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Additional records of Late Cretaceous and Early Palaeogene echinoids from the Gschliefgraben (Ultrahelvetic, Upper Austria)

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ABSTRACT:

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Late Cretaceous and Early Palaeogene echinoid faunules collected in recent years from the surface of an active mudflow at the Gschliefgraben near Gmunden (east of the Traunsee, Upper Austria) are both fairly diverse and of considerable palaeobiogeographic interest. So far, only (Late) Campanian taxa have been described and illustrated. In the present paper, notes are presented on additional Campanian, Maastrichtian and Palaeogene taxa, namely *Lampadocorys*? *estermanni* sp.nov., *Lampadocorys*? sp.nov. 1, *Lampadocorys*? sp.nov. 2, *Rispolia* cf. *subtrigonata* (CATULLO), *Seunaster* cf. *heberti* (SEUNES), *Echinocorys ancileformis* MOSKVIN & SHIMANSKAYA, *Echinocorys* ex gr. *fonticola* ARNAUD, *Ganbirretia*? sp., *Micraster aturicus* HÉBERT *in* SEUNES, *Micraster corcolumbarium* DESOR, *Micraster stolleyi* (LAMBERT *in* DE GROSSOUVRE), *Pseudogibbaster*? sp., and *Coraster beneharnicus* SEUNES. These species indicate a close relationship with the Tethyan areas of northern Spain and SW France, the Crimea, Georgia and the northern Caucasus, although a number of holasteroid and micrasterid taxa would appear to be more common and widely distributed in boreal settings (e.g., NW Europe).

Key words: Cretaceous, Palaeogene, Campanian, Maastrichtian, Danian, Echinoids, Austria, Palaeobiogeography, New taxon.

INTRODUCTION

Collections recently made, mostly by private collectors, from the surface of an active mudflow at the Gschliefgraben (Text-fig. 1), comprise comparatively numerous echinoids, in varying states of preservation, as well as ammonites and inoceramid bivalves. As pointed out by KENNEDY & SUMMESBERGER (1999), there is no measurable section at the Gschliefgraben; a synthetic section based on estimated thicknesses as well as on previously published stratigraphic data (PREY 1983, KENNEDY & SUMMESBERGER 1984) is shown in Text-fig. 2.

Although the echinoid fauna of the Gschliefgraben is relatively diverse, albeit not abundant, and has been known for over 150 years, there are virtually no published data. Until recently there was only the sketchy information provided by VON HAUER (1858), who

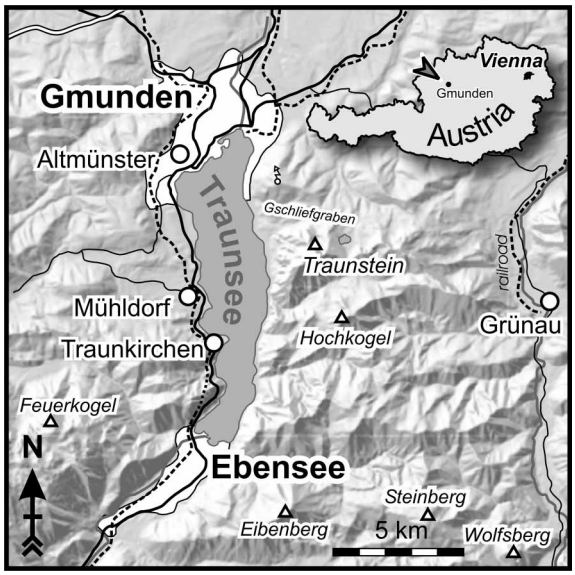

Fig. 1. Location of the Gschliefgraben near Gmunden (Upper Austria), superimposed on a digital height model. Inset shows the position of the study area within Austria. Thick dark lines: major roads; thin dark lines: minor roads; stippled lines: railroad; grey lines: rivers; white circles and white areas: villages and urban areas; triangles: mountains

recorded *Ananchytes ovata*, *Micraster gibbus*?, *Pyrina carinata*? and *Diplopodea* sp. [sic!] (determined by MICHELIN, according to VON HAUER 1858) and by PREY (1983), who listed *Ananchytes ovata*, *Linthia insignis*, *Prenaster alpinus*, *Conoclypeus anachoreta* and cidarid spines. From larger sets of echinoids, housed both at the Naturhistorisches Museum Wien (NHMW) and in private collections, JAGT (1999) isolated the typically (Late) Campanian species, but noted that some of these might actually have ranged into the Maastrichtian, as based on stratigraphic distribution elsewhere. These included the following taxa: rhabdocidarid (?) indet., *Pseudoffaster caucasicus* (DRU), *Echinocorys* gr. *conica* (AGASSIZ)?, *Echinocorys* ex gr. *subglobosa* (GOLDFUSS), *Echinocorys* sp., *Cardiaster* gr. *cordiformis/granulosus*, *Micraster* ex gr. *schroederi/glyphus* and *Micraster aturicus* HÉBERT in SEUNES.

The present faunules include stegasterids, additional morphotypes of *Echinocorys* and *Ganbirretia*?, four micrasterids as well as a corasterid, while one new species is erected, *Lampadocorys*? *estermanni* sp. nov. Palaeobiogeographically, these new records are of special note in demonstrating a close link with Tethyan echinoid

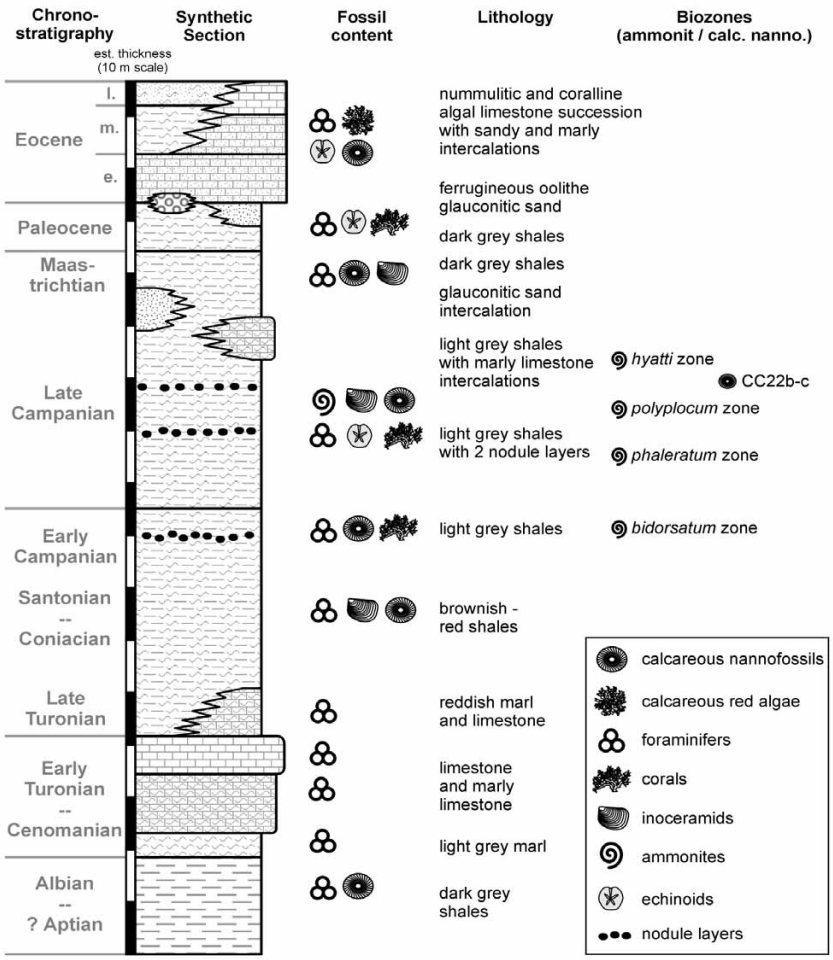

Fig. 2. Synthetic section of the Gschliefgraben window (Ultrahelvetic, Austria), as based on data supplied by PREY (1983), and modified after KENNEDY & SUMMESBERGER (1984) incorporating data recently published by KENNEDY & SUMMESBERGER (1999), TRÖGER & *al.* (1999), and WAGREICH (1999)

faunas from northern Spain (Navarra, Pyrenees) and SW France (French Pyrenees, Landes), and even further afield (Georgia and the Caucasus). Species represented are of Early Campanian (*Echinocorys* ex gr. *fonticola*), Late Campanian (*Micraster aturicus*, *M. corcolumbarium*, *M. stolleyi*, *Lampadocorys*? *estermanni* sp.nov.), Maastrichtian (*Seunaster*) and possibly Paleocene (*Coraster beneharnicus*, *Echinocorys ancileformis)* age.

The late Professor Gundolf ERNST would have taken a keen interest in these new echinoid records from Austria, which, although stratigraphically rather poorly constrained, allow correlation with northern Tethyan areas as well as with more Boreal settings in NW Europe. Ultimately, these records may hopefully be assembled in a sequence-stratigraphic context, thus reflecting Professor ERNST's main research interests. In view of this, we wish to dedicate the present paper to his memory.

STUDY AREA

The Gschliefgraben, a tectonic window exposing ultrahelvetic rocks otherwise covered by the Flysch Nappe, is situated immediately north of the Northern Calcareous Alps in Upper Austria (see Text-fig. 1). Rocks exposed are predominantly marls, but subsidiary amounts of glauconitic sandstone and nummulitic limestone are also present. The sedimentary succession comprises Albian (Lower Cretaceous) to Eocene (Palaeo gene) strata (PREY 1983). Despite this long range, macrofossils are restricted to certain levels and occur most commonly in Upper Campanian and Eocene strata. Being an area of active mudflows and subject to constant downhill slides, outcrop conditions change rapidly. Due to this it is impossible to measure a section at this outcrop. For comparison purposes a synthetic section was compiled by KENNEDY & SUMMESBERGER (1984) from lithological and biostratigraphical data presented by PREY (1983) (see Text-fig. 2).

MATERIAL AND METHODS

All material used in this study comes from the Gschliefgraben tectonic window and is housed either in the collection of the Natural History Museum Vienna (abbreviated NHMW) or in the private collection of Ferdinand ESTERMANN (Gmunden, Upper Austria; abbreviated EST). Due to the special outcrop conditions (active mudflow, see PREY 1983) the stratigraphic provenance of most specimens is unclear. To compensate for this obvious drawback, calcareous nannofossils from matrix samples of selected specimens have been investigated by one of us (Michael WAGREICH).

SYSTEMATIC PALAEONTOLOGY

Order Holasteroida DURHAM & MELVILLE, 1957
Suborder Stegasterina LAMBERT, 1917
Family Stegasteridae LAMBERT, 1917
Genus *Lampadocorys* POMEL, 1883 ?

TYPE SPECIES: *Holaster sulcatus* COTTEAU, 1873, p. 401 (170), by original designation (POMEL 1883, p. 46).

REMARKS: SMITH & JEFFERY (2000, pp. 270-274) included in the genus *Stegaster* forms with a contiguous plastron (e.g. *Holaster bouillei* COTTEAU, *in* de BOUILLÉ, 1873), as well as species with a disjunct plastron (e.g. *Stegaster cotteaui* SEUNES, 1889; *Stegaster palaeocenicus* SMITH & GALLEMÍ, 1999). Recently, however, in a paper on the phylogeny and revised classification of the Holasteroida, SMITH (2004; see also *The Echinoid Directory* [www.nhm.ac.uk/palaeontology/echinoids]) proposed to use the genus *Lampadocorys* for the latter group. This is also supported by his phylogenetic analysis which shows forms with contiguous and those with disjunct plastron to fall within different clades within the Stegasterina. According to SMITH, *Lampadocorys* is closely related to *Sternopatagus* DE MEIJERE, 1902 and *Sanchezaster* LAMBERT *in* SÁNCHEZ ROIG 1924, which he interprets as a synonym of *Sternopatagus*. *Sternopatagus* differs from *Lampadocorys* in having symmetrical episternal plates, a thin test and a marginal fasciole (however, see below).

Lampadocorys is characterised by an ovate, thick-shelled test; an elongate apical disc with four gonopores; nonpetaloid ambulacra; a disjunct, meridosternous plastron; a sternal plate followed by biserially offset episternals; a deep sulcus anterior of the peristome; an anteriorly displaced, small, subcircular peristome; an inframarginal periproct, just visible in oral view, as well as fine aboral and coarser oral tuberculation.

The present stegasterids with disjunct plastron from the Upper Campanian of the Gschliefgraben are tentatively referred to this genus based on their similar test architecture, plastron plating, shell thickness, tuberculation and position of periproct and peristome. They differ, however, in having a moderately to strongly developed frontal notch, which does not occur in the type species and other species usually assigned to this genus (*L. cotteaui*, *L. ennisi*).

Lampadocorys? *estermanni* sp.nov.
(Pl. 1, Figs 1-6; Pl. 2, Figs 1-6; Text-figs 3B, C, E, F)

TYPES: Holotype is NHMW 2003z0067/0001 (*ex* Estermann Colln, EST 46); paratype is NHMW 2003z0067/0002.

LOCUS TYPICUS: Gschliefgraben tectonic window, near Gmunden, Upper Austria.

STRATUM TYPICUM: Grey calcareous marls of Late Campanian age (see Appendix).

DERIVATIO NOMINIS: Named after Ferdinand ESTERMANN (Gmunden), who collected and donated the types and allowed us to use his collection of Gschliefgraben echinoids for this study.

MATERIAL: In addition to the types, one specimen (Estermann Colln, no. EST 40 (= *ex* 136)).

Measurements (in mm):

	Length	Height	Width
Estermann EST 40 (*ex* 136)	74.3	48.1	76.7
NHMW 2003z0067/0001 (holotype)	-	*c*. 59	75.2
NHMW 2003z0067/0002 (paratype)	>76	-	71.5

DESCRIPTION: Test of medium to large size, either

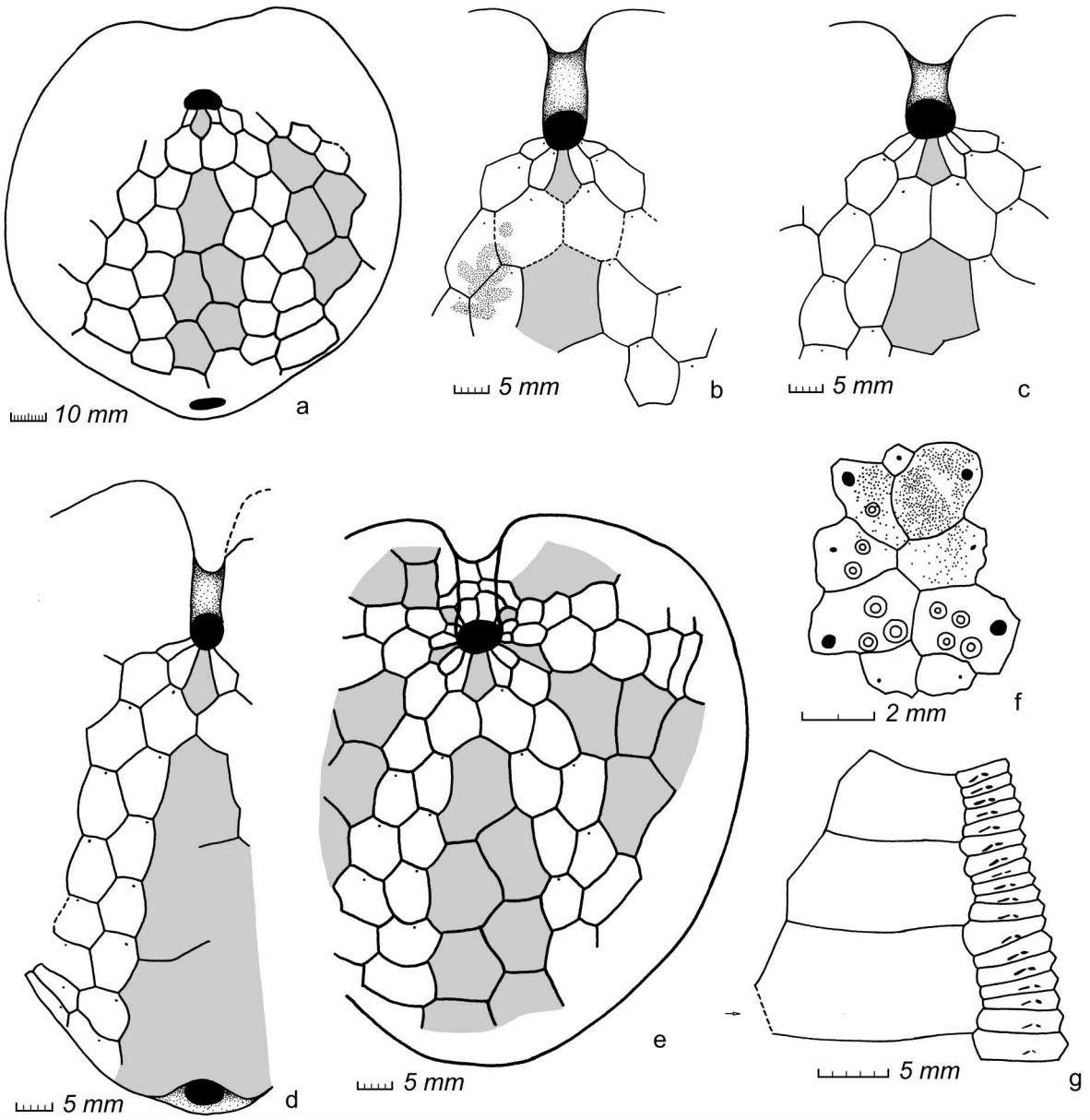

Fig. 3. Camera-lucida drawings of species of *Lampadocorys*; A – *Lampadocorys*? sp. nov. 2, oral plating (NHMW 1998z0098/0035); B, C, E, F – *Lampadocorys*? *estermanni* sp. nov., oral plating (B, C and E) and apical disc (F); B and F are holotype, NHMW 2003z0098/000; E is paratype, NHMW 2003z0098/0002; C is Estermann Colln, EST 136; D, G – *Lampadocorys*? sp. nov. 1, oral plating (D) and adapical ambulacral structure (G; interambulacrum 1b - ambulacrum IIa, small arrow marks half test height) (Estermann Colln, EST 151)

uncrushed but abraded or crushed to varying degrees and partially damaged. Test plating thick. Outline (weakly) cordate, broadly rounded anteriorly, truncated posteriorly. The greatest width lies in the anterior third. Frontal notch narrow, deep and well-defined. It deepens markedly halfway towards ambitus and continues into peristome. The apical portion of frontal ambulacrum, however, is flush with the test. In profile, the highest point coincides with the apical disc. The test slopes strongly anteriorly and is concave above ambitus. Posteriorly the test slopes more gradually into low, truncated posterior. Sides almost flat to weakly convex. Lower surface more or less flat to shallowly concave (towards peristome). Plastron meridosternous, with disjunct labral and sternal plates (Text-figs 3B, C, E). Sternal plate followed by biserially offset episternals. The adoral architecture of the paired interambulacra is obscured in most specimens. Only in the paratype (NHMW 2003z0067/0002) could the sutures be traced on most of the adoral surface. In that specimen, interambulacra 2, 3 and 4 are disjunct, similar to the plastron. In all three a narrow plate similar in shape to the labrum (but smaller) is found in contact with the peristome. The disjunction occurs between this small plate and the following interambulacra plate and is caused by an enlargement and/or rotation of the second plate in the adjacent ambulacra columns. Interambulacrum 1, however, has a different structure; here the interambulacrum is clearly contiguous and constricted only between the first and second interambulacral plate (Text-fig. 3E). It is unclear whether this is the normal condition or the result of abnormal development (possibly due to injury).

