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The genus *Typocidaris* (Cidaroida; Echinoidea) in the Upper Cretaceous of the Maastricht area (Belgium and the Netherlands)

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Abstract

Compilation of earlier work shows that 19 names have been used for Cidaroida from the Belgian and Dutch Campanian and Maastrichtian. Most of these have to be rejected or are doubtful, because of the poor state of preservation of the specimens involved. *Typocidaris* is reintroduced as a separate genus. Four species are described and discussed; *T. ubaghsi* is new.
Key-words: Cidaroida, Echinoidea, Maastrichtian, Cretaceous, Belgium, The Netherlands.

Résumé

Pour la description des échinides cidaroides du Campanien et du Maastrichtien belge et néerlandais, 19 dénominations ont été utilisées dans le passé. La plupart de celles-ci doivent être rejetées ou ont trait à des espèces insuffisamment connues, ayant été intoduites pour des spécimens de conservation médiocre. *Typocidaris* est réintroduit comme genre indépendant. Quatre espèces sont décrites, dont une, *T. ubaghsi,* est nouvelle.
Mots-clefs: Cidaroida, Echinoidea, Maastrichtien, Cretacé, Belgique, Pays-Bas.

Introduction

Fossil remains of Cidaroid Echinoids are by no means rare in Upper Cretaceous deposits. In the Low Countries, as well as elsewhere, they are frequently found as isolated and interambulacral plates. Many hundreds of such fossils are present in almost every important collection, public or private. On the other hand, complete coronas of Cidaroida are exceedingly rare. Even a few plates, remaining in anatomical connection, are an exceptional, and thus valuable fossil. This phenomenon is partly due to the life habits of Cidaroida, browsing on hard substrates and hence living in erosional environments (KIER, 1977). The structural weakness of the cidaroid test does not favor its preservation either. The stereomes of adjacent plates hardly possess any interlocking processes, so that the plates fall easily apart, after the animal's death and after decay of the connecting tissues (SMITH, 1984).

Unfortunately, isolated skeletal remains of Cidaroida are rarely identifiable. In the past, this has often resulted in a profusion of "species", many of which cannot be accepted. In earlier literature, I recorded no less than 19 names for Cidaroida from the Maastrichtian of the Maastricht area. Three of these are characteristic for Danian, rather than Maastrichtian strata: a frequent error of earlier authors, due to insufficient stratigraphical knowledge at that time. Nine taxa have to be rejected, for reasons explained herein. The presence of another four could not be confirmed. Two species, one of them new, had to be added to the list. This means that the original 19 species are reduced to a mere five, four of them belonging to the genus *Typocidaris*. A survey of former and present opinions on the composition of the cidaroid faunas of the Upper Cretaceous in the Maastricht area, is given in table 1.

Abbreviations used in the text

D	:	diameter of the corona, at the ambitus
h	:	height of the corona
ds	:	diameter of the apical system
dp	:	diameter of the peristome
Lg	:	province of Liège
NLb	:	province of Dutch Limburg
BLb	:	province of Belgian Limburg
NL	:	the Netherlands
B	:	Belgium
DDR	:	German Democratic Republic
DK	:	Denmark
D	:	Federal Republic of Germany
E	:	Spain
F	:	France
GB	:	United Kingdom of Great Britain and Northern Ireland
PL	:	People's Republic of Poland
SU	:	Union of Socialist Soviet Republics
KBIN	:	Royal Belgian Institute for Natural Sciences, Brussels, B.
NHMM:		Natural History Museum, Maastricht, NL.

In the synonymy lists, the conventional signs of A.V. DHONDT (1972) have been adopted.

Table 1
Cidaroida from the Upper Cretaceous in the Maastricht area, recorded by different authors.

	Bosquet, 1857	Cotteau, 1874	Lambert, 1897	Mourlon, 1881	Lambert, 1911	Smiser, 1935	Meijer, 1965	Geys herein		
								Gu	Ma	Da
Cidaris arenata					×	×		–	–	
baylei									×	
ciplyensis			×		×	×		–	–	
danica		×	×				×			×
faujasi	×	×	×	×	×	×		–	–	
filamentosa						×		–	–	
forchhammeri	×			×		×				×
hardouini	×	×	×	×		×				×
lingualis	×			×				○	○	
ornatissima				×				○	○	
perornata						×		–	–	
pistillum	×			×				×		
pseudohirudo					×	×		–	–	
regalis	×			×				○	○	
sceptrifera		×				×			×	
schlueteri					×	×		–	–	
serrata			×		×	×	×		×	
sorigneti				×				○	○	
subvesiculosa	×			×		×		–	–	
ubaghsi								×		
venulosoides					×	×		–	–	

×: recorded; –: doubtful or rejected; ○: unconfirmed.
Gu: Gulpen Chalk; Ma: Maastricht Chalk; Da: Danian.

Typocidaris: independent genus or junior synonym of *Stereocidaris*?

Typocidaris has been a well established genus, ever since it has been erected by Pomel (1883). Animals belonging to *Typocidaris* are characterised by the possession of sutural grooves and almost fully developed interambulacral scrobicules. Only the uppermost scrobicule in each ambulacrum can be reduced.
The genus has been united to *Stereocidaris* Pomel, 1883, by Fell & Pawson (1966), together with *Phalacrocidaris* Lambert, 1902.
I tried to construct a cladogram, illustrating a possible relationship between some Stereocidarinae (Fig. 1). This subfamily separates from stem-Cidaridae by the acquisition of sutural grooves (threshold 1). The subsequent acquisition of coronal depressions (threshold 2) gave rise to the genus *Temnocidaris* Cotteau, 1863 (type-species *T. magnifica* Cotteau, 1863). The genus *Stereocidaris* Pomel, 1883 [type-species *S. cretosa* (Mantell, 1835)] arose by reduction of most adapical scrobicules (threshold 3).

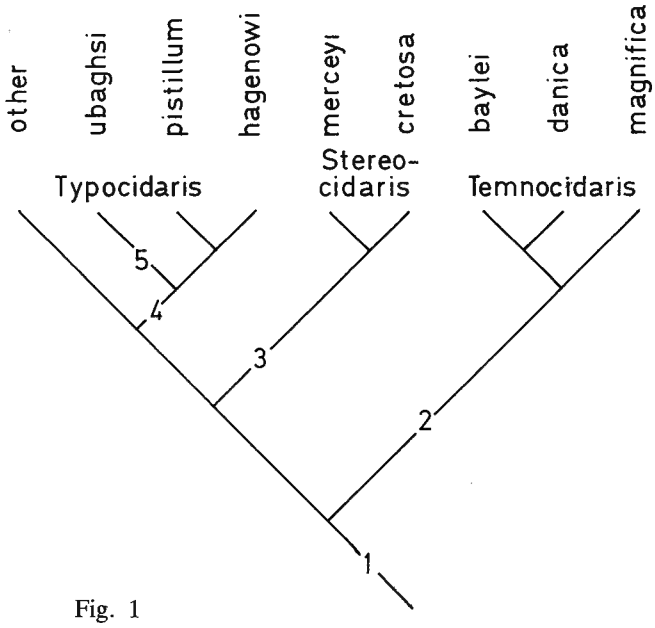

Fig. 1

In this context, *Stereocidaris, Temnocidaris* and *Typocidaris* should be considered as separate genera. If ancestors of *Stereocidaris* should belong to *Typocidaris,* the former genus should have to be considered a subgenus of the latter. This view has already been supported by LAMBERT & THIERRY (1910). Our present state of knowledge is insufficient however, to permit a final statement.
Phalacrocidaris does not belong to the Stereocidarinae: it misses the characteristic sutural grooves. In my opinion, its similarity to *Stereocidaris* is due to convergence, rather than to relationship.

Systematic descriptions

Class Echinoidea LESKE, 1778
Subclass Perischoechinoidea M'COY, 1854
Order CIDAROIDA CLAUS, 1880
Family CIDARIDAE GRAY, 1825
Subfamily STEREOCIDARINAE LAMBERT, 1900
Genus *Typocidaris* POMEL, 1883

Type-species:
Cidaris malum GRAS, 1848 (original designation).

Typocidaris pistillum (QUENSTEDT, 1852)
(Pl. 1, Figs. 1-6)

* . 1852 *Cidaris pistillum,* QUENSTEDT, p. 578, pl. 49, fig. 20.
. 1910 *Cyathocidaris pistillum,* LAMBERT & THIERRY, p. 146.
. 1928 *Cidaris Hagenowi,* RAVN, p. 17, pl. 2, fig. 8.
. 1928 *Cidaris Bolli,* RAVN, p. 15, pl. 1, figs. 8, 20.
1939 cf. *Cidaris Bolli,* KONGIEL, p. 6, pl. 1, figs. 5-6.
. 1972 *Stereocidaris pistillum,* NESTLER, pp. 172-180, pl. 1-3.
. 1973 *Stereocidaris pistillum,* KUTSCHER, pp. 108-109, figs. 1, 2, 6.
. 1975 *Stereocidaris pistillum,* NESTLER, p. 82, fig. 131.
(for full synonymy, cf. NESTLER, 1972).

