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Hemiaster (Leymeriaster) eluvialis, a new echinoid from the late Maastrichtian of NE Belgium and SE Netherlands

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Abstract

Hemiaster (Leymeriaster) eluvialis sp. nov. from the Gulpen and Maastricht formations (late Maastrichtian, *Belemnitella junior* Zone) in the type area of the Maastrichtian Stage is described and illustrated. The new species is compared with other members of the subgenus *Leymeriaster*, and especially with *H. (L.) maestrichtensis*, which occurs in the same area. *H. (L.) eluvialis* is interpreted as a descendant of the *H. (L.) moulinsanus - H. (L.) maestrichtensis* group, showing a combination of paedomorphic and peramorphic traits. *H. (L.) eluvialis* made its first appearance in the Maastrichtian type area during deposition of the Lanaye Member (top Gulpen Formation), while *H. (L.) maestrichtensis*, the only other representative of the subgenus *Leymeriaster* in the area, appeared later (Emael Member, Maastricht Formation).

Key-words: Echinoidea, *Hemiaster*, Belgium, The Netherlands, late Maastrichtian.

Résumé

Hemiaster (*Leymeriaster*) *eluvialis* sp. nov. provenant des formations de Gulpen et de Maastricht (Maastrichtien supérieur, Zone à *Belemnitella junior*) de la région-type de l'étage Maastrichtien, est comparé avec d'autres espèces appartenant au sous-genre *Leymeriaster* et particulièrement avec *H.* (*L.*) *maestrichtensis*, présent dans la même région. *H.* (*L.*) eluvialis, qui est interprété comme un descendant du groupe *H.* (*L.*) *moulinsanus - H.* (*L.*) *maestrichtensis*, montre une combinaison de caractères pédomorphes et péramorphes. *H.* (*L.*) *eluvialis* apparaît, dans la région-type du Maastrichtien, dans le Membre de Lanaye (sommet de la Formation de Gulpen) tandis que *H.* (*L.*) *maestrichtensis*, le seul autre représentant du sous-genre *Leymeriaster* dans la région débute plus tard (Membre d'Emael, Formation de Maastricht).

Mots-clefs: Echinoidea, *Hemiaster*, Belgique, Pays-Bas, Maastrichtien supérieur.

Introduction

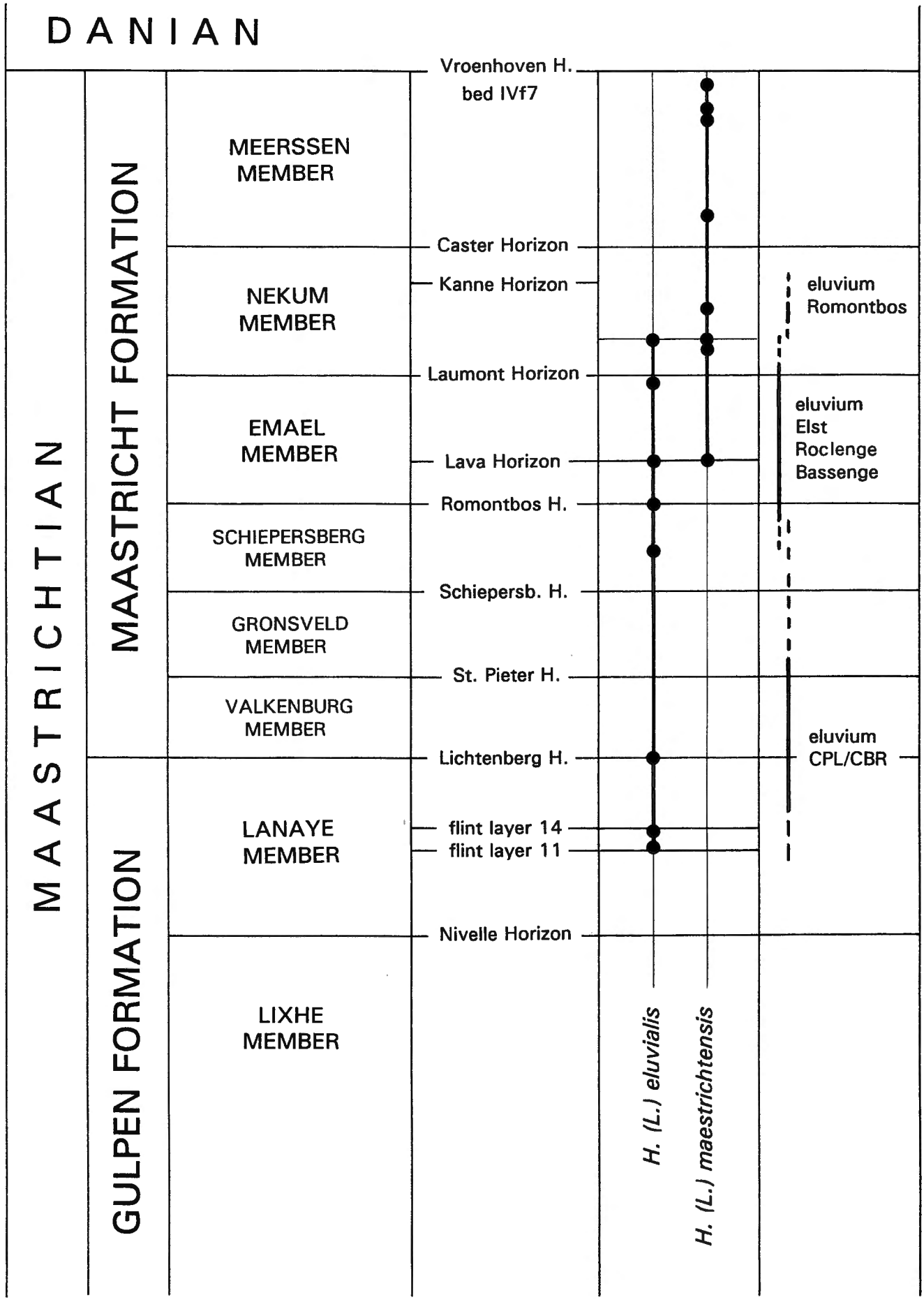
The genus *Hemiaster* is an important element of the Campanian-Maastrichtian echinoid faunas of NE Belgium and SE Netherlands. Five species have so far been recorded (VAN DER HAM, 1984, 1985a, 1985b; VAN DER HAM *et al.*, 1987). *Hemiaster (Bolbaster) aquisgranensis* SCHLÜTER, 1899 is known to range from the Vaals Formation to the lower Maastricht Formation (early Campanian to late Maastrichtian). The other species, *H. (B.) koninckanus* d'ORBIGNY, 1855, *H. (B.) prunella* (LAMARCK, 1816), *H. (Leymeriaster) maestrichtensis* SCHLÜTER, 1897 and *Hemiaster* sp., are of late Maastrichtian age (ranging from the uppermost Gulpen Formation to the upper Maastricht Formation).