Apical disc mostly poorly preserved, except in the holotype (NHMW 2003z0067/0001), situated anterior of centre, elongated, with four gonopores and hydropores extending on to genital 2 and anterior oculars (Text-fig. 3F).

Paired ambulacra nonpetaloid, bearing partitioned anisopores. The pores in each pair are markedly unequal, the adradial ones being slit-like and almost twice the size of perradial ones. Distally, the pores within each pair are placed distinctly *en chevron*. There are 5-7 ambulacral plates to each interambulacral plate adapically, 2-3 towards the ambitus. Pores in the flush portion of the frontal ambulacrum are comparable to those of the paired ambulacra (Pl. 2, Fig. 2). Within frontal notch, however, pores are small partitioned isopores and barely visible (Pl. 2, Fig. 5).

Peristome very small, (near) circular to elongate (*c*. 5.2 mm across = 7.2 % of test width; *c*. 5.4 mm in the holotype), with very few, small phyllodal pores surrounding it. Labral plate not projecting. Periproct much larger (W = 7.6 mm; H = 8.7 mm in EST 151; W = 8.9 and H 7.3 in EST 40), (sub)circular, low on posterior face and visible in oral view.

Tuberculation on upper test surface uniform with scattered, slightly sunken primary tubercles, amongst densely packed miliaries. Floor of frontal notch with dense cover of miliaries. Tubercles on the lower surface are more densely spaced and generally larger, especially on the plastron and in the anterior interambulacra. Periplastronal areas lack primaries and bear a dense cover of miliaries only. The holotype (see Pl. 2, Fig. 4) has traces of a marginal fasciole.

DISCUSSION: Using the key provided by SMITH & JEFFERY (2000, p. 271), this lot links up with *Stegaster cotteaui* and *Stegaster palaeocenicus*, which also have ambulacra separating the labrum from the sternal plates and are now considered to belong to the genus *Lampadocorys* by SMITH (2004).

Unlike *L. cotteaui*, *L.*? *estermanni* sp.nov. has a cordate outline, a deep and well-defined frontal notch, a tall profile and concave anterior slope, low ambulacral plates with well-developed elongate to slit-like pores and interambulacral plates incorporated into the margin of the peristome. *Lampadocorys cotteaui* has been recorded from the upper Upper Maastrichtian of the French Pyrenees (Pyrénées Atlantiques) and the Bay of Biscay section of Bidart (France). According to SMITH & JEFFERY (2000, p. 272), *L. cotteaui* resembles *Seunaster heberti* (SEUNES, 1889) (Maastrichtian, French Pyrenees and ?NW Turkey), but is distinguished by higher ambulacral plates and a disjunct plastronal structure. Confusion of *L.*? *estermanni* sp.nov. with *L. palaeocenicus*, from the Upper Danian (Paleocene) of Navarra (northern Spain), is impossible on account of test outline and profile and on the structure of the antero-lateral interambulacra (IA 2 and 3) which are not disjunct in the latter.

The type species of *Lampadocorys* (*Holaster sulcatus*) is comparatively poorly known. It cannot, however, be confused with *L.*? *estermanni* sp.nov., because in *L. sulcatus* the frontal notch is virtually absent, the peristome is less anterior, and the profile and oral side much more rounded. Note that the plating of the oral surface given by COTTEAU (1873) does not appear to be accurate.

Two other species were attributed to the genus *Lampadocorys* by LAMBERT & THIÉRY (1924), viz. *L. airaghii* LAMBERT *in* LAMBERT & THIÉRY, 1924 (= *L. sulcatus* AIRAGHI, 1903 non COTTEAU, 1873) and *L. dallagoi* AIRAGHI, 1903. Both species differ markedly from *L.*? *estermanni* sp.nov., the former is much smaller, has an extremely shallow frontal notch adapically and ambitally, and a broad, moderately deep groove subambitally, and a less anteriorly displaced peristome (c. 35 % test length away from the anterior margin) (see AIRAGHI 1903, pl. 2, figs 1, 2a, b). The latter has a much wider frontal notch, being a broad indentation rather than a true groove with

near-parallel walls (compare AIRAGHI 1903, pl. 1, fig. 2a, b; 1906, pl. 4, fig. 2a, b). Unfortunately, the plastron plating and test architecture of these two species are insufficiently known.

Similarly, all stegasterids, some of which might also belong in the affinity of *Lampadocory*s, described in LAMBERT's (1931) note on Cretaceous echinoids from the Heraclea region (Anatolia, Turkey) are all clearly different from *L.*? *estermanni* sp.nov.

Lampadocorys? *estermanni* sp.nov. is easily distinguished from *L. ennisi* SMITH & WRIGHT, 2003 from the Upper Cenomanian of Yorkshire (England), which shows a contiguous plastron, completely lacks a frontal notch and is generally very different in shape and profile.

Thus, the distinguishing features of *Lampadocorys*? *estermanni* sp.nov. are pore structure, ambulacral plating, test profile (height > 50% of length; concave anterior), disjunct plastronal structure and presence of a (?partial) marginal fasciole. In having a fasciole, it is reminiscent of other stegasterids such as *Guettaria* and *Rispolia*. However, the former differs in having supplementary gonopores, a bilobed subanal heel and large tubercles scattered on the apical surface; the latter is distinguished by a supramarginal periproct above a bilobed subanal heel and a labiate peristome.

AGE: Matrix samples analyses for calcareous nannoplankton content by Michael WAGREICH (University of Vienna) have yielded a Middle to Late Campanian age (standard zones CC18-CC23) for the holotype (NHMW 2003z0067/0001) and a Santonian to Maastrichtian age for the paratype (NHMW 2003z0067/0002) (see Appendix).

Lampadocorys? sp.nov. 1
(Pl. 3, Figs 1-4; Text-fig. 3D, G)

MATERIAL: One specimen in the Estermann Collection (no. EST 151), from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width
Estermann EST 151	92.1	59.7	81.7

DESCRIPTION: Test of large size with thick test plating. Outline elongated cordate, broadly rounded anteriorly, truncated posteriorly. The greatest width lies in the anterior third. Frontal notch narrow, very deep and well defined. It deepens markedly halfway towards ambitus and continues into peristome. The apical portion of frontal ambulacrum, however, is flush with the test. In profile, the highest point coincides with the apical disc, which is situated markedly anterior. The test slopes strongly anteriorly and is concave above ambitus. Posteriorly, the test slopes more gradually into a very low, truncated posterior end. The sides are weakly convex. The oral surface is more or less flat to faintly concave (around the peristome). Plastron meridosternous or orthosternous, with disjunct labral and sternal plates (Text-fig. 3D).

Apical disc poorly preserved, situated anterior of centre, elongated, with four (?) gonopores.

Paired ambulacra nonpetaloid, bearing partitioned anisopores. The adradial pore in each pair being distinctly elongated (slit-like) and up to twice the size of perradial one. Distally, the pores within each pair are placed slightly *en chevron* but not as strong as in the previous species (Text-fig. 3G).

The peristome is very small and has a subcircular outline (c. 5.0 mm diameter). The labral plate does not project. The periproct, which lies low on the posterior face, is distinctly larger and also subcircular (c. 8.4 mm diameter). It slightly overhangs and is visible in oral view.

Tuberculation on aboral surface mostly abraded, but primaries seem to have been scattered between densely packed miliaries. On the oral surface primaries are larger and much more closely spaced, especially in the interambulacra, where the areoles nearly abut. The peri-plastronal areas lack primary tubercles and bear a dense cover of miliaries only.

DISCUSSION: Albeit similar to *Lampadocorys*? *estermanni* sp.nov. overall, the present specimen differs from that species in having a much deeper frontal notch (compare Text-figs 3B, C and E with 3D), and a more elongated and more strongly tapering posteriorly outline. Due to the limited number of specimens available it is difficult to judge the range of variation of these forms. For the time being, we prefer to regard the two forms as distinct species. The present species is, however, not formally named, because only a single specimen is available.

AGE: Test preservation and lithology of the adhering sediment is closely comparable to that of specimens of *Lampadocorys*? *estermanni* sp.nov., for which a Middle to Late Campanian age is suggested (see above).

Lampadocorys? sp.nov. 2
(Pl. 4, Figs 1-6; Text-fig. 3A)

?1906. *Paronaster cupuliformis* AIRAGHI, pp. 108-110, pl. 4, fig. 1a, b.

1959. *Paronaster cupuliformis* AIRAGHI, 1906; POSLOVSKAIA & MOSKVIN, p. 266, pl. 13, fig. 2; pl. 14, figs 1, 2; text-fig. 73a-c.

v.1999. *Titanaster* ?; JAGT, p. 8.

MATERIAL: Two specimens, Estermann Colln EST 64 (= *ex* 134) and NHMW 1998/z/98/35 (*ex* Hütter Colln), previously (JAGT 1999, p. 8) held to be possibly congeneric with *Titanaster*. All from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width
Estermann EST 64	*c*. 100	*c*. 74	*c*. 99
NHMW 1998z0098/0035	~115 mm	~122 mm	>48 mm

DESCRIPTION: Test large with weakly cordate outline. Test plating extremely thick, about 3.0 to 3.5 mm. Anterior margin broadly rounded with very shallow, wide frontal sinus opening into a deep groove with nearly vertical walls subambitally. Posterior margin bluntly pointed. The greatest width lies subcentrally. In profile, the test is highly arched to bell-shaped. Anterior, posterior and lateral sides steeply sloping and moderately convex. The greatest height coincides with the anterior part of the apical disc.

Position of apical disc slightly eccentric anteriorly, elongate with four large, circular gonopores.

Paired ambulacra nonpetaloid, with large partitioned anisopores. The adradial pore in each pair is strongly elongate, about twice as the length of the corresponding perradial pore, with a slit to teardrop-shaped outline. Pores in the aboral part of the frontal ambulacrum closely comparable to those of the paired ambulacra. Subambitally, within the frontal groove the pores are much smaller, partitioned isopores. Apically the ambulacral plates are very low, with 7 to 11 ambulacral plates bordering each interambulacral plate. The plastron is disjunct and of the orthosternous type. The disjunction occurs between the sternum and the labrum, which are separated by second plate of the medial plate rows of ambulacra I and V (Text-fig. 3A). The labrum is short and does not project over the peristome. Interambulacra 1 and 4 are likewise disjunct.

The peristome is subcircular (*c*. 8.2 mm in diameter) and displaced far anteriorly (*c*. 20 % test length away from the anterior margin). The periproct is poorly preserved in the specimens studied. It seems to have been oval (transversely elongate) and larger than the peristome. It lies low on the posterior face, slightly overhangs and is partially visible in oral view.

The tuberculation of the aboral side is generally sparse, but large primary tubercles are present on supraambital plates in the interporiferous zone of the paired ambulacra and in the interambulacra. Orally, ambulacra II and IV, as well as all interambulacra, are covered by larger perforate, crenulate tubercles. The peri-plastronal areas lack primary tubercles and are covered with densely spaced miliaries instead.

DISCUSSION: The present specimen seems to be conspecific with material described as *Paronaster cupuliformis* by POSLAVSKAYA & MOSKVIN (1959). The only difference concerns the disjunct plastron, which involves the third plates of ambulacra 1a and 5b, whereas it is the second plates in the Gschliefgraben specimen. The type specimen of *P. cupuliformis*, as described and figured by AIRAGHI (1906), however, is distinctly different. The apical disc and adjacent area are strongly raised/inflated, giving the test a pointed appearance in profile. Furthermore, the posterior end is transversely truncated and the density of large tubercles is greater on the aboral surface. Unfortunately nothing is known about plastronal plating and apical disc structure in AIRGHI's specimen. Until the type material of *Paronaster cupuliformis* is redescribed, we prefer not to associate our material with AIRAGHI's species.

There are three other nominal species with a similar gross morphology, namely '*Echinocorys*' *concava* CATULLO, 1827 (see also AIRAGHI 1903), '*Galerites*' *caudatus* CATULLO, 1827 and *Lampadaster*? *gauthieri* LAMBERT, 1896. Unfortunately, CATULLO's species are poorly known and in urgent need of redescription; currently it is impossible to evaluate their relationship to the present material. *Lampadaster*? *gauthieri* from Madagascar is overall closely similar but differs in having a continuous plastron and a second gonopore in genital plate 3 (not in all genitals as in typical *Lampadaster*) and the first episternal plate (2a) abuts both adradial sutures [no contact between plate 2b (sternum) and 3b] (based on LAMBERT 1896, pp. 319-322).

AGE: Matrix samples taken from specimen NHMW 1998z0098/0035 have yielded a Late Campanian age (nannofossil zone CC22c) (see Appendix).

Genus *Rispolia* LAMBERT, 1917

TYPE SPECIES: *Nucleolites subtrigonatus* CATULLO, 1827, p. 226, by original designation (LAMBERT, 1917, p. 27).

REMARKS: *Rispolia* closely resembles *Seunaster*, according to SMITH [*The Echinoid Directory* (www.nhm.ac.uk/palaeontology/echinoids), state 16.07.2004], but differs mainly in showing biserially offset episternal plates, while *Seunaster* has more or less paired ones. According to SMITH [*The Echinoid Directory* (www.nhm.ac.uk/palaeontology/echinoids), state 16.07.2004], *Cardiaster gillieroni* DE LORIOL, 1873 (type species of *Stegaster* POMEL, 1883 is very poorly know and in need of redescription. Based on shape alone, it appears to be indistinguishable from juve-

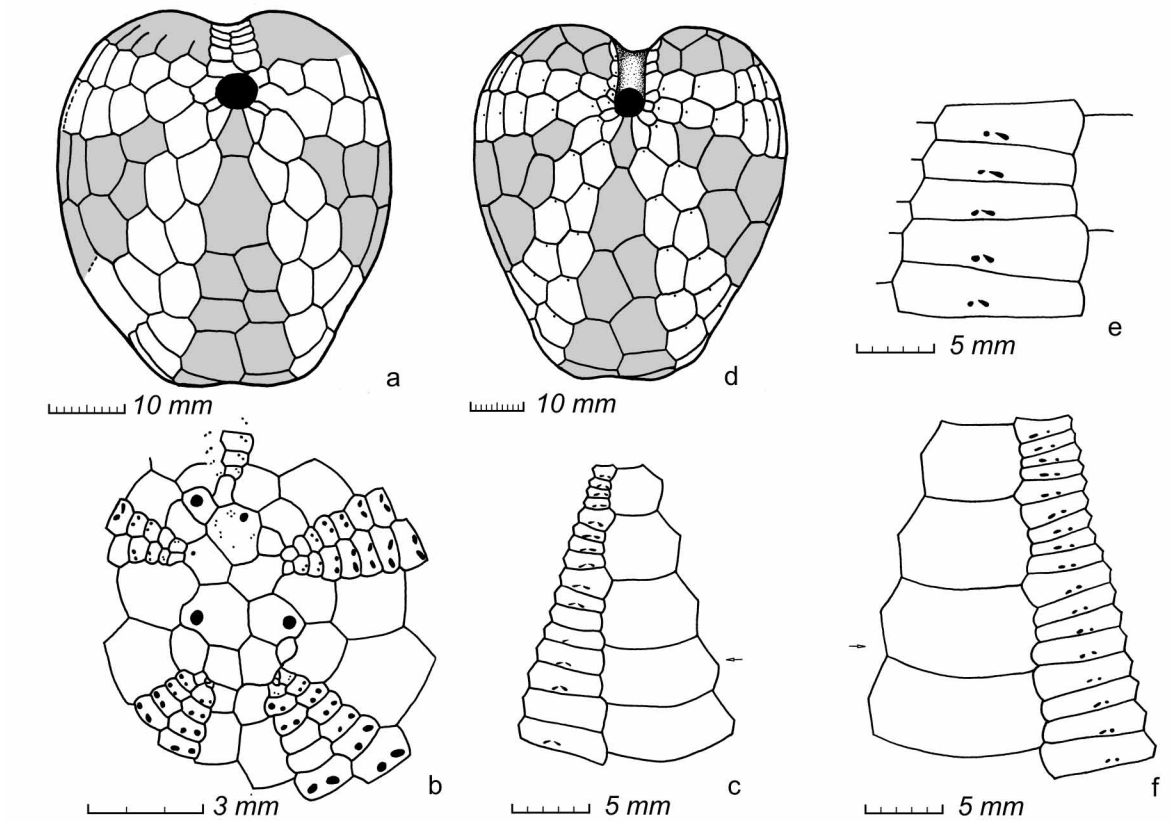

Fig. 4. Camera-lucida drawings of species of *Seunaster* and *Rispolia*; A-C -- *Seunaster* cf. *heberti* (SEUNES, 1889), oral plating (A), apical disc (B) and adapical ambulacral structure (C; ambulacrum IVb - interambulacrum 4a, small arrow marks half test height); A is Estermann Colln, EST 230; B and C are Estermann Colln, EST 139); D-F -- *Rispolia* cf. *subtrigonata* (CATULLO, 1827), oral plating (D), ambital (E; ambulacrum IVb) and adapical (F; interambulacrum 1b - ambulacrum IIa, small arrow marks half test height) ambulacral structure (D and E are Estermann Colln, EST 15)

nile specimens of *Rispolia*; for the time being, it must be considered a *nomen dubium.*

Typical features of *Rispolia* are a cordate test with a shallow frontal sinus aborally, which becomes much deeper at the ambitus and forms a deep groove adorally; an elongate, holasteroid-type apical disc with four gonopores; nonpetaloid or weakly petaloid ambulacra; a small, strongly anteriorly displaced peristome; a marginal periproct; contiguous, meridosternous plastron plating; a labral plate followed by single sternal plate and biserially offset episternal plates; enlarged primary tubercles absent; no fascioles in adult specimens (LAMBERT & THIÉRY 1924, p. 413 stated that a fasciole is present in juveniles but lost in adults).