Locus typicus:
Rügen, German Democratic Republic.

Stratum typicum:
Schreibkreide, Lower Maastrichtian.

Occurrences outside the Maastricht-area:
DDR: Lower Maastrichtian of Rügen (NESTLER, 1972); DK: Maastrichtian of Møn, Sjaelland and Jylland (RAVN, 1928), as *Cidaris hagenowi* and *Cidaris bolli*; PL: Maastrichtian of the Lublin-area (KONGIEL, 1939), as *Cidaris bolli.*

Specimens studied:
Hallembaye (C.P.L.-quarry) (Lg, B); 4.5 m over Loën Horizon, Zevenwegen Beds, Gulpen Formation, Upper Campanian: 1 specimen (coll. J. Jagt, n° 1180). Hallembaye (C.P.L.-quarry) (Lg, B); Lanaye Beds, Gulpen Formation, Maastrichtian: 1 impression in flint (coll. L. Indeherberghe). Brunssumer Heide (NLb, NL); reworked from Gulpen Formation, Maastrichtian: 1 impression in flint (coll. NHMM, n° Boersma 503).

Dimensions:
Both flint impressions are fragments. The dimensions of the J. Jagt specimen are given below: D = 27 mm; h = 12 mm; ds = 10 mm; dp = 7 mm; d/D-ratio = 0.44; ds/D-ratio = 0.37; dp/D-ratio = 0.26.

Description:
Moderately small *Typocidaris,* with a circular peristome, which is not sunken. Gill slits are absent.
Ambulacra are sinuous and wide. Poriferous zones are slightly depressed. Pores are not conjugate; neural grooves are present. The pores of each pair are separated by a tiny granule, which shows a small, transverse groove. The pore pairs are very slightly oblique. Interporiferous areas are fairly wide and densely granulated. Vertical, regular series of granules, one on every ambulacral plate, adjoin the poriferous zones. Perradially, between these series of larger granules, the remaining space is covered by a very dense, very fine granulation. These small, perradial granules are arranged in horizontal rows: two rows of three to four granules on each plate. The granules diminish in size towards the perradial suture.
At the ambitus, 16 ambulacral plates correspond in height to one interambulacral plate. There are 5 interambulacral plates in a series. Primary tubercles are perforate and non crenulate, except on the adapical side of tubercles above the ambitus. The areoles are slightly conical and moderately sunken. Their distal border has a steep slope, but is neither vertical, nor undercut. Scrobicules are surrounded by a full ring of small scrobicular tubercles, which are accompanied by a crescent-shaped elevation on the distal side. At the ambitus, a scrobicular ring consists of 15 tubercles. The uppermost scrobicule of each interambulacrum is rudimentary. Extrascrobicular surfaces are covered by a very dense, fine granulation. These granulated surfaces completely surround the scrobicules, but are best developed interradially. Adradially, a mere two or three granules separate the scrobicular rings from the sutures. Interradially, the granules are arranged in irregular series radiating from the scrobicules. In our specimens, there are no clearly visible furrows between these series. Horizontal and interradial sutures are depressed. Small, deep depressions are present on horizontal adapical sutures.

Diagnostic features:
1. Interambulacral scrobicules widely separated.
2. 5 or 6 interambulacral plates in a series.
3. Uppermost interambulacral plate reduced.
4. Sutures sunken, with deep depressions on adapical horizontal sutures.

5. Ambulacral interporiferous areas well developed, with two regular marginal vertical series of granules; perradial granules smaller and arranged in irregular horizontal series, two on each plate.
6. Interporous granules with a transverse groove.
7. Scrobicular tubercles distally accompanied by a crescent shaped elevation.

Discussion:
The typical configuration of the interporiferous granulation, as it occurs in *T. pistillum,* is known in very few other species. This makes them easy to recognise and hard to confuse with other Cidaroida.
Differences between the coronas of *T. pistillum* and *T. hagenowi* (DESOR, 1858) (NESTLER, 1972, Pl. 4-5; Maastrichtian of Rügen, D.D.R.), which occurs in the same strata, are small and subtle. According to NESTLER (1972), the main differences are: a/ the lack of a transverse groove on the interporous granuliform partition in *T. hagenowi,* b/ the absence of crescent-like elevations near the scrobicular tubercles in *T. hagenowi,* c/ the periphery of the areoles, which is vertical to undercut in *T. hagenowi,* but less steep in *T. pistillum,* and d/ the areoles of *T. hagenowi,* which are so deep that only the mamelon thrusts out over the rim, while the entire upper part of the boss does so in *T. pistillum.*
Ambulacral plates of *T. danica* RAVN, 1928 (Pl. 2; Danian of Denmark) are similar to those of *T. pistillum* and of *T. hagenowi.* They also show one marginal tubercle and two horizontal rows of smaller, perradial tubercles. Yet, *T. danica* has more interambulacral plates in each series (7) than both other species. In how much this difference is sufficient to justify the distinction of *T. danica* as a separate species, remains to be etablished. Examination of RAVN's type specimens would be necessary.

Typocidaris sceptrifera (KONIG in MANTELL, 1822)
(Pl. 1, Figs. 7-9)

* . 1822 *Cidaris sceptrifera,* MANTELL, p. 194, pl. 17, fig. 12(r).
. 1840 *Cidaris sceptrifera,* AGASSIZ, p. 10.
. 1841 *Cidarites sceptrifera,* ROEMER, p. 28.
. 1846 *Cidaris sceptrifera,* AGASSIZ & DESOR, p. 328.
. 1848 *Cidaris sceptrifera,* BRONN, p. 300.
1850 *Cidaris sceptrifera,* SORIGNET, p. 6.
1850 *Cidaris sceptrifera,* DIXON, p. 338.
1854 *Cidaris sceptrifera,* MORRIS, p. 74.
. 1855 *Cidaris sceptrifera,* DESOR, p. 13, pl. 5, fig. 28(r).
1859 *Cidaris sceptrifera,* COQUAND, p. 1013.
. 1860 *Cidaris sceptrifera,* COTTEAU & TRIGER, p. 253, pl. 42, figs. 1-8 (r + c).
. *Cidaris sceptrifera,* COTTEAU, pp. 251-256, pl. 1056, figs. 57-58.
v . 1874 *Cidaris sceptrifera,* COTTEAU, p. 641.
1875 *Cidaris sceptrifera,* QUENSTEDT, p. 175, pl. 68, fig. 4.
1878 *Cidaris sceptrifera,* COTTEAU, pp. 430-434, pl. 78, figs. 2-5.
. 1882 *Cidaris sceptrifera,* WRIGHT, pp. 54-57, pl. 5, figs. 16-17; pl. 6, figs. 2-6; pl. 7, figs. 1-2; pl. 7a, figs. 1, 3.
1883 *Cidaris sceptrifera,* COTTEAU, -. 11.
1892 *Stereocidaris sceptrifera,* SCHLÜTER, pp. 110-118, pl. 14, figs. 6-7; pl. 16, figs. 5-6.
. 1910 *Stereocidaris sceptrifera,* LAMBERT & THIERRY, p. 152.
1911 *Stereocidaris sceptrifera,* LAMBERT, p. 60, pl. 2, fig. 31.
1925 *Stereocidaris sceptrifera,* LAMBERT, p. 24.
1928 *Stereocidaris sceptrifera,* LAMBERT & JEANNET, p. 116.
1928 *Cidaris sceptrifera,* RAVN, p. 25.
v 1935 *Stereocidaris sceptrifera,* SMISER, p. 24, pl. 2, fig. 2.
1939 *Stereocidaris sceptrifera,* KONGIEL, p. 14, pl. 2, fig. 3.
. 1968 *Stereocidaris sceptrifera,* HYNDA, pp. 196-197, pl. 40, figs. 5-7.
1970 *Stereocidaris sceptrifera,* BŁASZKIEWICZ, p. 159.
. 1974 *Stereocidaris sceptrifera,* SAVCHINSKAYA, pp. 309-310, pl. 94, fig. 7.
1979 *Typocidaris sceptrifera,* FOURNIER, p. 9.
. 1980 *Stereocidaris sceptrifera,* FISCHER, p. 266, pl. 131, fig. 3.
non 1882 *Cidaris sceptrifera,* WRIGHT, pl. 6, figs. 1a-1h.
non 1928 *Stereocidaris sceptrifera,* MORTENSEN, pp. 226-227.
non 1966 *Stereocidaris sceptrifera,* FELL, p. U327, figs. 242-3a, b.

Locus typicus:
Lewes, Sussex, England.

Stratum typicum:
"Upper Chalk".