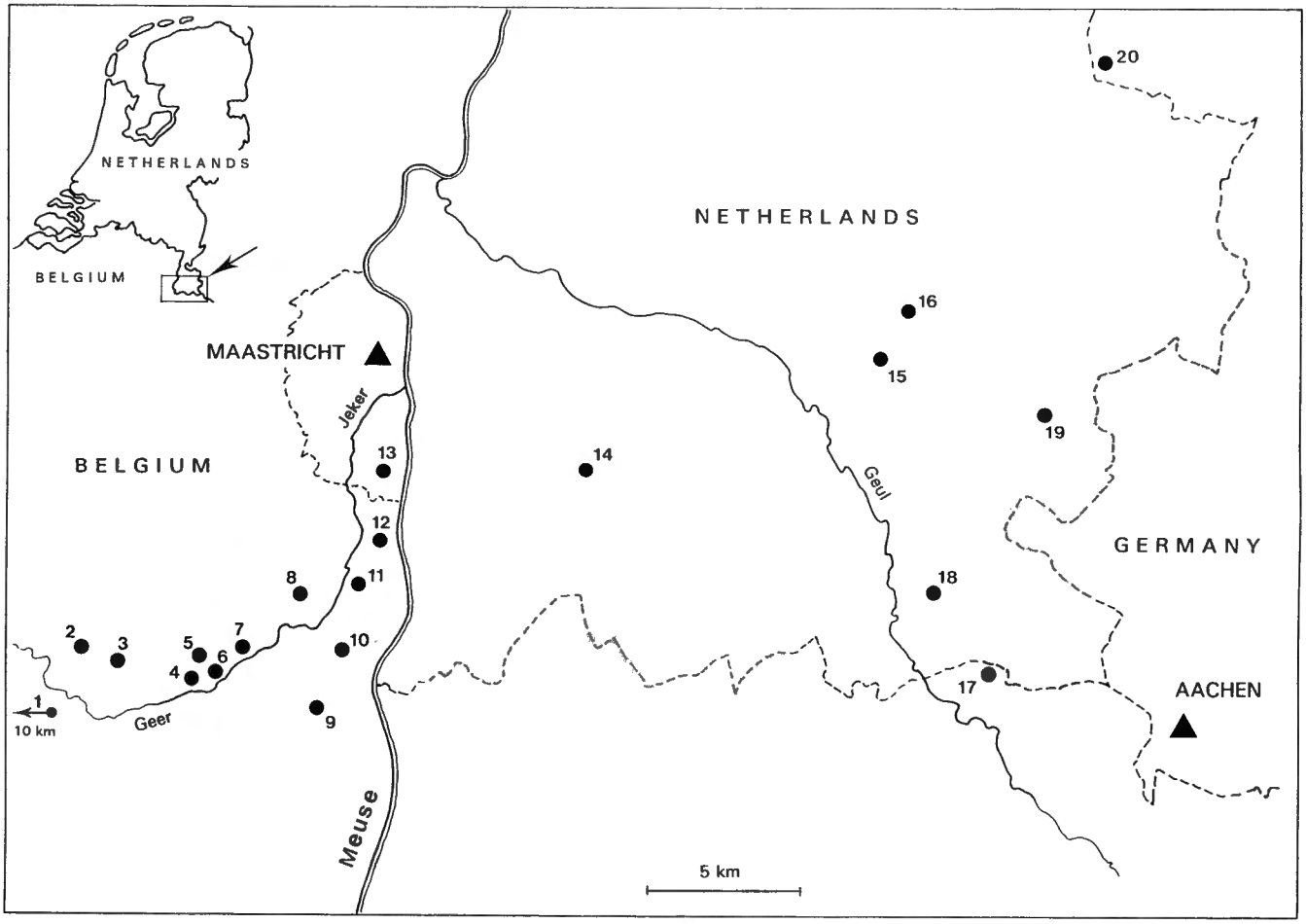
Hemiaster sp. was first recognised as new for the area during the early 1980-s, when it appeared to be fairly common in flint material in eluvial deposits. That it had not been noted earlier may probably be ascribed to lack of collecting from such deposits. Rare test material from the Gulpen and Maastricht Formation biocalcarenites was identified by MEIJER (1965) as *H. (L.) maestrichtensis*, a closely related species. The lack of a comprehensive modern treatment of the genus precluded its further identification. Only after consulting D. Néraudeau, who made a thorough ontogenetic and palaeo-ecological study of the genus *Hemiaster* (NÉRAUDEAU, 1990), did it become evident that *Hemiaster* sp. represented an undescribed species. In the present paper it is described as a new species in the subgenus *Leymeriaster*: *H. (L.) eluvialis*, and compared with other members of *Leymeriaster* occurring in NW Europe, especially with *H. (L.) maestrichtensis*.

Stratigraphical distribution

Hemiaster (L.) eluvialis occurs in the late Maastrichtian Gulpen and Maastricht Formations (Text-fig. 1): Lanaye Member (between flint layers 11 and 14), Valkenburg Member (near Lichtenberg Horizon), Schiepersberg Member, Emael Member (near Romontbos Horizon, near Lava Horizon, and uppermost part just below Laumont Horizon), Nekum Member (lower part). The species is known also from the Kunrade Member (= eastern facies of lower Maastricht Formation up to base of Emael Member) and from flint eluvium. The latter derives from the upper Lanaye Member and the base of the Maastricht Formation at the type locality and Terstraeten (locality 17), and from the lower Maastricht Formation (Schiepersberg Member to Nekum Member?) at several more western localities (Elst, Roclenge-sur-Geer, Bassenge). Reworked flint material of *H. (L.) eluvialis* was found on several occasions in gravel deposits of the River Maas.

The entire range of *H. (L.) eluvialis* belongs to the


DANIAN
MAASTRICHTIAN
MAASTRICHT FORMATION
GULPEN FORMATION
MEERSSEN MEMBER
NEKUM MEMBER
EMAEL MEMBER
SCHIEPERSBERG MEMBER
GRONSVELD MEMBER
VALKENBURG MEMBER
LANAYE MEMBER
LIXHE MEMBER
Vroenhoven H.
bed IVf7
Caster Horizon
Kanne Horizon
Laumont Horizon
Lava Horizon
Romontbos H.
Schiepersb. H.
St. Pieter H.
Lichtenberg H.
flint layer 14
flint layer 11
Nivelle Horizon
eluvium Romontbos
eluvium Elst Roclenge Bassenge
eluvium CPL/CBR
H. (L.) eluvialis
H. (L.) maestrichtensis



Text-fig. 2 — Geographical distribution of *Hemiaster (Leymeriaster) eluvialis* sp. nov. 1 = Vechmaal, 2 = Elst (field), 3 = Elst (Maurissen quarry), 4 = Roclenge-sur-Geer, 5 = Bassenge (field), 6 = Bassenge (quarry), 7 = Wonck, 8 = Romontbos quarry, 9 = CPL and CBR quarries, 10 = Loën, 11 = Marnebel quarry, 12 = Albertkanaal (Tranchée de Caster), 13 = ENCI quarry, 14 = Blankenberg quarry, 15 = Fromberg, 16 = Winthagen, 17 = Terstraeten, 18 = Elzet, 19 = Simpelveld, 20 = Brunsummerheide.