Rispolia cf. *subtrigonata* (CATULLO, 1827)
(Pl. 3, Figs 5-9; Text-figs 4D-F)

MATERIAL: A single specimen (Estermann Colln, EST 15 [= *ex* 161]), from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width
Estermann EST 15	66.8	36.7	59.8

DESCRIPTION: Test medium sized, badly weathered with thick test plating. The outline is cordate, fairly broadly rounded anteriorly and tapering markedly to a truncated posterior. The greatest width lies in the anterior third. The frontal notch is narrow, fairly deep and well defined. It deepens markedly halfway towards ambitus and into peristome. The apical portion of frontal ambulacrum, however, is flush with test. In profile, test slopes strongly anteriorly (not concave). Posteriorly, the test slopes gradually, then abruptly to truncated posterior end. The sides are weakly convex. Lower surface with slightly concave ambulacral areas. The plastron is transitional between the orthosternous and meridosternous architectural type. The labral and sternal plates are in contact, but the contact is narrow. The episternal plates are biserially offset.

Apical disc poorly preserved; four gonopores (three visible), elongated, situated well anterior of centre.

Paired ambulacra nonpetaloid, bearing simple, partitioned isopores in most poriferous zones. In the posterior rows of the anterior petals (IIa and IVb), however, the pores in each pair are markedly unequal (partitioned anisopores) and placed *en chevron* most distally towards the ambitus. The adradial pores are slit-like and up to twice the size of the perradial pores. In the frontal ambulacrum relatively small isopores occur.

The peristome is small and subcircular (c. 5.5 mm diameter). The periproct is larger and subcircular to slightly oval (H – c. 8, W – c. 7 mm). It lies high on the posterior face and is not visible in oral view.

Tuberculation mostly abraded.

DISCUSSION: In not having ambulacra separate labral and sternal plates, this specimen keys out with '*Stegaster*' *bouillei*, '*S*.' *altus*, and '*S*.' *heberti* (see SMITH & JEFFERY 2000, p. 271). However, these species are now referred to the genus *Seunaster* (see below) by SMITH [*The Echinoid Directory* (www.nhm.ac.uk/palaeontology/echinoids), state 16.07.2004], as they possess near-symmetric, paired episternal plates. EST 15, in contrast, has biserially offset episternal plates and is better referred to *Rispolia*. In view of the fact that this feature is not always as clear cut as in the present case, the species assigned to *Seunaster* are here briefly considered as well.

Rispolia subtrigonata CATULLO, 1827 (= *Holaster italicus* AGASSIZ, 1840; see LAMBERT & THIÉRY 1924, p. 413) is now known from the Coniacian-Campanian of northern Italy (CATULLO 1827), the 'Maastrichtian' of Constantine and Oran in northern Algeria (BLAYAC & COTTREAU 1909; LAMBERT 1932), as well as from the 'Cenomanian and Maastrichtian' of Tunisia (SOLIGNAC 1927; Coniacian-Santonian according to ZAGHBIB-TURKI 1987). EST 15 is very similar to *R. subtrigonata* in most aspects but differs by its much lower profile (based on the illustrations in AIRAGHI 1903 and photographs of BMNH material provided by A.B. SMITH).

Rispolia boulei (LAMBERT, 1896) from Madagascar is based on a fragmentary specimen, which hampers comparison with the present material. However, it does show adapically sunken ambulacra, a feature not present in EST 15.

Rispolia decaryi LAMBERT, 1921 from the 'Aturien' of Madagascar differs from the present specimen in having an utterly different, oval outline, pointed anterior end and in the development of strong keels bordering the sunken frontal ambulacrum.

Rispolia douvillei LAMBERT *in* LAMBERT & THIÉRY 1924 from the 'Maastrichtian' of Algeria differs by its swollen oral surface, different profile, more projecting subanal heel, and strongly keeled interambulacra 2 and 3.

Seunaster bouillei has been recorded from the Lower Maastrichtian of Sarasate (Navarra, Spain), the upper Upper Maastrichtian of Bidart (France) and the French Pyrenees (Gan and Rébénac, Maastrichtian), as well as from the Maastrichtian of Alicante (Spain), Turkey, the Crimea, Georgia and the northern Caucasus. In contrast to material of *S. bouillei* described by SMITH *& al*. (1999, p. 110, pl. 5, figs 1-3; text-figs 21, 22) and SMITH & JEFFERY (2000, p. 272, text-fig. 115), the labral/sternal contact in our material is less wide, the episternal plates are not near-symmetrical; the peristome is less anteriorly displaced; in profile, the test has a more oblique posterior, and in plan view, it shows a distinct posterior taper. In addition, ambulacral plates are low and relatively wide, with 4-6 ambulacral plates per interambulacral plate adapically, and ambitally 3-4 (Text-figs 4E, F).

Seunaster altus, from the Lower Maastrichtian of Navarra, the upper Upper Maastrichtian of Bidart and Pyrénées Atlantiques (France) and the Maastrichtian of Alicante (Spain), Tunisia, Turkey, Bulgaria, Georgia and the northern Caucasus, is close to *S. bouillei*, but test width almost equals test length, with height > 70% of test length, labral and sternal plates have a broader contact and ambulacral plates much taller. EST 15 differs from *S. altus* in being less domed or conical in profile, in lacking an ambitally very deep frontal notch, and in having less tall ambulacral plates (3-6 *vs.* 1-2 ambulacral plates per interambulacral plate), and apparently, a different pore structure.

Seunaster heberti is a low form with a more rounded outline and fewer ambulacral plates per interambulacral plate aborally than in either *S. bouillei* or the specimen considered here. Additionally, in profile test shape is very different.

With just a single specimen before us and an incomplete knowledge of the intraspecific variation in this group (and in *R. subtrigonata* in particular), we prefer the use of open nomenclature; the present material appears most closely related to *R. subtrigonata*, but differs by its profile.

AGE: The exact provenance of this specimen is unknown, due to the mudflow nature of the outcrop area. Lithology and preservation differ from all other specimens studied, suggesting that EST 15 originated from a different stratigraphic level.

Genus *Seunaster* LAMBERT *in* BLAYAC, 1912

TYPE SPECIES: *Holaster bouillei* COTTEAU *in* DE BOUILLÉ, 1873, p. 24, by original designation (LAMBERT *in* BLAYAC 1912, p. 385).

REMARKS: SMITH & JEFFERY (2000, p. 270) considered *Seunaster* and *Synochitis* LAMBERT, 1917 (p. 30), which both have *Holaster bouillei* as type species, to be junior

synonyms of *Stegaster* POMEL, 1883 (p. 48). The type species of *Stegaster* (*Cardiaster gillieroni* DE LORIOL, 1873), however, is very poorly known and data on plastron plating and apical disc structure are lacking. SMITH [*The Echinoid Directory* (www.nhm.ac.uk/palaeontology/echinoids), state 16.07.2004] thus proposed to consider *Stegaster* a *nomen dubium* for the time being and noted that, based on shape alone, it was indistinguishable from juvenile specimens of *Rispolia*. Apart from the type species *S. bouillei,* SMITH included in the genus *S. altus* (SEUNES, 1889) and *S. heberti* (SEUNES, 1889).

Typical features of *Seunaster* are a cordate test with shallow frontal sinus aborally, which becomes much deeper at the ambitus and adorally; an elongate, holasteroid-type apical disc with four gonopores; nonpetaloid ambulacra with small, often slightly elongated pore pairs; aboral ambulacral plates whose width much exceeds their height; a small, strongly anteriorly displaced peristome; a marginal periproct; contiguous, meridosternous to orthosternous plastron plating; a labral plate followed by single sternal plate and more or less paired episternal plates; enlarged primary tubercles apparently absent aborally (the plate surface is, however, preserved in few specimens); no fascioles known (but see below).

Seunaster cf. *heberti* (SEUNES, 1889)
(Pl. 5, Figs 1-3, 8, 9; Text-figs 4A-C)

MATERIAL: Several specimens in the Estermann Colln: EST 135 (= *ex* 139), 230 (= *ex* 161), as well as a large matrix slab containing four specimens (no registration number). Three deformed specimens in the NHMW Colln (NHMW 2003z0067/0007-9). All from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width
Estermann EST 135 (*ex* 139)	50.4	>20	45.7
Estermann EST 230 (*ex* 161)	50.8	>11.9	44.7
Estermann slab, specimen 1	>39.1	>10	38.8
Estermann slab, specimen 2	35.2	-	32.8
Estermann slab, specimen 3	36.4	-	32.3

DESCRIPTION: Test medium sized, of varying preservation (partially abraded and pyritised or crushed and missing portions of test). Test plating is relatively thin. Outline elongate, narrowly rounded anteriorly, tapering to truncated posterior. Greatest width lies anteriorly or medially. The frontal notch is comparatively shallow, apparently continuing into peristome. The apical portion of frontal ambulacrum is flush with the test. In profile the tallest point coincides with the apical disc, which lies well anterior of centre (about 40 % test length away from the anterior margin). Sides are weakly convex. Lower surface sediment flattened, with labral and sternal plates in broad contact. Plastron orthosternous with large, nearly symmetrical sternum followed by smaller episternals (Text-fig. 4A). Apical disc well preserved in EST 135 (Text-fig. 4B), elongate, with four gonopores.

Paired ambulacra are nonpetaloid, with partitioned isopores. The pores in each pair are rounded adapically, and adorally, to elongate on the aboral surface, where they are placed *en chevron*. Pore pairs in frontal ambulacrum partially unequal (anisopores) and much smaller, oblique. Periproct lies fairly high on truncated posterior. It is subcircular and relatively large. The peristome is slightly oval, antero-posteriorly elongated (W – 4.0 mm, L – 3.3 mm in specimen 2 on the slab). It is strongly anteriorly displaced and lies about 15 % test length from the anterior margin.

Tuberculation entirely abraded in most cases, but ambulacral plates show comparatively large tubercles. Where preserved, tuberculation seems to be much denser on the oral (especially the antero-lateral part) than on the aboral surface.

In one specimen (NHMW 2003z0067/0009) traces of a weakly defined marginal fasciole can be found just below the ambitus in the anterior portion of the test. It could not be traced posteriorly owing to insufficient preservation.

DISCUSSION: This form is characterised by having a poorly developed frontal notch, a low test (in profile) with a comparatively high periproct, a different pore structure in ambulacrum III, adapically 4-5 ambulacral plates per an interambulacral plate, ambitally 2-3 (Text-fig. 4C), and ambulacral plates not as low as in *R.* cf. *subtrigonata* (see above).

It comes closest to *S. heberti*, but has a more anteriorly displaced apical disc and adapically appears to have more numerous ambulacral plates. Whether or not this falls within the range of variation of *S. heberti* cannot be determined at present, which is why we favour the use of open nomenclature.

For the first time traces of a fasciole could be documented for a member of the genus *Seunaster*. This does not have to be a peculiar feature of the species under discussion. Instead it is likely that it was never recorded since these stegasterids are very often subject to abrasion of the tuberculation. Indeed, according to SMITH [*The Echinoid Directory* (www.nhm.ac.uk/palaeontology/echinoids)], a marginal fasciole is a common feature in the family Stegasteridae which is only secondarily lost in the adults of some taxa.

AGE: Although we cannot be entirely sure of the stratigraphic age of this specimen, due to the mudflow

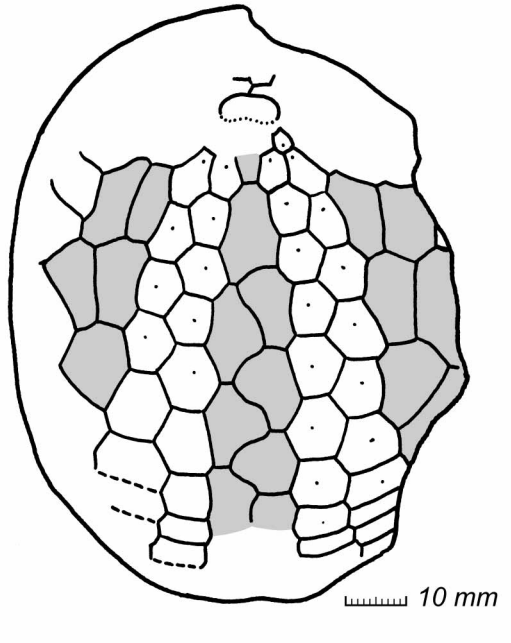

Fig. 5. Camera-lucida drawing of oral surface of *Echinocorys ancileformis* MOSKVIN & SHIMANSKAYA, 1981 (Estermann Colln, EST 61)

nature of the outcrop area, a comparison with French and Spanish occurrences would suggest a Maastrichtian age.

Family Holasteridae PICTET, 1857
Genus *Echinocorys* LESKE, 1778

TYPE SPECIES: *Echinocorytes scutatus* LESKE, 1778, by subsequent designation of LAMBERT (1898).

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

Echinocorys ancileformis MOSKVIN & SHIMANSKAYA, 1981
(Pl. 6, Figs 1-3; Text-fig. 5)

1981. *Echinocorys ancileformis* MOSKVIN & SHIMANSKAYA, pp. 135, 136, pl. 1, fig. 3; pl. 2, fig. 1; text-fig. 2.

MATERIAL: Two specimens, Estermann Colln, EST 61 and EST 141 (*ex* 63), from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width	
Estermann EST 141(63)	133.0	110.5	>63	deformed
Estermann EST 61	~137	~113	72.7	fragmentary

DESCRIPTION: Test large, up to 140 mm in length, with an oval, antero-posteriorly elongated outline. The greatest width lies about halfway along the test length. In profile, the test is highly arched with a flat base. Greatest height situated posterior of the apical disc on a raised keel formed by the adapical interambulacrum 5. The margin of the test is relatively angular. The plastron is only weakly inflated.

The apical disc belong to the elongate type with four gonopores and five small ocular pores; situated anteriorly, about 30 % test length away from the anterior margin in specimen EST 61, whereas it seems to lie subcentrally in the deformed specimen EST 141(63).

Ambulacra nonpetaloid, straight and open. The pores are small, oblique partitioned isopores, which lie approximately halfway along the adoral plate sutures. Ambulacral plates very low adapically, with up to seven ambulacral plates bordering a single interambulacral plate. At the ambitus, the ambulacral plates are slightly taller and here there are about 2 to 3 ambulacral plates per interambulacral plate. A sharp keel is developed adapically in interambulacrum 5. The plastron is meridosternous with a short labrum (Text-fig. 5).

Tuberculation very sparse consisting of few small, perforate, crenulate primary tubercles and loosely scattered miliaries per plate only. Peri-plastronal areas (ambulacra I and V) without primaries, bearing few miliary and secondary tubercles only.

The peristome lies close to the anterior margin on the oral side of the test. The periproct lies inframarginally close to the posterior margin on the oral side of the test.

DISCUSSION: The large size, flat base, sharp keel and weak oral tuberculation are characteristic of the species *E. ancileformis* from the Upper Paleocene of the former USSR. The type material of this species ranges in test length between 62 and 125 mm and is slightly more depressed (test height about 45 % test length) than the specimens from the Gschliefgraben, but all other features are almost identical.

OCCURRENCE: Gschliefgraben, Upper Austria; Upper Paleocene of western Ustyurt, Kazakhstan (MOSKVIN & SHIMANSKAYA 1981).

Echinocorys ex gr. *fonticola* ARNAUD, 1897

1897. *Echinocorys fonticola* ARNAUD, p. 680.

1902. *E.*[*chinocorys*] *fonticola*, ARNAUD, 1902; ARNAUD, pp. 31, 32, pls 2-4.
1903. *Echinocorys gibbus*, LAMARCK (*Ananchytes*), 1816, Variété: *Echinocorys fonticola*, ARNAUD; LAMBERT, pp. 63-65, pl. 3, figs 3, 4.
1993. *Echinocorys fonticola* ARNAUD, 1902; HANCOCK & *al*., p. 142
v 1999. *Echinocorys* sp. 2 (cf. *fonticola* ARNAUD 1897); SUMMESBERGER & *al*., p. 169, pl. 11, fig. 3.
2001. *Echinocorys gibba fonticola* ARNAUD; NÉRAUDEAU & ODIN, pp. 622, 633, pl. 2, figs 36, 37.

