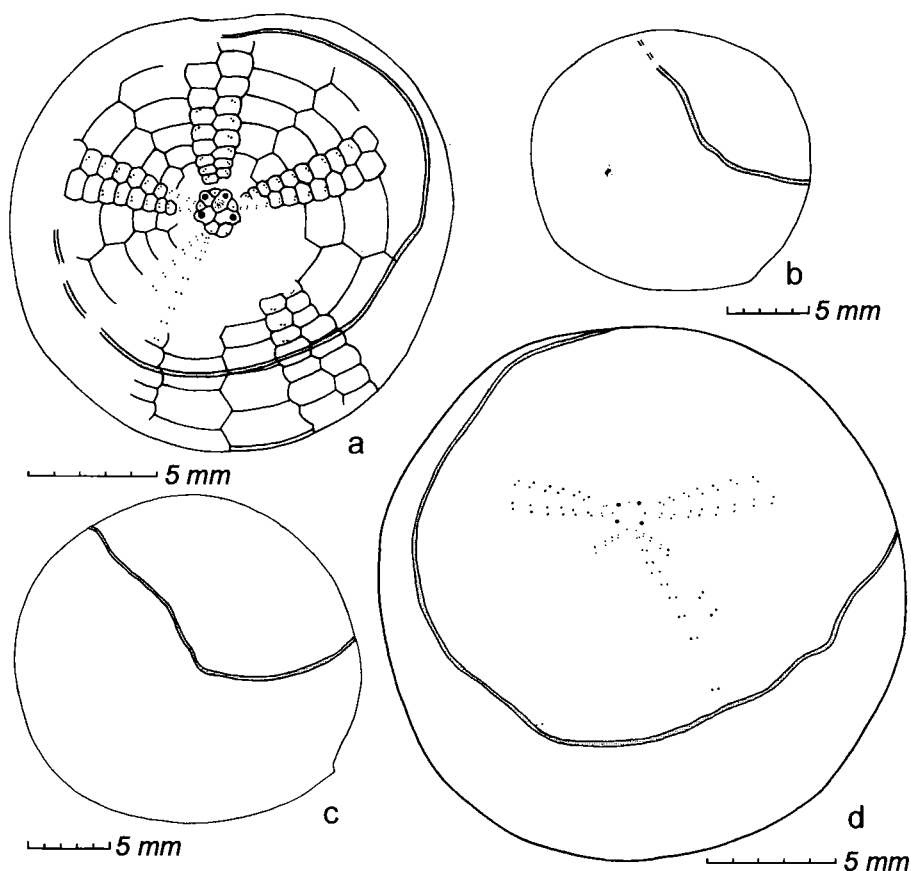


Fig. 28: *Coraster vilanovae* COTTEAU, 1886; a–b: NHMW 2000z0200/0006 from Haidhof, Lower Austria; a: aboral view, b: right lateral view; c–d: IPUW 1992/29 from Haidhof, Lower Austria, c: right lateral view, d: aboral view.

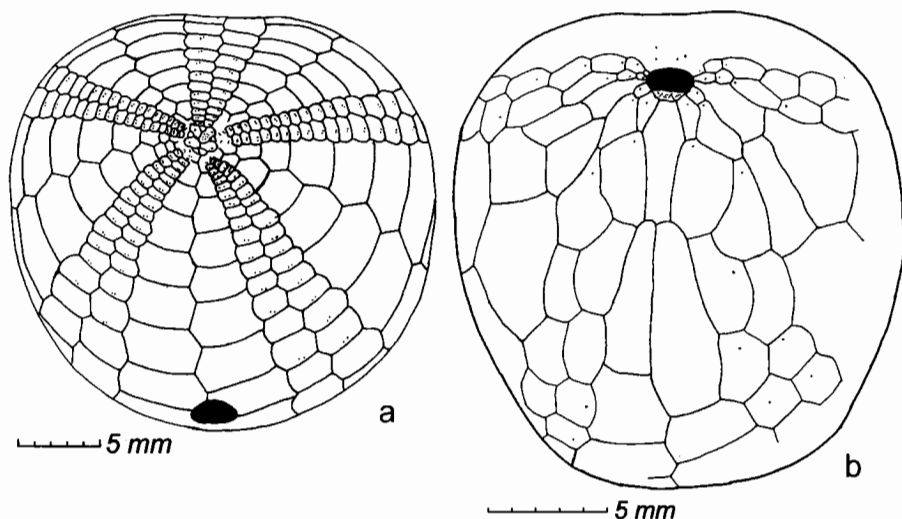


Fig. 29: *Coraster vilanovae* COTTEAU, 1886; a: aboral view of NHMW 1997z0178/0413, interambulacra shaded; b: oral view of NHMW 2000z0200/0003, interambulacra shaded; both from Haidhof, Lower Austria.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0001	20.8 mm	19.3 mm	18.7 mm
NHMW 2000z0096/0012	16.4 mm	15.9 mm	15.2 mm
NHMW 2000z0096/0018	19.0 mm	18.8 mm	18.5 mm
NHMW 2000z0096/0019	17.0 mm	>16.0 mm	16.2 mm

Remarks: The specimens considered here fit the description and figures given by COTTEAU (1886) and SMITH et al. (1999). There are, however, two specimens (NHMW 1997z0178/0413 and IPUW 1992/27-2), which show considerable differences. The former is much more depressed (TH about 79% of TL) and has rimmed gonopores, the second is distinctly elongated anteroposteriorly and also much more depressed (TW about 95% of TL and TH about 82% of TL); both specimens have a distinct but shallow frontal groove. These two specimens are here included in *C. vilanovae* because there is not enough material to judge if they represent just two extreme morphotypes of *C. vilanovae* or belong to a new species of *Coraster*.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof, and Klement (Lower Austria). Danian of the French and Spanish Pyrenees (COTTEAU, 1886; SEUNES, 1888; SMITH et al. 1999); Maastrichtian to Danian of Alicante and Navarra, Spain (SMITH et al., 1999); Late Cretaceous of Tersakhan in Turkestan, Transcaspiian Region (COTTEAU, 1889); Maastrichtian (ANTHULA, 1900) and Late Paleocene (MOSKVIN, 1982) of Daghestan; Danian of northwest Turkey (BÖHM, 1927) Early to Late Maastrichtian of the Transcaspiian Region (POSLAVSKAYA & MOSKVIN, 1960); Early Maastrichtian to Late Danian of Georgia (POSLAVSKAYA & MOSKVIN, 1960) and the Northern Caucasus (MOSKVIN & POSLAVSKAYA, 1959); Maastrichtian of Bulgaria (TZANKOV, 1982); Maastrichtian to Danian of Austria (JAGT, 1999).

Diagnosis: Test globular, to ovoid, with shallow frontal sinus. Apical disc ethmophract with 3 gonopores (genital plate 4 not perforated). Ambulacra nonpetaloid with small pores. Labrum long and slender; plastron mesamphisternous. Peristome situated very close to the anterior margin. Peripetalous fasciole present, passing just close behind the apical system posteriorly and at the ambitus anteriorly.

Orthaster dagestanensis MOSKVIN, 1982

Figs. 30–32; Pl. 13, Figs. 4–8

- 1959 *Ornithaster munieri* (SEUNES). – MOSKVIN & POSLAVSKAYA: 276; pl. 18; figs. 11 a–c; text-fig. 86
 1960 *Ornithaster munieri* (SEUNES). – POSLAVSKAYA & MOSKVIN: 63; pl. 3, fig. 5; text-fig. 13
 1960 *Ornithaster marsooi* (SEUNES). – POSLAVSKAYA & MOSKVIN: 63; pl. 3, fig. 6; text-fig. 14
 1982 *Orthaster dagestanensis*. – MOSKVIN: 104; pl. 10, figs. 1 a–e; text-figs. 1 a–c
 1982 *Orthaster okhliensis*. – MOSKVIN: 105; pl. 10, figs. 3 a–e; text-figs. 1 g–i
 2000 *Orthaster dagestanensis* MOSKVIN. – SMITH & JEFFERY: 357; text-figs. 146 A–B, D

Material: 191 specimens: 7 in the Ritter-Gulder coll. (IPUW, no registration nos.), 9 in the Weinfurter coll. (IPUW 1992/27-1, 199 2/27-3 to 10), 46 in the Zapfe coll. (NHMW 1997z0178/0418), 2 in the Kühn coll. (NHMW 2000z0096/0007 to 8), 17 registered (NHMW 2000z0096/0002, 2000z0096/0004, 2000z0096/0006, 2000z0096/0009–11, 2000z0096/0013–17, 2000z0096/0020–23, 2000z0096/0026; 2000z0200/0005) and 110 unregistered specimens in the NHMW coll.

Description: Size and shape: Test small, commonly 9–20 mm long and of globular shape. The maximum width lies slightly anterior of the centre, coinciding with the apical disc. The outline of the test is nearly circular, test width ranging from 93 to 101% of TL (Mean: 97.0%). Anterior margin rounded with shallow, broad frontal groove; posterior margin rounded to bluntly pointed. In profile the test is high and oval to rhomboidal. The maximum height lies slightly posterior of the centre, halfway between the apical disc and the posterior margin, and is ranges from 84 to 98% of TL (Mean: 90.3%).

Apical disc: The apical disc lies anterior of the centre and is often slightly depressed. It belongs to the ethmophract type and has 3 large gonopores (genital plate 4 is not perforated) and 5 small ocular pores (Figs. 32 b, e). In some, well preserved, specimens a thin stereom layer, which is perforated in the centre, can be found covering the gonopores (Figs. 32 c–d).

Ambulacra: On the aboral surface the ambulacra are nonpetaloid, straight and open distally. The uppermost 5 to 9 pore pairs in each half ambulacrum are rather closely spaced, further distally, they are less closely spaced. The pore pairs are oblique and lie near the centre of the adoral plate margin. The pores are partitioned isopores with laterally positioned neural canal and narrow attachment area (compare SMITH, 1980). The pores in each pair are separated by a highly raised, knob-like interporal partition. On the ambulacral plates beside the episternal plates (i. e. in ambulacra I and V) and on the plates near the peristome the pore pairs are slightly larger. The poriferous zones are very slightly depressed adapically. The interporiferous zones are about as wide as a single poriferous zone adapically to several times as wide at the ambitus and show the same tuberculation as the interambulacra. Ambulacrum III is slightly depressed between the apex and the ambitus.

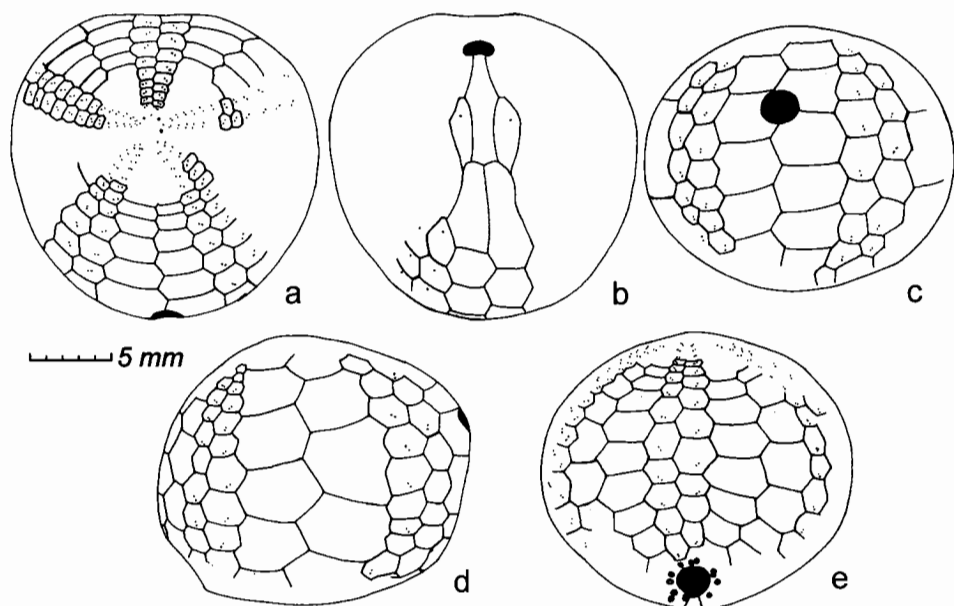


Fig. 30: *Orthaster dagestanensis* MOSKVIN, 1982; a-e: NHMW 2000z0096/0023 from Haidhof, Lower Austria. a: aboral view, b: oral view, c: view of posterior end, d: left lateral view, e: view of anterior end.