Occurrences outside the Benelux-countries:
F: Turonian of Sarthe dept. (COTTEAU & TRIGER, 1860); Coniacian to Maastrichtian of Aude dept. (LAMBERT, 1911), Charente, Charente-Maritime, Eure, Eure-et-Loire, Loir-et-Cher, Marne, Oise, Seine-et-Oise, Seine-Maritime, Somme and Yonne depts. (COTTEAU, 1862). GB: Santonian of Kent, Sussex and Wiltshire (WRIGHT, 1882). D: Upper Turonian of Salzgitter (SCHLÜTER, 1892). DDR: Lower Maastrichtian of Rügen (ROEMER, 1841). DK: Coniacian and Santonian of Bornholm (RAVN, 1928). E: Campanian of Tremp-area (LAMBERT, 1925). SU: Coniacian of the Don-Basin; Turonian to Campanian of the Volhynian-Podolian Plateau, Ukranian S.S.R. (HYNDA, 1968; SAVCHINSKAYA, 1974).

Figured specimens in the K.B.I.N.-collections:
IST 10250, figured herein, Pl. 1, Fig. 8. IST 10251, figured herein, Pl. 1, Fig. 7. IST 10252, figured herein, Pl. 1, Fig. 9. (Specimens IST 9093 and IST 9094 are incomplete and isolated radioles, figured by SMISER (1935), pl. 2, fig. 2 a-b).

Specimens studied:
Maastricht (NLb, NL); Maastricht Formation, Maastrichtian: 16 fragments, among which IST 10250,

10251 and 10252. Valkenburg (NLb, NL); Maastricht Formation, Maastrichtian: 22 fragments. Sibbe (NLb, NL); Maastricht Formation, Maastrichtian: 2 fragments. Vroenhoven (BLb, B); Maastricht Formation, Maastrichtian: 1 fragment.

Description:
Interambulacral primary tubercles are perforate, non crenulate. The diameter of the scrobicule is 3.5 times larger than the mamelon's. Only the mamelon protrudes over the scrobicular ring. Some scrobicules are slightly elliptical. Scrobicules are deeply sunken. Their distal borders are steep, but never overhanging. Scrobicular rings are complete and raised. They consist of 14 coarse tubercles, alternating with smaller, radially elongated granules. Scrobicules are not confluent, but scrobicular rings of adjacent plates touch each other adorally and adapically. Only in the vicinity of the apical system, a narrow row of very small granules can occur along the horizontal sutures. The uppermost scrobicule in each ambulacrum is reduced and its tubercle rudimentary. Adradial extrascrobicular surfaces are exceedingly narrow and limited to an irregular row of small granules. Adorally, the scrobicules are moderately wide and covered by an irregular, dense, fine granulation. The interradial suture is depressed in a conspicuous furrow. On the adapical half of the corona, horizontal sutures are marked by distinct grooves.
Ambulacra are sinuous and moderately narrow. Poriferous zones are strongly depressed. Pores are not conjugate, but separated by a granuliform interporous partition. Neural grooves can be seen. The axes of the pore-pairs are almost horizontal. Interporiferous areas are covered by a dense granulation. These granules are arranged in four vertical series. A fifth and a sixth series can occur in the vicinity of the ambitus. The outermost granules are slightly larger than the others. There is no horizontal regularity in their arrangement. The ratio ambulacral to interambulacral plates, at the ambitus, is 20 to 1.

Discussion:
Typocidaris sceptrifera has been compared to *T. subvesiculosa* (D'ORBIGNY, 1850) (COTTEAU, 1862, Pl. 1059, 1060, 1061; Upper Cretaceous of Western Europe). Yet, *T. sceptrifera* is easily recognised by its strikingly coarse, raised scrobicular rings. Moreover, its interradial extrascrobicular surfaces are narrower and its granulation is coarser than in *T. subvesiculosa*.
Very coarse scrobicular rings are also a characteristic feature in *T. forchhammeri* (AGASSIZ & DESOR, 1846) (COTTEAU, 1863, Pl. 1078, 1079; Danian of Western Europe). The latter species shows only two vertical series of granules in its interporiferous surfaces, while *T. sceptrifera* has four or six. The scrobicules of *T. forchhammeri* are shallow, while those of *T. sceptrifera* are deep.
The species under discussion has been described and named, based on radioles. A correlation between these radioles and coronal parts has subsequently been made by FORBES in DIXON (1850), who figured two nearly complete coronas, in connection with radioles. A clear description of coronal plates was first given by COTTEAU & TRIGER (1860). Hence, we use the name *T. sceptrifera* in the meaning of the latter authors.
Specimen n° V85 of AGASSIZ' collection, was included in the synonymy of *T. sceptrifera* by DESOR (1855), by COTTEAU & TRIGER (1860) and by COTTEAU (1862). This must be an error. According to LAMBERT & JEANNET (1928), specimen n° V85 belongs to *Pseudocidaris galeotti* (DESOR, 1855) from the Cenomanian of Mexico!
Some authors have confused *T. sceptrifera* with *Stereocidaris cretosa* (MANTELL, 1835). As early as 1840, MORRIS considered them as synonymous. Yet, MANTELL's interpretation of both species was mainly based on earlier figures, without proper description or explanation. The situation was clarified by COTTEAU (1862), who re-established, with full motivation, the existence of both species. In spite of COTTEAU's argumentations, the synonymy of these species persisted in the works of subsequent British authors, such as WRIGHT (1882), who figured a specimen of *S. cretosa*, under the name *T. sceptrifera* (Pl. 6, Figs. 1a-1b). The same error was made by MORTENSEN (1928) (Fig. 76) and by FELL (1966) (Figs. 242-3a, b), who reproduced WRIGHT's figure. *S. cretosa* is easily distinguished from *T. sceptrifera* by its strongly reduced adapical scrobicules, and its much wider interporiferous zones and interradial extrascrobicular surfaces. *S. cretosa* is the type-species of the genus *Stereocidaris*.

Typocidaris serrata (DESOR, 1858)
(Pl. 2, Figs. 1-4)

* . 1858 *Cidaris serrata,* DESOR, p. 450 (pro parte).
. 1862 *Cidaris serrata,* COTTEAU, pp. 306-308, pl. 1074, figs. 1-11.
. 1867 *Cidaris hirudo,* WRIGHT, pp. 64-67, pl. 10, figs. 2-3 (pro parte) (non SORIGNET, 1850).
1887 *Cidaris serrata,* GAUTHIER, pp. 251-252 (radioles).
. 1892 *Cidaris serrata,* SCHLÜTER, p. 83.
1897 *Cidaris serrata,* LAMBERT, p. 142, pl. 2, fig. 9.
1910 *Typocidaris serrata,* LAMBERT & THIERRY, p. 152.
1911 *Typocidaris serrata,* LAMBERT, pp. 34, 42, 46, 69.
v . 1935 *Typocidaris serrata,* SMISER, p. 23, pl. 1, fig. 12c (non fig. 12b).
1939 *Typocidaris serrata,* KONGIEL, pp. 12-13, pl. 1, figs. 21-25.
1968 *Stereocidaris serrata,* HYNDA, p. 197, pl. 40, fig. 10.
1970 *Typocidaris serrata,* BŁASZKIEWICZ, p. 159.
v ? 1984 *Stereocidaris* cf. *serrata,* NAIDIN, p. 26.

Locus typicus:
Meudon, Seine-et-Oise, France.

Stratum typicum:
"Sénonien supérieur".

Occurrences outside the Maastricht-area:
F: "Sénonien" of Seine-et-Oise (COTTEAU, 1862), Marne (GAUTHIER, 1887); Campanian of Charente (GEYS, unpublished). PL: Maastrichtian of the Lublin area (KONGIEL, 1939). SU: Upper Maastrichtian of the Lvov-area, Ukrainia (HYNDA, 1968); Maastrichtian of Mangyshlak-peninsula, Kazachstan (NAIDIN, e. a., 1984).

Figured specimens in the K.B.I.N.-collections:
IST 9086, figured by SMISER (1935), pl. 1, fig. 12c. IST 9087 and IST 9088, resp. a coronal fragment and a radiole, figured by SMISER (1935; pl. 1, fig. 12a-b) and 9083, IST 9084 and IST 9085, figured and described by LAMBERT (1897, 1910), are unconvincing.

Specimens studied:
Sibbe (NLb, NL); Maastricht Fm., Maastrichtian: 1 interambulacrum with parts of adjacent ambulacra (IST 9086). Kanne (Albert Canal) (BLb, B); 1st Bryozoa-bed, Meerssen Beds, Maastricht Fm., Maastrichtian: 1 interambulacrum with parts of adjacent ambulacra (coll. J. Jagt, n° 2283). Vroenhoven (Albert Canal) (BLb, B): Geulhem Beds, Houthem Fm., Danian: 1 specimen (coll. J. Jagt n° 494). Maastricht (St. Pietersberg) (NLb, NL); Maastricht Fm., Maastrichtian: 2 fragments (coll. NHMM n° MM-7262). Kunrade (NLb, NL); Kunrade Fm., Maastrichtian: 1/5 corona (coll. M. Van Birgelen). Hallembaye (CPL-quarry) (Lg, B); Lanaye Beds, Gulpen Fm., Lower Maastrichtian: 3 impressions in flint (coll. L. Indeherberge).