Belemnitella junior Zone (ROBASZYNSKI *et al.*, 1985). It includes the foram zones F to K of HOFKER (1966).

Material

The following specimens were studied (strata shown in Text-fig. 1, localities in Text-fig. 2):

Lanaye Member. Cadier en Keer, Blankenberg quarry (between flint layers 11 and 12): Van der Ham coll. 313; Maastricht, ENCI quarry (between flint layers 11 and 14): Van der Ham coll. 120.

Lanaye Member or base Maastricht Formation. Albertkanaal, Tranchée de Caster, near Emael: Meijer coll. 855.

Valkenburg Member. Maastricht, ENCI quarry (near Lichtenberg Horizon): Van der Ham coll. 398, 399.

Schiepersberg Member. Maastricht, ENCI quarry: Kuypers coll. 827, 868.

Emael Member. Eben, Romontbos quarry (near Romontbos Horizon): Van Birgelen coll. 649-13; Eben, Romontbos quarry (near Lava Horizon): Van der Ham coll. 307; Emael, Marnebel quarry (near Laumont Horizon): Meijer coll. 936.

←

Text-fig. 1 — Stratigraphical distribution of *Hemiaster (Leymeriaster) eluvialis* sp. nov. and *Hemiaster (Leymeriaster) maestrichtensis* SCHLÜTER, 1897, and stratigraphical position of the eluvial deposits in the CPL/CBR and Romontbos quarries and several more westerly localities (Elst, Roclenge-sur-Geer, Bassenge). Stratigraphy after FELDER (1975). The dots represent stratigraphically collected specimens (see Material), and the connecting lines reflect the inferred ranges of both species.

Nekum Member? Emael, Marnebel quarry: Dortangs coll. 124.
Nekum Member (lower part). Eben, Romontbos quarry: Van der Ham coll. 152, 176.
Kunrade Member. Fromberg (field): Vlieks coll. unregistered; Winthagen (small quarry): Van Birgelen coll. 262 (Pl. 2, Fig. 3).
Flint eluvium. Vechmaal (quarry): Indeherberge coll. 3017, 3018; Elst (field): Indeherberge coll. 3011; Elst, Maurissen quarry: Defour coll. 269, 270, 271, 277a, 291-294, 399, 416, Indeherberge coll. 3024, 3025, 3026, 3027-3035, Meuris coll. 7-9, 13,16, 18, 19, Van der Ham coll. 609; Roclenge-sur-Geer (field): Indeherberge coll. 3036; Bassenge (field): Indeherberge coll. 3016; Bassenge (quarry): Indeherberge coll. 3013; Wonck (small exposure): Indeherberge coll. 3014, 3015; Hallembaye/Lixhe, CPL and CBR quarries: Defour coll. 1B, C, D, F, H, J-M, O-Q, 15, 20, 163a, 364, 373, 538, De Wit coll. 1022, Indeherberge coll. 196-199, 416-422, 471-477, 479-485, 512, 514, 515, 517, 518, 615, 616, 3010, Meuris coll. 1-3, 4, 5 (Pl. 3, Figs. 1-5), 6, Natuurhistorisch Museum Maastricht coll. NHMM 1993050, Van Birgelen coll. 303, Van der Ham coll. 82, 92d, 224-226, 234, 242, 275, 396, 449, 475, 544, 635; Loën (disused quarry): Indeherberge coll. 3012; Terstraeten (small exposure): Van der Ham coll. 525.
Gravel. Brunssumerheide (gravel pit): Appeldoorn coll. 51, Thiel coll. unregistered, Van der Ham coll. 38a, 39, Vlieks coll. '951'; Simpelveld, Rode Put (gravel pit): Vlieks coll. unregistered; Elzet (gravel pit): Felder coll. ZE 112; Zuid-Limburg (locality unknown): Van der Ham coll. 118.

Systematic description

Order Spatangoida CLAUS, 1876
Suborder Hemiasterina FISCHER *in* MOORE, 1966
Family HEMIASTERIDAE CLARK, 1917
Genus *Hemiaster* DESOR *in* AGASSIZ & DESOR, 1847
Subgenus *Leymeriaster* LAMBERT & THIÉRY, 1924

Original diagnosis: Test moderately inflated, with weakly depressed anterior ambulacrum and very unequal petals, the posterior ones being very short.

Type species (original designation). *Hemiaster leymeriei* DESOR *in* AGASSIZ & DESOR, 1847

Hemiaster (Leymeriaster) eluvialis sp. nov.
Pls. 1 & 2; Pl. 3, Figs. 1-5; Text-fig. 3.

1965 *Hemiaster maestrichtensis*, MEIJER, p. 23 (*pars*: Cr4 and Mb only).
1984 *Hemiaster* sp., VAN DER HAM, p. 175.
1985a *Hemiaster* sp., VAN DER HAM, p. 111.
1987 *Hemiaster* sp., VAN DER HAM *et al.*, pp. 33, 37, pl. 2, fig. 2.

DERIVATIO NOMINIS: The trivial name refers to the 'vuursteeneluvium', the flint-bearing eluvial deposit in SE Netherlands and NE Belgium from which the holotype, the paratypes and many other specimens were collected.