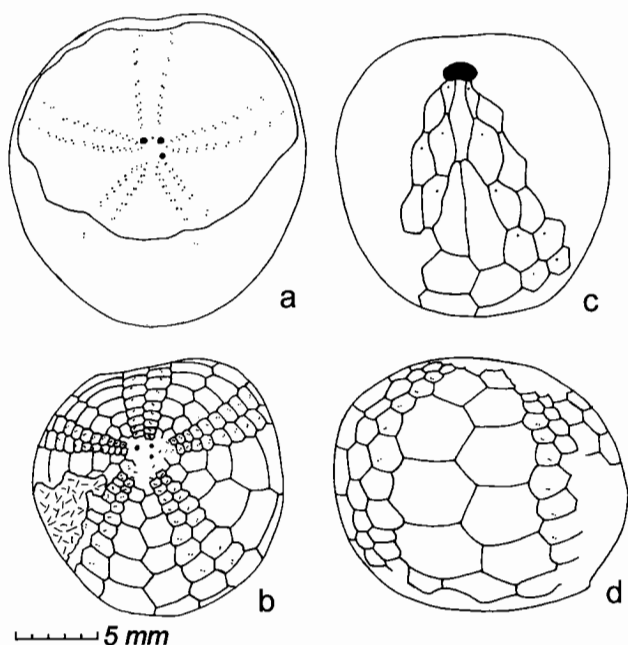


Fig. 31:
Orthaster dagestanensis
MOSKVIN, 1982; a: aboral view
of NHMW 2000z0096/0009;
b: aboral view of NHMW
2000z0096/0006; c-d:
NHMW 2000z0096/0004, c:
oral view, d: right lateral view;
all specimens from Haidhof,
Lower Austria.

Interambulacra: The interambulacra are slightly inflated. Interambulacrum 5 forms a rounded, weakly developed keel on the aboral side of the test. The tuberculation is fairly dense, consisting of small perforate, crenulate primary tubercles and a high number of large miliaries. Within the "peripetalous" fasciole, on the plastron and near the margin of the oral side the primary tubercles are slightly larger. Adorally interambulacrum 5 consists of a long and slender labrum and a short, mesamphisternous plastron.

Peristome: The peristome faces anteriorly and lies very close to the anterior margin on the oral side of the test, varying from almost marginally to 15% TL away from the anterior margin. It is small (commonly between 1.5 and 2.0 mm wide) and circular. The posterior margin of the peristome is strongly raised and the labrum very slightly projects over the peristome.

Periproct: The periproct lies marginally in interambulacrum 5 and has a circular shape. It is slightly larger than the peristome, commonly 1.5 to 2.2 mm wide.

Fascioles: "Peripetalous" fasciole present, passing just close behind the apical system posteriorly and at the ambitus anteriorly. Immediately behind the anterior paired ambulacra it shows a distinct kink. The fasciole band is narrow and consists of small miliary tubercles. No primary or secondary tubercles are included and the fasciole band is distinctly differentiated from the aboral tuberculation, thus it belongs to the orthofasciole type sensu NÉRAUDEAU et al. (1998). For the exact position and shape of the peripetalous fasciole see Figs. 31 a and 32b. No subanal or latero-anal fascioles.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0009	17.9 mm	16.7 mm	16.0 mm
NHMW 2000z0096/0011	19.2 mm	18.7 mm	17.3 mm
NHMW 2000z0096/0017	12.8 mm	12.2 mm	11.7 mm

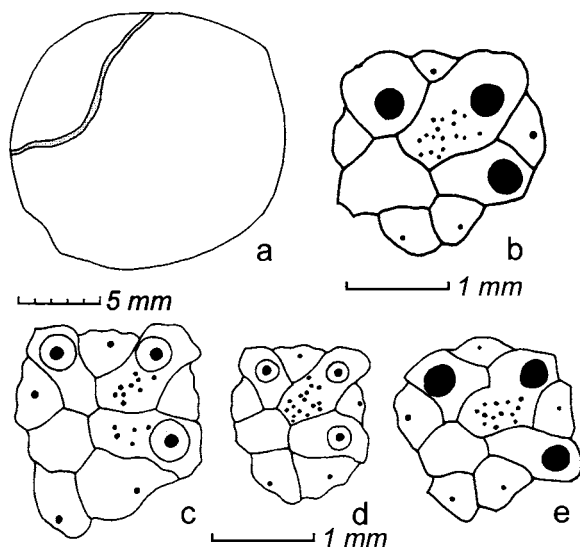


Fig. 32:
Orthaster dagestanensis MOSKVIN,
 1982; a: left lateral view of IPUW
 1992/27-5; b: apical disc of
 NHMW 2000z0200/0005; c:
 apical disc of NHMW
 2000z0096/0026; d: apical disc
 of NHMW 2000z0096/0024; e:
 apical disc of NHMW
 2000z0096/0004; all specimens
 from Haidhof, Lower Austria.

Remarks: The specimens correspond very well to the description and figures given by MOSKVIN (1982). The genus *Orthaster* is very similar to *Coraster*, they can, however, easily be distinguished by the number of gonopores. No reference to the thin layer of stereom, which effectively reduces the size of the gonopores, in some of the present specimens or a similar structure could be found in the literature. In fact this feature is present only in part of the specimens, usually the well preserved ones, but not exclusively. The function of this layer is unclear, maybe it is related to sexual dimorphism, which however was not reported for any member of the *Corasteridae* up till now.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof, Klement and Bruderndorf (Lower Austria). Early to Late Danian of Georgia (POSILAVSKAYA & MOSKVIN, 1960) and the northern Caucasus (MOSKVIN & POSILAVSKAYA, 1959); Early Palaeocene of Dagestan and Late Paleocene of Dagestan and Western Ustyurt region (MOSKVIN, 1982).

Orthaster sp.

Fig. 33; Pl. 13, Figs. 1–3

Material: Two specimens: 1 in the Zapfe coll. (NHMW 1997z0178/0410) and 1 in the NHMW coll. (NHMW 2000z0096/0024).

Description: Size and shape: Test small, commonly 15 mm long and distinctly elongated anteroposteriorly. Test width about 86–89% of test length. The maximum height lies posterior of the apical disc in interambulacrum 5, one third the distance between the apical disc and the posterior margin away from the apical system. No frontal sinus, but the area anterior of the peristome on the oral side of the test is depressed and forms a groove running towards the ambitus.

Apical disc: The apical disc lies slightly anterior of the centre, is ethmophract and has 3 large gonopores. The ocular pores are barely visible.

Ambulacra: Below the ambitus ambulacrum III is depressed and forms a groove running towards the peristome.

Interambulacra: Interambulacrum 5 forms a high, sharp keel on the aboral surface.

Fascioles: No fascioles visible.

Peristome: The peristome is oval in outline and lies close to the anterior margin (largest diameter 0,9 mm). Its posterior margin is highly raised.

Periproct: The periproct lies marginally in interambulacrum 5 and is oval, vertically elongate (largest diameter between 1.2 and 1.3 mm).

Dimensions:	TL	TW	TH
NHMW 2000z0096/0024	14.5 mm	12.9 mm	13.6 mm
NHMW 1997z0178/0410	14.5 mm	12.5 mm	13.7 mm

Remarks: The present specimens fall outside the usual variation of *Orthaster dagestaensis*, and are therefore considered as different species since no intermediate specimens have been found. They could, however, not be identified with an existing species of *Orthaster*, but since only two specimens are available, no new species is erected. Morphologically they are very similar to *Coraster beneharnicus* SEUNES.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria).

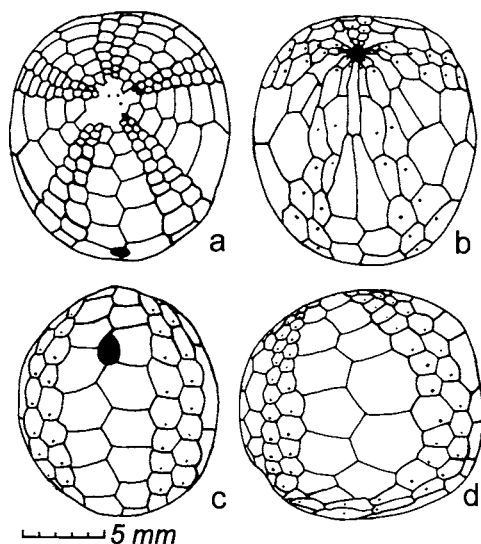


Fig. 33:
Orthaster sp.; a–d NHMW 2000z0096/
 0025 from Haidhof, Lower Austria, a: ab-
 oral view, b: oral view, c: view of posterior
 end, d: left lateral view.

Genus *Homoeaster* POMEL, 1883

Diagnosis: Test globular, to ovoid, without frontal groove. Apical disc ethmophract with 4 gonopores, situated anteriorly. Paired ambulacra nonpetaloid to subpetaloid, with small pores. Peristome circular, non-labiate, downward facing. Labrum long and slender; plastron mesamphisternous. Peripetalous fasciole present, passing just above the periproct posteriorly and at or immediately beneath the ambitus anteriorly.

Homoeaster evaristei (COTTEAU, 1886)

Fig. 34; Pl. 14, Figs. 7–9

- 1886 *Ornithaster evaristei*. – COTTEAU: 72; pl. 9, figs. 5–8
 1900 *Inflataster abichi*. – ANTHULA: 63; pl. 2, figs. 6 a–e
 1927 *Ornithaster cordiformis*. – BÖHM: 196; pl. 12, figs. 3, 3 a–b
 1927 *Physaster abichi* (ANTHULA). – BÖHM: 197
 1959 *Homoeaster tunetanus* POMEL. – MOSKVIN & POSLAVSKAYA: 274; pl. 18, figs. 1 a–b
 1959 *Homoeaster abichi* (ANTHULA). – MOSKVIN & POSLAVSKAYA: 274; pl. 18, figs. 2 a–c
 1982 *Homoeaster abichi* (ANTHULA). – TZANKOV: 104; pl. 46, figs. 2, 2 a–b, 3, 3 a–b
 1982 *Ornithaster cordiformis* BÖHM. – TZANKOV: 105; pl. 46, figs. 4, 4 a–c
 1983 *Homoeaster* ?n. sp. aff. *tuneatus* POMEL. – SCHULZ: 718; pl. 1, figs. 4 a–c; text-fig. 3
 1995 *Ornithaster?* *evaristei* COTTEAU. – GALLEMÍ et al.: tab. 1
 1995 *Ornithaster?* sp. – GALLEMÍ et al.: tab. 1
 1999 *Homoeaster evaristei* (COTTEAU). – SMITH et al.: 130; pl. 11, figs. 1–3; text-fig. 38
 2000 *Homoeaster evaristei* (COTTEAU). – SMITH & JEFFERY: 358; text-figs. 148 A–D

Material: 1 specimen in the NHMW coll. (NHWM 2000z0200/0004).

Description: Size and shape: Test of medium size and subcircular outline without frontal groove. Anterior margin rounded; posterior bluntly pointed. The maximum width lies

anterior of the centre, about 35% TL away from the anterior margin coinciding with the apical disc. Test length and width are subequal. In profile the test is gibbous. The maximum height lies centrally and is about 75% of TL.

Apical disc: The apical disc lies anterior of the centre and is slightly inflated. It belongs to the ethmophract type and has 4 large gonopores and 5 small ocular pores (Fig. 34 d).

Ambulacra: On the aboral surface the ambulacra are nonpetaloid, straight and open distally. The uppermost 12 pore pairs in each half ambulacrum are rather closely spaced, further distally, they are less closely spaced and lie in shallow depressions. The pore pairs lie near the centre of the adoral plate margin. The pores are elongate isopores (compare SMITH, 1980) with an interporal partition in form of a raised area of stereom, which links the two pores. At the ambitus and on the oral side the pores are smaller partitioned isopores with laterally positioned neural canal and an interporal partition in form of a raised knob. The interporiferous zones are about as wide as a single poriferous zone adapically, widen gradually towards the ambitus and show the same tuberculation as the interambulacra.

Interambulacra: The interambulacra are flush with the ambulacra. There are rather few perforate, crenulate primary tubercles, but a fairly dense secondary and miliary tuberculation. Within the "peripetalous" fasciole, on the plastron and near the margin of the oral side the tubercles are slightly larger. Adorally interambulacrum 5 consists of a long and slender labrum and a short, mesamphisternous plastron.

Peristome: The peristome lies about 25% of TL away from the anterior margin. It is small, circular and faces downwards.

Periproct: The periproct lies marginally in interambulacrum 5 and has an oval (transversely elongate) shape. It is slightly larger than the peristome and just visible from above.

Fascioles: "Peripetalous" fasciole present, passing immediately below the ambitus anteriorly and just above the periproct posteriorly. The fasciole band is narrow and consists of small miliary tubercles. No primary or secondary tubercles are included and the fasciole band is distinctly differentiated from the aboral tuberculation, thus it belongs to the orthofasciole type sensu NÉRAUDEAU et al. (1998). For the exact position of the peripetalous fasciole see Fig. 34 a and c. No subanal or latero-anal fascioles.

Dimensions:	TL	TW	TH
NHWM 2000z0200/0004	34.2 mm	>33 mm	25.7 mm

Remarks: The single specimen available corresponds well to the description and figures of *Homoeaster evaristei* given by SMITH et al. (1999) and SMITH & JEFFERY (2000).

