GEOLOGICA CARPATHICA, AUGUST 2005, 56, 4, 317–326

# *Geinitzaster* gen. n. (Asteroidea, Echinodermata) from Upper Cenomanian strata of the Bohemian Cretaceous Basin

JIŘÍ ŽÍTT

Institute of Geology, Academy of Sciences of the Czech Republic, Rozvojová 135, 165 02 Praha 6, Czech Republic; zitt@gli.cas.cz

*(Manuscript received February 25, 2004; accepted in revised form December 9, 2004)*

**Abstract:** A new genus, *Geinitzaster,* is erected for *Oreaster decoratus* Geinitz, 1871, originally described from the Upper Cenomanian of Saxony, Germany, and recently found also in the Upper Cenomanian of the Bohemian Cretaceous Basin. This enigmatic asteroid species lived in nearshore environments and is now known from only four localities in Bohemia: Předboj, Kuchyňka near Brázdim, Radim and Velim-Veronika. The morphology of the dissociated ossicles is studied in detail and the function and position of individual ossicle types in the asteroid skeleton are discussed.

**Key words:** Cenomanian, Bohemian Cretaceous Basin, morphology, Echinodermata, Asteroidea, new genus.

## Introduction

Isolated asteroid ossicles described as *Oreaster decoratus* by Geinitz (1871) from the Upper Cenomanian of Saxony show a peculiar morphology. Preliminary assignment to this species of some Bohemian specimens have now been confirmed after a recent study (2000) of Geinitz's originals in the Staatliches Museum, Dresden. Additional material was subsequently extracted from the Bohemian samples of an asteroid project (grant GACR 2001–2003). Renewed excavations at the locality of Kuchyňka near Brázdim have also yielded important new material, including a set of asteroid ossicles. Some specimens were also collected at Radim. Thus, the number of ossicles known from Bohemia far exceeds the Saxonian material, providing a good basis for a more complete study of ossicle variation. From Bohemia, the species was first briefly mentioned by Žítt (in press a); in the present paper its morphology is described in detail and the functional types of skeletal elements are discussed.

## Geographical and stratigraphic settings

The localities of Předboj, Kuchyňka, Radim and Velim-Veronika (Fig. 1) are situated near the southern margin of the Bohemian Cretaceous Basin in central Bohemia.

The most recent accounts of the geology and paleontology of the Předboj site are those by Žítt (1993) and Žítt et al. (1999a). The section, in a completely filled old quarry, was reconstructed on the basis of field documentation and samples supplied by O. Nekvasilová (Žítt et al. 1999a) as well as on published data (Svoboda 1986). The Proterozoic lydite bedrock is transgressively overlain by a relatively thin (about 2 m thick) succession of conglomeratic rocks, upon which follow siltstones. The asteroids come from the silty to carbonate matrix of a coarse-grained conglomerate about 1.5 m above its base. The age of this matrix is Late Cenomanian, more specifically, the boundary interval of the *Rotalipora cushmani* and the overlying *Praeactinocamax plenus* Biozones.

The Kuchyňka section, situated in a quarry on the southwesterly slope of Kuchyňka Hill near Brázdim, was described by Záruba (1948) and Žítt et al. (1999b, 2002). The asteroid ossicles studied come from the top and median portions of the coarse-grained lydite conglomerate, overlain by siltstones. The conglomerate matrix is formed by yellowish to whitish sand with a relatively rare macrofauna. The ossicles of *Geinitzaster* were collected by washing the sand. The asteroid ossicles are associated with small gastropods, echinoids, rare bra-


**Fig. 1.** A sketch map of the Bohemian–Saxonian Cretaceous Basin (shaded) showing localities of *Geinitzaster decoratus* (Geinitz). **1** — Předboj, **2** — Kuchyňka near Brázdim, **3** — Radim, **4** — Velim-Veronika.