MATERIAL: A single specimen in the Estermann Colln (no. EST 135(65)), from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width	Remarks
Estermann EST 135(65)	>100	~98.9	~70.2	deformed

DESCRIPTION: Test large, about 100 mm in length, with slightly antero-posteriorly elongated, oval outline. Both anterior and posterior margin rounded, with only a small rostrum above the periproct. Greatest width subcentrally. In profile, test highly inflated to gibbose. Maximum height coinciding with the apical disc. Oral surface flattened, slightly concave around the peristome and slightly inflated along the plastron posteriorly. The lower edge of the test is rounded.

The apical disc belong to the elongate type with four gonopores and five small ocular pores; situated subcentrally.

Ambulacra nonpetaloid, straight and open. The pores are oblique, partitioned isopores, which lie about halfway along the adoral sutures of the plates. The ambulacral plates are low; adapically there are about five ambulacral plates bordering each interambulacral plate. This number decreases to three ambitally. On the oral side ambulacra I and V are slightly depressed, forming broad, naked peri-plastronal areas. The plastron is meridosternous, with a short labrum. Aboral tuberculation is sparse; oral tuberculation denser with larger primaries.

The peristome lies close to the anterior margin and is roughly kidney-shaped. The periproct is situated inframarginally near the posterior margin and lies entirely orally. It seems to be oval, antero-posteriorly elongate.

DISCUSSION: Material from the Lower Campanian of Wentneralm I (Gams/Hieflau, Styria, Austria), contained in the NHMW collections has previously been assigned to this group (SUMMESBERGER & *al*. 1999).

At Tercis-les-Bains (Landes, France), *E. fonticola* has recently been demonstrated to occur in interval -5.2 to + 6.4 m by NÉRAUDEAU & ODIN (2001, fig. 4, table 1), meaning Campanian, in part co-occurring with *Offaster pilula*, which, with successive representatives of the *Galeola senonensis/papillosa* lineage, is a good marker for the lower Lower Campanian in NW Europe, but which ranges into the lower Upper Campanian in Navarra (KÜCHLER 2000a, b).

OCCURRENCE: Gschliefgraben, Upper Austria; Lower-?Upper Campanian of Tercis, France (ARNAUD 1902, LAMBERT 1903, HANCOCK & *al*. 1993, NÉRAUDEAU & ODIN 2001); Lower Campanian of Wenteralm I, Gams (SUMMESBERGER & *al*. 1999).

Family *incertae sedis*
Genus *Ganbirretia* GAUTHIER, 1903 ?

TYPE SPECIES: *Ganbirretia douvillei* GAUTHIER, 1903, by monotypy.

Ganbirretia? sp.
(Text-figs 6, 7)

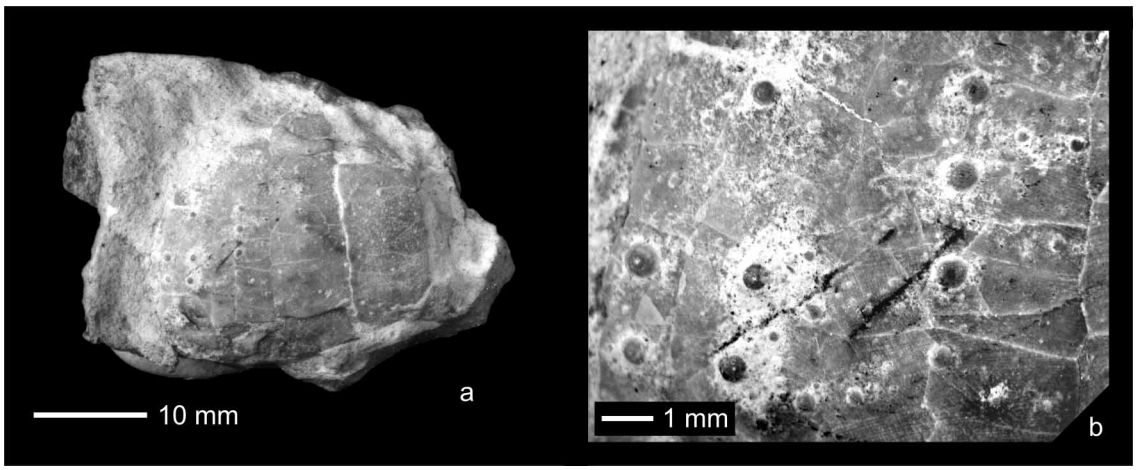

Fig. 6. *Ganbirretia*? sp. (NHMW 2003z0067/0005)

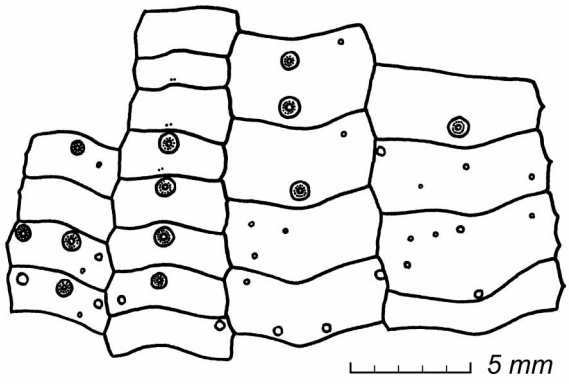

Fig. 7. Camera-lucida drawing of ambital plating of *Ganbirretia*? sp. (NHMW 2003z0067/0005)

MATERIAL: Two highly crushed and fragmentary specimens from the Gschliefgraben near Gmunden, Austria (NHMW 2003z0067/0005-6).

DESCRIPTION: Test small, up to *c.* 40 mm in length, with oval or slightly cordate(?) outline. Frontal notch, if present, shallow and broad. Profile obscured through sedimentary compaction, but assumed to have been high and arched. Test plating extremely thin, usually less than 0.5 mm thick. Aboral plates more or less hexagonal adapically, becoming more rectangular towards the ambitus. In one specimen (NHMW 2003z0067/0005), the horizontal sutures are strongly curved, those of the interambulacra towards the oral side, those of the ambulacra towards the apex (Text-figs 6A, 7). Plastron appears to be meridosternous and continuous. Apical disc structure unknown. Sutures seem to have been weak, since sedimentary compaction did not result in fracturing of the plates (as *e.g.* in the stegasterids and micrasterids described in this paper) but followed the sutures. Tuberculation extremely sparse, but many plates bear a single (rarely two) large, crenulate, perforate primary tubercles (Text-figs 6, 7). Secondary and miliary tubercles are similarly sparse. Periproct marginally, above ambitus. Peristome eccentric anterior.

DISCUSSION: Similar material was described by RADIG (1973) from the Upper Cretaceous of northern Spain under the name *Ganbirettia* sp. The type material of this genus is, however, poorly known and is in need of re-evaluation. Familial assignment of this taxon is unclear as well; some authors have attributed it to the Urechinidae.

Another taxon with similarly thin test plating and this type of tuberculation is *Echinocorys* n. sp. of ERNST (1967, p. 213). This material will be redescribed (by C. NEUMANN); however, our specimens cannot be considered congeneric with that form since the position of its periproct is inframarginal (i.e., comparable to *Echinocorys*), whereas it is supra-marginal in ours.

We cannot exclude the possibility that these extremely thin-shelled specimens in fact represent juvenile stegasterids, a hypothesis based on the similar position of the periproct but not supported by the strong differences in test thickness. Other co-occurring taxa (micrasterids, *Cardiaster*, ...), however, can be excluded by their strongly different tuberculation.

Order Spatangoida CLAUS, 1876
Suborder Micrasterina FISCHER *in* MOORE, 1966
Family Micrasteridae LAMBERT, 1920

Genus *Pseudogibbaster* MOSKVIN, 1983 ?

TYPE SPECIES: *Protobrissus akkajensis* POSLAVSKAYA & MOSKVIN, 1959, p. 290, by original designation.

Pseudogibbaster? sp.
(Pl. 7, Figs 1-9; Text-figs 8, 9)

MATERIAL: Twenty-eight specimens from the Gschliefgraben near Gmunden, Austria (NHMW 1972/1502; NHMW 1999z0098/0011-14, 16-28, 30-33, 36-40).

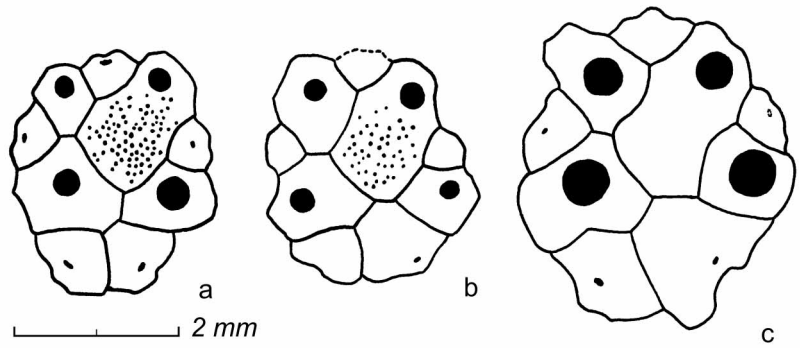

Fig. 8. Camera-lucida drawings of apical discs of *Pseudogibbaster*? sp. (A is NHMW 1998z0098/0039; B is 1998z0098/0040; C is 1998z0098/0018)

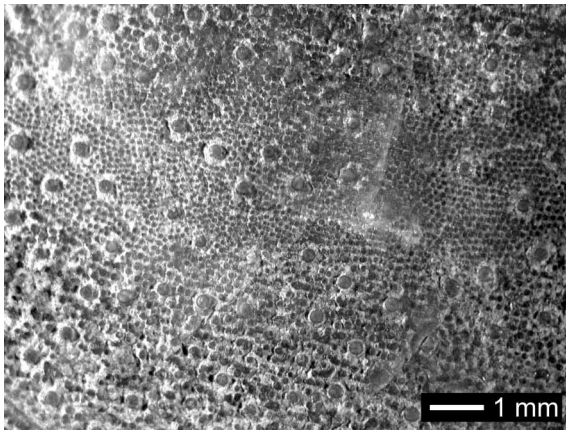

Fig. 9. Peripetalous pseudofasciole of *Pseudogibbaster*? sp., in interambulacrum 1 (NHMW 1998z0098/0025)

Measurements (in mm):

	Length	Heighth	Width
NHMW 1998z0098/0018	54.5	36.8	55.4
NHMW 1998z0098/0025	53.4	37.9	54.1
NHMW 1998z0098/0039	49.6	35.7	49.4
NHMW 1998z0098/0040	43.0	32.8	42.6

DESCRIPTION: Test moderately large, cordate with distinct yet fairly shallow frontal notch. Posterior margin very bluntly pointed. Greatest width between first and second third of test length (usually along line 1b-4a). In profile, highest point on the weakly rounded keel in interambulacrum 5 or coinciding with the apical disc. Gently sloping to anterior margin from the apex. Posterior end vertically truncated.

Apical disc ethmophract with four moderately large gonopores. In some specimens the madreporite extends towards the posterior and separates the posterior genitals (Text-fig. 8C). In others, the posterior genital plates abut (Text-fig. 8A), but all intermediates exist (e.g., Text-fig. 8B).

The paired ambulacra are petaloid and bear elongate isopores to anisopores within the petals. The pores are closely spaced and separated by shallow ridges. The petals are slightly sunken, straight and 30-40 % (posterior) or 50-60 % (anterior), respectively, of the corresponding test radius (in plan, aboral view). The anterior paired petals diverge at an angle of about 100-110 degrees, the posterior ones at c. 70-85 degrees. The frontal ambulacrum is nonpetaloid, although in some weathered specimens it has a semipetaloid look. The adapical pores of ambulacrum III are enlarged, closely spaced, oblique partitioned isopores with a knob-like interporal partition. More distally they become smaller and less closely spaced. All pores beyond the petals seem to be double pores, even those on the peri-plastronal areas and in the phyllodes. While the latter are anisopores with extensive attachment area and a large interporal partition in the form of a transverse ridge, the others are small, strongly oblique partitioned isopores. The phyllodes are small with few closely spaced pores. Adorally, ambulacrum III forms a broad shallow groove leading into the peristome. The plastron is protamphisternous with a large triangular to broadly bottle-shaped labrum and a strongly oblique suture between the two sternal plates. The labrum has a broad contact with sternal plate 5b2 (left-hand plate in oral view) and a narrow contact with 5a2 (right-hand plate). In some specimens (e.g. NHMW 1998z0098/0040), the contact is with plate 5b2 only. The episternals are biserially offset.

The tuberculation of the aboral surface is more or less homogeneous with fairly closely spaced primaries and densely crowded secondary and miliary tubercles in between. The tubercles on the oral surface are larger, especially on the plastron and in the antero-lateral areas. There are two fascioles: an incomplete peripetalous and a subanal one. Both represent parafascioles *sensu* NÉRAUDEAU & *al*. (1998) with a broad band of miliary tubercles which includes also some primaries (Text-fig. 9). While the subanal fasciole is ovate with a slight indentation below the periproct and completely closed, the peripetalous fasciole is not. It runs around the posterior and anterior paired petals, close to their tips, but does not cross ambulacrum III. It 'effaces' in interambulacrum 2 and 'reappears' in 3.

The peristome is close to the anterior margin (at c. 15-17 % test length), and has an oval (transversely elongated) to slightly kidney-shaped outline; the labrum slightly projects. It is 5.2 *vs.* 3.8 mm in a 57.5 mm specimen (NHMW 1998z0098/0022). The periproct lies high on the posterior face, is subcircular to slightly vertically oval and somewhat larger than the peristome (5.4 *vs*. 4.8 mm in specimen NHMW 1998z0098/0022).

DISCUSSION: This species, which is one of the commoner, if not the commonest, echinoid at the Gschliefgraben, has been posing several problems. Despite the abundant, well-preserved material available, we have not been able to identify this taxon to the genus and species levels. The general morphology of the test suggests assignment to the Micrasterina.

Micraster may be ruled out since in that genus the peristome faces anteriorly and is situated much more anteriorly; moreover, there is a stronger projection of the labrum, and it has a mesamphisternous plastron, narrower labral plate and lacks a peripetalous fasciole.

Isomicraster and *Mokotibaster* are distinguished by their petaloid frontal ambulacrum, stronger projection of the labrum (*Isomicraster*), mesamphisternous plastron, and lack of any fasciole.

Plesiaster differs in displaying much longer petals, which extend most of the distance to the ambitus in plan view, and a subpetaloid ambulacrum III.

Isaster and *Cyclaster* (= *Brissopneustes, Isopneustes*) differ markedly in lacking a gonopore in the madreporite, in addition to other test features.

Macraster and *Douvillaster* are ruled out on account of their much longer and open petals, subpetaloid ambulacrum III, and a lack of a subanal fasciole and many other differences.

Gibbaster, which otherwise is closely similar, is excluded since it has a petaloid frontal ambulacrum, the peristome faces anteriorly and is situated more anterior, the plastron is mesamphisternous, and it lacks a peripetalous fasciole.

The present specimens are here tentatively placed in *Pseudogibbaster* on the basis of the following features: a shallow frontal notch; near-vertical posterior face; enlarged pores in the adapical part of ambulacrum III; similarly short petals; small peristome, which is slightly anteriorly inclined not covered by the labrum; longitudinally elongate labrum; asymmetric sternal plates with oblique median suture; position of periproct; presence of a subanal fasciole and traces of a peripetalous fasciole.

All known species of *Pseudogibbaster*, however, are of Early Paleocene age, whereas our material is assumed to be Late Campanian, based on association with other taxa. Additionally, there are some minor morphological differences, e.g. the more strongly divergent anterior petals and deeper petals. Because of these shape differences (which could also be of a species-specific nature), the difference in stratigraphic age and the fact that no Russian specimens of *Pseudogibbaster* were available for direct comparison, this identification can only be tentative.

Closely similar to the present taxon is *Micraster renati* (GAUTHIER, 1886) (for a description and illustrations, see STOKES 1975, p. 77, text-fig. 30b, pl. 8, fig. 8; pl. 9, figs 1-4) from the Upper Turonian-Lower Coniacian of France. The present material differs mainly in the pore structure in the adapical part of ambulacrum III (elongate ansisopores in *M. renati*), and in having a slightly more downward-facing peristome as well as in the presence of a peripetalous fasciole.

Genus *Micraster* AGASSIZ, 1836

TYPE SPECIES: *Spatangus coranguinum* var. a *anglicum* LESKE, 1778, by subsequent designation of POMEL (1883).

Micraster stolleyi (LAMBERT *in* DE GROSSOUVRE, 1901) (Pl. 8, Figs 7, 8)

1901. *Isomicraster stolleyi* LAMBERT *in* DE GROSSOUVRE, p. 959.
1975. *Micraster stolleyi* LAMBERT 1901; STOKES, p. 79, text-fig. 30f (with additional synonymy).
2000. *Micraster stolleyi* (LAMBERT, *in* DE GROSSOUVRE, 1901); JAGT, p. 285, pl. 25, figs 7-11.

MATERIAL: A single specimen, Estermann Collection, EST 155 (= *ex* 138), from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width
Estermann EST 155	*c*. 72	35.8	68.6

DESCRIPTION: Test large for species, tall, cordate in outline with distinct, yet shallow frontal notch, tallest just anterior of centre, with steep anterior and very low, truncate posterior. Anteriorly more or less angular, tapering to truncated posterior; greatest width at c. 40% of test length.