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria). Maastrichtian of Dagestan (ANTHULA, 1900); Danian of north-western Turkey (BÖHM, 1927); Early Maastrichtian and Early-Late Danian of the northern Caucasus (MOSKVIN & POSLAVSKAYA, 1959, POSLAVSKAYA & MOSKVIN, 1960); Early-Late Danian of the Crimea (MOSKVIN & POSLAVSKAYA, 1959); Maastrichtian and Early-Late Danian of Georgia (POSLAVSKAYA & MOSKVIN, 1960); Maastrichtian of Bulgaria (TZANKOV, 1982); Early Maastrichtian *Inoceramus* Marls of Bavaria (SCHULZ, 1983); Maastrichtian Quípar-Jorquera Formation and Danian of Alicante and Danian of Navarra, Spain (GALLEMI et al., 1995; SMITH et al., 1999); Danian Kangilia Formation of East Greenland (SMITH & JEFFERY, 2000); Maastrichtian of Mozambique and Maastrichtian or Paleocene of Senegal (SMITH & JEFFERY, 2000).

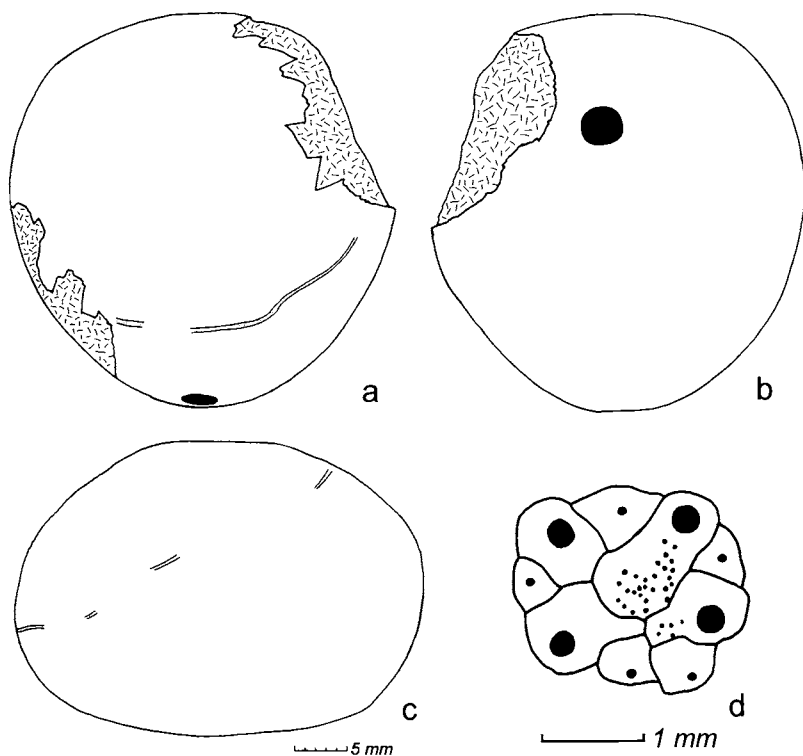


Fig. 34: *Homoeaster evaristei* (COTTEAU, 1886); a–d: NHMW 2000z0200/0004 from Haidhof, Lower Austria. a: aboral view, b: oral view, c: left lateral view, d: apical disc.

Corasteridae indet.

Material: 77 specimens: 9 in the Ritter-Gulder coll. (no. registration nos.) and 68 un-registered specimens in the NHMW coll.

Remarks: These specimens most probably belong to one of the species described above, but could not be determined due to their poor preservation.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof, Bruderndorf and Klement (Lower Austria).

Family Schizasteridae LAMBERT in DONCIEUX, 1905

Genus *Linthia* DESOR, 1853

Diagnosis: Test heart shaped with distinct frontal sinus. Apical disc ethmolytic with 4 gonopores. Ambulacrum III depressed, nonpetaloid; paired ambulacra petaloid, straight and slightly depressed. Peripetalous fasciole deeply embayed between petal; latero-anal fasciole present.

Linthia cf. houzeau COTTEAU, 1878

Figs. 35 and 36; Pl. 10, Figs. 5–6

1878 *Linthia houzeau*. – COTTEAU: 10; pl. 1, figs. 27–29

1935 *Linthia houzeau* COTTEAU. – SMISER: 87–88; pl. 8, figs. 3 a–h

1960b *Linthia* nov. spec. – KÜHN: 164

1989 *Linthia houzeau* COTTEAU. – ROMAN: 303; pl. 1, figs. 7, 9–10

2000 *Linthia houzeau* COTTEAU. – SMITH & JEFFERY: 333

Material: 5 specimens in the NHMW coll. (NHMW 2000z0096/0027 to 31).

Description: Size and shape: Test small, up to 32 mm long, heart-shaped with subequal test length and width. Anterior margin rounded with distinct frontal sinus. Posterior margin transversely truncated. The maximum width lies anterior of the centre, coinciding with the position of the apical disc. In profile the test is low and slightly wedge shaped. The maximum height lies around the apical system.

Apical disc: The apical disc lies slightly anterior of the centre, belongs to ethmolytic type and has four large gonopores (Fig. 36).

Ambulacra: Ambulacrum III is depressed adapically, increasingly so towards the anterior margin, where it forms a moderately deep frontal sinus. The pore pairs are partitioned isopores with axially positioned neural canal (compare SMITH 1980). They are oblique and arranged in straight rows. The pores in each pair are subequal in size and separated by a raised ridge. In the distal part of ambulacrum III on the aboral surface only small unipores occur. The paired ambulacra are petaloid. The anterior paired petals form an obtuse angle of about 130°, the posterior paired petals an acute angle of about 60°. The posterior paired petals are about two third as long as the anterior paired petals and about

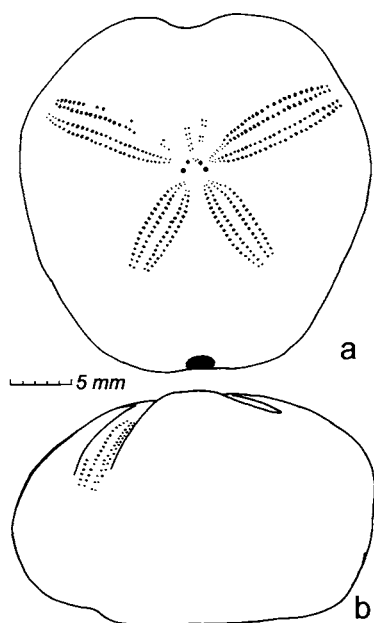


Fig. 35:

Linthia cf. houzeau COTTEAU, 1878; a–b: NHMW 2000z0096/0027 from Haidhof, Lower Austria. a: aboral view, b: left lateral view.

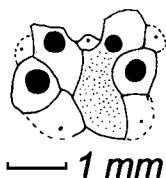


Fig. 36:
Linthia cf. *houzeau* COTTEAU, 1878; apical disc of NHMW 2000z0096/
0027 from Haidhof, Lower Austria.

50% the length of the corresponding test radius. The anterior paired petals are about 80% the length of the corresponding test radius. The pores within the petals are elongated isopores (see SMITH, 1980). The interporiferous zones are about half to two thirds the width of a single poriferous zone.

Adorally the ambulacra form small phyllodes consisting of large unipores rimmed by a broad periporal area. The pores are elongated and possess a distinct neural canal on their adoral side. The periporal area is relatively broad on the aboral side of the pores, whereas it is almost non-existent on the adoral side.

Interambulacra: On the aboral side the interambulacra are inflated between the petals. Adorally interambulacrum 5 consists of a broad labrum and a mesamphisternous plastron. Due to the heavy abrasion of the specimens, nothing can be said about the tuberculation.

Peristome: The peristome lies near the anterior margin on the oral side of the test, about 15 to 20% away from it. It has a crescentic, transversely elongated shape and is 4 to 5 mm wide. The labrum slightly projects and bears a distinct rim.

Periproct: The periproct lies marginally in interambulacrum 5. It is vertically elongate and slightly larger than the peristome (about 3.8 mm wide and 5 mm long).

Fascioles: No fascioles visible, probably due to weathering of the specimens.

Dimensions:	TL	TW	TH
NHMW 2000z0096/0027	28.6 mm	17.7 mm	18.0 mm
NHMW 2000z0096/0029	31.2 mm	30.5 mm	22.3 mm
NHMW 2000z0096/0031	26.5 mm	26.3 mm	18.4 mm

Remarks: The limited number of the specimens, their heavy abrasion and generally rather poor preservation makes an exact specific determination impossible. The specimens, however, appear to be very similar to *Linthia houzeau* COTTEAU as described and figured by SMISER (1935) and SMITH & JEFFERY (2000). The only difference is, that the anterior paired petals diverge at a slightly smaller angle.

Occurrence: Sandstone facies of the Bruderndorf Fm. (Late Danian, Paleocene) at Haidhof (Lower Austria). Late Danian 'Calcaire grossier' of Eysden and Mons, Belgium (COTTEAU, 1878; SMISER, 1935); Late Danian 'Calcaire de Vigny' of the Paris Basin (ROMAN, 1989).

5. DISCUSSION

A total of 19 taxa are here recorded from the Late Danian (Paleocene) Bruderndorf Formation of Austria, most of which have not been recorded previously from Austria. With the exception of KÜHN (1930, 1960b), the echinoid fauna of the Bruderndorf Fm.

has received only scant attention. The unusually large number of specimens available for the present study (> 1,200 specimens) and their relatively good preservation made it possible to record even the rarer species. When this echinoid fauna was reported for the first time by KÜHN (1930), only few poorly preserved specimens were available, and this led to some errors, which could now be corrected based on plenty of well-preserved specimens (Table 1).

Most of the species reported here are well known from the Late Cretaceous and Paleocene (Table 2). In fact four of them occur exclusively in the Danian. One species, *Echinocorys scutata* forma *ovata*, however, was not known from the Danian up till now. The occurrence of a very large morphotype of *Echinocorys* with a test length of up to 94 mm is interesting, because this genus shows a dramatic reduction in test size from the Late Campanian onwards, which reaches its climax with the dwarf forms in the Danian (KONGIEL, 1949; KÖSTER, 1954, 1955; ERNST, 1972).

The echinoid fauna of the Bruderndorf Fm. shows affinities to Northern and Southwestern Europe, as well as to those of Eastern Europe, the Caucasus and the Transcasian region (Table 3). It has eight taxa in common with Northern and seven with Southwestern Europe, six with the Caucasus and eight with the Transcasian region. Four taxa are even more widely distributed: *Hemiasper stella* and *Plagiochasma cruciferum* occur also in the eastern USA, *H. stella* and *Homoeaster evaristei* in Greenland and Eastern Africa and *Adelopneustes montainvillensis* in Northern Africa. This leads to the conclusion that the echinoid fauna of the Danian was rather homogeneous and widely distributed and that the distribution of taxa was facies-dependent rather than regionally marked. From a study of the echinoid fauna of northern Spain SMITH et al. (1999) concluded that these echinoid faunas underwent major reorganisations after the K/Pg-event, with both immigration and emigration taking place, leading to an exchange of taxa between various regions. This could explain the pattern observed here, where taxa of different geographic origin coexist at a single site.

The studied fauna comes from two different palaeoenvironments: a siliciclastic environment and a coralline algae-dominated carbonate environment. The siliciclastic environment is dominated by burrowing and ploughing irregular echinoids, whereas the carbonate environment is dominated by epibenthic grazing regular echinoids, which might have used the corallinaceae rhodoliths as secondary hardgrounds. The echinoid fauna of the siliciclastic environment is far more diverse (17 taxa), but that might be due to a sampling bias in the hard limestones of the carbonate environment. Both palaeoenvironments appear to be situated in upper shelf settings, as true deep-water specialists are lacking. This correspond well to the results of SCHMID (1962), who concluded a depositional depth of 100 to 200 metres, on the basis of the foraminifera fauna.

6. CONCLUSION

The echinoid fauna of the Danian Bruderndorf Formation is fairly diverse (19 taxa) and generally confirms the Danian age suggested by the study of other fossil groups. It shows equally strong ties to the North and Southwestern European echinoid faunas and these of the Caucasus and Transcasian region. This supports the theory of a

Before revision	Reference	After revision	Remarks
<i>Typocidaris cf. rosenkrantzi</i> RAVN	KÜHN (1930a), KÜHN (1960b)	-----	specimens lost, record not verified
<i>Globaster ravni</i> BRÜNNICH-NIELSEN	KÜHN (1960b)	<i>Adelopneustes boehmi</i> (NIETSCH)	genus name misspelt; erroneous generic determination; junior synonym
<i>Pseudopyrina subovalis</i> RAVN	KÜHN (1960b)	<i>Adelopneustes montainvillensis</i> (SORIGNET)	
<i>Proccassidulus laymeriei</i> (COTTEAU)	KÜHN (1960b)	-----	specimens lost, record not verified
<i>Echinocorys cf. obliquus</i> (NILSSON)	KÜHN (1930a)	<i>Echinocorys scutata</i> forma <i>pyrenaica</i> SEUNES	
<i>Echinocorys sulcatus</i> (GOLDFUSS)	KÜHN (1930a)	<i>Echinocorys scutata</i> forma <i>pyrenaica</i> SEUNES	
<i>Echinocorys sulcatus</i> (GOLDFUSS)	THENIUS (1974), SCHULTZ (1998)	<i>Echinocorys scutata</i> forma <i>ovata</i> (LESKE)	
<i>Echinocorys schafferi</i> KÜHN	KÜHN (1930a)	<i>Echinocorys scutata</i> forma <i>ovata</i> (LESKE)	junior synonym
<i>Echinocorys</i> nov. spec.	KÜHN (1930a)	<i>Echinocorys scutata</i> forma <i>ovata</i> (LESKE)	
<i>Garumnaster lamberti</i> KÜHN	KÜHN (1930a), KÜHN (1960b)	<i>Echinocorys scutata</i> forma <i>pyrenaica</i> SEUNES	erroneous generic determination; junior synonym
<i>Coraster villanovae</i> nov. subspec.	KÜHN (1960b)	<i>Orthaster dagestanensis</i> MOSKVIN	species name with only one l; erroneous determination
<i>Isaster</i> nov. spec.	KÜHN (1960b)	<i>Isaster aquitanicus</i> (GRATELOUP)	
<i>Hemiaster</i> sp.	KÜHN (1930a)	<i>Hemiaster stella</i> (MORTON)	
<i>Brissopneustes vindobonensis</i> KÜHN	KÜHN (1930a), KÜHN (1960b), THENIUS (1974), SCHULTZ (1998)	<i>Cyclaster aturicus</i> (SEUNES)	junior synonym; genus relegated into synonymy by JEFFERY (1998)
<i>Brissopneustes</i> sp.	KÜHN (1930a)	<i>Cyclaster aturicus</i> (SEUNES)	
<i>Linthia</i> nov. spec.	KÜHN (1960b)	<i>Linthia cf. houzeaui</i> COTTEAU	

Tab. 1: Echinoid taxa known prior to the present study and their revised names.