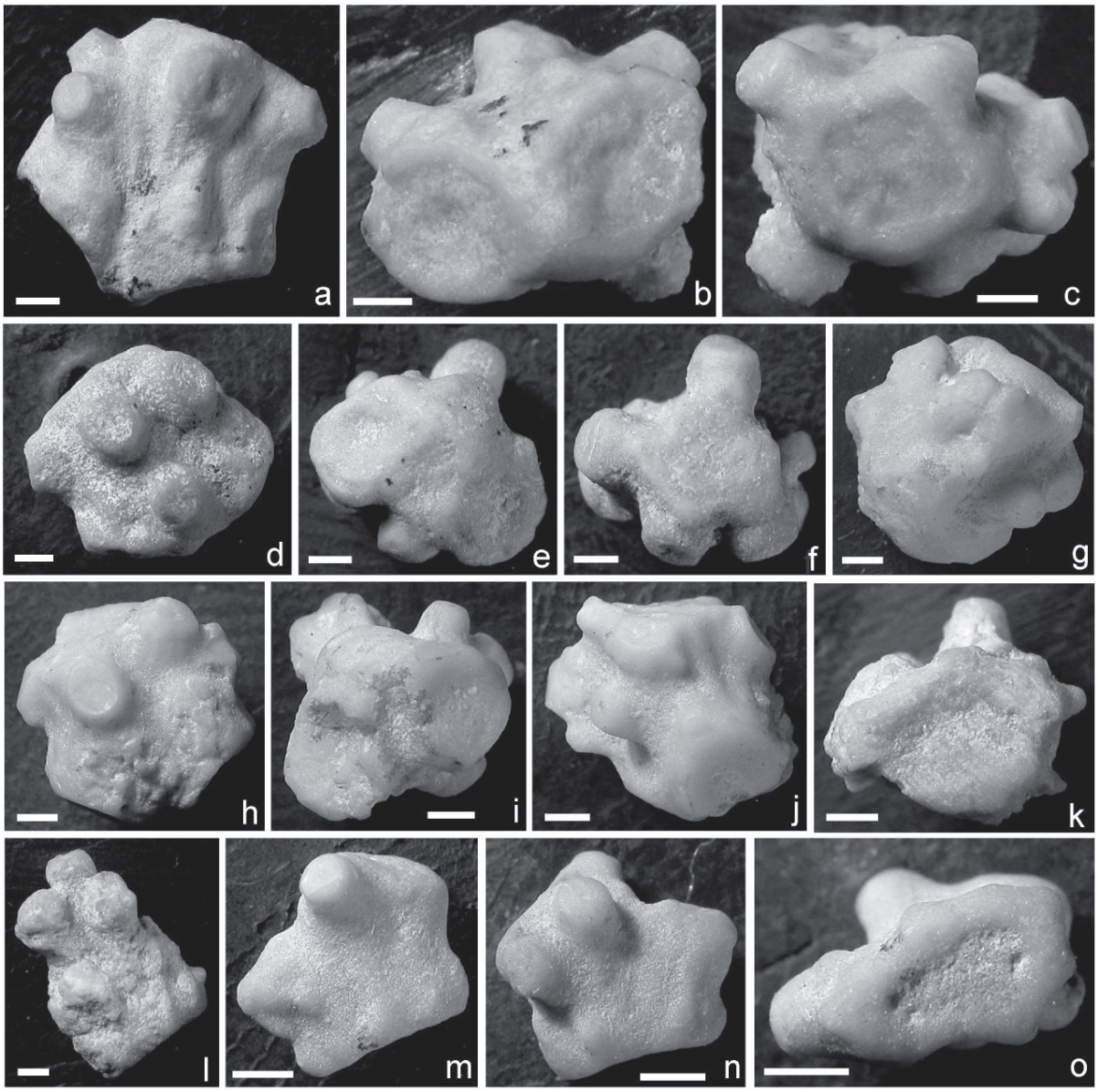


**Fig. 2.** *Geinitzaster decoratus* (Geinitz), ossicles of type A. **a–c** — No. O 6339, Kuchyňka near Brázdim; **d–f** — No. O 6340, Předboj; **g–j** — No. O 6341, Velim-Veronika; **k, l** — No. O 6342, Kuchyňka near Brázdim; **m–o** — No. O 6343, Předboj. All specimens are housed in the National Museum, Prague. Scale bars represent 1 mm.