Paired petals moderately sunken, straight, anterior ones *c*. 1.5 times longer than posterior; inner series of pores subcircular, outer ones elongate with wide, low interporal partition. Apical portion of ambulacrum III also sunken and with comparable pore structure but shorter than paired petals.

Peristome close to anterior border, matrix filled. Labral plate conspicuous, widest in upper portion and tapering to narrow contact with plastronal plates which are covered in sunken tubercles surrounded by rings of miliaries. Plastronal plates long but comparatively narrow, with well-arranged rows of tubercles with rings of miliaries, decreasing in size both medially and posteriorly. Peri-plastronal area with dense cover of miliaries. No trace of subanal fasciole; periproct very low on test posterior (7.8 *vs.* 35.8 mm = 21.8 %), but poorly preserved (crushed).

Apical disc missing. Upper surface tuberculation uniformly consisting of dense cover of primary tubercles set in closely spaced miliaries.

DISCUSSION: The present specimen is larger than comparative material from the lower Upper Campanian of the Hannover-Misburg area (Germany) and of the Maastrichtian type area (NE Belgium and SE Netherlands), and closer to material, both in size and profile, from southern Poland and former Russian territories (see e.g., *Isomicraster faasi* in POSLAVSKAIA & MOSKVIN 1959, p. 285, pl. 23, fig. 1; and *M. stolleyi* in MĄCZYŃSKA 1968). Yet it shows all typical features of *M. stolleyi*, e.g. all ambulacra of the same structure, the lack of a subanal fasciole, the subconical test profile and the size and shape of the labral plate, plus the position of periproct, low on the truncated posterior.

Earlier records from Austria include the material from the Gosau Group of the Gams area, Styria (SUMMESBERGER & *al*. 1999, p. 170, pl. 11, figs 4, 6; pl. 12, figs 2, 4, 6, as *Micraster* gr. *fastigatus*/*stolleyi*).

According to STOKES (1975, fig. 28), *M. stolleyi* is typical of the (lower) Upper Campanian of England, northern Germany, Belgium and southern Poland (his 'Province Nord'), where it co-occurs with representatives of the *M.* gr. *schroederi*/*glyphus* lineage. However, there are also records of *M. stolleyi* from the Campanian of the south-central Pyrenees (GALLEMÍ 1982; GALLEMÍ *& al*. 1983), which need to be re-evaluated.

Micraster corcolumbarium DESOR, 1858
(Pl. 8, Figs 4, 5)

1858. *Micraster cor-columbarium* DESOR, p. 365.
1975. *Micraster corcolumbarium* DESOR 1858; STOKES, p. 67, pl. 3, figs 6-8 (with additional synonymy).
1999. *Micraster* gr. *schroederi*/*glyphus*; JAGT, p. 10, pl. 2, figs 1-3, 7, 8.
2001. *Micraster corcolumbarium*; NÉRAUDEAU & ODIN, p. 628, pl. 4, figs 85, 86.

MATERIAL: Material (NHMW 1998z0098/0003, 1998z0098/0005, 1998z0098, 44) from the Gschliefgraben previously illustrated by JAGT (1999) appears better referred to *M. corcolumbarium* than to *M*. ex gr. *schroederi*/*glyphus*, although differences are slight (see STOKES 1975). Test outline, especially in smaller individuals, appears less angular than in *M*. ex gr. *schroederi*/*glyphus*, although the bilateral asymmetry noted by STOKES (1975) is not expressed. Peristome close to anterior border, and covered by prominent labral plate which is widest anteriorly and tapers to narrow contact with sternal plates (for a more detailed description the reader is referred to JAGT 1999).

DISCUSSION: According to literature sources, *M. corcolumbarium* is confined to the Upper Campanian of the Pyrenean province (*sensu* STOKES 1975). At Tercis-les-Bains (Landes, France), this species is recorded (NÉRAUDEAU & ODIN 2001, fig. 4, table 1) from the interval ?13.45 m to 67.0 m of the D'Avezac Unit, meaning Upper Campanian; there appears to be no range overlap with *M. aturicus*.

Micraster aturicus HÉBERT *in* SEUNES, 1891
(Pl. 8, Figs 1-3, 6)

1891. *Micraster aturicus* HÉBERT, 1880 *in* SEUNES, p. 30, pl. 4, fig. 1; pl. 5, fig. 1.
1999. *Micraster aturicus* HÉBERT in SEUNES 1891; JAGT, p. 10, pl. 1, figs 16-18; pl. 2, figs 9-14.
2001. *Micraster aturicus*; NÉRAUDEAU & ODIN, p. 628, pl. 4, figs 79-81.

MATERIAL: Two poorly preserved specimens (NHMW 2003z0067/0003-4), identified as *M. aturicus* on the basis of the position of the labral plate (anteriorly, even visible in plan view), the width of and dense tubercle cover of the plastronal plates, as well as the concave sides of test. JAGT (1999) is referred to for illustrations of additional, better-preserved material from the Gschliefgraben near Gmunden, Austria.

DISCUSSION: At Tercis-les-Bains (Landes, France), *M. aturicus* has been recorded from the interval 69.0 to 94.3 m (NÉRAUDEAU & ODIN 2001, fig. 4, table 1) in the D'Avezac Unit, corresponding to the higher Upper Campanian; there is no overlap in range with *M. corcolumbarium* (see above).

KÜCHLER (2000a, b) recorded an *antiquus*/*aturicus* Event in the Upper Campanian (*Hoplitoplacenticeras marroti* Zone) of the Barranca (Navarra), and a distinct acme in the distribution of *M. aturicus* in the lower part of that zone.

Family Corasteridae LAMBERT *in* LAMBERT & THIÉRY, 1924
Genus *Coraster* COTTEAU, 1886

TYPE SPECIES: *Coraster vilanovae* COTTEAU, 1886, p. 70, by monotypy.

DIAGNOSIS: Test globose to ovoid, with shallow frontal groove if present. Apical disc ethmophract with four gonopores. Ambulacra nonpetaloid with small partitioned isopores. 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 beneharnicus SEUNES, 1888
(Pl. 5, Figs 4-7; Text-figs 10, 11)

*1888. *Coraster Beneharnicus* SEUNES, pp. 804-805, pl. 29, fig. 1a-d.
1975. *Coraster beneharnicus* SEUNES; VILLATTE *in* PLAZIAT & *al*., p. 635, pl. 1, figs 1-6, text-figs 6, 8.
v1999. *Coraster vilanovae* COTTEAU 1886; JAGT, p. 8.
1999. *Coraster beneharnicus* SEUNES, 1888; SMITH & *al*., p. 130, pl. 10, figs 1-5, 11-13, text-figs 36, 37b.
2000. *Coraster beneharnicus* SEUNES, 1888; SMITH & JEFFERY, p. 356.

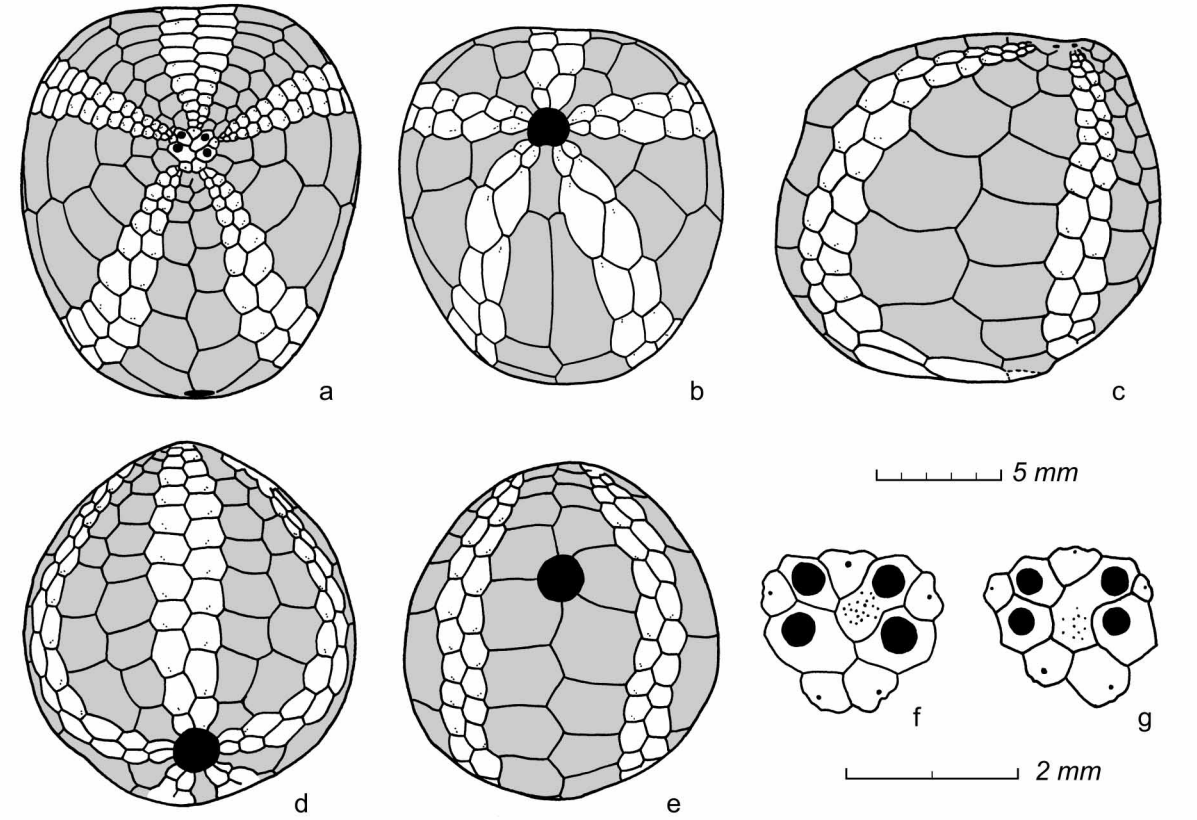

Fig. 10. Camera-lucida drawings of *Coraster beneharnicus* SEUNES, 1888; A – aboral view (Estermann Colln, EST 147); B – oral view (Estermann Colln, EST 141); C – lateral view (Estermann Colln, EST 147); D – anterior view (Estermann Colln, EST 147); E – posterior view (Estermann Colln, EST 146); F – apical disc (Estermann Colln, EST 147); G – apical disc (Estermann Colln, EST 146)

MATERIAL: Eleven specimens in the Estermann Colln (EST 141, 142(240), 143(236), 144(238), 145(237), 146(232), 147(233), 149(239), 160(235), 169(234), 194); five in the NHMW Colln (NHMW 1998z0098/0034); all from the Gschliefgraben near Gmunden, Austria.

Measurements (in mm):

	Length	Height	Width
Estermann EST 141	14.8	13.5	13.7
Estermann EST 146(232)	14.2	12.4	12.7
Estermann EST 147(233)	14.6	12.5	13.5
Estermann EST 169(234)	13.9	11.5	12.6

DESCRIPTION: Test small ranging from 13.9 to 18.3 mm in the studied material, globose in lateral profile, ovoid in horizontal outline (Text-fig. 10A), slightly longer than wide, with indistinct frontal notch which deepens adorally to form a broad and shallow groove extending to peristome (Pl. 5, Fig. 5; Text-fig. 10D). Test width ranging from 82 to 91 % test length; height ranging from 89 to 93 % test length. Greatest width anteriorly along line 1b and 4a. Non-petaloid ambulacra, more or less flush, with small, oblique partitioned isopores; ambulacral plates high. Interambulacrum 5 forming a rounded keel on the aboral side of the test. Weak subanal heel (Pl. 5, Fig. 7; Text-fig. 10C); plastron amphisternous with long labral plate and (near) symmetric sternal plates (Text-fig. 10B).

Apical disc ethmophract with four gonopores (Text-fig. 10F), lying about 25 % test length away from the anterior margin. In one specimen the madreporite separates the posterior genital plates (Text-fig. 10G); peristome positioned anteriorly at *c.* 25% of test length

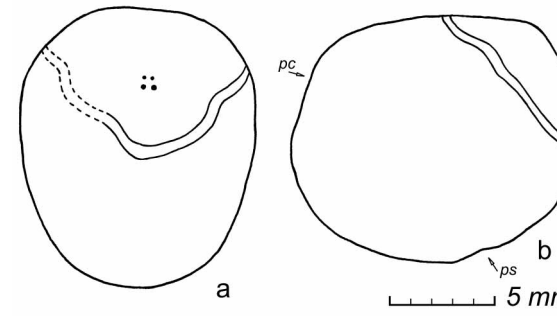

Fig. 11. Camera-lucida drawings of *Coraster beneharnicus* SEUNES, 1888 showing the shape and course of the peripetalous fasciole (A and B are Estermann Colln, EST 234)

from anterior margin, non labiate or weakly so (Text-fig. 10B).

The peristome lies close to the anterior margin (about 20 % test length away from it), facing anteriorly. It is small (c. 1.5 to 2.0 mm wide) and circular to slightly oval. The posterior margin of the peristome is strongly raised. The labrum does not project over the peristome. The periproct lies high on the posterior face and has a circular to slightly oval shape (c. 1.5 to 2.5 mm wide).

Tuberculation very dense, consisting of small perforate, crenulate primary tubercles and a high number of miliaries. Attached to the primary tubercles are relatively long, needle-like spines with a broad base (preserved in specimen EST 169(234)). Peripetalous fasciole well developed, appearing highly inclined in profile, with a distinct kink in the anterior plate rows of the posterior paired interambulacra (Text-figs 11A, B). The fasciole band is narrow and corresponds to the orthofasciole type *sensu* NÉRAUDEAU & *al*. (1998).

DISCUSSION: *Coraster beneharnicus* constitutes another palaeobiogeographically interesting addition to the echinoid faunules from the Gschliefgraben. Previous records of this species are from the Lower Paleocene (Danian) of the French and Spanish Pyrenees and of Navarra (Spain). It differs from the 'typical' forms from the Pyrenees only by its slightly less elongated outline.

KROH (2001, p. 414, pl. 14, figs 1-6; text-figs 27-29) described the closely related *C. vilanovae* COTTEAU, 1886 (p. 70, pl. 9, figs 1-4) from the Bruderndorf Formation (Lower Paleocene) of Haidhof and Klement (Lower Austria). The present species differs from *C. vilanovae* in having a more angular and elongate test with a weak subanal heel and with the frontal groove extending to the peristome (see also SMITH & *al*. 1999; SMITH & JEFFERY 2000).

OCCURRENCE: Gschliefgraben, Upper Austria; Danian of the French and Spanish Pyrenees (SEUNES 1888; SMITH & *al*. 1999).

AGE: Matrix samples taken from five specimens (NHMW 1998z0098/0034) have yielded only poorly preserved nannofossils. The observed spectrum, however, is very similar to that found in samples taken from specimens of *Lampadocorys* (see Appendix) and a Campanian age thus appears probable. This contrasts markedly with the known range of this species, to date recorded exclusively from Danian strata. Unfortunately, our specimens lack stratigraphic constraint (due to the nature of the outcrop, see above). Hence, it is currently impossible to determine whether the species actually has a longer range than previously thought or if the nannofossils are reworked.

CONCLUSIONS

The most important elements in the present echinoid faunules are stegasterids and micrasterids not considered in JAGT's (1999) account. Additionally, newly discovered material including two species of *Echinocorys*, a representative of *Ganbirretia*? and a corasterid are discussed and illustrated. Recent studies on holasteroid phylogeny (SMITH 2004) and on Late Cretaceous holasteroids from Great Britain (SMITH & WRIGHT 2003) have furnished many new data. The group of taxa previously (SMITH & JEFFERY 2000) assigned to the genus *Stegaster* is now referred to *Seunaster* and *Lampadocorys*, the former with a contiguous and the latter with a disjunct plastron. Both genera are present in the Gschliefgraben fauna. Whereas the species of *Seunaster* identified here appears to be related to a taxon from the Upper Cretaceous of the French and Spanish Pyrenees, those of *Lampadocorys* are considered new. Calcareous nannoplankton samples taken from the matrix adhering to these specimens have yielded a Late Campanian age (nannozone CC22).

For the first time, also Paleocene (or potentially Paleocene, see above under *C. beneharnicus*) echinoids are described from the Gschliefgraben, being represented by the small spatangoid *Coraster beneharnicus* and a large species of *Echinocorys*, *E. ancileformis*. The generally poorly preserved Eocene echinoids will be described in the near future.

While some micrasterids, the single cardiasterid and some echinocorids documented from this locality (see JAGT 1999) are elements typical of the North Temperate realm, the holasteroids and corasterids documented here and in JAGT (1999) are Tethyan realm representatives. They document a distinct biogeographical relationship with the French and Spanish Pyrenees (*Coraster beneharnicus*, *Seunaster* cf. *heberti*), Italy (*Rispolia* cf. *subtrigonata*), and the Caucasus (*Echinocorys ancileformis*, *Pseudoffaster caucasicus*). This fits well with the inferred palaeogeographic position of the Gschliefgraben (Ultrahelvetic) at the southern slope of the European continental plate and at the transition between the North Temperate and Tethyan realms. Yet, it also reflects the fairly homogeneous nature of southern European upper bathyal faunas, which are of low diversity in comparison to coeval shallow-water faunas. An admixture of Temperate and Tethyan elements has also been observed for most other groups studied from this locality (e.g., calcareous nannofossils, WAGREICH 1999; inoceramids, TRÖGER & *al*. 1999; ammonites, KENNEDY & SUMMESBERGER 1984, 1999).

The relatively common occurrence of stegasterids in Upper Campanian strata at the Gschliefgraben suggests an outer shelf to upper slope setting for these sediments. Similar palaeoenvironments with stegasterids have been

documented from the Maastrichtian to Paleocene of the Navarra region in Spain (SMITH & *al*. 1999). The heterogeneous nature of the fauna, however, with a co-occurrence of deep-water taxa such as stegasterids and more shallow-water forms such as micrasterids calls for a more refined interpretation. Two explanations appear likely:

1 – the shallow-water forms were transported basinwards by debris flows;

2 – there are actually two horizons within the section, one documenting a shallower setting and the other a deeper one.