Chrono- stratigraphy		Taxa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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Tab. 2: Overview of the stratigraphic distribution of echinoid taxa recorded from the Danian Bruderndorf Fm. of Austria.

widespread, homogeneous echinoid fauna during the Danian in Europe, resulting from a major faunal reorganisation following the K/Pg event. Two different palaeoenvironments have been recognised, a siliciclastic environment, dominated by burrowing or ploughing irregular echinoids and a carbonate environment, dominated by epibenthic regular echinoids.

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Taxa Region	Eastern USA	Greenland	Southwest Europe	Northern Europe	Central Europe	Eastern Europe	Caucasus	Transcaspiian Region	Western Africa	Northern Africa	Eastern Africa
<i>Hyposalenia heliophora</i> (AGASSIZ & DESOR)											
<i>Adelopneustes boehmi</i> (NIETSCH)											
<i>Adelopneustes montainvillensis</i> (SORIGNET)											
<i>Adelopneustes aff. akkajensis</i> (ENDELMAN)											
<i>Plagiophasma cruciferum</i> (MORTON)											
<i>Echinocorys scutata</i> forma ovata (LESKE)											
<i>Echinocorys scutata</i> forma pyrenaica SEUNES											
<i>Echinocorys scutata</i> forma A											
<i>Echinocorys scutata</i> forma B											
<i>Cyclaster aturicus</i> (SEUNES)											
<i>Isaster aquitanicus</i> (GRATELOUP)											
<i>Hemiaster stella</i> (MORTON)											
<i>Coraster vilanovae</i> COTTEAU											
<i>Orthaster dagestanensis</i> MOSKVIN											
<i>Orthaster</i> sp.											
<i>Homoeaster evaristei</i> (COTTEAU)											
<i>Linthia cf. houzeaui</i> COTTEAU											

Tab. 3: Overview of the geographic distribution of echinoid taxa recorded from the Danian Bruderndorf Fm. of Austria.

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Plate 1

- Fig. 1: Cidaridae indet., spine fragment, lateral view (NHMW 2000z0096/0054), Haidhof, Lower Austria.
- Fig. 2: Cidaridae indet., spine base, lateral view (NHMW 2000z0096/0054), Haidhof, Lower Austria.
- Fig. 3: Cidaridae indet., interambulacral plate (NHMW 2000z0096/0055), Haidhof, Lower Austria.
- Fig. 4: Cidaridae indet., interambulacral plate (Remark: The perforation of the mamelon is covered by sediment, it was visible under the light microscope.) (NHMW 2000z0096/0055), Haidhof, Lower Austria.
- Fig. 5: *Hyposalenia heliophora* (AGASSIZ & DESOR, 1846), aboral view (NHMW 2000z0096/0049), Haidhof, Lower Austria.
- Fig. 6: *Hyposalenia heliophora* (AGASSIZ & DESOR, 1846), oral view (NHMW 2000z0096/0049) Haidhof, Lower Austria.
- Fig. 7: *Hyposalenia heliophora* (AGASSIZ & DESOR, 1846), lateral view (NHMW 2000z0096/0049) Haidhof, Lower Austria.

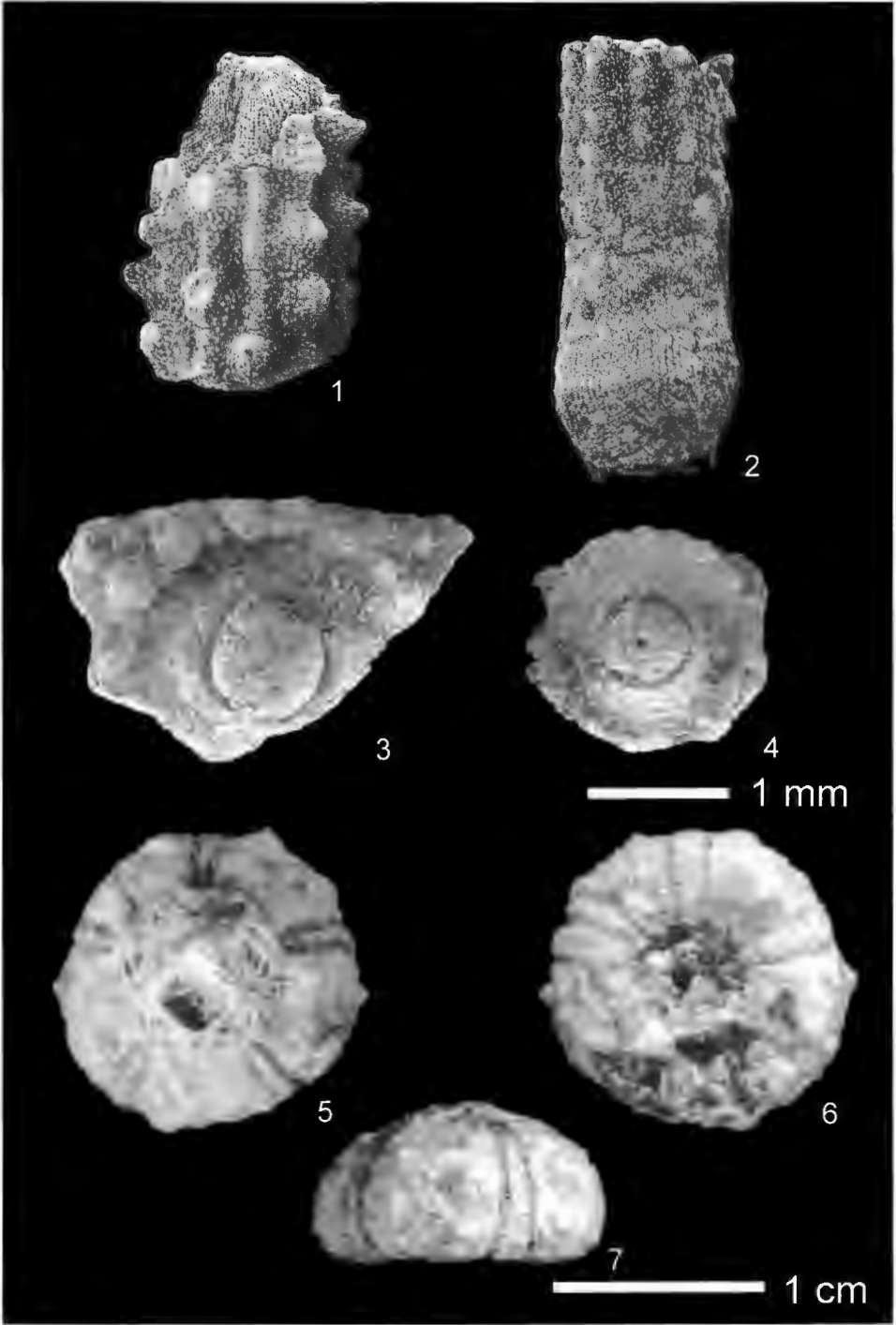


Plate 2

- Fig. 1: *Adelopneustes boehmi* (NIETSCH, 1921), aboral view (NHMW 2000z0096/0046) Bruderdorf, Lower Austria.
- Fig. 2: *Adelopneustes boehmi* (NIETSCH, 1921), oral view (NHMW 2000z0096/0046) Bruderdorf, Lower Austria.
- Fig. 3: *Adelopneustes montainvillensis* (SORIGNET, 1850), aboral view (NHMW 1997z0178/0411b) Haidhof, Lower Austria.
- Fig. 4: *Adelopneustes montainvillensis* (SORIGNET, 1850), oral view (NHMW 1997z0178/0411b) Haidhof, Lower Austria.
- Fig. 5: *Adelopneustes montainvillensis* (SORIGNET, 1850), lateral view (anterior is left) (NHMW 1997z0178/0411b) Haidhof, Lower Austria.
- Fig. 6: *Adelopneustes montainvillensis* (SORIGNET, 1850), aboral view (NHMW 1997z0178/0411a) Haidhof, Lower Austria.
- Fig. 7: *Adelopneustes montainvillensis* (SORIGNET, 1850), oral view (NHMW 1997z0178/0411a) Haidhof, Lower Austria.

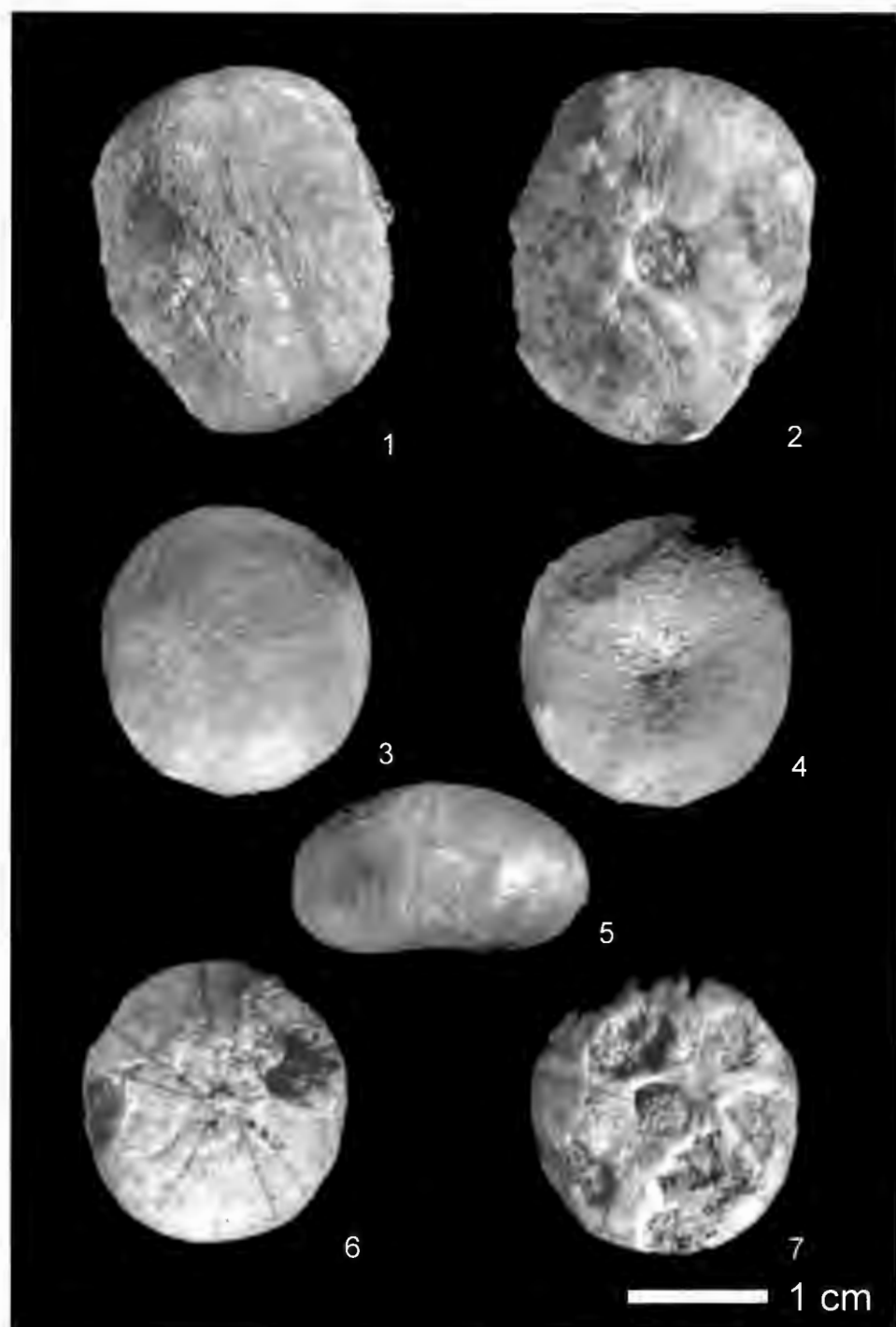


Plate 3

- Fig. 1: *Adelopneustes* aff. *akkajensis* (ENDELMAN, 1980), aboral view (NHMW 2000z0096/0048) Haidhof, Lower Austria.
- Fig. 2: *Adelopneustes* aff. *akkajensis* (ENDELMAN, 1980), oral view (NHMW 2000z0096/0048) Haidhof, Lower Austria.
- Fig. 3: *Adelopneustes* aff. *akkajensis* (ENDELMAN, 1980), lateral view (anterior is left) (NHMW 2000z0096/0048) Haidhof, Lower Austria.
- Fig. 4: *Plagiochasma cruciferum* (MORTON, 1830), aboral view (NHMW 2000z0096/0044) Haidhof, Lower Austria.
- Fig. 5: *Plagiochasma cruciferum* (MORTON, 1830), oral view (NHMW 2000z0096/0044) Haidhof, Lower Austria.
- Fig. 6: *Plagiochasma cruciferum* (MORTON, 1830), lateral view (anterior is right) (NHMW 2000z0096/0044) Haidhof, Lower Austria.
- Fig. 7: *Plagiochasma cruciferum* (MORTON, 1830), aboral view (NHMW 1997z0178/0412) Haidhof, Lower Austria.
- Fig. 8: *Plagiochasma cruciferum* (MORTON, 1830), oral view (NHMW 1997z0178/0412) Haidhof, Lower Austria.