chiopods, worms, bivalves, rudists (*Araeopleura* sp., *Ichthyosarcolites* sp.), amongst other faunal elements (see Žítt et al. 2002). A find of the belemnite *Praeactinocamax plenus* (Blainville) was mentioned by Klein (1952). The overall character of the macrofauna (including the asteroid ossicles studied here) is partially or fully identical to that of the Předboj section (see above) and confirms the Late Cenomanian age of these sediments.

The Radim section has not been precisely described yet, although it was mentioned by Ziegler (1982) and Žítt (1992). Rare asteroid material was found together with other macrofauna (e.g. the rudist species *Radiolites undulatus*) in reddish siltstones to limestones with gneiss clasts filling the basal parts of a depression several meters deep, eroded in the crystalline bedrock during the Cretaceous transgression. The macrofaunal taphocoenosis is of the Předboj type, which may indicate a similar age for this horizon.

The Velim-Veronika section is situated in the western part of an abandoned quarry near Velim. This section is close to the well-known Velim-Václav section (e.g. Žítt & Nekvasilová 1994, 1996; Žítt et al. 1997; Žítt in press b). The rather complex filling of the deep depression is formed by Late Cenomanian, coarse-grained conglomerate overlain by claystone passing upwards into siltstone with sponges. The basal parts of the northern side of the conglomerate body have yielded finds of *Geinitzaster decoratus*, occurring in a highly fossiliferous (large oysters, brachiopods, corals, echinoid remains, worms, etc.) sandy–clayey limestone matrix among large boulders. The conglomerate was dated as Late Cenomanian (Žítt et al.1997) on the basis of foraminifers (a low-diversity

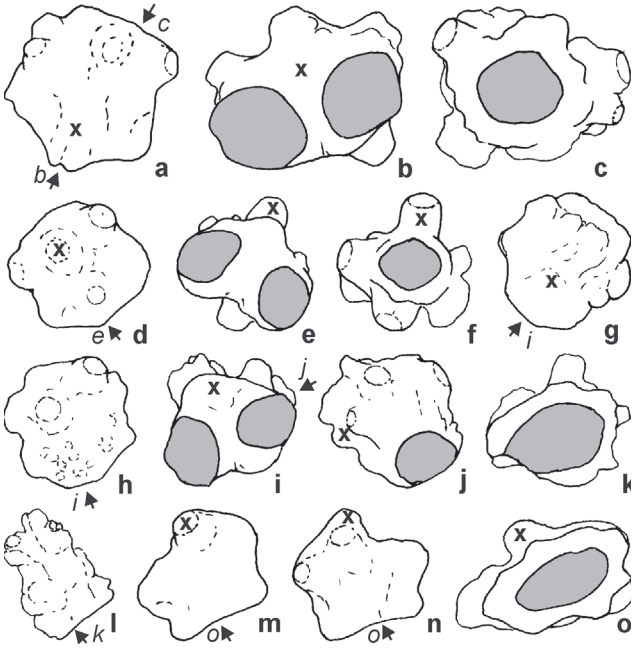


**Fig. 3.** A sketch complementing Fig. 2 in showing simplified morphology, location of articulation facets (shaded), position and orientation of different views (arrow with the respective letter; letter x placed inside some drawings). For data on specimens including their dimensions, see Fig. 2.

association with *Guembelitria cenomana* Keller). This age is also supported by finds of *Praeactinocamax plenus* and the brachiopod *Thecidiopsis bohemica* Backhaus.