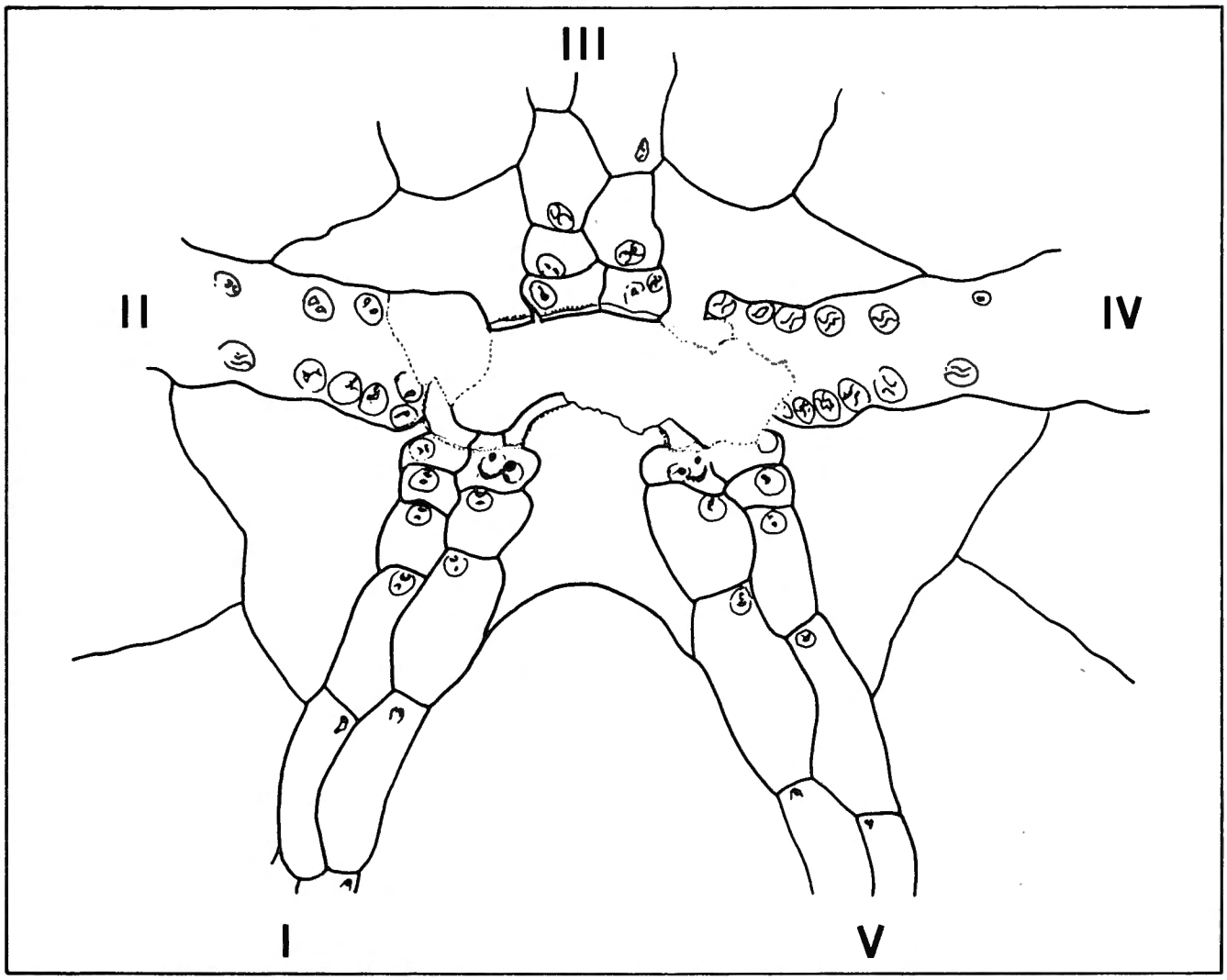
TYPES: NHMM 1993050 (Pl. 1; Pl. 2, Figs. 1, 2, 4, 6; Text-fig. 4a), in the collections of the Natuurhistorisch Museum at Maastricht, is designated holotype. It consists of an internal flint mould and most of the external mould of the outer test surface in the surrounding flint. The specimen was collected by L. Indeherberge in the southernmost part of the CBR quarry near Lixhe, Belgium (5°39' E. Long., 50°45' N. Lat.; locality 9 in Text-fig. 2), from the 'Vuursteeneluvium' (flint eluvium), which, at the type locality, contains the flint residue of the upper part of the Lanaye Member (Gulpen Formation) and the base of the Maastricht Formation (Text-fig. 1; see FELDER, 1983), both of late Maastrichtian age (*Belemnitella junior* Zone). The following specimens, all from the same locality and the same deposit, were selected as paratypes: Defour coll. 1B, Indeherberge coll. 518, Meuris coll. 4, 5 (Pl. 3, Figs. 1-5) and Van der Ham coll. 544, 635.

DIAGNOSIS: Comparatively large leymeriasterid *Hemiaster* with bulging anterior side. Ambulacrum III with short, narrow adapical groove. Groove and petals bordered by raised interambulacral margins. Pore pairs in groove separated by tiny ridges that extend up to interambulacral margins. Peripetalous fasciole indented between anterior petals and ambulacrum III, crossing ambulacrum III at end of groove.

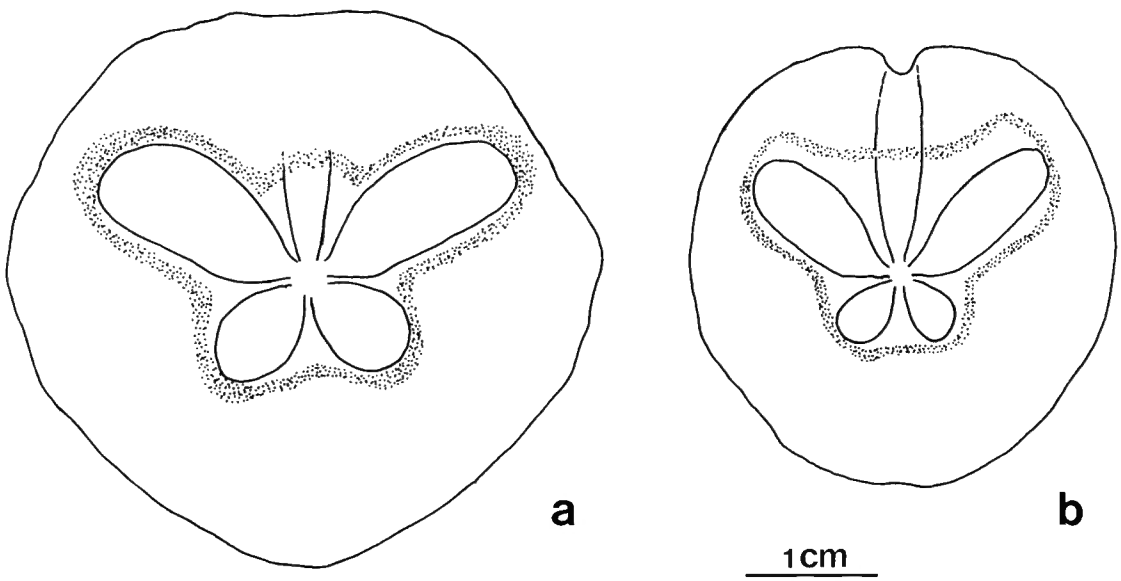
DESCRIPTION: Test length (TL) up to 32-52 (average 41.5) mm; ambitus broadly obovate; width 97-106% TL, maximum in anterior series of interambulacra 1 and 4; height 66-75% TL, maximum in adapical parts of interambulacra 2 and 3. Apical system posterior of centre, ethmophract; genitals 1 and 4 almost separated (sexual dimorphism as to gonopore size absent). Keel in interambulacrum 5 rounded, moderately raised. Anterior side of test vertical and slightly concave to slightly convex at ambitus, bulging between ambitus and anterior groove. Posterior side vertical to slightly inclined anteriorly. Oral side slightly convex.