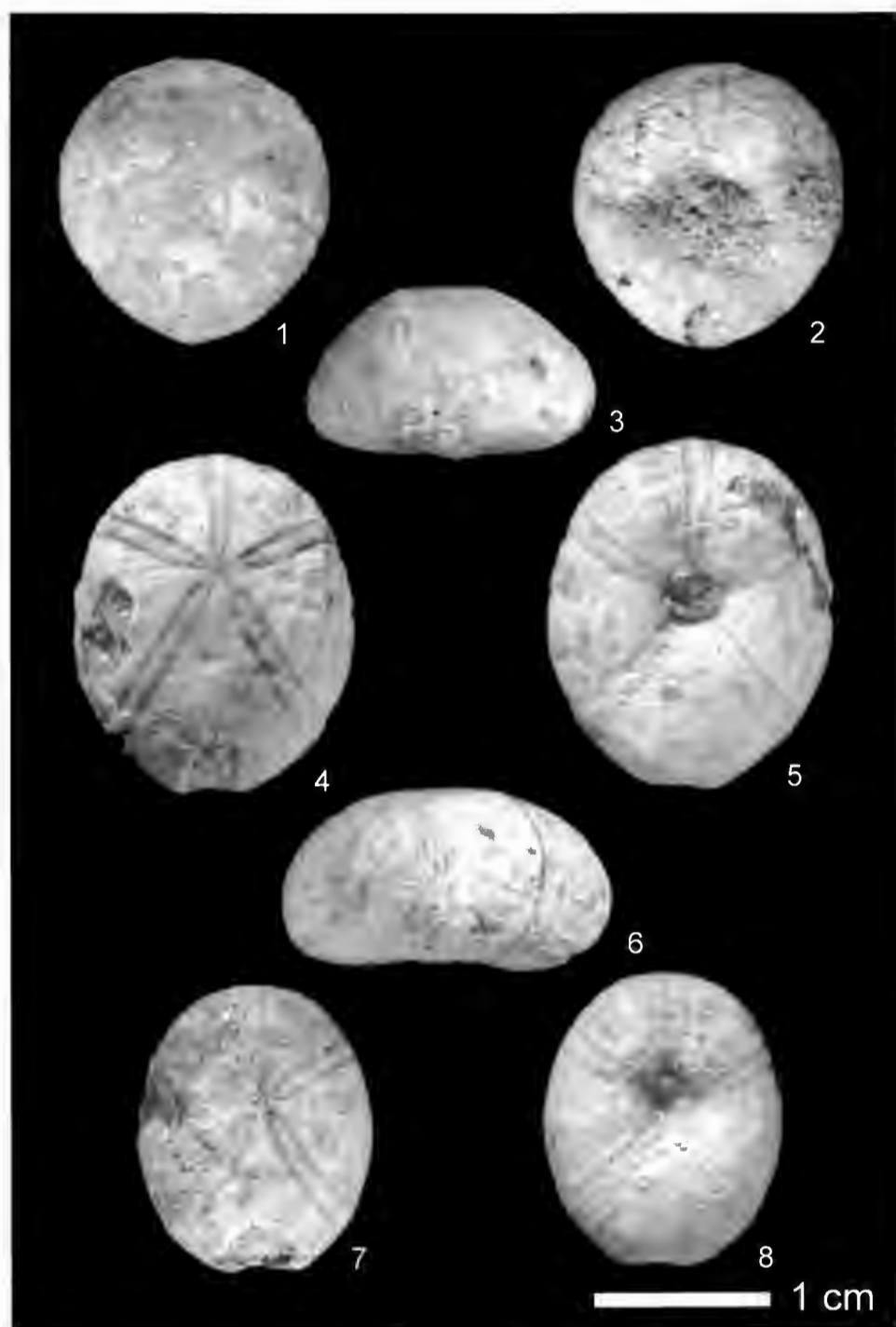


Plate 4

- Fig. 1: *Echinocorys scutata* forma *ovata* (LESKE, 1778), aboral view (NHMW 1997z0178/0406)
Haidhof, Lower Austria.
- Fig. 2: *Echinocorys scutata* forma *ovata* (LESKE, 1778), oral view (NHMW 1997z0178/0406)
Haidhof, Lower Austria.
- Fig. 3: *Echinocorys scutata* forma *ovata* (LESKE, 1778), lateral view (NHMW 1997z0178/0406)
Haidhof, Lower Austria.

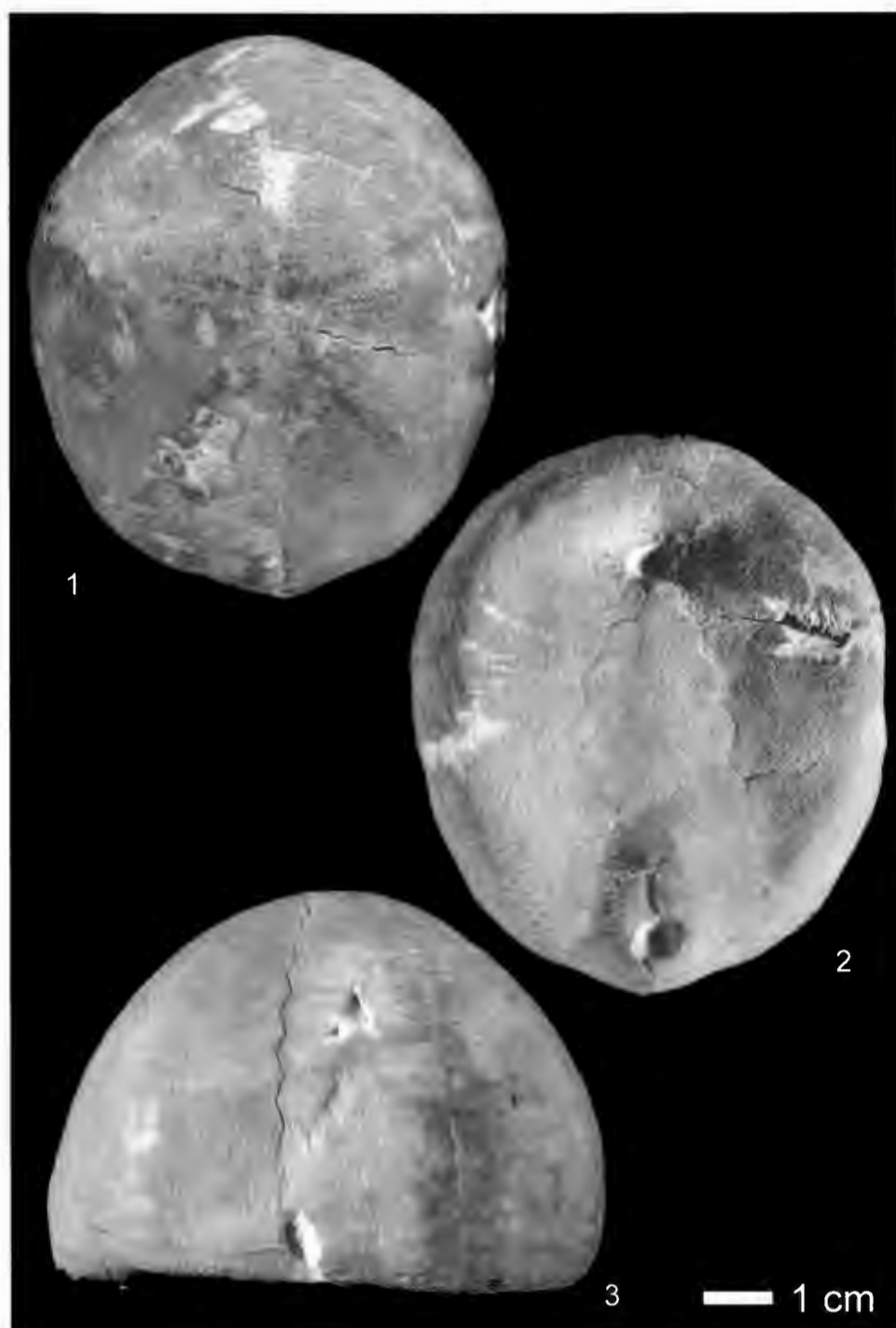


Plate 5

- Fig. 1: *Echinocorys scutata* forma *ovata* (LESKE, 1778), aboral view (NHMW 1997z0178/0405)
Haidhof, Lower Austria.
- Fig. 2: *Echinocorys scutata* forma *ovata* (LESKE, 1778), oral view (NHMW 1997z0178/0405)
Haidhof, Lower Austria.
- Fig. 3: *Echinocorys scutata* forma *ovata* (LESKE, 1778), lateral view (NHMW 1997z0178/0405)
Haidhof, Lower Austria.

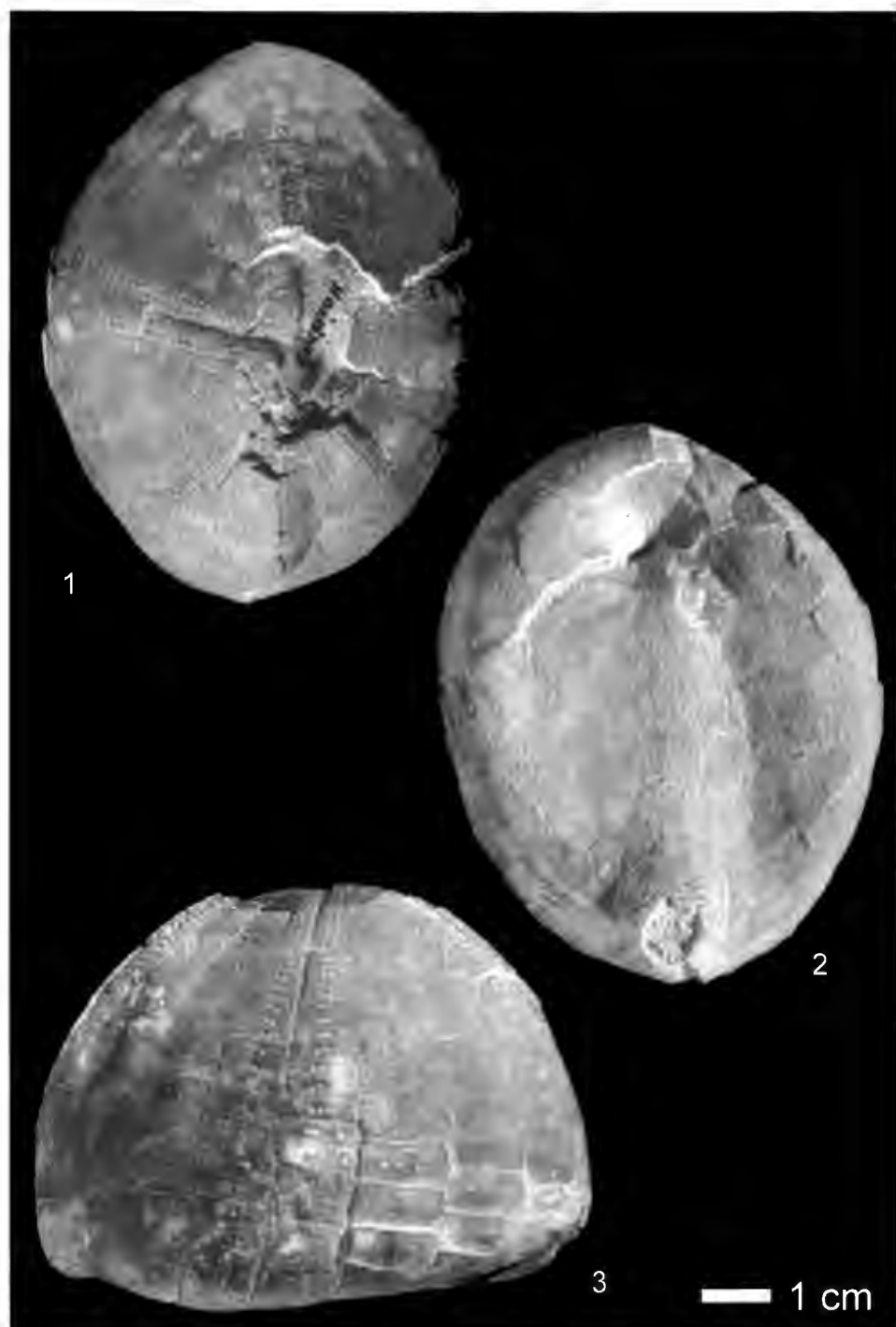


Plate 6

- Fig. 1: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, aboral view (NHMW 1997z0178/0416c) Haidhof, Lower Austria.
- Fig. 2: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, oral view (NHMW 1997z0178/0416c) Haidhof, Lower Austria.
- Fig. 3: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, lateral view (NHMW 1997z0178/0416c) Haidhof, Lower Austria.
- Fig. 4: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, apical disc (NHMW 1997z0178/0416b) Haidhof, Lower Austria.
- Fig. 5: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, oral view (NHMW 2000z0096/0005) Haidhof, Lower Austria.