## Material and preservation

The asteroid ossicles are very rare in all strata studied, and the available material represents collecting efforts over a number of years. The Předboj specimens were collected by O. Nekvasilová during her brachiopod studies in 1960–1970 before the quarry was infilled. The total number of ossicles is 30. Sediments from Kuchyňka, Radim, and Velim-Veronika were washed in large volumes mainly by the present author. From Kuchyňka section, a total of 64 ossicles were collected by washing of about 80 kg of the sandy conglomerate matrix. Weathered portions of reddish to yellowish, relatively hard silty limestone to siltstone (about 40 kg in total) from Radim were washed between the 1980s and 2002 and have yielded only 16 ossicles. Only two — albeit highly typical — *Geinitzaster* ossicles were found in old residues from Velim-Veronika carried out in collaboration with O. Nekvasilová in 1972. No additional specimens were found at this site despite washing tens of kilogrammes of sediment (yellowish sandy bioclastic conglomerate matrix) over several years.

The preservation of the ossicles is nearly identical at all localities. It is important to note that ossicles with high processes are mostly completely preserved, and that breakage of the processes is rare (e.g. Fig. 4a,j). Primary fragmentation of part of one ossicle was encountered in the Kuchyňka sands. However, secondary fragmentation occurred frequently during washing of these sands, and several specimens were lost due to dense fracturing and resultant fragility. In spite of the mostly complete preservation of individual ossicles, their surface features often show a slight abrasion. Such cases can be attributed to the effect of slight — otherwise non-destructive — mechanical wear (possibly by sand grains) in combination with later diagenetic dissolution. As a result, some morphological details (e.g. articulation facets) are partly obscured and, occasionally, the morpho-functional types of ossicles (see below) are hardly determinable.

The paucity of ossicles of *G. decoratus* in samples is striking, especially in comparison to abundant remains of other, non-echinoderm macrofauna. However, if only asteroids are considered, the scarcity of *G. decoratus* decreases significantly. Ossicle numbers of other asteroid species (mainly Goniasteridae and Stauranderasteridae) in the samples studied range mostly from tens to a few hundreds (Předboj) only. The overall rare occurrence of asteroids is obvious from all studied Cenomanian samples, in contrast to those from some basal Early Turonian deposits (Žítt in press a).

## Systematic description

Asteroidea de Blainville, 1830
Order: ?Valvatida Perrier, 1884
Family: unknown, probably new

*Geinitzaster* gen. n.

**Derivation of name:** After H.B. Geinitz, German paleontologist and geologist, who first described the present species.

**Type species:** *Oreaster decoratus* Geinitz, 1871, by monotypy.

**Type horizon and locality:** Untere Pläner at Plauen, Saxony, Germany. Upper Cenomanian.

**Diagnosis:** The unknown skeleton comprising large, massive ossicles with one or more cylindrical projections on their outer faces to which spines or tubercles articulated. Some ossicles, probably from the disc or in dorsal, proximal arm portions, are tall with outer faces around and distally articulated with similar elements terminated by spine bases. Probable marginals are mostly elongated (i.e. wide). Probable superomarginals vary widely, some of them being tall, others rather flat. Some superomarginal-like elements have wedge-like facets abradially. Adambulacral-like ossicle massive, with a single spine base on the outer face. Probable abactinals are simple plates with mostly one spine base and small facets around.

**Remarks:** The species described as *Oreaster decoratus* most probably has nothing in common with the genus *Oreaster* which comprises only Recent forms as does the family Oreasteridae Fisher, 1911. In the past, this name was used for species of unknown affinities; Geinitz had probably noted the apparent similarities to Forbes's (1848) species *O. coronatus* (later *Stauranderaster coronatus*; see Spencer (1907)). Spencer (1913) placed Geinitz's species tentatively as belonging in *Stauranderaster*, noting that it could well be related to a number of Jurassic genera. The systematic position of *Geinitzaster*