The second hypothesis lacks substantiation since calcareous nannoplankton evidence suggests that the stegasterids occurred contemporaneously with the micrasterids. Whenever possible, more rigorous collecting at the Gschliefgraben is called for, with better documentation of association of faunal elements. Co-occurrences of echinoids with e.g. inoceramid bivalves and ammonites should be clearly marked as such to allow more detailed age assignments, and eventually, a more reliable picture of the zonal distribution of these and other macrofaunal elements. Echinoid data presented above demonstrate beyond doubt that the Gschliefgraben may prove of prime importance in linking elements typical of North Temperate settings on the one hand and predominantly Tethyan taxa on the other.

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REFERENCES

AGASSIZ, L. 1836. Notice sur les fossiles Crétacés du Jura Neuchâtelois. *Mémoires de la Société des Sciences Naturelles de Neuchâtel*, **1**, 126-145.

— 1840. Catalogus systematicus Ectyporum Echinodermatum fossilium Musei Neocomiensis, secundum ordinem zoologicum dispositus; adjectis synonymis recentioribus, nec non stratis et locis in quibus reperiuntur. Sequuntur characteres diagnostici generum novorum vel minus cognitorum, 20 pp. *Oliv. Petitpierre*; Neuchâtel.

AIRAGHI, C. 1903. Echinidi della scaglia cretacea Veneto. *Memoria della Reale Accademia delle Scienze di Torino* (2) **53**, 315-330.

— 1906. Un nuovo genere della sottofamiglia delle'Echinocorynae'. *Atti della Societą Italiana di Scienze Naturali e Museo Civico di Storia Naturali di Milano*, **45**, 107-110.

ARNAUD, H. 1897. Divisions naturelles du Crétacé supérieur audessus du Santonien dans le sud-ouest et la région pyrénéenne. *Bulletin de la Société Géologique de France*, (3)**25**, 676-681.

ARNAUD, H. 1902. Les "*Echinocorys*" de Tercis. *Actes de la Société Linnéenne de Bordeaux*, **7**, 29-39.

DE BLAYAC, J. 1912. Esquisse géologique du bassin de la Seybousse et de quelques régions voisines. *Bulletin du Service de la Carte Géologique d'Algérie*, (**2**)**6**, 1-490.

DE BLAYAC, J. & COTTREAU, J. 1909. Échinides maëstrichtiens de Bordj-Sabath (Algérie). *Bulletin de la Société Géologique de France,* (4)**9**, 416-430.

DE BOUILLÉ, R. 1873. Paléontologie de Biarritz et des quelques autres localités des Basses Pyrénées. *Congrès Scientifique de France*, **39**, 427-450.

CATULLO, T.A. 1827. *Saggio di Zoologia fossile*, 348 pp. *Tipografia del Seminario*; Padova.

CLAUS, C.F.W. 1876. *Grundzüge der Zoologie* (3rd ed.), xii + 1254 pp. *N.G. Elwert'sche Universitätsbuchhandlung*; Marburg/ Leipzig.

COTTEAU, G.H. 1873. Échinides nouveaux ou peu connus. *Revue et Magasin de Zoologie* (3), **1,** 399-409 (168-178).

— 1886. Échinides nouveaux ou peu connus, (2)5. *Bulletin de la Société Zoologique de France*, **11**, 708-728.

GALLEMÍ, J. 1982. Distribución de los equinídos del Cretácico superior sudpirenaico. *Cuadernos Geología Ibérica*, **8**, 1049-1056.

GALLEMÍ, J., MARTÍNEZ, R. & PONS, J.M. 1983. Coniacian-Maastrichtian of the Tremp Area (South Central Pyrenees). *Newsletters of Stratigraphy*, **12**, 1-17.

GAUTHIER, V. 1886. Description de trois Échinides nouveaux recueillis dans la craie de l'Aube et l'Yonne. *Comptes Rendus Association Franćaise pour l'Avancement des Sciences*, *Congrès Grenoble*, **1885**, 356-362.

— 1903. Contributions à l'étude des Échinides fossiles. VII. Genre *Ganbirretia* Gauthier. *Bulletin de la Société Géologique de France* (4), **3**, 19-29.

DE GROSSOUVRE, A. 1901. Recherches de la Craie supérieure, 1. Stratigraphie générale, avec une Monographie du genre *Micraster*, par J. LAMBERT. *Mémoire du Service pour la Carte Géologique Détaillée de France*, viii + 1013 pp. *Imprimerie nationale*; Paris.

DESOR, E. 1855-1858. *Synopsis des échinides fossiles*, lxviii + 490 pp. *Ch. Reinwald*, Paris; *Kriedel & Niedner*; Wiesbaden.

DURHAM, J.W. & MELVILLE, R.V. 1957. A classification of echinoids. *Journal of Paleontology*, **31**, 242-272.

ERNST, G. 1967. Über Fossilnester in *Pachydiscus*-Gehäusen und das Lagenvorkommen von Echiniden in der Oberkreide NW-Deutschlands. *Paläontologische Zeitschrift*, **41**, 211-229.

HANCOCK, J.M., PEAKE, N.B., BURNETT, J., GHONDT, A.V., KENNEDY, W.J. & STOKES, R.B. 1993. High Cretaceous biostratigraphy at Tercis, south-west France. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre*, **63**, 133-148.

HAUER, F. VON 1858. Ueber die Eocengebilde im Erzherzogthume Oesterreich und in Salzburg. *Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt*, **9**, 103-137.

JAGT, J.W.M. 1999. Late Campanian echinoids and crinoids from the Gschliefgraben (Ultrahelvetic, Austria). *Beiträge zur Paläontologie*, **24**, 7-22.

— 2000. Late Cretaceous-Early Palaeogene echinoderms and the K/T boundary in the southeast Netherlands and northeast Belgium - Part 4: Echinoids. *Scripta Geologica*, **121**, 181-375.

KENNEDY, W.J. & SUMMESBERGER, H. 1984. Upper Campanian ammonites from the Gschliefgraben (Ultrahelvetic, Upper Austria). *Beiträge zur Paläontologie*, **11**, 149-206.

— & — 1999. New Late Campanian Ammonites from the Gschliefgraben near Gmunden (Ultrahelvetic, Austria). *Beiträge zur Paläontologie*, **24**, 23-39.

KROH, A. 2001. Echinoids from the Danian (Lower Paleocene) Bruderndorf Formation of Austria. *In*: PILLER, W.E. & RASSER, M.W. (*Eds*), Paleogene of the Eastern Alps. *Österreichische Akademie der Wissenschaften, Schriftenreihe der Erdwissenschaftliche Kommissionen*, **14**, 377-463.

KÜCHLER, T. 2000a. *Scaphites hippocrepis* (DeKay) IV, a new chronological subspecies from the Lower-Upper Campanian (Upper Cretaceous) boundary interval of northern Spain. *Acta Geologica Polonica*, **50**, 161-167.

— 2000b. Upper Cretaceous of the Barranca (Navarra, northern Spain); integrated litho-, bio- and event stratigraphy. Part II: Campanian and Maastrichtian. *Acta Geologica Polonica*, **50**, 441-499.

LAMBERT, J. 1896. Note sur quelques échinides crétacés de Madagascar. *Bulletin de la Société Géologique de France,* (3) **24,** 313-332.

— 1898. Note sur les Échinides de la craie de Ciply. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, **11** (1897), 141-190.

— 1903. Description des Échinides Crétacés de la Belgique principalement de ceux conservés au Musée royal de Bruxelles. I Etude monographique sur le Genre *Echinocorys*. *Mémoires du Musée Royal d'Histoire Naturelle de Belgique*, **2**, 1-151.

— 1917. Note sur quelques Holasteridae. *Bulletin de la Société des Sciences Historiques et Naturelles de l'Yonne*, **70**, 191-223.

— 1920. Étude sur quelques formes primitives de Spatangidés. *Bulletin de la Société des Sciences Historiques et Naturelles de l'Yonne*, **73**, 1-41.

— 1921. Échinides vivants et fossiles recueillis ą Madagascar par M. Raymond Decary. *Mémoires de la Société Académique d'Agriculture des Sciences, Arts et Belles-Lettres du Département de l'Aube,* (3) **58-59** (1921-1922), 13-55.

— 1931. Échinides Crétacés de la région d'Héraclée. *Annales de la Société Géologique de Belgique*, **54**, M1-M12.

— 1931-1932. Étude sur les échinides fossiles du Nord de l'Afrique. *Mémoires de la Société Géologique de France, N.S.* **16,** 1-108 (1931), 109-228 (1932).

LAMBERT, J. & THIÉRY, P. 1909-1925. Essai de nomenclature raisonnée des Échinides, iii + 1-80 (1909); 81-160 (1910); 161-240 (1911); 241-320 (1914); 321-384 (1921); 385-512 (1924); 513-607 (1925). *L. Ferrière*; Chaumont.

LESKE, N.G. 1778. Jacobi Theodori Klein Naturalis dispositio Echinodermatum, edita et descriptionibus novisque inventis et synonymis auctorum aucta, xxii + 278 pp. *G.E. Beer*; Lipsiae.

DE LORIOL, P. 1873. Échinologie helvétique; descriptions des oursins fossiles de la Suisse, 2. Échinides de la période crétacée, 398 pp. *H. Georg*; Genève.

MĄCZYŃSKA, S.S. 1968. Echinoids of the Genus *Micraster* L. Agassiz from the Upper Cretaceous of the Cracow-Miechów area. *Prace Muzeum Ziemi*, **12**, 87-168.

DE MEIJERE, J.C.H. 1902. Vorläufige Beschreibung der neuen, durch die Siboga-Expedition gesammelten Echiniden. *Tijdschrift van de Nederlandsche Dierkundige Vereeniging Leiden* (2)**8**, 1-16.

MOORE, R.C. (*Ed*.) 1966. Treatise on Invertebrate Paleontology, U. Echinodermata 3, xxx + 695 pp. *Geological Society of America*, Boulder and *University of Kansas Press*, Lawrence.

MOSKVIN, M.M. 1983. *Pseudogibbaster*, a new genus of Danian and Paleocene echinoids. *Paleontologicheskii Zhurnal*, **1983**, 112-115. [*In Russian*].

MOSKVIN, M.M. & SHIMANSKAYA, N.V. 1981. Paleotsenovye *Echinocorys* (morskie ezhi) na territorii SSSR. *Byulletin Moskovogo Obshchestva Ispytatelej Prirody, Otdel Geologii*, **56**, 127-137.

NÉRAUDEAU, D., DAVID, B. & MADON, C. 1998. Tuberculation in spatangoid fascioles: Delineating plausible homologies. *Lethaia*, **31**, 323-334.

NÉRAUDEAU, D. & ODIN, G.S. 2001. Echinoids from the geological site at Tercis les Bains (Landes, SW France). *In*: ODIN, G.S. (*Ed.*), The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and Correlation with Europe and other Continents. *Developments in Palaeontology and Stratigraphy*, **19**, 612-634. *Elsevier*; Amsterdam.

PICTET, F.J. 1857. Traité élémentaire de Paléontologie ou Histoire naturelle des animaux fossiles considérés dans leurs rapports zoologiques et géologiques (Seconde édition), **4**, xvi + 768 pp. *J.-B. Baillière et fils*; Paris.

PLAZIAT, J.C., TOUMARKINE, M. & VILLATTE, J. 1975. L'âge des calcaires pélagiques et néritiques de la base du Tertiaire (Danien, Paléocène), Bassin basco-cantabrique et béarnais (Espagne, France). Mise au point sur leurs faunes d'Échinides. *Eclogae Geologicae Helvetiae*, **68**, 613-647.

POMEL, A. 1883. Classification méthodique et genera des échinides vivants et fossiles, 131 pp. *A. Jourdan*; Alger.

POSLAVSKAIA, N.A. & MOSKVIN, M.M. 1959. Klass Echinoidea. Morskie ezhi. *In*: MOSKVIN, M.M. (*Ed.*), Atlas verkhnemelovoj fauny severnogo Kavkaza u Kryma, pp. 242-304. *Gostoptechisdat*; Moskva.

PREY, S. 1983. Das Ultrahelvetikum-Fenster des Gschliefgrabens südöstlich von Gmunden (Oberösterreich). *Jahrbuch der Geologischen Bundesanstalt*, **126**, 95-127.

RADIG, F. 1973. Beiträge zur Kenntnis der höheren Oberkreide der Baskischen Depression (Nordspanien) und ihrer Echinozoen-Fauna. *Erlanger Geologische Abhandlungen*, **94**, 1-68.

SÁNCHEZ ROIG, M. 1924. Revision de los Eqiniodos fosilos Cubanos. *Memorias de la Sociedad Cubana Historia Natural* "*Felipe Poey*", **6**, 6-50.

SEUNES, J. 1888. Échinides crétacés des Pyrénées occidentales. Série I. *Bulletin de la Société Géologique de France* (3), **16**, 791-815.

— 1889. Échinides crétacés des Pyrénées occidentales. Série II. *Bulletin de la Société Géologique de France* (3), **17**, 804-824.

— 1891. Échinides crétacés des Pyrénées occidentales. Série II. *Bulletin de la Société Géologique de France* (3), **19**, 23-32.

SMITH, A.B. 2004. Phylogeny and systematics of holasteroid echinoids and their migration into the deep-sea. *Palaeontology* **47**, 123-150.

SMITH, A.B. The Echinoid Directory. *www.nhm.ac.uk/palaeontology/echinoids*.

SMITH, A.B., GALLEMÍ, J., JEFFERY, C.H., ERNST, G. & WARD, P.D. 1999. Late Cretaceous-early Tertiary echinoids from northern Spain: implications for the Cretaceous-Tertiary extinction event. *Bulletin of the Natural History Museum London (Geology)*, **55**, 81-137.

SMITH, A.B. & JEFFERY, C.H. 2000. Maastrichtian and Palaeocene echinoids: a key to world faunas. *Special Papers in Palaeontology,* **63**, 1-406.

SMITH, A.B. & WRIGHT, C.W. 2003. British Cretaceous echinoids. Part 7, Atelostomata, 1. Holasteroida. *Monographs of the Palaeontographical Society*, **156 (619)**, 440-568.

SOLIGNAC, M. 1927. Carte géologique de la Tunisie. Étude géologique de la Tunisie septentrionale, xiii + 756 pp. *Imprimerie J. Barlier & cie*; Tunis.

STOKES, R.B. 1975. Royaumes et provinces fauniques du Crétacé établis sur la base d'une étude systématique du genre *Micraster*. *Mémoires du Muséum National d'Histoire Naturelle Paris*, **C31**, 1-94.

SUMMESBERGER, H., WAGREICH, M., TRÖGER, K.-A. & JAGT, J.W.M. 1999. Integrated biostratigraphy of the Santonian/Campanian Gosau Group of the Gams Area (Late Cretaceous; Styria, Austria). *Beiträge zur Paläontologie*, **24**, 155-205.

TRÖGER, K.-A., SUMMESBERGER, H. & SKOUMAL, P. 1999. Inoceramidae from the Campanian (Upper Cretaceous) of the Gschliefgraben (Ultrahelvetic; Austria). *Beiträge zur Paläontologie*, **24**, 41-61.

WAGREICH, M. 1999. Calcareous nannofossil assemblages from the Gschliefgraben near Gmunden (Ultrahelvetic, Austria). *Beiträge zur Paläontologie*, **24**, 63-67.

ZAGHBIB-TURKI, D. 1987. Les échinides du Crétacé de Tunisie. Paléontologie générale: systématique, paléoécologie, paléobiogéographie, 613 pp. Université de Tunis, unpublished PhD thesis, Tunis.

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Revised version accepted: 20th August 2004.

Appendix

Matrix sample of *Lampadocorys*? *estermanni* n. sp. (paratype, NHMW 2003z0067/0002):

Biscutum sp.

Cribrosphaerella ehrenbergii (Arkhangelsky 1912) Deflandre 1952

Glaukolithus sp.

Lucianorhabdus cayeuxii Deflandre 1959

Micula decussata Vekshina 1959

Prediscosphaera cretacea (Arkhangelsky 1912) Gartner 1968

Watznaueria barnesae (Black 1959) Perch-Nielsen 1968

Possible age: Santonian to Maastrichtian

Matrix sample of *Lampadocorys*? *estermanni* sp.nov. (holotype, NHMW 2003z0067/0001, *ex* EST 46):

Arkhangelskiella cymbiformis Vekshina 1959

Biscutum constans (Gorka 1957) Black 1959

Biscutum sp aff. *magnum*

Broinsonia parca constricta Hattner, Wind & Wise 1980

Broinsonia parca parca (Stradner 1963) Bukry 1969

Chiastozygus litterarius (Gorka 1957) Manivit 1971

Cribrosphaerella ehrenbergii (Arkhangelsky 1912) Deflandre 1952

Eiffellithus eximius (Stover 1966) Perch-Nielsen 1968

Eiffellithus turriseiffelii (Deflandre & Fert 1954) Reinhardt 1965

Gartnerago obliquum (Stradner 1963) Noel 1970

Glaukolithus diplogrammus (Deflandre 1954) Reinhardt 1964

Lucianorhabdus cayeuxii Deflandre 1959

Micula decussata Vekshina 1959

Prediscosphaera cretacea (Arkhangelsky 1912) Gartner 1968

Reinhardtites cf. *levis* Prins & Sissingh in Sissingh 1977

Stradneria crenulata (Bramlette & Martini 1964) Noel 1970

Watznaueria barnesae (Black 1959) Perch-Nielsen 1968

Age: Middle to Late Campanian, standard zones CC18–CC23

Matrix sample of *Lampadocorys*? sp.nov. 2 (NHMW 1998z0098/0035):

Arkhangelskiella cymbiformis Vekshina 1959

Biscutum constans (Gorka 1957) Black 1959

Braarudosphaera bigelowi (Gran & Braarud 1935) Deflandre 1959

Broinsonia parca constricta Hattner, Wind & Wise 1980

Broinsonia parca parca (Stradner 1963) Bukry 1969

Calculites obscurus (Deflandre 1959) Prins & Sissingh 1977

Chiastozygus sp.