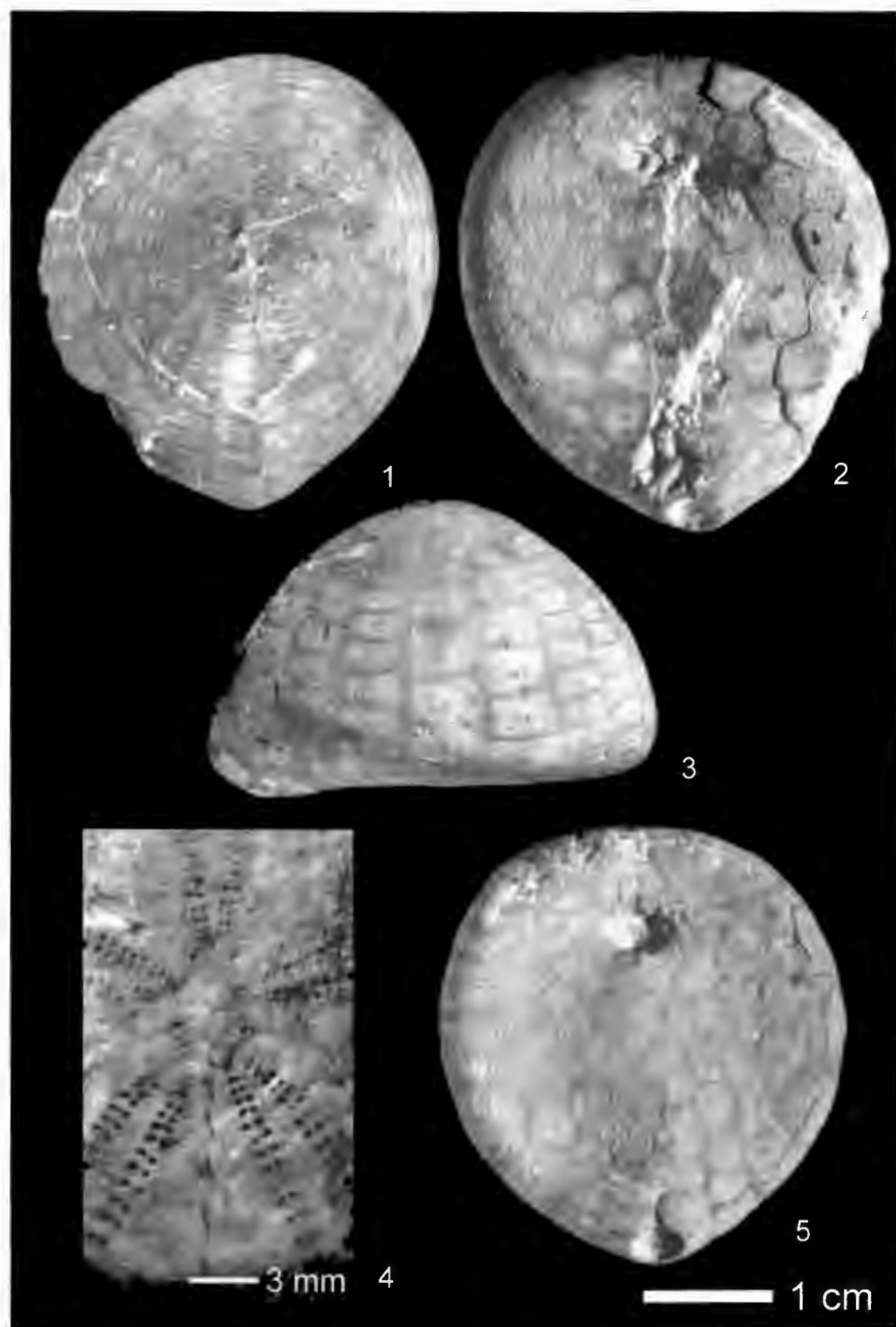


Plate 7

- Fig. 1: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, aboral view (NHMW 1997z0178/0416d) Haidhof, Lower Austria.
- Fig. 2: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, oral view (NHMW 1997z0178/0416d) Haidhof, Lower Austria.
- Fig. 3: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, lateral view (NHMW 1997z0178/0416d) Haidhof, Lower Austria.
- Fig. 4: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, lateral view (Holotype of *Garumnaster lamberti* KÜHN, 1930) (NHMW 1930V9) Bruderndorf, Lower Austria.
- Fig. 5: *Echinocorys scutata* forma *pyrenaica* SEUNES, 1888, aboral view (Holotype of *Garumnaster lamberti* KÜHN, 1930) (NHMW 1930V9) Bruderndorf, Lower Austria.

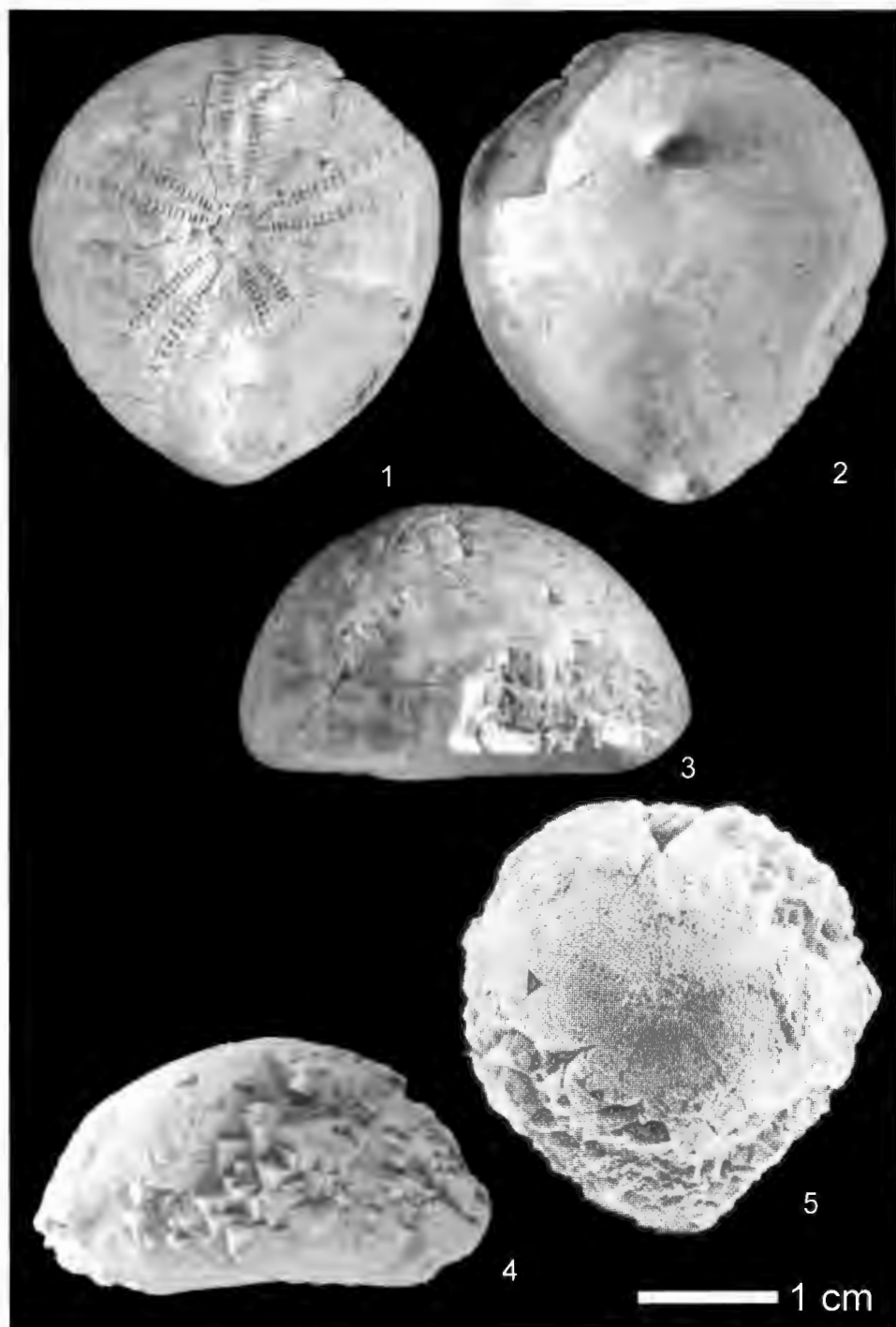


Plate 8

Fig. 1: *Echinocorys scutata* forma A, aboral view (NHMW 1997z0178/0408) Haidhof, Lower Austria.

Fig. 2: *Echinocorys scutata* forma A, oral view (NHMW 1997z0178/0408) Haidhof, Lower Austria.

Fig. 3: *Echinocorys scutata* forma A, lateral view (NHMW 1997z0178/0408) Haidhof, Lower Austria.

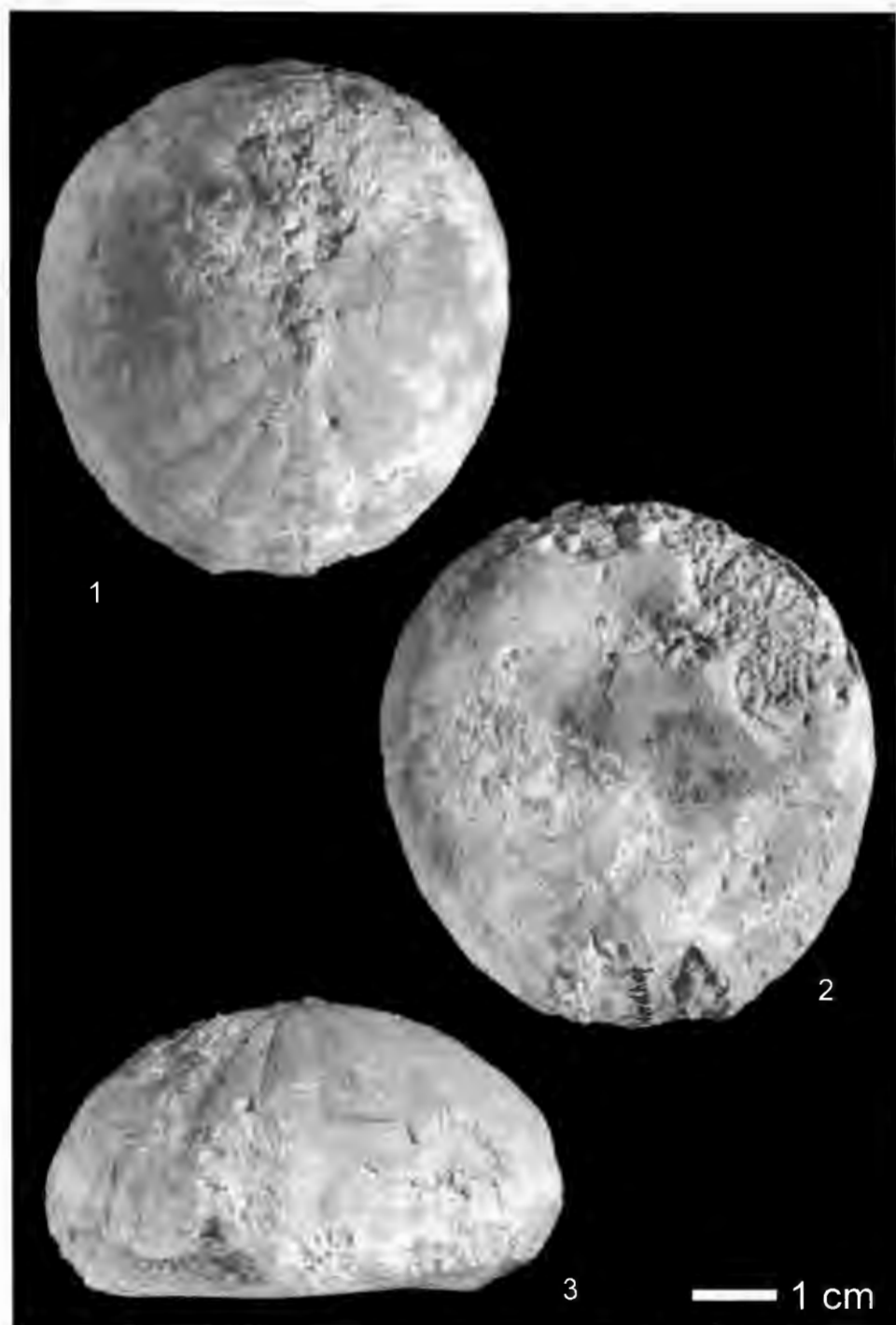


Plate 9

- Fig. 1: *Cyclaster aturicus* (SEUNES, 1888), aboral view (NHMW 2000z0096/0003) Haidhof, Lower Austria.
- Fig. 2: *Cyclaster aturicus* (SEUNES, 1888), oral view (NHMW 2000z0096/0003) Haidhof, Lower Austria.
- Fig. 3: *Cyclaster aturicus* (SEUNES, 1888), lateral view (NHMW 2000z0096/0003) Haidhof, Lower Austria.
- Fig. 4: *Cyclaster aturicus* (SEUNES, 1888), lateral view (NHMW 2000z0096/0043) Haidhof, Lower Austria.
- Fig. 5: *Cyclaster aturicus* (SEUNES, 1888), aboral view (NHMW 2000z0096/0043) Haidhof, Lower Austria.
- Fig. 6: *Cyclaster aturicus* (SEUNES, 1888), oral view (NHMW 2000z0096/0043) Haidhof, Lower Austria.