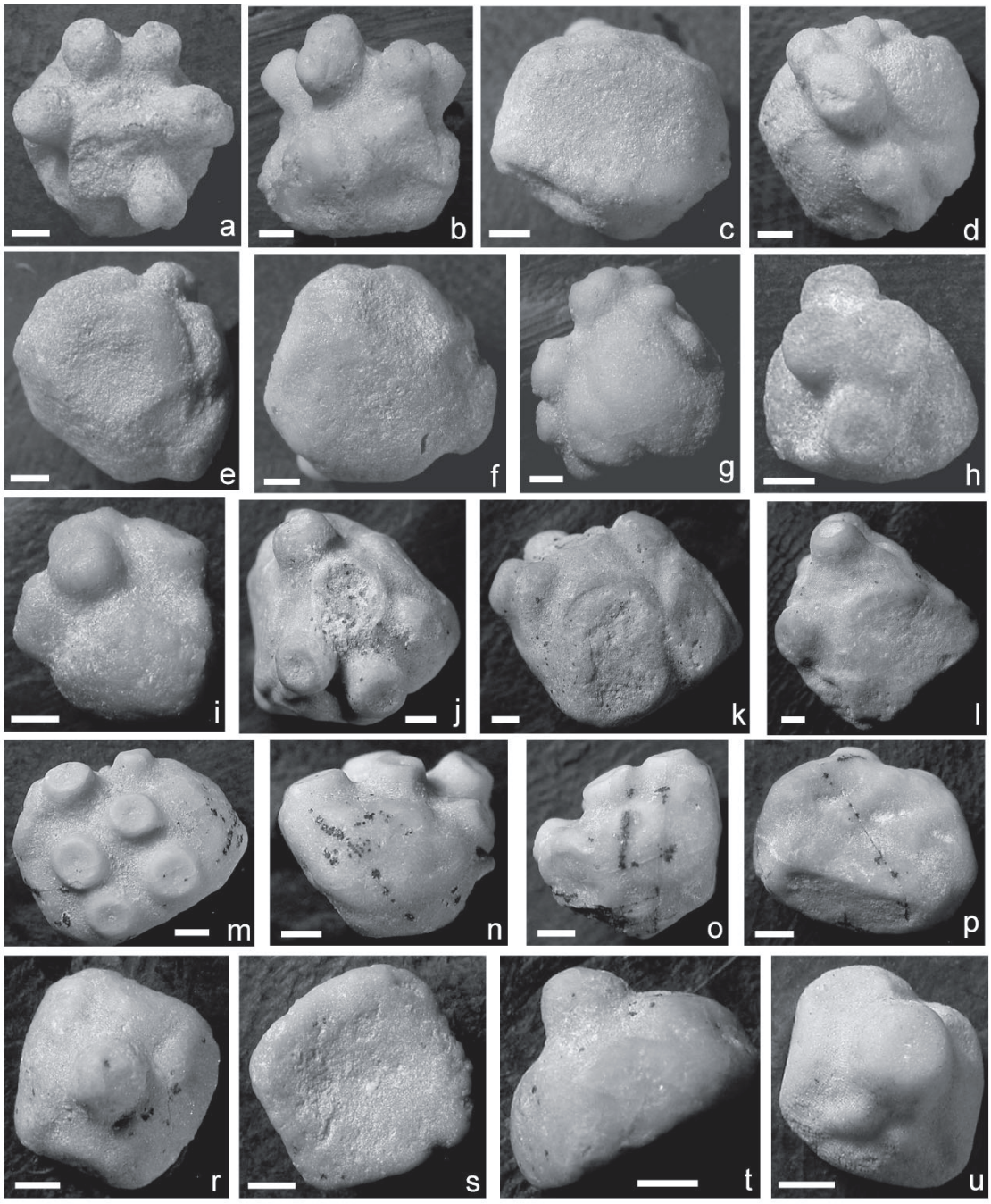


**Fig. 4.** *Geinitzaster decoratus* (Geinitz). **a–c** — Ossicle of type B, No. O 6344 (a — distal view), Radim; **d–g** — ossicle of type D, No. O 6345 (d — distal view), Radim; **h–i** — ossicle of type D, No. O 6346 (h — distal view), Radim; **j–l** — ossicle of type E, No. O 6347 (j — distal view), Předboj; **m–p** — ossicle of type F, No. O 6348 (m — distal view), Předboj; **r–t** — ossicle of type C, No. O 6349 (r — distal view), Předboj; **u** — ossicle of type C, No. O 6350 (distal view), Radim. All specimens are housed in the National Museum, Prague. Scale bars represent 1 mm.

gen. n. needs additional comparative studies; these are beyond the scope of the present paper.