Description:
Ambulacra are sinuous and moderately narrow. Poriferous zones are depressed. The pores are not conjugate. The axis of the pore-pairs is subhorizontal. Interporiferous areas are moderately narrow and show six vertical series of granules. Adradial granules are more important in size than perradial ones. At the ambitus, the ratio of ambulacral to interambulacral plates is 15 to 1.
Interambulacral plates are 5 in a series. Primary tubercles are perforate, non crenulate. The areoles are conical and moderately shallow, so that the bosses protrude highly over the rim of the scrobicular rings. Scrobicular rings are complete and consist of 15 small scrobicular tubercles, which are only slightly larger than surrounding granules. In each ambulacrum, the uppermost scrobicule is reduced. Extrascrobicular surfaces are densely granulated. Adradially, these surfaces are interrupted by the scrobicular rings, which touch the adradial sutures. Interradial extrascrobicular surfaces are well developed only on the adapical side. Horizontal and interradial sutures are depressed and visible as faint grooves on the corona.

Diagnostic features:
1. Interradial extrascrobicular area relatively narrow and sinuous.
2. Interradial and horizontal sutures depressed.
3. Scrobicular rings with 15 small tubercles.
4. Interporiferous areas moderately narrow, with six vertical series of granules, of which the perradial ones are very small.

Discussion:
Typocidaris serrata has few characteristic features and therefore, the species is difficult to recognise. Confusion with some other species is easy. Some features permit however, to distinguish them. Areoles are much deeper in *T. hagenowi* (DESOR, 1858) (NESTLER, 1972, Pl. 4-5; Maastrichtian of Rügen, D.D.R.) and in *T. sceptrifera* (KOENIG in MANTELL, 1822). Moreover, interporiferous zones of *T. hagenowi* have a very different granulation. Scrobicular rings are coarser and ambulacra are narrower in *T. forchhammeri* (AGASSIZ & DESOR, 1846). Interradial extrascrobicular surfaces are wider and/or differently structured in *T. subvesiculosa* (ORBIGNY, 1850) (COTTEAU, 1862, pl. 1059-1061; Upper Cretaceous of Western Europe), in *T. hirudo* (SORIGNET, 1850) (COTTEAU, 1862, pl. 1054; "Sénonien" of Western Europe), in *"Cidaris" faujasi* DESOR, 1856 (COTTEAU, 1863, pl. 1077; "Sénonien" of France) and in *T. serrifera* (FORBES, 1850) (COTTEAU, 1862, pl. 1071; "Sénonien" of France).
The holotype of *T. serrata* has never been figured. The first proper description and useful figures of the species were published by COTTEAU (1862). hence, the name had to be used herein, sensu COTTEAU.
For reasons explained above, part of the specimens figured as *Cidaris hirudo,* by WRIGHT (1867) (pl. 10, figs. 2-3), problably belong to *T. serrata.*
T. serrata has been mentioned from the Lower Maastrichtian of Rügen (D.D.R.) by DESOR (1858) and by SCHLÜTER (1892). These records are based on incomplete radioles and therefore highly questionable.

Typocidaris ubaghsi nov. sp.
(Pl. 2, Figs. 5-9)

1928 *Stereocidaris* cf. *Merceyi,* KRENCKEL, p. 18, fig. 2, figs. 21-23.

Locus typicus:
Heure-le-Romain, prov. Liège, Belgium.

Stratum typicum:
Lower Gulpen Formation, Upper Campanian.

Holotype:
K.B.I.N., n° IST 10253.

Occurrence outside the Benelux:
DDR: Lower Maastrichtian of Rügen (H. KRENCKEL, 1928).

Dimensions:
D = 42-48 mm; h = 29 mm; ds = 13-23 mm; dp = 10-17 mm; h/D = 0,60-0,69; ds/D = 0,31-0,48; dp/D = 0,24-0,35.

Description:
The peristome is not sunken; gill slits are absent.
Ambulacra are sinuous and wide. Poriferous zones are depressed. The pores are not conjugate, but a neural groove is visible near the adoral suture of each plate. A granule is present between the pores of each pair. The axes of the pore-pairs are slightly oblique. The interporiferous areas are densely granulated. Adradially, there is a single regular, vertical series of granules, each corresponding with a pore-pair. Perradially, the remaining parts of each interporiferous area are covered with a very dense, irregular, fine granulation. The latter granules are not arranged in vertical series, but in horizontal rows of 5 to 7. There are about 80 plates in each ambulacral series. At the ambitus, 23 ambulacral plates correspond in height to one interambulacral plate.
Interambulacral plates are five in a series. Primary tubercles are perforate, non crenulate. The areoles are slightly conical and deeply sunken. The distal border of the areoles is vertical, or undercut. The areoles are surrounded by 19 small, scrobicular tubercles. The uppermost scrobicule of each interambulacrum is rudimentary. Extrascrobicular surfaces are covered by a very dense, fine granulation. Interradial, as well as adoral extrascrobicular areas are well developed and wide. Adradially, these granulated surfaces are much narrower. The granules are arranged in more or less regular rows, radiating from the scrobicules and separated by faint furrows, running from each scrobicule to the scrobicules on both adjacent plates of the other series. Horizontal, as well as interradial sutures are clearly visible and depressed.

Diagnostic features:
1. Widely separated interambulacral scrobicules.
2. 5 or 6 interambulacral plates in a series.
3. Uppermost interambulacral plate reduced.
4. Distinct sutural grooves.
5. Ambulacral interporiferous areas wide, with two regular vertical series of granules, separated by a wide perradial belt of small granules, arranged in irregular horizontal rows.

Affinities:
The new species shows a superficial similarity to *"Cidaris"* s. l. *perlata* (SORIGNET, 1850) (G. COTTEAU, 1862, pl. 1062, 1063), from the "Senonian" of France. Both species have wide perradial interporiferous areas, covered with a dense granulation. But on closer examination, very important differences come to light. The ambulacra of *T. ubaghsi* are wider and more sinuous than in *C. perlata*. The latter species has considerably more plates in each interambulacral series than the former, for specimens of similar size. Still more important: diagnostic features for Stereocidarinae, such as the high shape of interambulacral plates and sutural grooves, are not sufficiently prominent in *C. perlata*. Hence, the relationship between *T. ubaghsi* and *C. perlata* is more than questionable: the latter species probably does not belong to the Stereocidarinae at all.
The ambulacra of *Stereocidaris* s.s. *cretosa* (MANTELL, 1835) (COTTEAU, 1862, pl. 1067; "Sénonien" of Western Europe) are also very similar to those of *T. ubaghsi*. However, the granules of *S. cretosa* are arranged in 6 to 8 regular, vertical series. Those of *T. ubaghsi* are arranged in horizontal rows, without any vertical regularity. The same lack of vertical regularity is displayed in the ambulacral granules of *Stereocidaris* s.s. *merceyi* (COTTEAU, 1862) (pl. 1068; Lower "Sénonien" of France). Yet, both species are clearly different from *T. ubaghsi,* in having strongly reduced, rudimentary adapical interambulacral scrobicules. For that reason, *T. ubaghsi* does not belong to the genus *Stereocidaris* s.s.

Phylogenetical considerations:
The closest relative known, to the species under discussion is probably *Typocidaris hagenowi* (DESOR, 1858), from the Lower Maastrichtian of Rügen, D.D.R. Its ambulacra have the same structure as those of *T. ubaghsi*: vertical series of well developed primary tubercles on the adradial sides of the interporiferous areas. Perradilally, smaller granules occur, arranged in two horizontal rows on each plate. *T. hagenowi* differs from *T. ubaghsi,* because the vertical regularity in the arrangement of perradial granules did not completely disappear in the former. These granules are less numerous and less tightly packed in *T. hagenowi* than in *T. ubaghsi.*
A plausible interrelationship is illustrated in the cladogram (Fig. 1). From this figure, one can read that the similarity between the ambulacra of *S. merceyi* and *T. ubaghsi* is probably due to convergence. During its evolution, *T. ubaghsi* and its ancestors can have passed the following thresholds: a/ differentiation from a Typocidaroid ancestor, by the acquisition of multiple horizontal rows of perradial granules on each ambulacral plate (threshold 4), b/ differentiation from the stem-*T. hagenowi* by the loss of vertical regularity in perradial granules (threshold 5).
The fragments from the Lower Maastrichtian of Rügen (D.D.R.), which were provisionally identified as *Stereocidaris* cf. *merceyi* by KRENCKEL (1928), probably belong to *T. ubaghsi.* KRENCKEL's description fits the new species very well. I disagree with NESTLER (1972) who believed KRENCKEL's specimens to belong to *Temnocidaris baylei* COTTEAU, 1863. The latter species can be easily identified by its numerous coronal depressions, which are absent in the fragments described by KRENCKEL.

Doubtful species

By far the great majority of the Cidaroid remains in Cretaceous strata consists of isolated interambulacral plates and radioles. The identification of both kinds of fossils is particularly difficult, especially when their preservation is not optimal. Unfortunately, this is very often the case in the material I studied.