Ambulacrum III with a short, narrow groove adapically of fasciole; length of groove 20-23% TL, width 4.5-8% TL. Poriferous zones in groove with up to 16 pore pairs separated by tiny ridges that extend up to thickened raised, often slightly overhanging interambulacral margins (Pl. 2, Fig. 6); each pore pair with a depressed interporal partition. Interporiferous zone 3-4 times wider than a single poriferous zone, densely covered with miliary tubercles.

Anterior petals strongly depressed, bordered by thickened raised interambulacral margins, much longer than posterior ones, making an angle of ca. 120°; length 41-48% TL, width 9-12% TL. Poriferous zones within a petal similar, but anterior one usually more flexed, up



Text-fig. 3 — Hemiaster (Leymeriaster) eluvialis sp. nov. Camera lucida drawing of plating around peristome. Same specimen illustrated in Pl. 2, fig. 5.



Text-fig. 4 — Peripetalous fascioles. a: *Hemiaster (Leymeriaster) eluvialis* sp. nov. (holotype), b: *Hemiaster (Leymeriaster) maestrichtensis* SCHLÜTER, 1897 (after MEIJER, 1955, fig. 5).>

to 35 pore pairs in each (including 3-4 very small adapical ones); inner pore rows with elliptical pores, outer ones with subcircular pores, which lie against the raised interambulacral margins; pores within a pair conjugate by a shallow elongate depression, the interporal distance being 2-3 times the pore length (of inner row pores). Interporiferous zone about as wide as a single poriferous zone, densely covered with miliary tubercles.

Posterior petals strongly depressed, bordered by raised interambulacral margins, obovate, making an angle of ca. 80°; length 15-20% TL (= 34-42% of length of anterior petals). Poriferous zones flexed, up to 18 pore pairs in each.

Peristome at ca. 28% TL from anterior side, about kidney-shaped, bordered by a low rim; width ca. 20% TL. Labrum protruding into peristome, with 4-5 primary tubercles; lateral-posterior extensions in contact with 2 complete and 1/10 to 4/7 of a third ambulacral plate of ambulacra I and V (44-50 mm TL; Text-fig. 3). Phyllode with 8-10 isopores in ambulacra II and IV, and 4-6 isopores in ambulacra I, III and V (2 in each first adlabral plate in I and V). Suture between plastronal plates not distinct in available material.

Periproct high on posterior side, at ca. 37% TL from oral side, almond-shaped; length ca. 17% TL.

Primary tubercle density 3-4 per mm^2 in ambital zone, up to 9 per mm^2 towards apical system, and ca. 1 per mm^2 towards peristome. Tubercles scrobiculate; scrobicules tetragonal to hexagonal, closely packed in more or less distinct rows (Pl. 2, Fig. 3). Miliary tubercles occur in the petals, anterior groove and in adoral parts of all ambulacra, and mixed with small primaries in ambulacrum III between anterior groove and ambitus; miliary tubercles mixed with relatively large primaries (1-2 per mm^2) occur on the labrum and on either side of ambulacrum III between ambitus and anterior groove. Scattered miliaries may be present on the adoral parts of all interambulacra. Interambulacral plates often (especially in large tests) provided with a slightly raised 'centre'.

Peripetalous fasciole (Text-fig. 4a; Pl. 2, Fig. 3) closely following petal margins, round anterior petals connecting the slightly raised areas of the adjacent interambulacral plates, between the raised areas often in shallow grooves, indented between anterior petals and ambulacrum III, making a ca. 90° angle between each anterior petal and the anterior groove and crossing ambulacrum III at end of the groove; width slightly larger at all petal ends.

Comparisons

The subgenus *Leymeriaster* embraces species with sunken petals of which the posterior ones are much shorter than the anterior ones.

LAMBERT & THIÉRY (1924) listed 18 species, while TANAKA (1984) added two more. Excluding a few very poorly known species, and transferring several others to the subgenus *Bolbaster* POMEL, 1869, NÉRAUDEAU (1990) distinguished four stratigraphical groups within the subgenus *Leymeriaster* in the Cretaceous of NW Europe: 1. from the late Cenomanian of Aquitaine and Sarthe, France (e.g. *H. (L.) similis* d'ORBIGNY, 1855, p. 229, pl. 874, from the Cenomanian of Port-des-Barques, France), 2. from the early to middle Turonian of Touraine and Aquitaine, France (*H. (L.) leymeriei* DESOR *in* AGASSIZ & DESOR, 1847, p. 232, pl. 875, from the Turonian of Saint-Christophe, France), 3. from the late Turonian to Santonian of Aquitaine and Sarthe, France (e.g. *H. (L.) nucleus* DESOR *in* AGASSIZ & DESOR, 1847, from the early "Sénonien" of Thains, France, and *H. (L.) moulinsanus* d'ORBIGNY, 1855, p. 247, pl. 883, from the "Sénonien" of Royan, France), 4. from the Maastrichtian of Belgium and The Netherlands (*H. (L.) maestrichtensis* SCHLÜTER, 1897, p. 30, pl. 2, figs. 3 & 4, from the "Kreide-Tuff" of Maastricht, The Netherlands, which, contrary to Néraudeau's statement, does not occur in Campanian deposits).

H. (L.) eluvialis can be distinguished from all other species of *Leymeriaster* by the very short narrow groove in ambulacrum III and by the raised interambulacral margins that surround the petals. The position of the fasciole is also different in *H. (L.) eluvialis*: close along the greatest part of the anterior edge of the anterior petals. In all other species it crosses interambulacra 2 and 3 from the anterior ends of the anterior petals towards the groove in ambulacrum III (Text-fig. 4; see also NÉRAUDEAU, 1990, fig. 115).

At first sight *H. (L.) eluvialis* may be confused with *H. (L.) leymeriei*, since this species also has a relatively short groove (about as long as the anterior petas). However, in *H. (L.) eluvialis* it is even shorter (about half as long as the anterior petals), and, in contrast, is bordered by raised, finely ridged interambulacral margins. *H. (L.) eluvialis* has a nearly vertical posterior side, whereas this is distinctly inclined anteriorly in *H. (L.) leymeriei*.

Raised interambulacral margins along the groove, provided with tiny ridges originating between the pore pairs (Pl. 2, Fig. 6), occur also in *H. (L.) maestrichtensis* and probably also in *H. (L.) moulinsanus* (d'ORBIGNY, 1855, p. 247: "ambulacre impair ... formé de pores ovales, ... placés dans des fossettes spéciales"), but these two species can be easily distinguished from *H. (L.) eluvialis* by the long groove in ambulacrum III, which extends from the apex beyond the ambitus (compare Pl. 3, Figs. 1-5 with Pl. 3, Figs. 6-10 and with d'ORBIGNY, 1855, pl. 885 respectively).