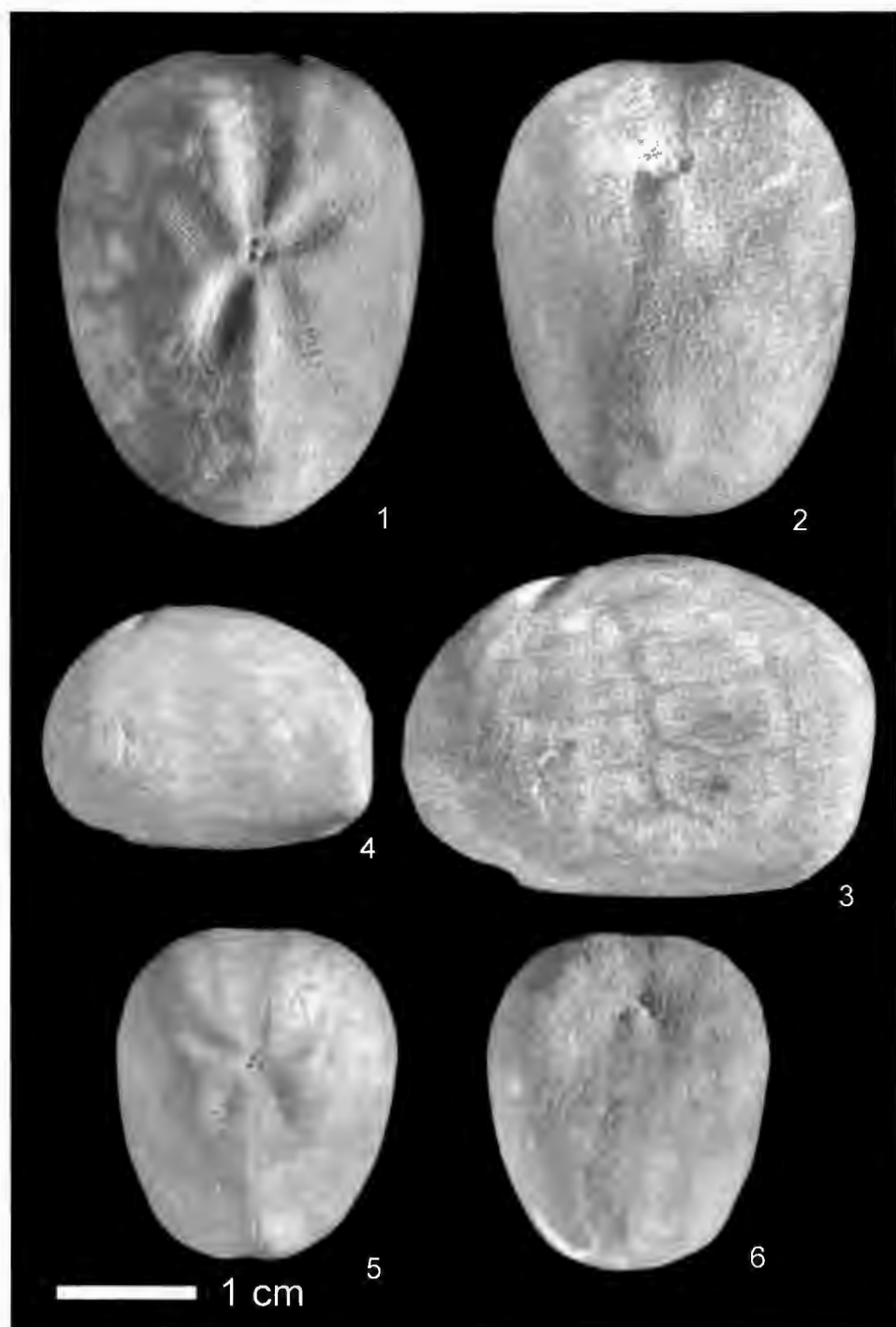


Plate 10

- Fig. 1: *Cyclaster aturicus* (SEUNES, 1888), aboral view (NHMW 2000z0096/0050) Haidhof, Lower Austria.
- Fig. 2: *Cyclaster aturicus* (SEUNES, 1888), oral view (NHMW 2000z0096/0050) Haidhof, Lower Austria.
- Fig. 3: *Cyclaster aturicus* (SEUNES, 1888), lateral view (NHMW 2000z0096/0050) Haidhof, Lower Austria.
- Fig. 4: *Cyclaster aturicus* (SEUNES, 1888), aboral view (Note the abnormal form of the petalodium, which was probably caused by an injury of petal I) (NHMW 2000z0096/0042) Haidhof, Lower Austria.
- Fig. 5: *Linthia* cf. *houzeau* COTTEAU, 1878, aboral view (NHMW 2000z0096/0027) Haidhof, Lower Austria.
- Fig. 6: *Linthia* cf. *houzeau* COTTEAU, 1878, lateral view (NHMW 2000z0096/0027) Haidhof, Lower Austria.

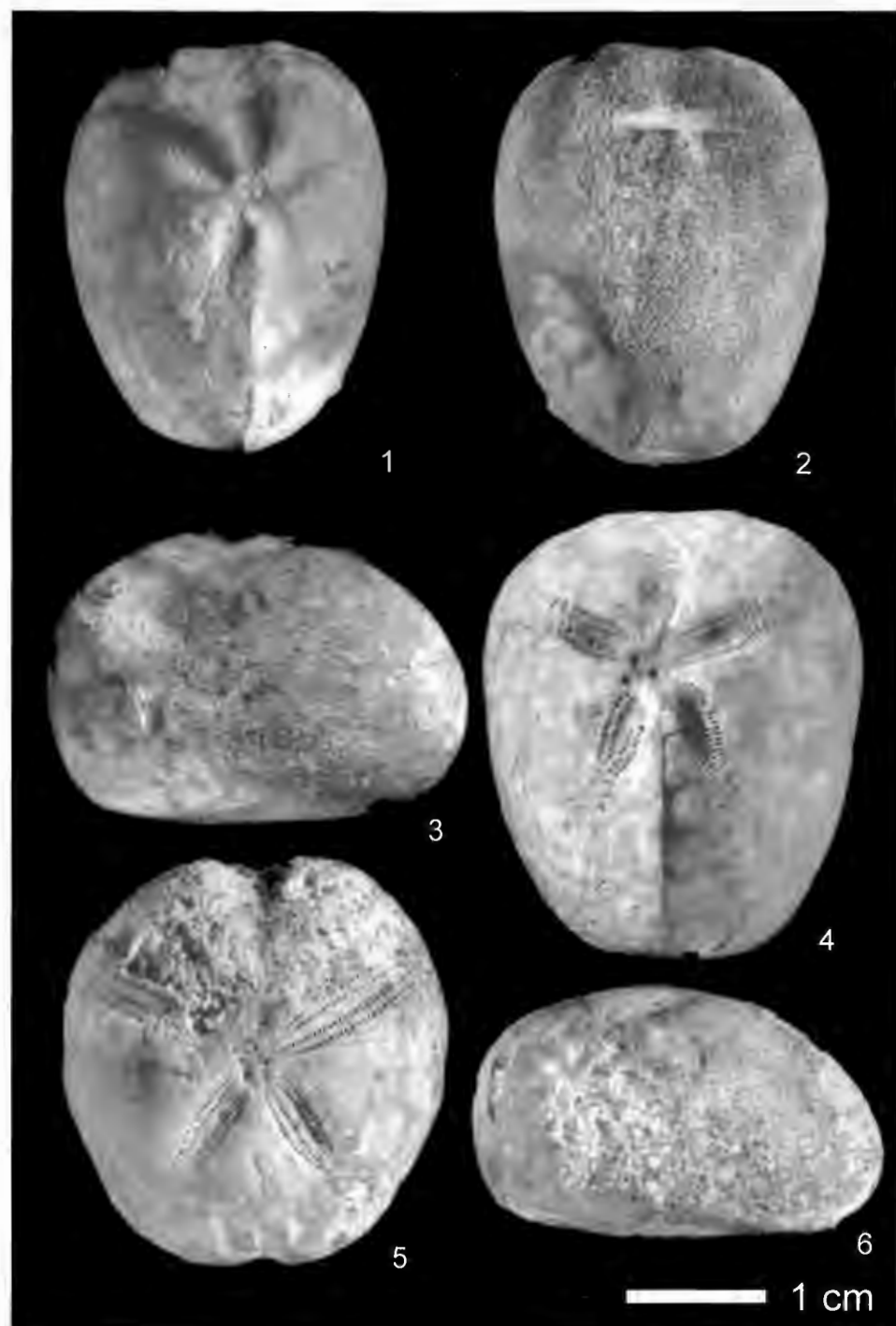


Plate 11

- Fig. 1: *Isaster aquitanicus* (GRATELOUP, 1836), aboral view (NHMW 2000z0096/0035) Haidhof, Lower Austria.
- Fig. 2: *Isaster aquitanicus* (GRATELOUP, 1836), oral view (NHMW 2000z0096/0035) Haidhof, Lower Austria.
- Fig. 3: *Isaster aquitanicus* (GRATELOUP, 1836), lateral view (anterior is up) (NHMW 2000z0096/0035) Haidhof, Lower Austria.
- Fig. 4: *Isaster aquitanicus* (GRATELOUP, 1836), aboral view (NHMW 2000z0096/0032) Haidhof, Lower Austria.