In a large number of species, interambulacral plates offer little or no diagnostic features, which allow an unequivocal identification. The interpretation of isolated interambulacral plates, not in connection with neighbouring plates, or with parts of an ambulacrum, is very often an almost impossible task. Establishing the presence of a given species on such poor evidence, is obviously risky. Still less justified is the introduction of new species, merely based on a few such fragments, although this was common practice during the 19th century. Hence, names created for isolated coronal plates must be approached with caution. The safest way to deal with them should be to consider them all invalid.

Analogous considerations can be made for taxa based on isolated radioles. Radioles, in anatomical association with the corona, are only known in a very restricted number of species. To my opinion, only such species can have identifiable radioles. When giving new names to isolated radioles, the risk of creating synonyms is real. These radioles can belong to species which are already known, but of which no specimen was ever found with the spines attached. The situation is still more complex because differently shaped radioles do not necessary belong to different species: the same animal can have several types of spines, covering its test. Inversely, some echinoids have radioles which can hardly be distinguished from each other. As a rule, isolated Cidaroid radioles can sometimes be identified up to genus-level, but rarely more accurately. Only very few species can be recognised, by their radioles alone. For these reasons, the naming of isolated radioles should be banned. Existing names, merely based on such material, must be considered as referring to morphospecies, not to taxonomic units.

From the preceeding, one can conclude that certain statements concerning the presence of species in the Maastrichtian of Belgium and The Netherlands, should be approached with caution. These "doubtful species" are shortly discussed below.

a. *"Dorocidaris" venulosoides* (SCHLÜTER, 1897) has been reported from the Ciply Phosphatic Chalk at Ciply, by LAMBERT (1911) (coll. KBIN n° IST 9082), who described a few isolated interambulacral plates.

b. *"Dorocidaris" faujasi* (DESOR, 1855) has been established as a "species", based on isolated radioles from Maastricht. Without acceptable arguments, a corona from the Cotentin peninsula was attributed to the same species, by COTTEAU (1865). Similar radioles were reported by COTTEAU (1865, 1874) from the Maastrichtian of Maastricht (NL), Valkenburg (NL), Folx-les-Caves (B) and Ciply (B). The same radioles were attributed to *Temnocidaris danica,* by LAMBERT (1897). Later, this author changed his opinion (LAMBERT, 1911): radioles from the Ciply Phosphatic Chalk were reinterpreted as belonging to *D. faujasi.* Isolated interambulacral plates were attributed to the same species (coll. KBIN, n° IST 9078), the main argument was their occurrence is the same beds as the radioles. Repeating LAMBERT's statements, without due criticism, radioles and fragments of *D. faujasi* were also mentioned by SMISER (1935) from the Ciply Phosphatic Chalk (coll. KBIN, n° IST 9079, 9080, 9081).

Radioles referred to *D. faujasi,* are very similar to a large number of other Cidaroid spines. The corona is still unknown, and therefore the species remains doubtful. More and better preserved fossils are needed, before the existence of *D. faujasi* can be established.

c. *"Stereocidaris" pseudohirudo* (COTTEAU, 1862) was erected for isolated radioles from the Campanian of Meudon (F). Similar radioles have been reported by LAMBERT (1911) from the Nouvelles Chalk at Harmignies (Hainaut, B) (coll. KBIN, n° IST 9052). This statement has been repeated uncritically by SMISER (1935).

d. *"Typocidaris" arenata* LAMBERT, 1911 was established for a single, isolated interambulacral plate from the Lower Gulpen Chalk (Campanian) at Heure-le-Romain (Liège, B) (coll. KBIN, n° 9092). The plate is not unlike those of *T. pistillum* (QUENSTEDT, 1852), which occurs in strata of the same age. No data being available on the ambulacra of *T. arenata,* the specimen described by LAMBERT is in fact unidentifiable.

e. *"Balanocidaris" schlueteri* LAMBERT, 1911 has been introduced for a single, isolated radiole from the Ciply Phosphatic Chalk (Maastrichtian) at Ciply (Hainaut, B) (coll. KBIN, n° IST 9068). It is a club-shaped radiole, but its state of preservation does not permit to distinguish the presence or absence of a perforation in its acetabulum. Hence, the radiole could belong to *Tylocidaris,* as well as to *Balanocidaris.*

f. *"Cidaris" ciplyensis* LAMBERT, 1911 is a name used for some small, isolated radioles from the Ciply Phosphatic Chalk (Maastrichtian) at Ciply (Hainaut, B) (coll. KBIN, n° IST 9059, 9060). These radioles were described as *C. montainvillensis* LAMBERT, 1897 (Dano-Montian of the Paris-Basin, France). The holotype of this taxon later showed to be a spine of *Typocidaris forchhammeri* (AGASSIZ & DESOR, 1846), so that the Ciply radioles were in need of a new name (LAMBERT, 1911). Perhaps misinterpreting LAMBERT's words, SMISER (1935) united *C. ciplyensis* with *C. forchhammeri.* Both syntypes, figured by LAMBERT (1897) are badly corroded fragments of radioles, showing no details of the base and lacking the top. They are in reality far less well preserved than shown on LAMBERT's figures. In my opinion, both syntypes are unidentifiable and *C. ciplyensis* should be ignored.

g. *"Balanocidaris" hardouini* DESOR, 1855 has been introduced for some isolated, small, club-shaped radioles from the Ciply Tuffaceous Chalk (Danian), at Ciply (Hainaut, B). Similar spines have been found by BINKHORST (1859) in Maastrichtian or Danian strata in the Maastricht area (Limburg, NL), by COTTEAU (1874) and by LAMBERT (1897) in the Malogne Beds (Maastrichtian or Danian) at Ciply and by SMISER (1935) in the Maastrichtian or Danian at Geulhem (Limburg, NL). The occurrence of this species in the Maastrichtian has not been convincingly demonstrated. MEIJER (1959) as well as GEYS & MARQUET (1983) consider it a typical Danian species, belonging to the genus *Tylocidaris*. Radioles of *Tylocidaris* are indeed common in deposits of Danian age (BROTZEN, 1959). The specimens figured by SMISER (1935) (coll. KBIN, n° IST 9072, 9073, 9074, 9075 and 9076) are somewhat eroded and show almost no definite generic characteristics. Yet, they probably belonging to *Tylocidaris*.

h. *"Cidaris" filamentosa* AGASSIZ, 1846. A few isolated radioles from Maastricht (NL) were assigned to this species by SMISER (1935) (coll. KBIN, n° 9061 and 9062). The species has been named by AGASSIZ & DESOR (1846) after a few isolated spines of unknown origin. The corona, corresponding to these radioles is completely unknown. The similarity between the radioles described by SMISER (1935) and some, which were attributed to *"C." forchhammeri* DESOR, 1846, is striking. Therefore I consider the presence of *"C" filamentosa* in the Low Countries unsufficiently demonstrated.

i. *"Cidaris" subvesiculosa* d'ORBIGNY, 1850 is a well known and common species in the "Senonian" of Western Europe. It has been reported by BOSQUET (1957) and by MOURLON (1880), from the Maastrichtian of Limburg (NL), in a list, without discussion. SMISER (1935) figured two coronal fragments and one radiole (coll. KBIN, n° IST 9089, 9090, 9091), which he attributed to this species. Both fragments are badly corroded and too small to be properly identified. The radiole is similar to those, figured by COTTEAU (1864) as *Cidaris subvesiculosa,* but also to those of *C. serrata,* and to some of *C. sceptrifera*! Hence, also this radiole is hardly identifiable. The presence of *C. subvesiculosa* in the Maastrichtian of the Low Countries has still to be demonstrated.

j. *"Cidaris" perornata* FORBES, 1850 is a rare species from the Upper Chalk of Sussex, England. Whereas at least one well preserved specimen, from England, with radioles attached, has been described by FORBES (1850), the fossils from continental Europe, assigned to the same species merely consist of isolated radioles and small fragments. SMISER (1935) reported the species from the Maastrichtian at Maastricht (NL), but his statement is based merely on some isolated spines (coll. KBIN, n° IST 9077). These spines are slender, thorny and similar to those attributed to *"C." spinosissima* AGASSIZ, 1846, *"C." leptacantha* AGASSIZ, 1846 or indeed, *"C." perornata*! Because of these uncertainties, I consider the presence of the latter species in the Upper Cretaceous of the Low Countries not demonstrated.

k. *Typocidaris forchhammeri* (AGASSIZ & DESOR, 1846) was first described from the Danian at Faxe (DK). It was subsequently reported from the Dano-Montian at Vigny (F) and from Mons (B). Unfortunately, a lot of nomenclatorial confusion exists for the Belgian specimens. The collections of the K.B.I.N. posses a large number of coronal fragments, which are to be classified in this species. They are labelled "Maastrichtian - Voort colliery, Limburg, Belgium". Knowing that Danian strata in Limburg were often misinterpreted as Upper Maastrichtian, and taking into account the known stratigraphical distribution of the species elsewhere, there is no unequivocal evidence for the presence of *T. forchhammeri* in the Belgian Upper Cretaceous. Most probably, the species is confined to Danian and Montian deposits.