Raised, finely ridged interambulacral edges along the groove are definitely absent in specimens of *H. (L.) similis* (from the late Cenomanian of Port-des-Barques, Charente-Maritime, France), *H. (L.) leymeriei* (from the early Turonian of Briollay, Anjou, France) and *H. (L.) nucleus* (from the late Turonian of the Vendée, France), according to detailed photographs of these species and material of *H. (L.) leymeriei* provided by D. Néraudeau). Raised, finely ridged edges is considered here as a derived character, and, consequently, its presence in *H. (L.) eluvialis*, *H. (L.) maestrichtensis* and *H. (L.) moulinsanus* may be regarded as an indication for close relationship

between these three species. Also the shape of the labrum in *H. (L.) eluvialis* suggests close affinity to the *maestrichtensis - moulinsanus* group (compare Text-fig. 3 with MEIJER, 1955, fig. 4e).

As mentioned above, the very short narrow groove in ambulacrum III and the raised interambulacral margins round the petals are special characters of *H. (L.) eluvialis*. A well-extended groove in ambulacrum III, if present, develops late in ontogeny in *Hemiaster* (MCNAMARA, 1987; NÉRAUDEAU, 1990, fig. 15). Therefore, the short narrow groove in *H. (L.) eluvialis* may be a paedomorphic trait. Since specimens of *H. (L.) eluvialis* are generally larger than specimens of *H. (L.) maestrichtensis* and probably also *H. (L.) moulinsanus*, the short narrow groove might be characterised as neotenic (*sensu* MCNAMARA, 1986). The larger size of *H. (L.) eluvialis* might also explain the higher number of plates in ambulacra I and V in contact with the labrum (Text-fig. 3: 2.1-2.6 in *H. (L.) eluvialis* versus ca. 1.5 in *H. (L.) maestrichtensis*), as this number increases with size (NÉRAUDEAU, 1990, figs. 41b, 115). The raised, thickened interambulacral margins surrounding the petals may be considered a peramorphic trait, due to accelerated development of these parts in comparison to the nonmarginal areas of the interambulacra. Such a combination of paedomorphic and peramorphic features in *H. (L.) eluvialis* represents an example of dissociated heterochrony (see DAVID, 1989; MCNAMARA, 1990; NÉRAUDEAU, 1990). Accepting the short groove as paedomorphic, and the raised, thickened interambulacral margins as peramorphic, it may be hypothesized that *H. (L.) eluvialis* evolved from the *H. (L.) moulinsanus - H. (L.) maestrichtensis* group.

Stratigraphical and biogeographical notes

While *Hemiaster (Leymeriaster) eluvialis* occurs in the Gulpen and Maastricht Formations (Text-fig. 1: from the Lanaye Member to the lower part of the Nekum Member), *H. (L.) maestrichtensis* is confined to the Maastricht Formation (Text-fig. 1: from the Emael Member to the uppermost part of the Meerssen Member). Both species are also known from the Kunrade Member (= eastern facies of lower Maastricht Formation up to base of Emael Member). The former is also known from flint eluvium that derives from the upper Lanaye Member to the base of the Maastricht Formation, the latter from younger flint eluviums that derive from the lower Maastricht Formation (Emael Member?) at Elst (Text-fig. 2: locality 3) and from the middle Nekum Member in the Romontbos quarry (Text-fig. 2: locality 8). The ranges of *H. (L.) eluvialis* and *H. (L.) maestrichtensis* overlap in the upper Emael Member and the lower Nekum Member. The species co-occur near the Lava Horizon and in an unnamed fossil-trash level in the lower Nekum Member. The range of *H. (L.) eluvialis* is confined to the *Belemnitella junior* Zone, that of *H. (L.) maestrichtensis* extends from the *Belemnitella junior* Zone into the *Belemnella casimirovensis* Zone of the upper Meerssen Member (ROBASZYNSKI *et al.*, 1985).

The first appearances of both species reflect different immigration phases. The first appearance of *H. (L.) eluvialis* in the late Maastrichtian of the Maastricht area coincides with a number of first appearances of other echinoid species. The stratigraphically oldest specimens of *H. (L.) eluvialis* are from the middle part of the Lanaye Member, between the flint layers 11 and 14 in the ENCI quarry (locality 13). At the same level in this quarry occur for the first time in the area: *Nucleopygus scrobiculatus* (GOLDFUSS, 1829), *Hemipneustes oculatus* COTTEAU, 1890, *Hemipneustes striatoradiatus* (LESKE, 1778) and *Hemiaster (Bolbaster) prunella* (LAMARCK, 1816). *Oolopygus pyriformis* (LESKE, 1778) and *Catopygus fenestratus* AGASSIZ, 1840 reappear, the former occurring also in the Vijlen Member (extremely rare; Felder coll., Natuurhistorisch Museum, Maastricht), the latter also in the Vijlen Member (MEIJER, 1965) and in the Wahlwiller Bed at the base of the Lixhe Member (VAN DER HAM & VAN BIRGELEN, 1992).

H. (L.) maestrichtensis enters the area in a later immigration stage, being found from the Lava Horizon (Emael Member, Romontbos quarry) onwards, often together with the common echinoids *Faujasia apicalis* (DESOR *in* AGASSIZ & DESOR, 1847) and *Procassidulus lapiscancri* (LESKE, 1778). These two species are also known from the flint eluvium of the CPL and CBR quarries, which represents older strata (Lanaye Member to base Maastricht Formation). They are, however, very rare in that deposit (3 and 1 or 2 specimens known respectively).

BLESS (1991) described four different immigration phases of Tethyan elements in NE Belgium and SE Netherlands on the basis of belemnites, forams and ostracodes: 1. an early early Campanian phase, 2. a late early Campanian phase, 3. an early late Campanian phase, and 4. a late Maastrichtian phase. *H. (L.) eluvialis* and *H. (L.) maestrichtensis* belong to the last one. The pattern of first appearances of these species and the other echinoids mentioned above suggest that the late Maastrichtian immigration phase consists of two different subphases.

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PLATE 1

Hemiaster (Leymeriaster) eluvialis sp. nov., holotype, NHMM 1993050 (ex Indeherberge coll. 200), internal mould in flint preservation, late Maastrichtian, eluvium, CBR quarry, Lixhe, Belgium.

Fig. 1 — Aboral side, x 1.5.
Fig. 2 — Oral side, x 1.5.
Fig. 3 — Anterior side, x 1.5.
Fig. 4 — Left lateral side, x 1.5.
Fig. 5 — Aboral side, x 2.6.

PLATE 2

Hemiaster (Leymeriaster) eluvialis sp. nov.