Cretarhabdus sp.

Cribrosphaerella ehrenbergii (Arkhangelsky 1912) Deflandre 1952

Corollithion sp.

Eiffellithus eximius (Stover 1966) Perch-Nielsen 1968

Eiffellithus turriseiffelii (Deflandre & Fert 1954) Reinhardt 1965

Glaukolithus diplogrammus (Deflandre 1954) Reinhardt 1964

Kamptnerius magnificus Deflandre 1959

Lucianorhabdus cayeuxii Deflandre 1959

Lucianorhabdus cayeuxii Deflandre 1959 ssp. B

Manivitella pemmatoidea (Deflandre in Manivit 1965) Thierstein 1971

Microrhabdulus decoratus Deflandre 1959

Micula decussata Vekshina 1959

Prediscosphaera cretacea (Arkhangelsky 1912) Gartner 1968

Reinhardtites anthophorus (Deflandre 1959) Perch-Nielsen 1968

Reinhardtites cf. *levis* Prins & Sissingh in Sissingh 1977

Stradneria crenulata (Bramlette & Martini 1964) Noel 1970

Tranolithus orionatus (Reinhardt 1966) Perch-Nielsen 1968

Watznaueria barnesae (Black 1959) Perch-Nielsen 1968

Age: Late Campanian, standard zone CC22 (nannofossil zone CC22c; UC15d^{TP} - UC15e^{TP})

PLATES 1-8

PLATE 1

Lampadocorys? *estermanni* sp. nov.

1, 2 – **holotype**, NHMW 2003z0067/0001, in oral and aboral view, respectively.
3, 4 – Estermann Colln, EST 40, in aboral and oral view, respectively.
5, 6 – **paratype**, NHMW 2003z0067/0002, in aboral and oral view, respectively.

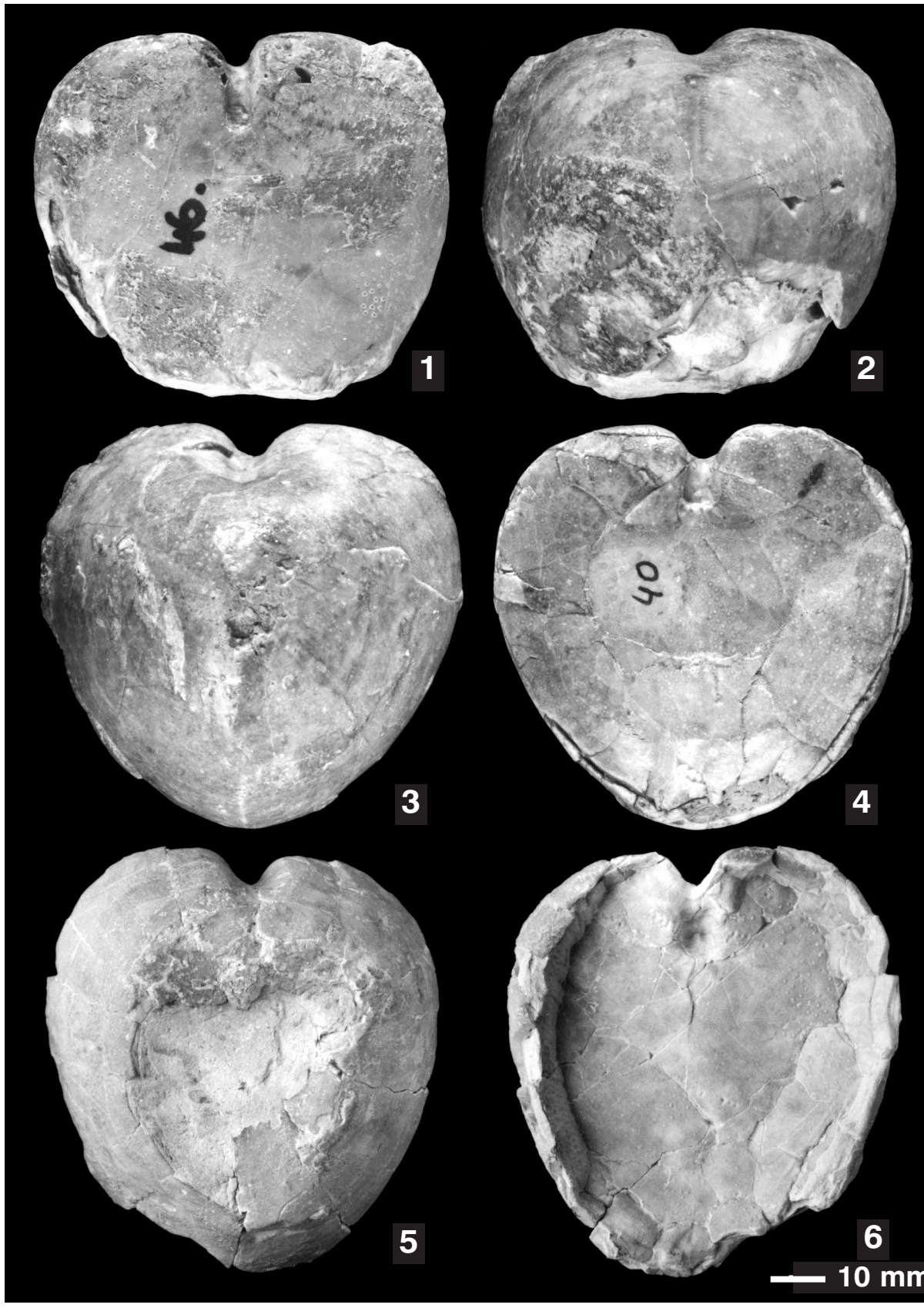
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PLATE 2

Lampadocorys? *estermanni* sp.nov.

1, 2, 4, 5 – holotype, NHMW 2003z0067/0001, in anterior view (1), *en chevron*-shaped elongate anisopores in adapical part of ambulacrum III (2), marginal fasciole in ambital interambulacrum 4 and ambulacrum V (4), minute partitioned isopores in ambital part of ambulacrum III (5).

3 – Estermann Colln, EST 40, in lateral view.

6 – paratype, NHMW 2003z0067/0002, in lateral view.

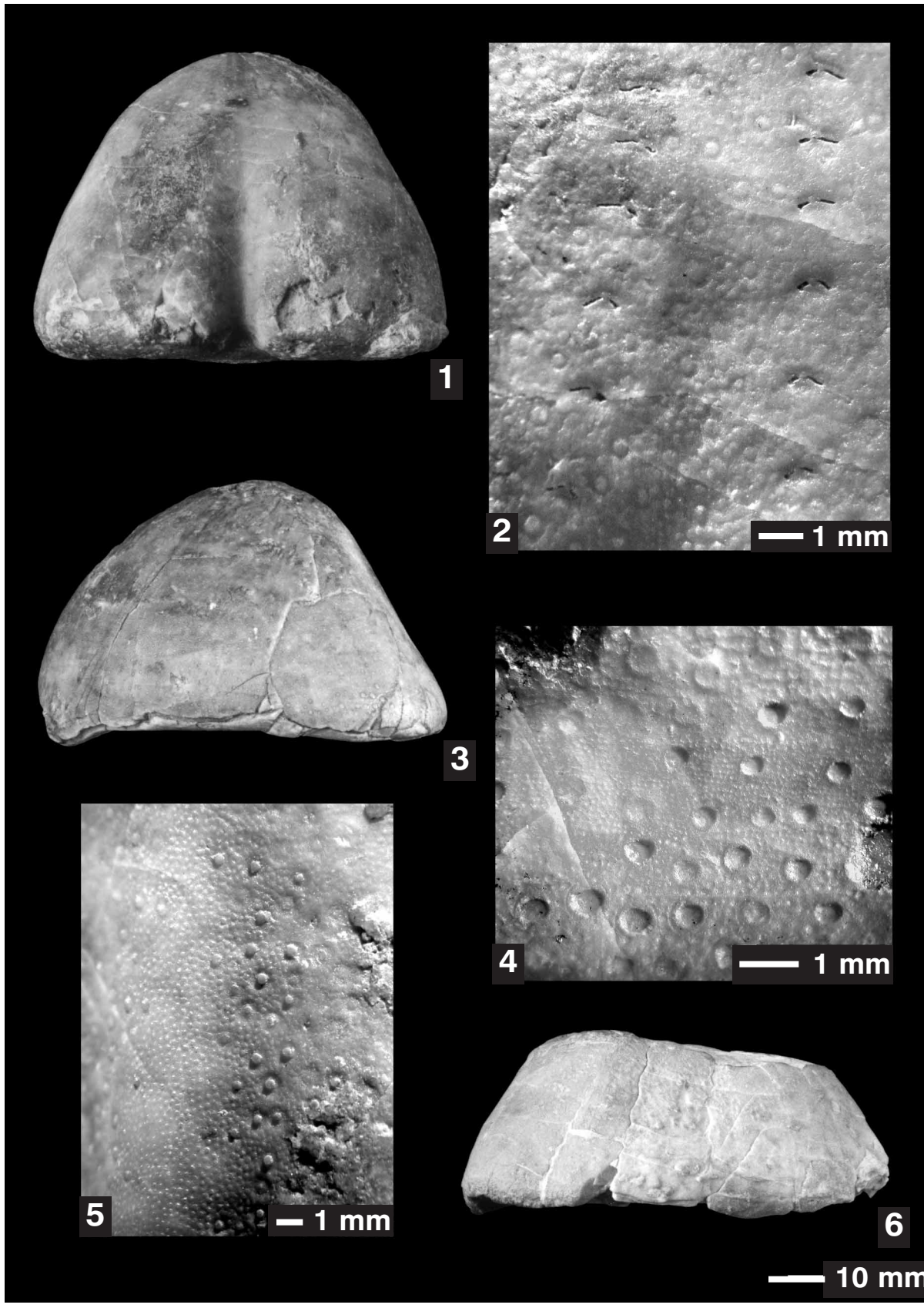
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PLATE 3

1-4 – *Lampadocorys*? sp.nov. 1; Estermann Colln, EST 151, in aboral, oral, lateral and posterior view, respectively.

5-9 – *Rispolia* cf. *subtrigonata* (CATULLO, 1827); Estermann Colln, EST 15, in lateral, posterior, aboral, oral and anterior view, respectively.

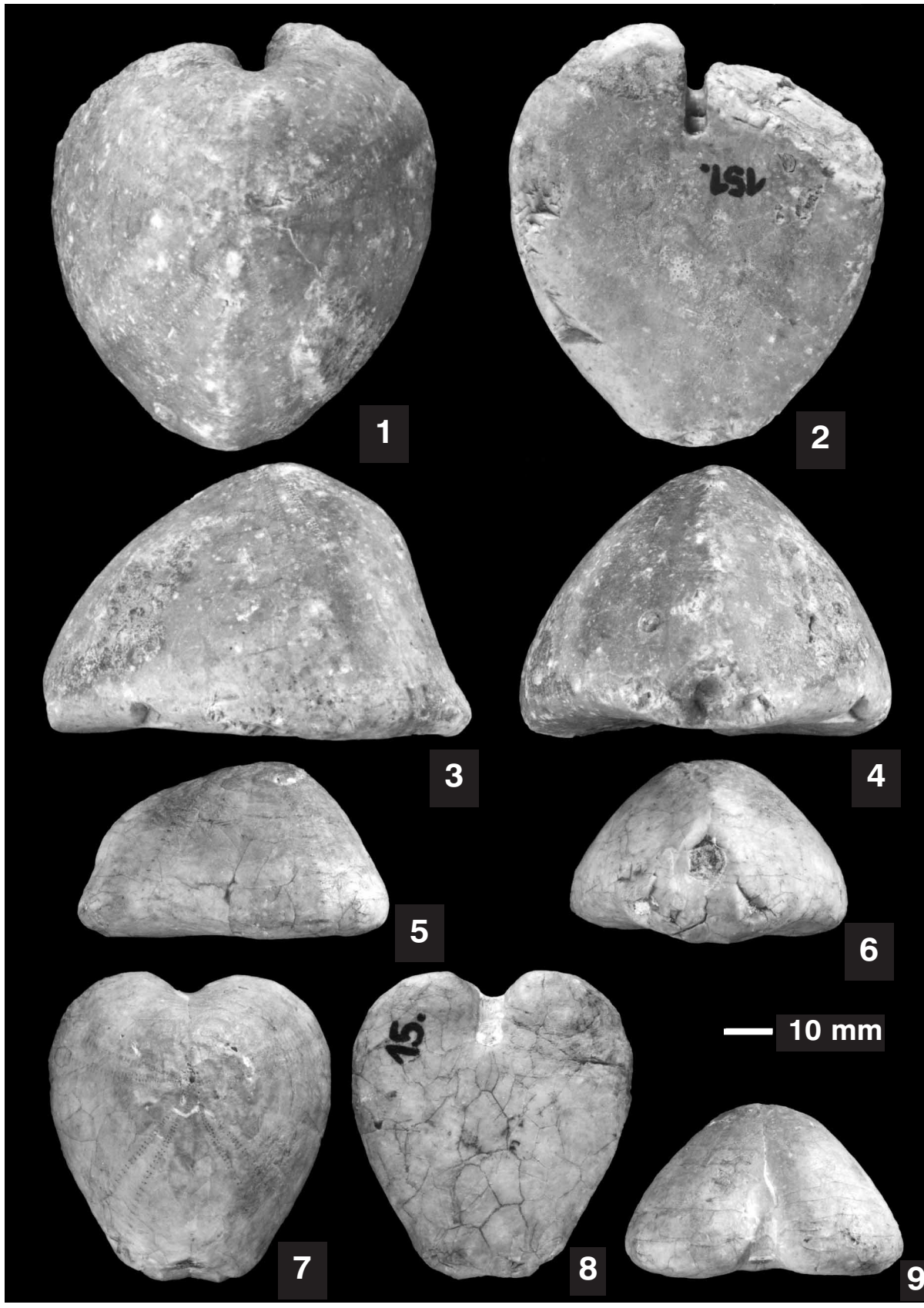
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PLATE 4

Lampadocorys? sp.nov. 2

1-3 – Estermann Colln, EST 64, in aboral, oral and lateral view [anterior to right] view, respectively.

4-6 – NHMW 1998z0098/0035, in aboral, oral and lateral [anterior to right] view, respectively.