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References

AGASSIZ, L., 1840. Catalogus systematicus ectyporum echinodermatum fossilium musei Neocomensis. Petitpierre, Neuchâtel, 20 pp.

AGASSIZ, L. & DESOR, E., 1846. Catalogue raisonné des familles, des genres et des espèces de la Classe des Echinodermes I. *Annales des Sciences Naturelles* 3, *Zoologie* 6: 305-374.

BINKHORST VAN DEN BINKHORST, J.T., 1859. Esquisse géologique et paléontologique des couches crétacées du Limbourg et plus spécialement de la craie tuffeau. Van Osch-America, Maastricht, 18 + 270 pp, 5 pl.

BŁASZKIEWICZ, A., e. a., 1970. Geology of Poland. II. Catalogue of Fossils. 2. Mesozoic-Cretaceous. Wydawnictwa Geologiczna, Warszawa, pp. 103-177.

BOSQUET, J., 1857. Fossiele fauna en flora van het Krijt van Limburg, In: STARING, W., De bodem van Nederland, Vol. 2: Bivalvia. Kruseman, Haarlem, pp. 376-388.

BRONN, H.G., 1848. Handbuch der Geschichte der Natur. III A. Nomenclator Palaeontologicus. Schweizerbart'sche Verlagshandlung, Stuttgart, 1381 pp.

BROTZEN, F., 1959. On *Tylocidaris* species (Echinoidea) andthe stratigraphy of the Danian of Sweden, with a bibliography of the Danian and the Paleocene. *Sveriges Geologiska Undersökning (C) Avhandlingar och Uppsatser, Årsbok* 54/2: 81 pp., 3 pl.

CLAUS, C.F.W., 1880. Grundzüge der Geologie, I + II. Marburg & Leipzig, 821 + 522 pp.

COQUAND, H., 1859. Synopsis des animaux et des végétaux fossiles observés dans la formation crétacé du sud-ouest da la France. *Bulletin de la Société Géologique de France* (2) 16: pp. 945-1023.

COTTEAU, G., 1857-1878. Etude sur les échinides fossiles du département de l'Yonne. Baillière, Paris, 518 pp., 84 pl.

COTTEAU, G., 1861-1867. Paléontologie française. Description des animaux invertébrés commencée par Alcide d'Orbigny. Terrain Crétacé 7, Echinides réguliers. Masson, Paris, 892 pp., pl. 1007-1204.

COTTEAU, G., 1874. Notes sur les échinides crétacés de la province du Hainaut. *Bulletin de la Société Géologique de France* (3) 2: 638-660.

COTTEAU, G., 1883. Echinides jurassiques, crétacés, éocènes du Sud-Ouest de la France. Mareschal & Martin, La Rochelle, 209 pp., 12 pl.

COTTEAU, G. & TRIGER, J., 1855-1869. Echinides du département de la Sarthe. J.B. Baillière, Paris, 458 pp., 75 pl.

DESOR, E., 1855-1859. Synopsis des Echinides fossiles. Reinwald, Paris, 490 pp., 44 pl.

DHONDT, A.V., 1972. Systematic revision of the Chlamydinae (Pectinidae, Bivalvia, Mollusca) of the European Cretaceous. Part 1. *Camptonectes. Bulletin van het Koninklijk Belgisch Instituut voor Natuurwetenschappen* 48, *Aardwetenschappen* 3, 60 pp., 2 pl.

DIXON, F., 1850. The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex. Longmans, London, 422 pp., 40 pl.

D'ORBIGNY, A., 1850. Prodrome de Paléontologie stratigraphique universelle des animaux mollusques et rayonnés, faisant suite au Cours élémentaires de Paléontologie et de Géologie stratigraphique. 2ième volume. Masson, Paris, 427 pp.

FELL, H.B. & PAWSON, D.L., 1966. Echinacea. In MOORE, R.C. (editor), Treatise on Invertebrate Paleontology, Part U, Echinodermata 3. Geological Society of America, New York and Lawrence, pp. U367-U437.

FISCHER, J.-C., 1980. Fossiles de France et des régions limitrophes. Masson, Paris, 444 pp., 195 pl.

FORBES, E., 1850. Notes on Cretaceous Echinodermata. In: DIXON, F., The Geology and Fossils of the Cretaceous and Tertiary Formations of Sussex. Longman, Brown, Green and Longmans, London, pp. 325-343.

FOURNIER, D., 1979. Catalogue des Oursins fossils du Muséum. Muséum d'Histoire Naturelle, Grenoble , 91 pp.

GAUTHIER, V., 1887. Echinides. Descriptions des espèces de la Craie de Reims et de quelques espèces nouvelles de l'Aube et de l'Yonne. In: PERON, A., Notes pour servir à l'histoire du terrain de Craie dans le sud-est du bassin Anglo-Parisien. G. Rouillé, Grenoble, pp. 223-255.

GEYS, J.F. & MARQUET, R., 1983. Fieldatlas on Cenozoic Fossils of Belgium. Part 2. Paleogene. Belgische Vereniging voor Paleontologie, Antwerpen, 203 pp., 79 pl.

GRAS, C.J.A., 1848. Description des oursins fossiles de l'Isère, précédée de notions élémentaires sur l'organisation et la glossologie de cette classe de Zoophytes et suivie d'une notice géologique sur les divers terrains de l'Isère. Grenoble, 96 pp., 6 pl.

GRAVESEN, P., 1979. Remarks on the regular echinoids in the Upper Maastrichtian and Lower Danian of Denmark. In BIRKELUND, T. & BROMLEY, R. (editors), Cretaceous-Tertiary boundary Events. Symposium I. The Maastrichtian and Danian of Denmark. København, pp. 72-73.

GRAY, J.E., 1825. An attempt to divide the Echinida, or Sea Eggs, into natural families. *Annals of Philosophy (N.S.)* 10: 423-431.

HYNDA, V.A., 1968. Typ Echinodermata, Pidtip Eleutherozoa, Klas Echinoidea. In: PASTERNAK, S.I., Stratygrafiya i fauna Kreidovikh vidkladiv zakhody Ukrainu / bez Karpat. Doumka, Kiev, pp. 192-232, pl. 40-50.

KIER, P.M., 1977. The poor fossil record of regular echinoids. *Paleobiology* 3: pp. 168-174.

KONGIEL, R., 1939. Materjaly do znajomosci polskich jezowcow kredowych. I. Jezowce regularne. *Prace Towarzystwa Przyjaciol Nauk w Wilnie. Wydzial nauk matematycznych i przyrodniczyck* 13, *Prace Zakladu Geologicznego Uniwersyietu Stefana Batorego w Wilnie, Nowa Serja* 8: 54 pp., 3 pl.

KRENCKEL, H., 1928. Die regulären Echiniden der pommerschen Kreide. *Abhandlungen aus dem geologisch-palaeontologischen Institut der Universität Greifswald* 7: 32 pp., 3 pl.

KUTSCHER, M., 1973. Die regulären Echiniden der weissen Schreibkreide (Unter-Maastricht) der Insel Rügen. *Der Aufschluss* 24: pp. 107-115.

LAMBERT, J., 1897. Note sur les Echinides de la Craie de Ciply. *Bulletin de la Société belge de Géologie, de Paléontologie et de Hydrologie* 11: pp. 141-190, pl. 2-5.

LAMBERT, J., 1900. Sur les Echinides de la faune Coralligène du Vésulien de Saint Gaultier (Indre), recueillis par M.E. Benoist. *Bulletin de la Société Géologique de France* (3) 28: pp. 473-489, pl. 1.

LAMBERT, J., 1902. Description des Echinides fossiles de la province de Barcelone. *Mémoires de la Société Géologique de France* 24: 128 pp., 10 pl.

LAMBERT, J., 1911. Description des Echinides Crétacés de la Belgique. II. Echinides de l'étage Sénonien. *Mémoires du Musée royal d'Histoire Naturelle de Belgique* 4: 81 pp., 3 pl.

LAMBERT, J., 1925. Révision des Echinides fossiles de la Catalogne. *Mémorias del Museo de Ciencias Naturales de Barcelona, Serie Géologica* 1/1: 102 + 62 pp., 4 + 8 pl.

LAMBERT, J. & JEANNET, A., 1928. Nouveau catalogue des moules d'Echinides fossiles du Musée d'Histoire Naturelle de Neuchâtel, exécutés sous la direction de L. Agassiz et E. Desor. *Denkschriften der Schweizerischen Naturforschenden Gesellschaft* 64/2: pp. 83-233, 2 pl.

LAMBERT, J. & THIERRY, P., 1909-1925. Essai de nomenclature raisonnée des Echinides. Ferrière, Chaumont, 607 pp., 15 pl.

LESKE, N.G., 1778. Jacobi Theodori Kleini naturalis dispositio echinodermatorum..., edita et descriptionibus novisque inventis et synonomis auctorem aucta. Leipzig, 278 pp., 54 pl.