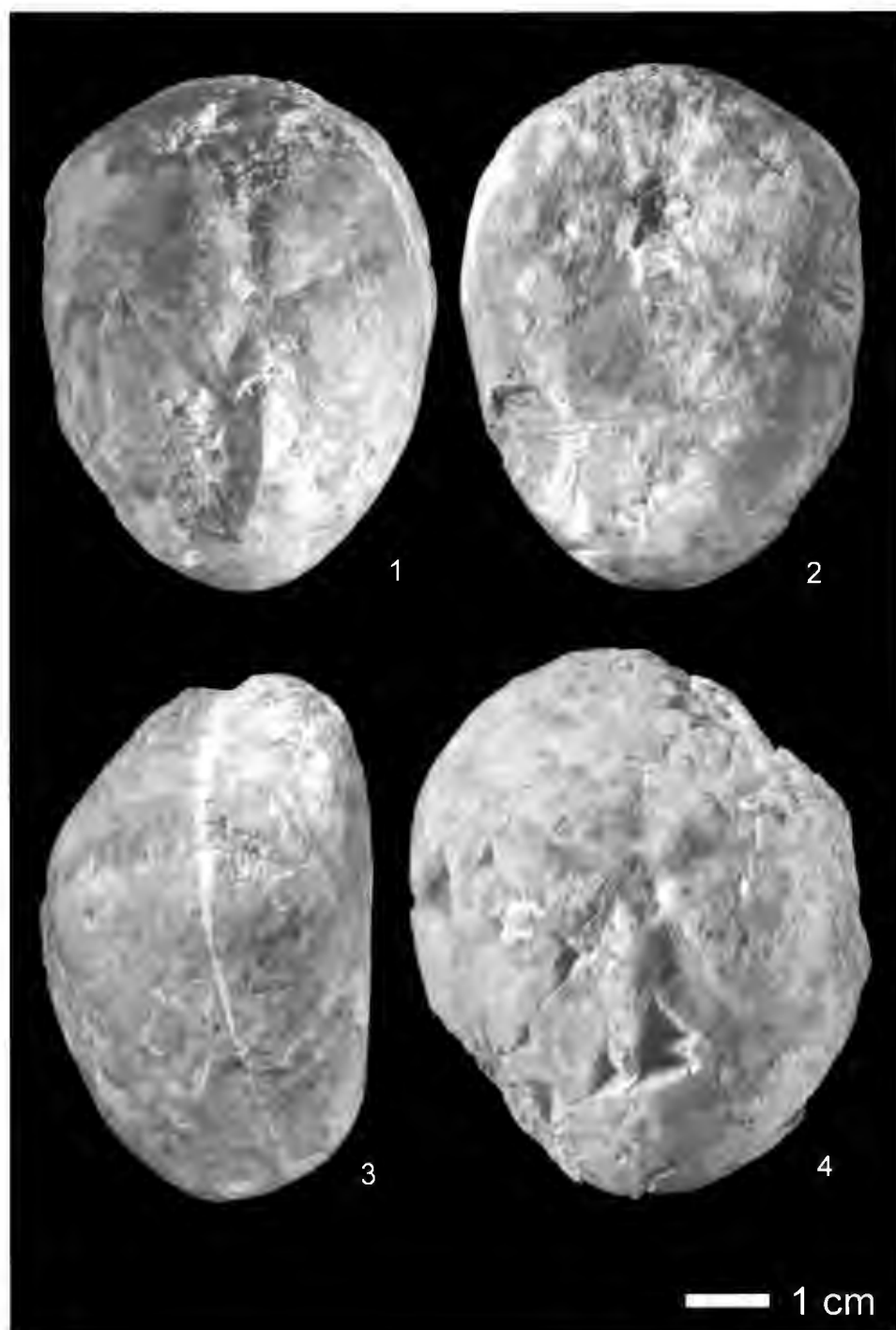


Plate 12

- Fig. 1: *Hemiaster stella* (MORTON, 1830), aboral view (NHMW 2000z0096/0040) Haidhof, Lower Austria.
- Fig. 2: *Hemiaster stella* (MORTON, 1830), oral view (NHMW 2000z0096/0040) Haidhof, Lower Austria.
- Fig. 3: *Hemiaster stella* (MORTON, 1830), lateral view (NHMW 2000z0096/0040) Haidhof, Lower Austria.
- Fig. 4: *Hemiaster stella* (MORTON, 1830), lateral view (NHMW 2000z0096/0039) Haidhof, Lower Austria.
- Fig. 5: *Hemiaster stella* (MORTON, 1830), aboral view (NHMW 2000z0096/0039) Haidhof, Lower Austria.
- Fig. 6: *Hemiaster stella* (MORTON, 1830), oral view (NHMW 2000z0096/0039) Haidhof, Lower Austria.
- Fig. 7: *Hemiaster stella* (MORTON, 1830), aboral view (NHMW 2000z0096/0041) Haidhof, Lower Austria.
- Fig. 8: *Hemiaster stella* (MORTON, 1830), lateral view (NHMW 2000z0096/0041) Haidhof, Lower Austria.

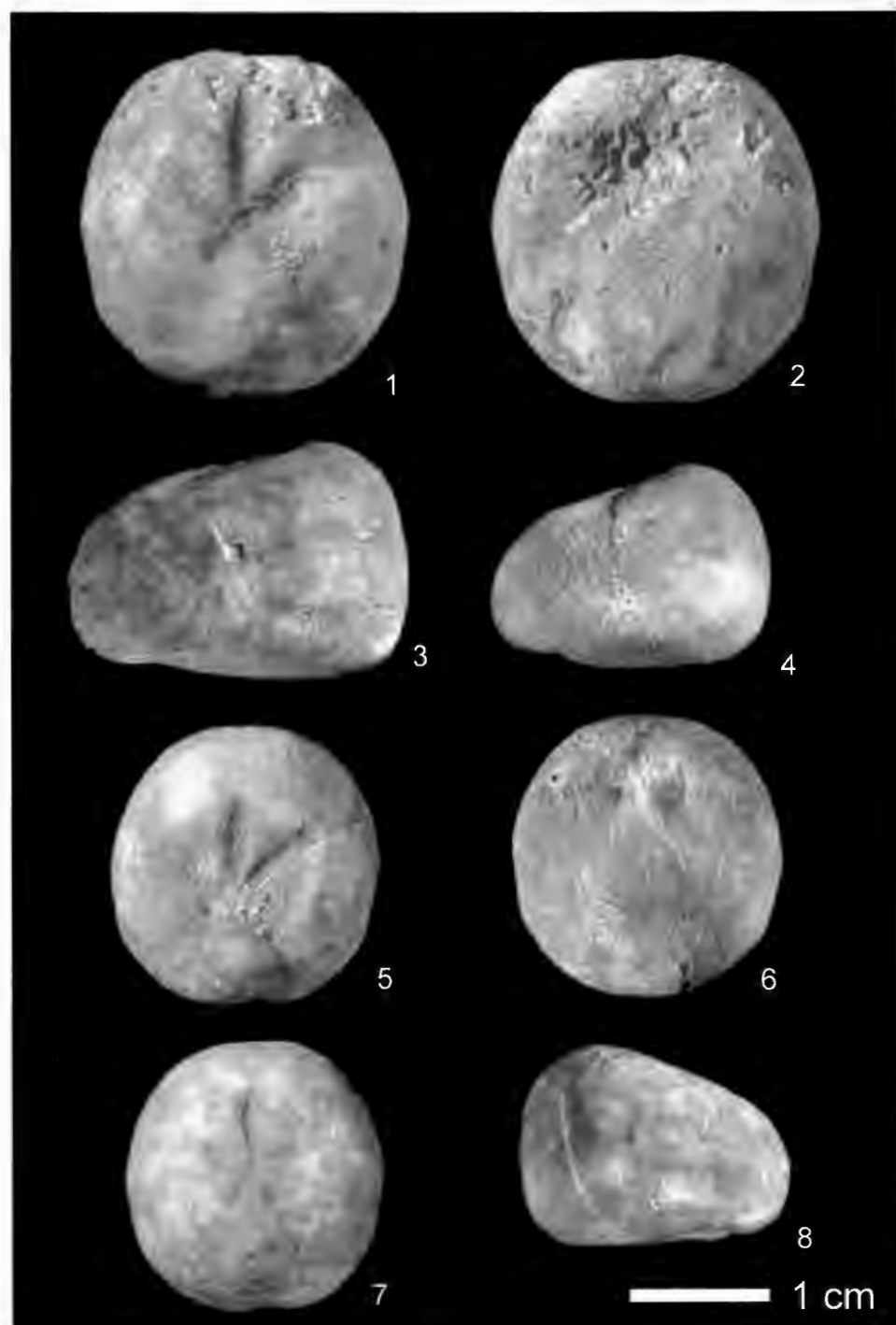


Plate 13

Fig. 1: *Orthaster* sp., aboral view (NHMW 1997z0178/0410) Haidhof, Lower Austria.

Fig. 2: *Orthaster* sp., oral view (NHMW 1997z0178/0410) Haidhof, Lower Austria.

Fig. 3: *Orthaster* sp., lateral view (NHMW 1997z0178/0410) Haidhof, Lower Austria.

Fig. 4: *Orthaster dagestanensis* MOSKVIN, 1982, aboral view (NHMW 2000z0096/0026) Haidhof, Lower Austria.

Fig. 5: *Orthaster dagestanensis* MOSKVIN, 1982, oral view (NHMW 2000z0096/0026) Haidhof, Lower Austria.

Fig. 6: *Orthaster dagestanensis* MOSKVIN, 1982, lateral view (NHMW 2000z0096/0026) Haidhof, Lower Austria.

Fig. 7: *Orthaster dagestanensis* MOSKVIN, 1982, aboral view (NHMW 2000z0096/0009) Haidhof, Lower Austria.

Fig. 8: *Orthaster dagestanensis* MOSKVIN, 1982, oral view (NHMW 2000z0096/0009) Haidhof, Lower Austria.

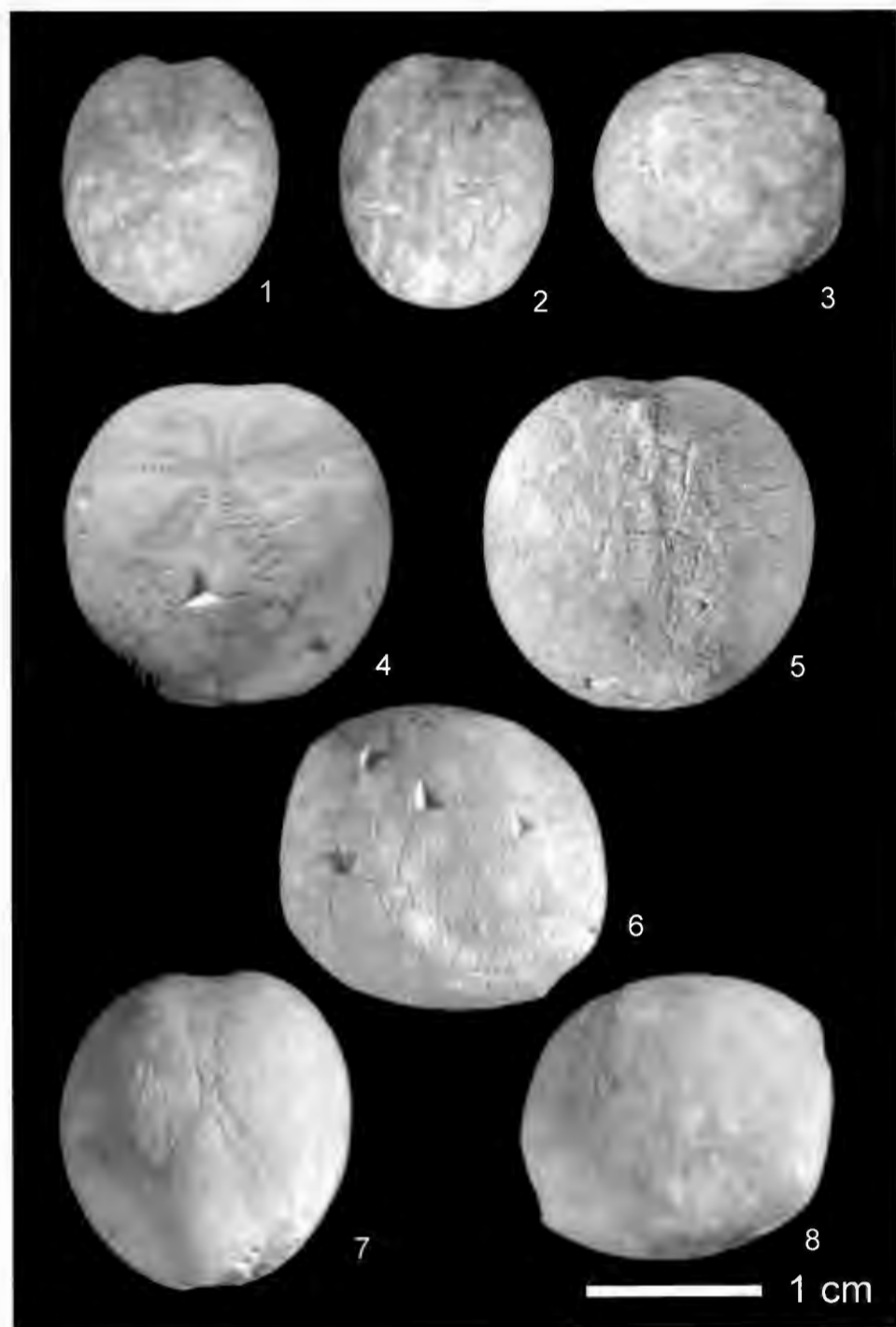


Plate 14

- Fig. 1: *Coraster vilanovae* COTTEAU, 1886, aboral view (IPUW 1992/29) Haidhof, Lower Austria.
- Fig. 2: *Coraster vilanovae* COTTEAU, 1886, right lateral view (IPUW 1992/29) Haidhof, Lower Austria.
- Fig. 3: *Coraster vilanovae* COTTEAU, 1886, oral view (IPUW 1992/29) Haidhof, Lower Austria.
- Fig. 4: *Coraster vilanovae* COTTEAU, 1886, aboral view (NHMW 2000z0200/0002) Haidhof, Lower Austria.
- Fig. 5: *Coraster vilanovae* COTTEAU, 1886, right lateral view (NHMW 2000z0200/0002) Haidhof, Lower Austria.
- Fig. 6: *Coraster vilanovae* COTTEAU, 1886, oral view (NHMW 2000z0200/0002) Haidhof, Lower Austria.
- Fig. 7: *Homoeaster evaristei* (COTTEAU, 1886), aboral view (NHMW 2000z0200/0004) Haidhof, Lower Austria.
- Fig. 8: *Homoeaster evaristei* (COTTEAU, 1886), oral view (NHMW 2000z0200/0004) Haidhof, Lower Austria.
- Fig. 9: *Homoeaster evaristei* (COTTEAU, 1886), left lateral view (NHMW 2000z0200/0004) Haidhof, Lower Austria.