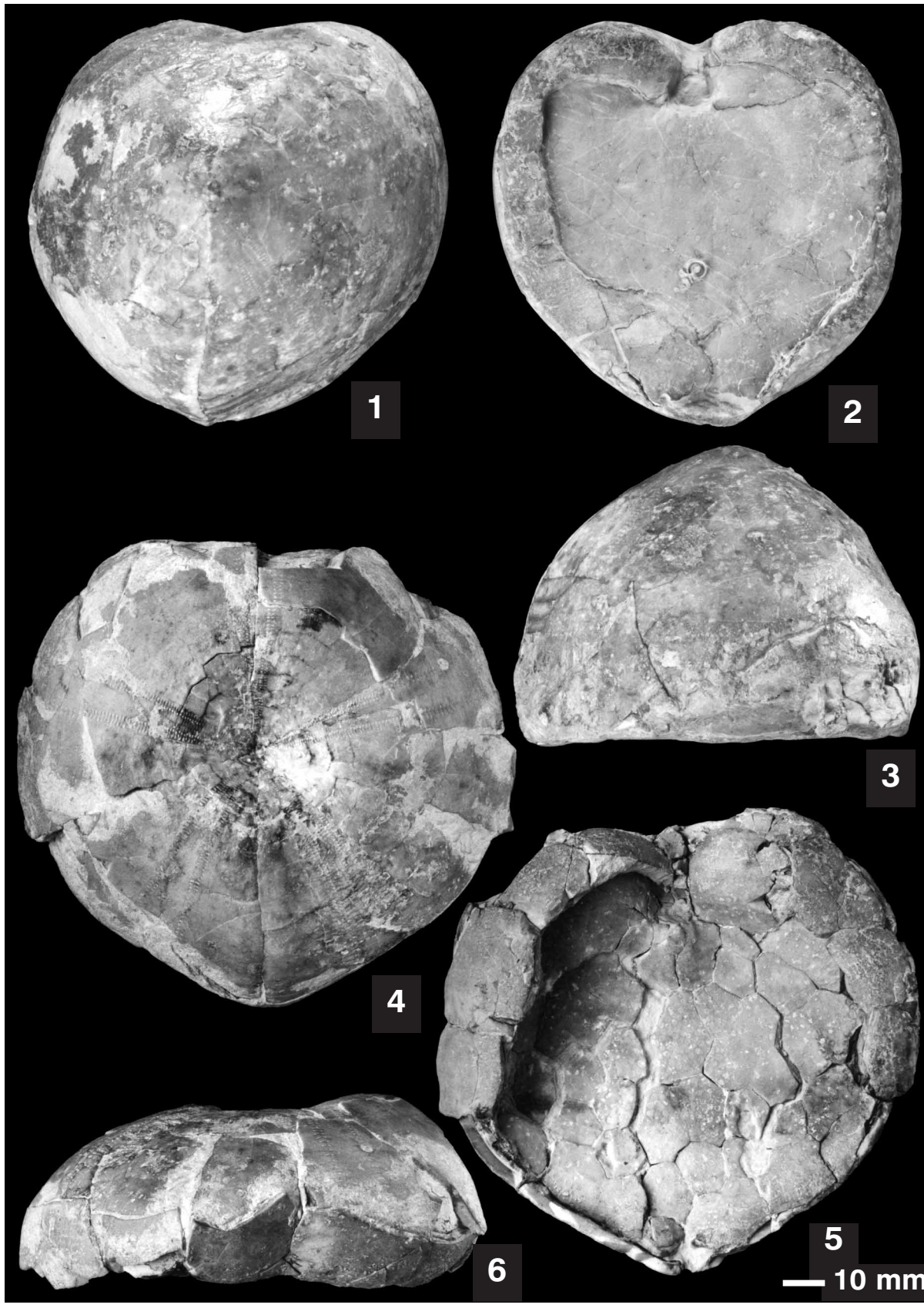
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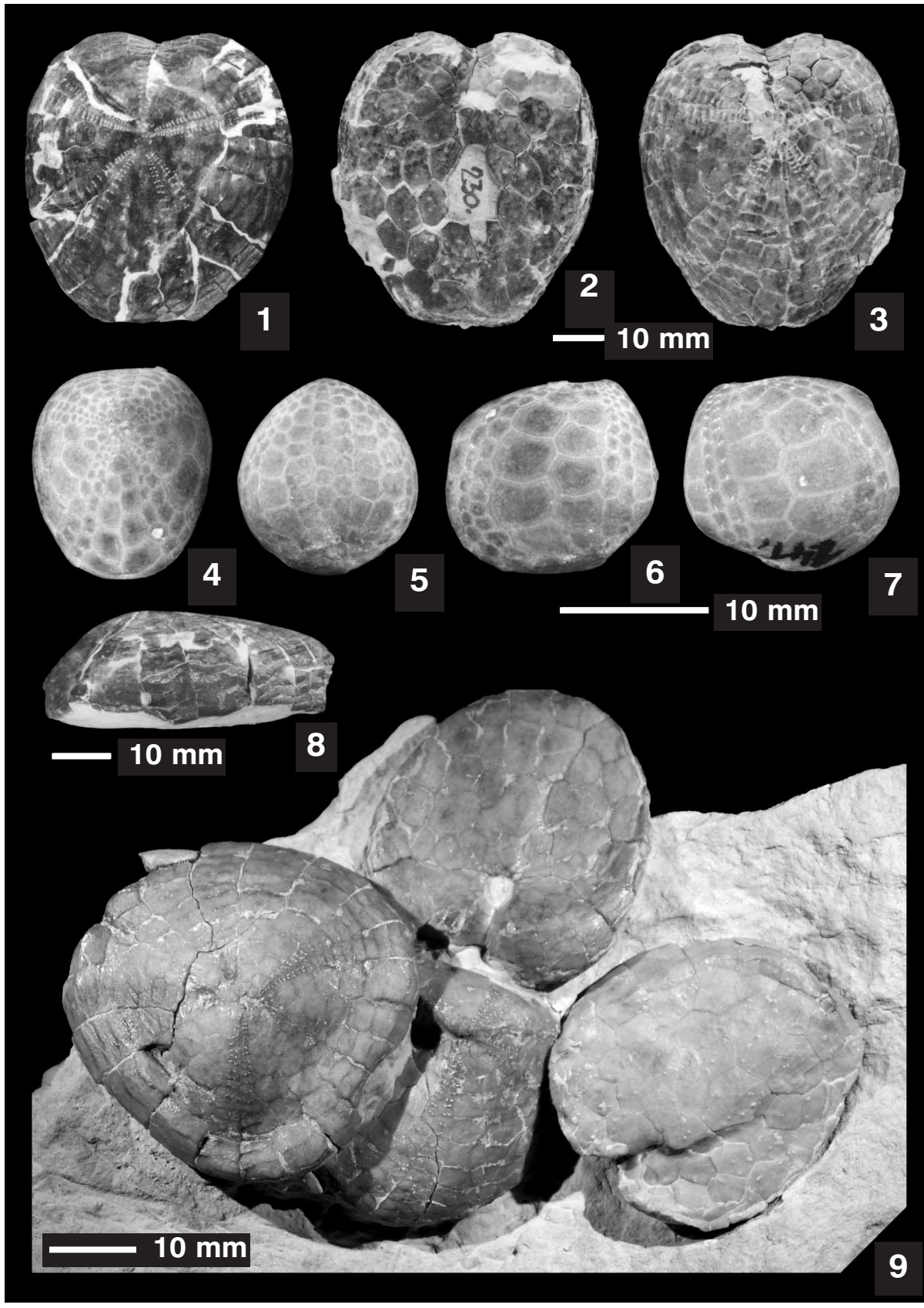
PLATE 5

1-3, 8, 9 – *Seunaster* cf. *heberti* (SEUNES, 1889); 1, 8 – Estermann Colln, EST 139, in aboral and lateral [anterior to left] view, respectively; 2, 3 – Estermann Colln, EST 140 (= *ex* 230), in oral and aboral view, respectively; 9 – Estermann Colln, no registration number.

4-7 – *Coraster beneharnicus* SEUNES, 1888; 4-6 – Estermann Colln, EST 147, in aboral, anterior and lateral [anterior to right] view, respectively; 7 – Estermann Colln, EST 141, in lateral view [anterior to left].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9

PLATE 6

Echinocorys ancileformis MOSKVIN & SHIMANSKAYA, 1981; Estermann Colln, EST 61, in aboral, oral and lateral [anterior to right] view, respectively.

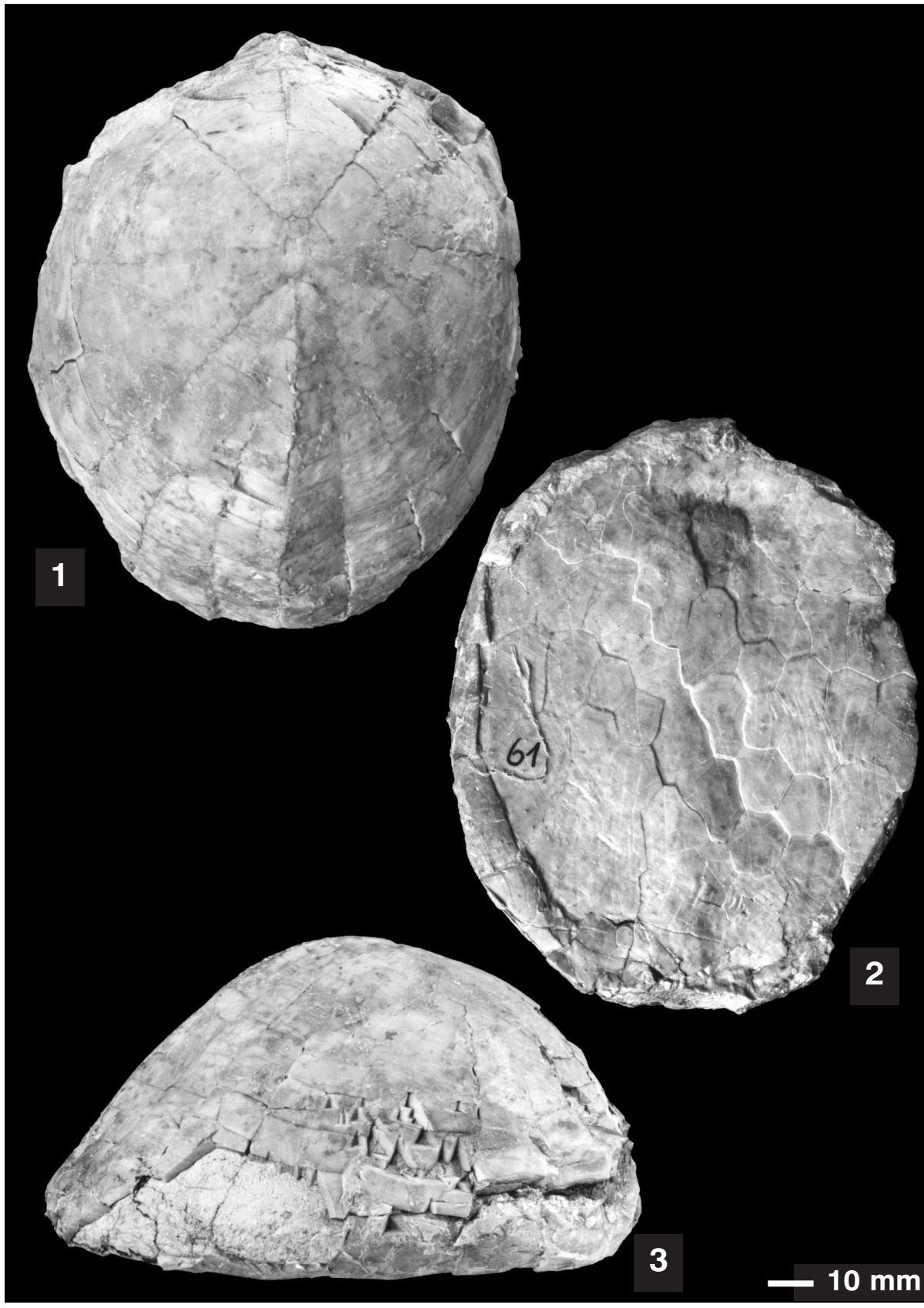
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PLATE 7

Pseudogibbaster? sp.

1-3 – NHMW 1998z0098/0018, in aboral, oral and lateral [anterior to right] view, respectively.

4-6 – Estermann Colln, EST 86, in aboral, oral and lateral [anterior to right] view, respectively.

7-9 – NHMW 1998z0098/0025, in aboral, oral and lateral [anterior to right] view, respectively.

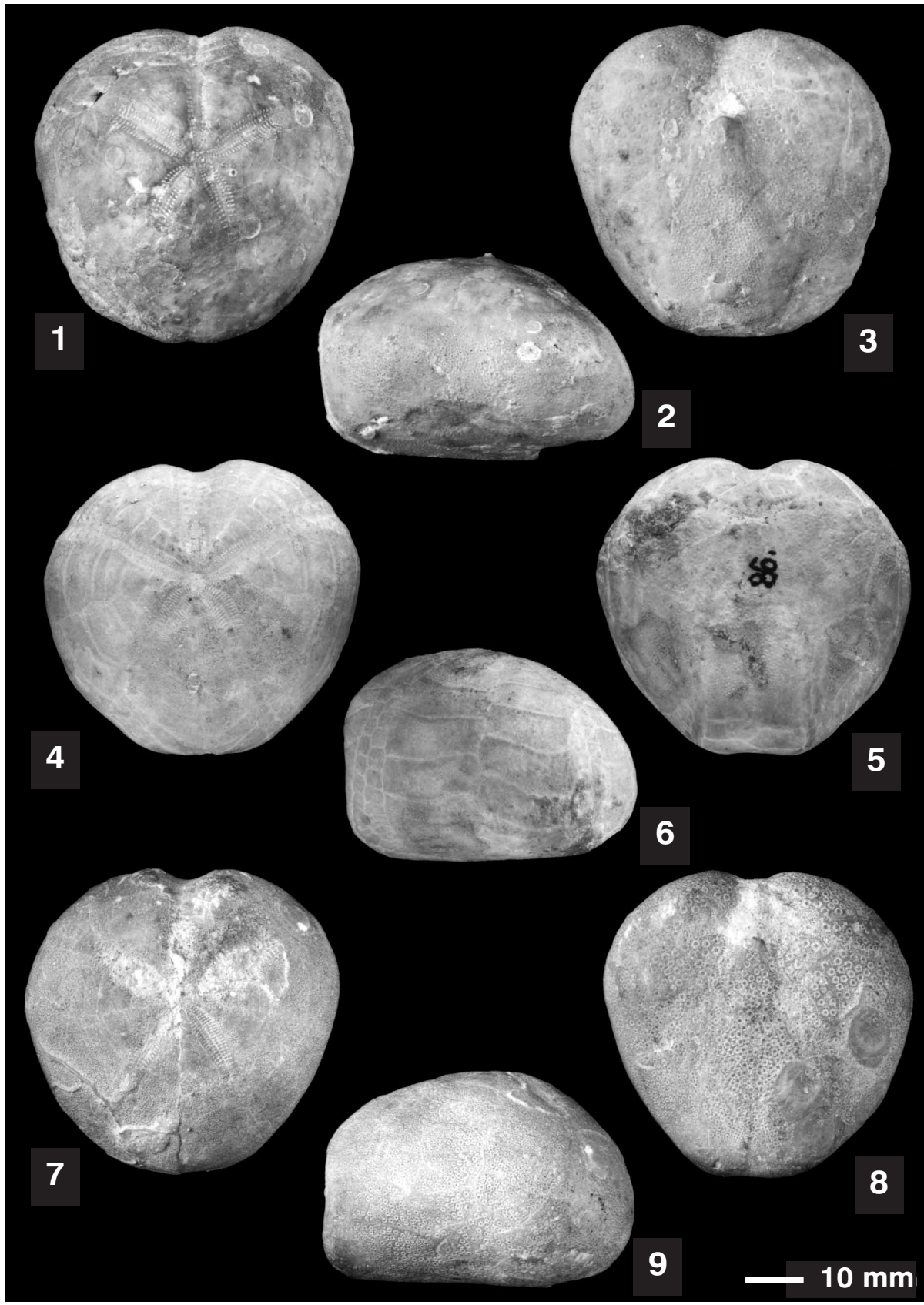
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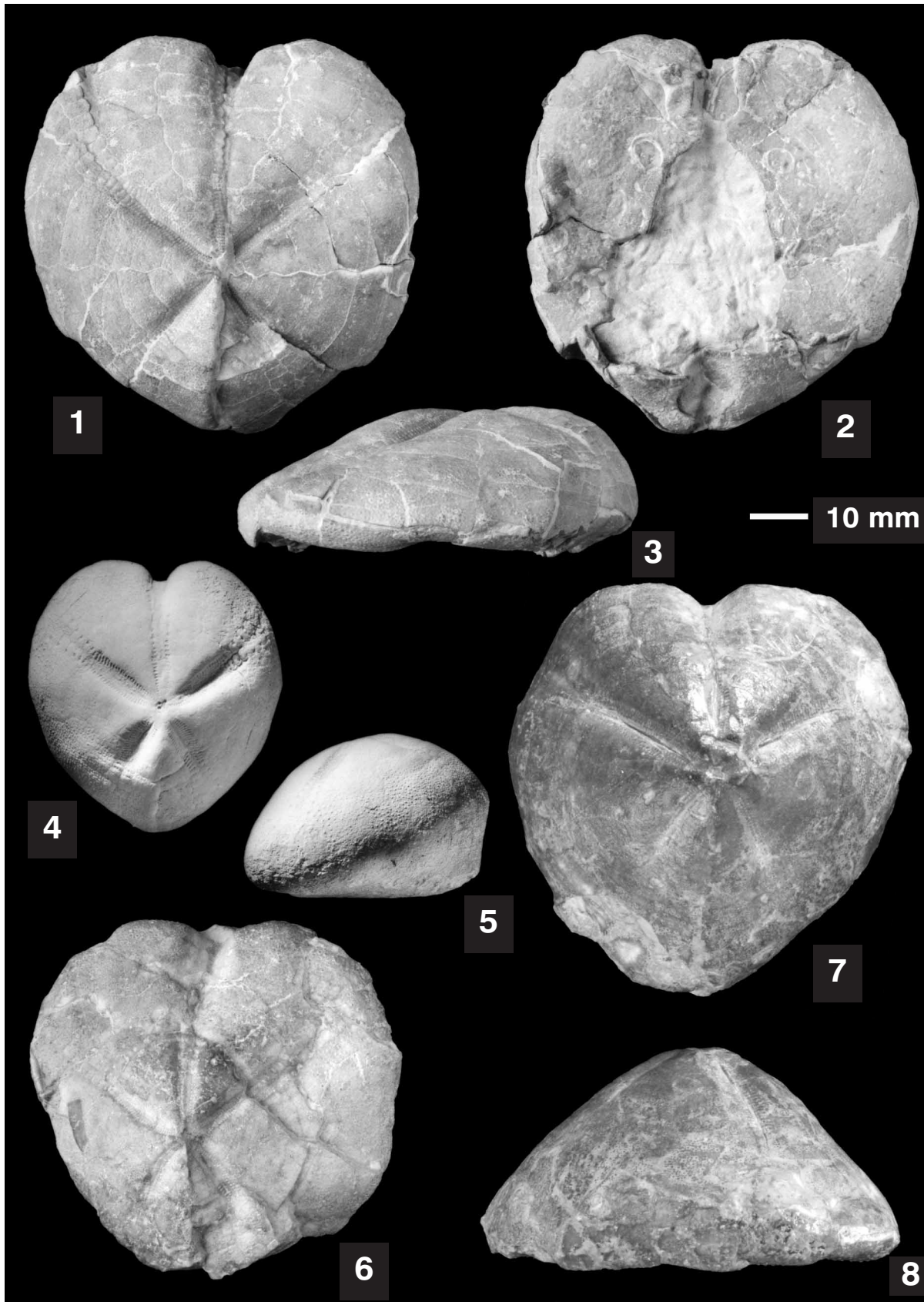
PLATE 8

1-3 – *Micraster aturicus* HÉBERT *in* SEUNES, 1891; NHMW 2003z0067/0003, in aboral, oral and lateral [anterior to left] view, respectively.

4, 5 – *Micraster corcolumbarium* DESOR, 1858; NHMW 1998z0098/0005, in aboral and lateral [anterior to left] view, respectively.

6 – *Micraster aturicus* HÉBERT *in* SEUNES, 1891; NHMW 2003z0067/0004, in aboral view.

7, 8 – *Micraster stolleyi* (LAMBERT *in* DE GROSSOUVRE, 1901); Estermann colln, EST 138, in aboral and lateral [anterior to right] view, respectively.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