*Geinitzaster decoratus* (Geinitz, 1871)
Figs. 2–9

**Type specimens:** Specimen SAK 6454, contained in the type series (Geinitz 1871, Pl. 22, Fig. 28), is here designated lectotype (Staatliches Museum collections, Dresden). Other specimens in the type series (Geinitz 1871, Pl. 22, Figs. 29, 31–33; Nos. SAK 6455–6458), also housed in the Staatliches Museum collections, are paralectotypes. The originals of Geinitz's (1871, Pl. 22, Figs. 26 and 30; Pl. 23, Figs. 1–6) could not be traced in these collections; their taxonomic position can therefore not be evaluated.

**Type horizon and locality:** Untere Pläner at Plauen, Upper Cenomanian, Saxony, Germany.

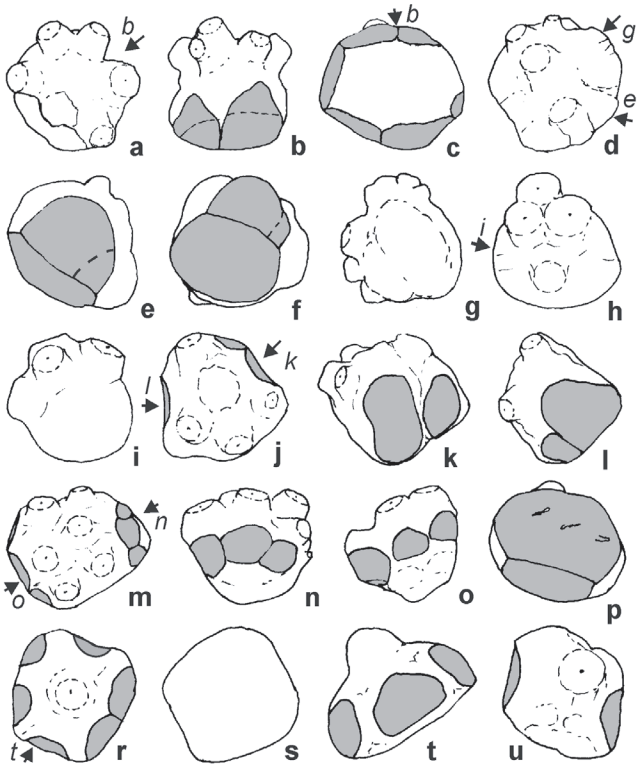


**Fig. 5.** A sketch complementing Fig. 4 in showing simplified morphology, location of articulation facets (shaded), position and orientation of different views (arrow with the respective letter). For data on specimens including their dimensions, see Fig. 4.

**Material:** Předboj — 30, Kuchyňka near Brázdim — 64, Radim — 16, Velim-Veronika — 2 isolated ossicles.

**Description:** Ossicles are basically of eleven morphological types, designated herein as A–K. All these, except for types C and I–K, may attain considerable sizes. Some terminological problems in the descriptions arise from the imprecisely known position in the skeleton of the majority of ossicles. The terms 'distal' and 'proximal' are used herein for each ossicle as if growing from basal faces or facets (proximal part) upwards or downwards to the outer face and tips of cylindrical bases of spines (distal part). The term 'lateral' facets is used without stating which of these is distal and proximal. The term 'subvertical' refers to each lateral flat structure (e.g. facet) on the ossicle oriented proximally downwards or upwards. The term 'adradial'(?) refers to parts of an ossicle to which some smaller elements clearly articulated close to each other in the way of articulation between, e.g. median superomarginals and abactinals (Breton 1992; aborals by Gale 1987) in *Metopaster*-like goniasterid.