M'COY, F., 1854. Contributions to British Palaeontology, or first description of three hundred and sixty species, and several genera of fossil Radiata, Articulata, Mollusca and Pisces, from the Tertiary, Cretaceous, Oolitic and Palaeozoic strata of Great Britain. Cambridge, 8 + 272 pp., 1 pl.

MEIJER, M., 1959. Sur la limite supérieure de l'étage Maastrichtien dans la région type. *Koninklijke Academie van België. Mededeling van de Klasse der Wetenschappen* (5) 45: pp. 316-338.

MEIJER, M., 1965. The stratigraphical distribution of Echinoids in the chalk and tuffaceous chalk in the neighbourhood of Maastricht (Netherlands). *Mededelingen van de Geologische Stichting (Nieuwe Serie)* 17: pp. 21-25.

MORRIS, J., 1854. A catalogue of British Fossils. J. Morris, London, 372 pp.

MORTENSEN, T., 1928. A monograph of the Echinoidea. I. Cidaroidea. C.A. Reitzel, København, 551 pp., 88 pl.

MOURLON, M., 1881. Géologie de la Belgique. F. Hayez, Bruxelles , 317 + 392 pp.

NAIDIN, D.P., BENYAMOVSKI, V.I. & KOPAEVICH, L.F., 1984. Metody izucheniya transgressii i regressii (na primere posdnemelovykh basseinov zapadnogo Kazakhstana.) Izdagelstvo Moskovskogo Universiteta, 163 pp.

NESTLER, H., 1972. Die Cidariden (Echinoidea) der Kreide (Unteres Maastricht) Rügens. *Wissenschaftliche Zeitschrift der Ernst-Moritz-Arndt-Universität Greifswald* 12, *Mathematisch-Naturwissenschaftliche Reihe* 2: pp. 171-190, 6 pl.

NESTLER, H., 1975. Die Fossilien der Rügener Schreibkreide. Neue Brehm-Bücherei 486. A. Ziemsen, Wittenberg-Lutherstadt, 120 pp.

POMEL, A., 1883. Classification méthodique et généra des Echinides vivants et fossiles. Alger, 131 pp., 1 pl.

QUENSTEDT, F.A., 1852. Handbuch der Petrefactenkunde. H. Laupp'sche Buchhandlung, Tübingen, 792 pp., 62 pl.

QUENSTEDT, F.A., 1875. Petrefactenkunde Deutschlands. 3. Echinodermen. Fues's Verlag, Leipzig, 714 pp.

RAVN, J.P.J., 1928. De regulaere echinider i Danmarks Kridtaflejringer. *Det Kongelige Danske Videnskabernes Selskabs Skrifter* 9, *Naturvidenskabelig og Mathematisk Afdeling* 4/1: pp. 5-62, pl. 1-4.

ROEMER, F.A., 1840-1841. Die Versteinerungen des norddeutschen Kreidegebirges. Hahn'sche Hofbuchhandlung, Hannover, 139 pp., 16 pl.

SAVCHINSKAYA, O.V., 1974. Typ Echinodermata - Iglokozhie. Klas Echinoidea - Morskie ezhi. In Atlas Verkhnemelovoi Fauny Donbassa. Moskva, Nedra, pp. 303-333, pl. 94-114.

SCHLÜTER, C., 1892. Die regulären Echiniden der norddeutschen Kreide. II. Cidaridae. Salenidae. *Abhandlungen der königlich-preussischen geologischen Landesanstalt, neue Folge* 5: 9 + 243 pp., 21 pl.

SCHLÜTER, C., 1897. Ueber einige exocyclische Echiniden der baltischen Kreide und deren Bett. *Zeitschrift deutschen geologischen Gesellschaft,* 49: pp. 18-50, pl. 1-2.

SMISER, J., 1935. A monograph of the Belgian Cretaceous Echinoids. *Mémoire du Musée royal d'Histoire Naturelle de Belgique* 68: 98 pp., 9 pl.

SMITH, A.B., 1984. Echinoid Palaeobiology. Allen & Unwin, London, 190 pp.

SORIGNET, L.A., 1850. Oursins fossils de deux arrondissements du département de l'Eure. Louviers & Andelys, Vernon, 4 + 83 pp.

WRIGHT, T., 1864-1882. Monograph on the British Fossils from the Cretaceous Formations. I. The Echinoids. Palaeontographical Society Monographs, London, 371 pp. 80 pl.

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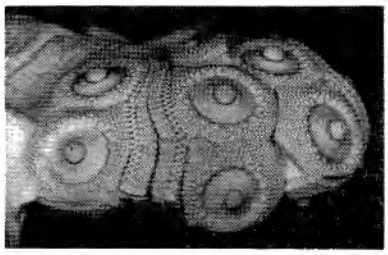

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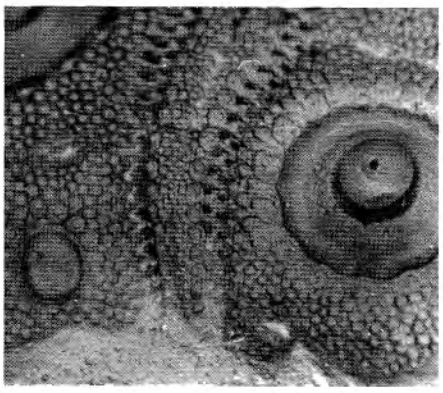

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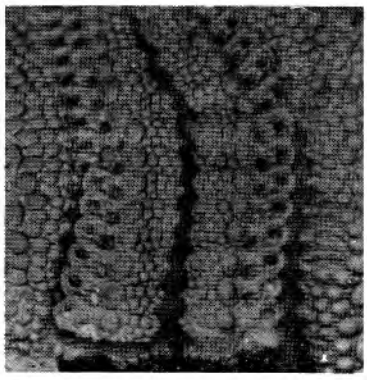

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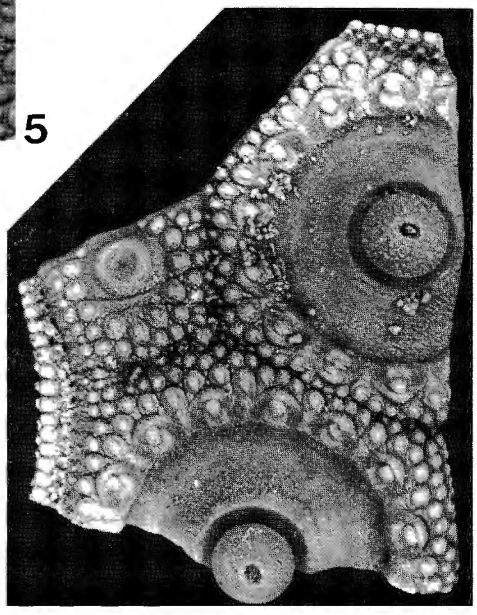

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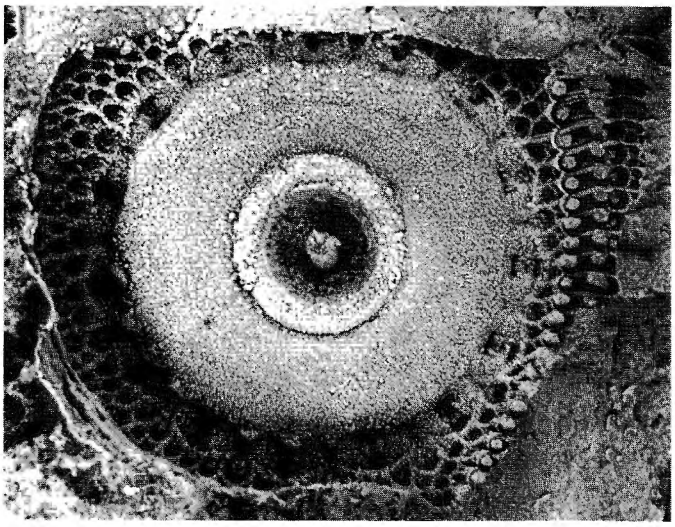

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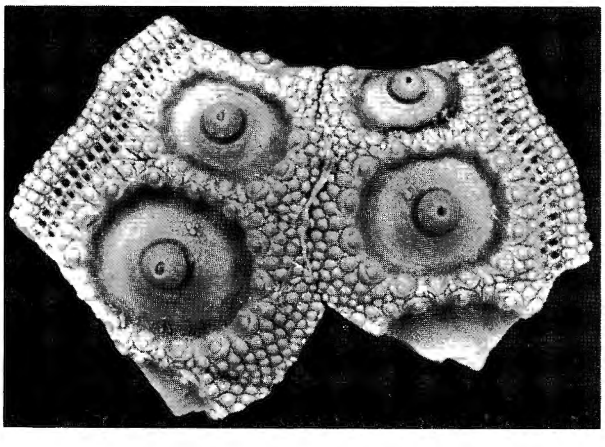