Fig. 1 — Holotype, silicone rubber cast of external mould that surrounded the test now dissolved, aboral side (compare with Pl. 1, Fig. 1), x 1.5.
Fig. 2 — Detail of aboral side of holotype, x 2.9.
Fig. 3 — Left anterior petal with surrounding fasciole. Van Birgelen coll. 262, late Maastrichtian, Kunrade Member, Winthagen, The Netherlands, x 2.8.
Fig. 4 — As Fig. 1, oblique anterior view of petals and groove in ambulacrum III, x 2.9.
Fig. 5 — Silicone rubber cast of external mould of oral surface, showing tuberculation, peristome (with folded margin) and isopores (compare with Text-fig. 3). Paratype, Indeherberge coll. 518, late Maastrichtian, eluvium, CBR quarry, Lixhe, Belgium, x 2.
Fig. 6 — As Fig. 1, oblique lateral view, showing petals and groove in ambulacrum III; note the 'fossettes spéciales' (arrow) extending from the outer pores up to interambulacrum 3 margin, x 3.9.

PLATE 3

Hemiaster (Leymeriaster) eluvialis sp. nov. compared with *Hemiaster (Leymeriaster) maestrichtensis* SCHLÜTER, 1897.

Figs. 1-5 — *H. (L.) eluvialis*, paratype, Meuris coll. 5, internal mould in flint preservation, late Maastrichtian, eluvium, CBR quarry, Lixhe, Belgium, x 1.5.
Fig. 1 — Aboral side.
Fig. 2 — Oral side.
Fig. 3 — Anterior side.
Fig. 4 — Left lateral side.
Fig. 5 — Posterior side.

Figs. 6-10 — *H. (L.) maestrichtensis*, Van der Ham coll. 543, internal mould in flint preservation, late Maastrichtian, Maastricht Formation, eluvium middle Nekum Member (see Text-fig. 1), Romontbos quarry, Eben, Belgium, x 1.5.
Fig. 6 — Aboral side.
Fig. 7 — Oral side.
Fig. 8 — Anterior side.
Fig. 9 — Left lateral side.
Fig. 10 — Posterior side.

Plate 1.

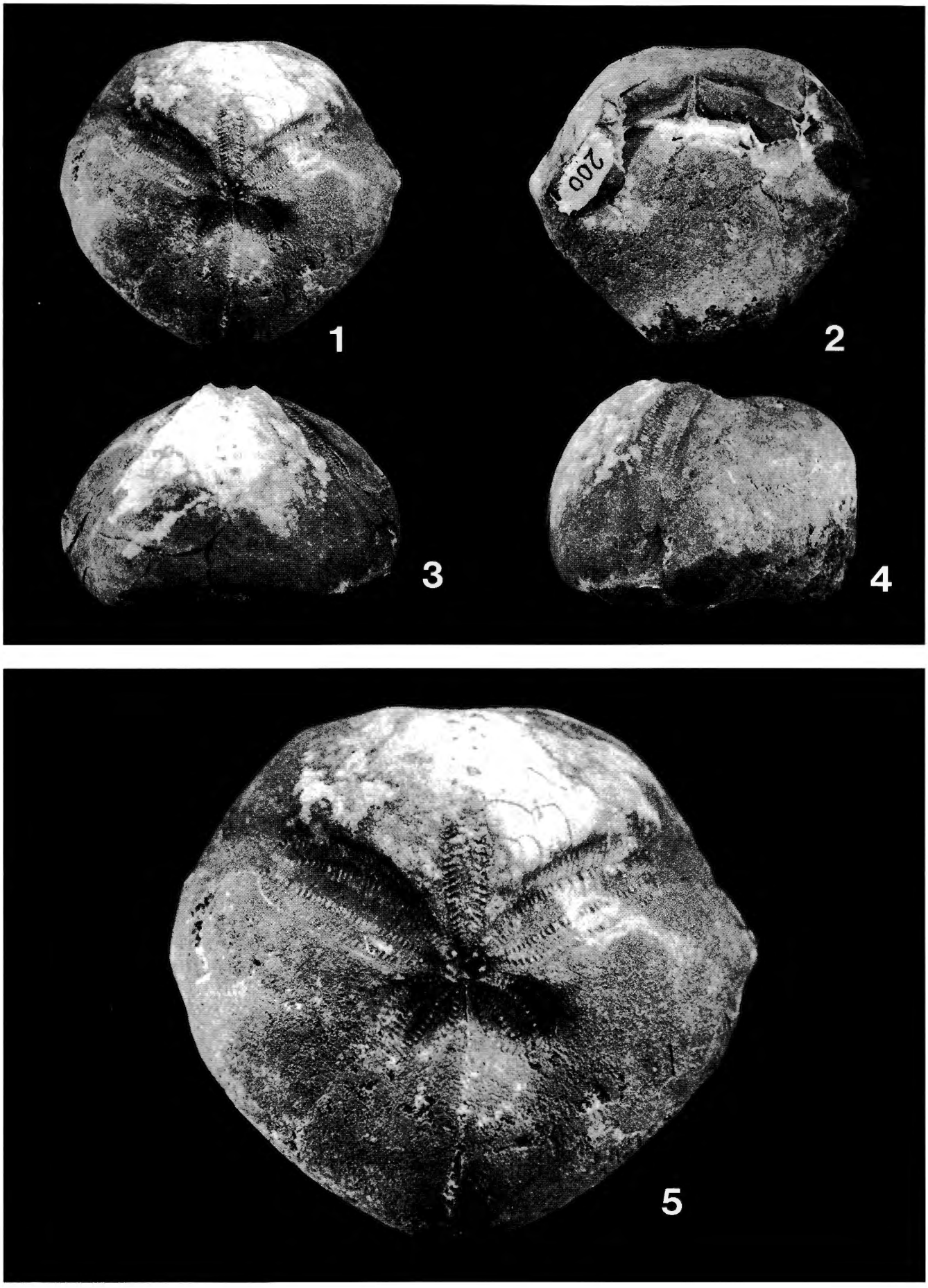
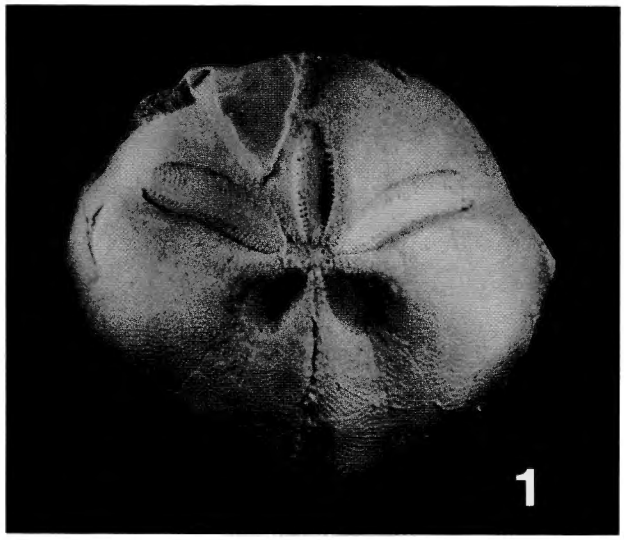
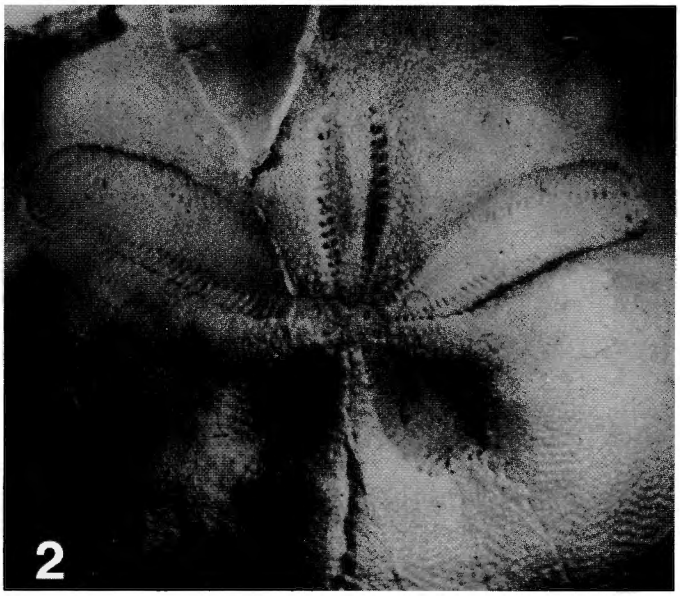
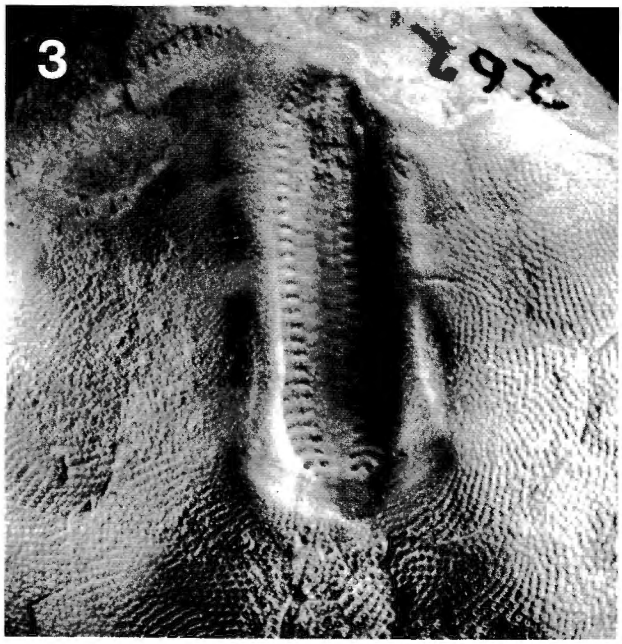
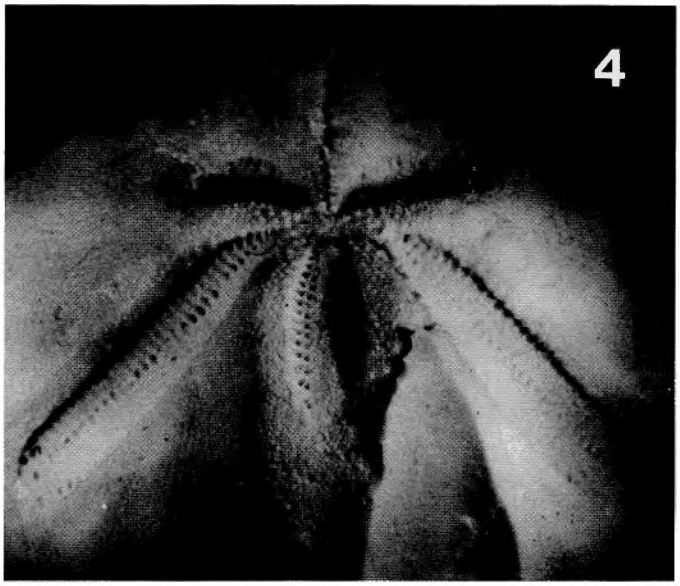


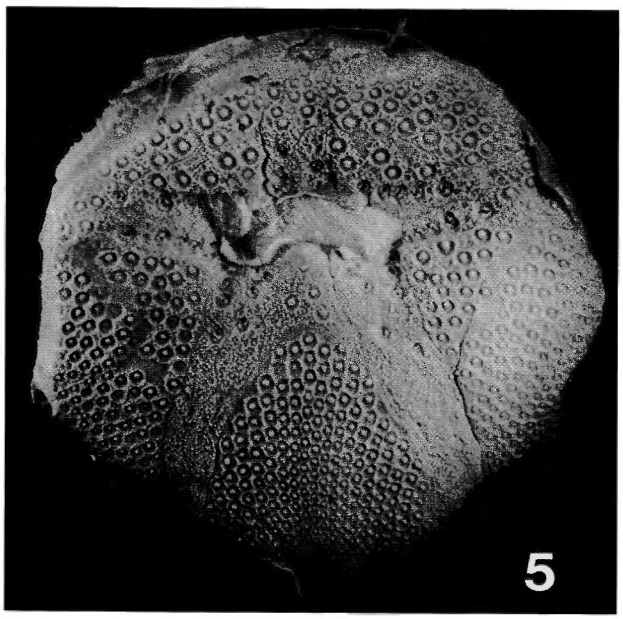
Plate 2.











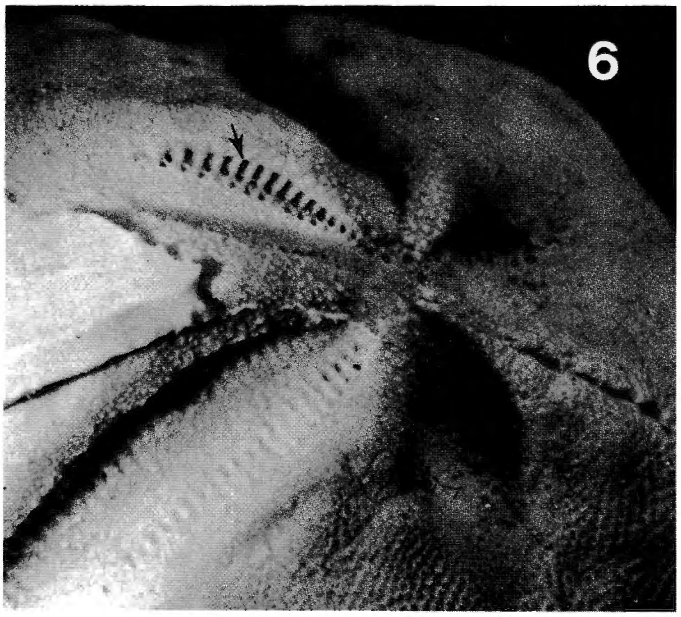


Plate 3.