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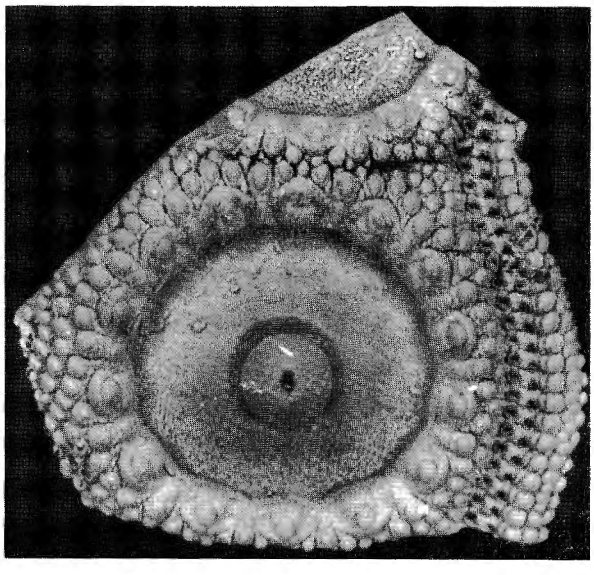

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PLATE 1

Fig. 1. Typocidaris pistillum *(QUENSTEDT, 1852) CPL-quarry, Hallembaye (Lg, B); Zevenwegen Chalk, Gulpen Fm., Upper Campanian; coll. J. Jagt, Venlo (n° 1180); adapical view; × 2.*

Fig. 2. *The same; lateral view; × 2.*

Fig. 3. *The same; adoral view; × 2.*

Fig. 4. *The same; adapical part of ambulacrum; × 8.*

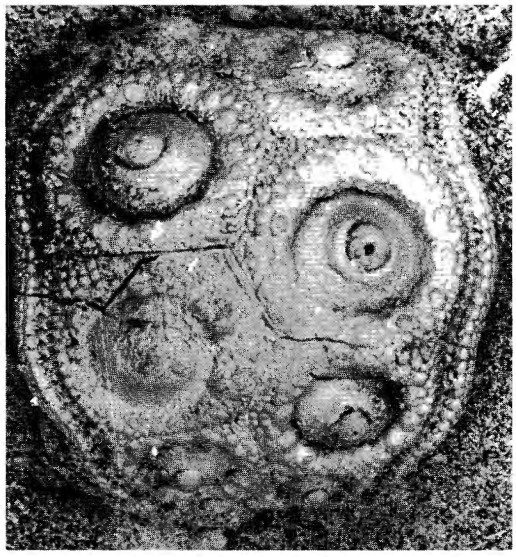
Fig. 5. *The same; ambital part of ambulacrum, showing perradial granulation; × 8.*

Fig. 6. Typocidaris pistillum *(QUENSTEDT, 1852) CPL-quarry, Hallembaye (Lg, B); Lanaye Chalk, Gulpen Fm., Lower Maastrichtian; coll. L. Indeherberghe, Zonhoven; fragment; × 6.*

Fig. 7. Typocidaris sceptrifera *(KONIG in MANTELL, 1822) Maastricht (NLb, NL); Maastricht Fm., Maastrichtian; coll. KBIN (n° IST 10251); fragment; × 5.*

Fig. 8. Typocidaris sceptrifera *(KONIG in MANTELL, 1822) Maastricht (NLb, NL); Maastricht Fm., Maastrichtian; coll. KBIN (n° IST 10250); fragment; × 4.*

Fig. 9. Typocidaris sceptrifera *(KONIG in MANTELL, 1822) Maastricht (NLb, NL); Maastricht Fm., Maastrichtian; coll. KBIN (n° IST 10252); fragment; × 5.*



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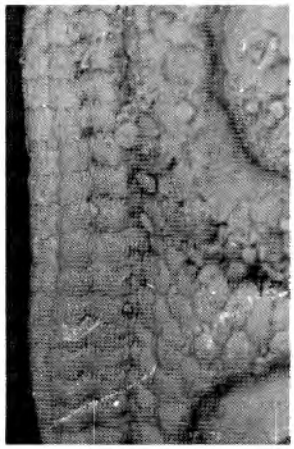

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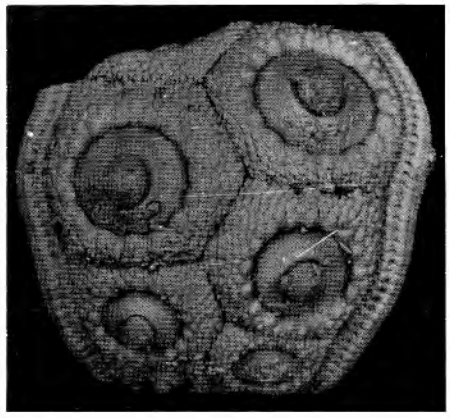

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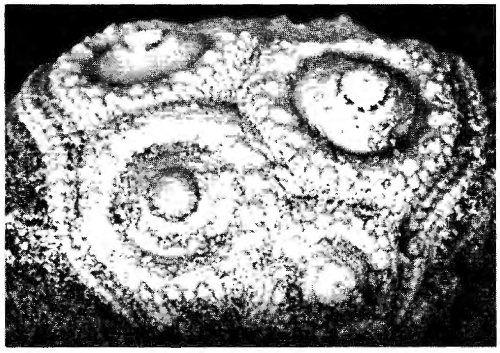

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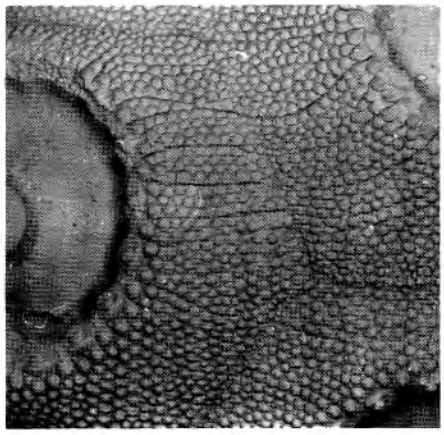

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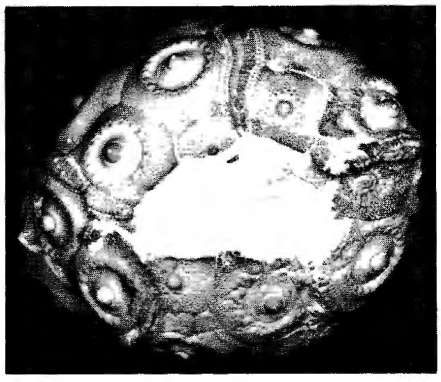

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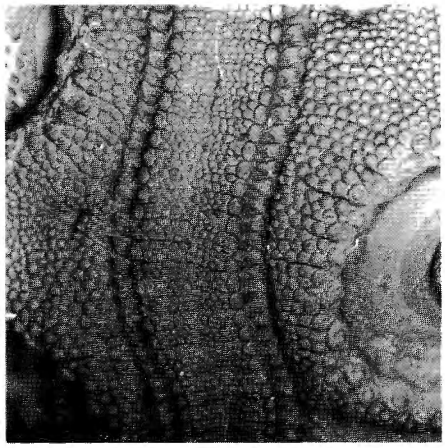

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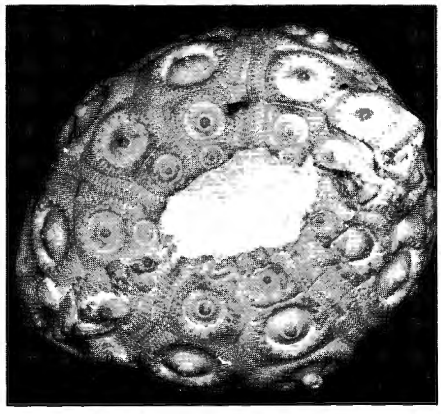

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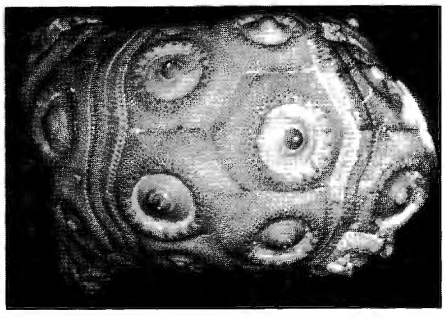

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PLATE 2

Fig. 1. Typocidaris serrata *(DESOR, 1858) Sibbe (NLb, NL); Maastrichtian; coll. KBIN (n° IST 9086); lateral view; × 4.*

Fig. 2. *The same; adapical view; × 4.*

Fig. 3. Typocidaris serrata *(DESOR, 1858) Albert Canal section, Kanne (BLb, B); Meerssen Chalk, Maastricht Fm., Maastrichtian; coll. J. Jagt, Venlo (n° 2283); lateral view; × 4.*

Fig. 4. *The same; detail of ambulacrum; × 11.*

Fig. 5. Typocidaris ubaghsi *nov. sp. Heure-le-Romain (Lg, B); Lower Gulpen Fm., Upper Campanian; coll. KBIN (n° IST 10253); adapical view; × 1,2.*

Fig. 6. *The same; adoral view; × 1,2.*

Fig. 7. *The same; lateral view; × 1,2.*

Fig. 8. *The same; detail of interambulacrum; × 4.*

Fig. 9. *The same; detail of ambulacrum; × 4.*