A-type is based on five figured and six additional specimens (2 — Předboj, 2 — Kuchyňka, 2 — Radim). Ossicles are elongated and more or less flattened, with well-defined proximal and distal ends. The flattened sides (i.e. outer face) bear irregularly distributed cylindrical processes (Figs. 2, 3) serving as bases for unknown spines. These bases, especially the longer ones, are inclined so that they point obliquely upwards (distally) (Figs. 2a,g, 3a,g). Two articulation facets are present on the proximal end of the ossicle. They are separated from each other in the ossicle plane of symmetry and are arranged in a roof-like manner, meeting under obtuse angles, with the ridge oriented proximally (Fig. 2b,e,i). One suboval facet, somewhat smaller, lies on the distal end of the ossicle (Fig. 2c,d). The distal elements articulated with this facet. These elements can be elongated, ending distally in a bundle of cylindrical bases of spines (Figs. 2l, 3l), or even flattened with another small facet distally, to which an unknown, small end-element undoubtedly articulated, possibly in the form of a large, spine-like process (Figs. 2m,n, 3m,n). Proximal facets of these elements are figured in Figs. 2k,o and 3k,o.

B-type is based on one figured and one unfigured (Radim) ossicle. High crown-like massive ossicles of circular outline in distal view (Figs. 4b, 5b). The margin of the distal end bears six cylindrical spine bases with central pores in their distal facets. Subvertical articulation facets are visible in lateral and proximal views, each composed of two parts: a shallow distal one and a deeper proximal one (Figs. 4b, 5b). In total, 6 facets are present (Fig. 5c).

C-type is based on two figured and two unfigured (Radim) ossicles. Relatively small, bilaterally symmetrical ossicles with mostly only one cylindrical spine base in the centre of the outer surface (Figs. 4r,t,u, 5r,t,u). The ossicles are approximately quadrangular in proximal or distal views, with six (Figs. 4r,t, 5r,t) or two (Figs. 4u, 5u) flat or slightly concave lateral articulation facets. The proximal (internal) face is flat or slightly concave, without any structure (Fig. 4s).

D-type is based on three figured and two unfigured (Předboj) ossicles. Large, massive, rather tall ossicles (Figs. 4d–g,h–i, 5d–g,h–i, 6a–c, 7a–c). They are mostly bilaterally symmetrical. Several cylindrical spine bases on the outer face are arranged in the plane of symmetry (Fig. 4d,h); this condition may be only approximative in some specimens (Fig. 6a). The inclined lateral parts of the outer face are convex (Fig. 4i) or divided into two convex lobes (Figs. 4g, 5g). Two articulation facets are possibly present, the first of them situated on the slightly overhanging end of the ossicle (see the upper facet in Fig. 5e,f) and slightly concave; the second, very extensive, flat and indistinct, meets the first one under an obtuse angle (ossicles in Fig.4d and 4i lie on this second facet). The first articulation facet in another specimen (Figs. 6c, 7c) is divided into two parts. This ossicle is positioned with this facet down in Figs. 6b and 7b. The shallower second facet (face?) of this ossicle is divided into 2–3 parts as if articulated by several smaller elements (Fig. 6c).

E-type is based on one figured and two unfigured (Předboj) ossicles. Large and massive, bilaterally symmetrical ossicles (Fig. 4j), to some extent similar to those of D-type. However, the lateral subvertical articulation facets are developed (Figs. 4k,l, 5k,l). The ossicle is wedge-shaped in aboral view. Its wider end has three small subvertical facets (situated on downwardly directed part in Fig. 4j). The most proximal part is flat or slightly concave and probably represents another articulation surface. This surface can be divided into two parts: one flat and the other slightly concave (unfigured ossicles, Předboj), similar to those in type F (Figs. 4p, 5p).

F-type is based on three figured ossicles. Ossicles with mostly low cylindrical bases for spine articulation on outer

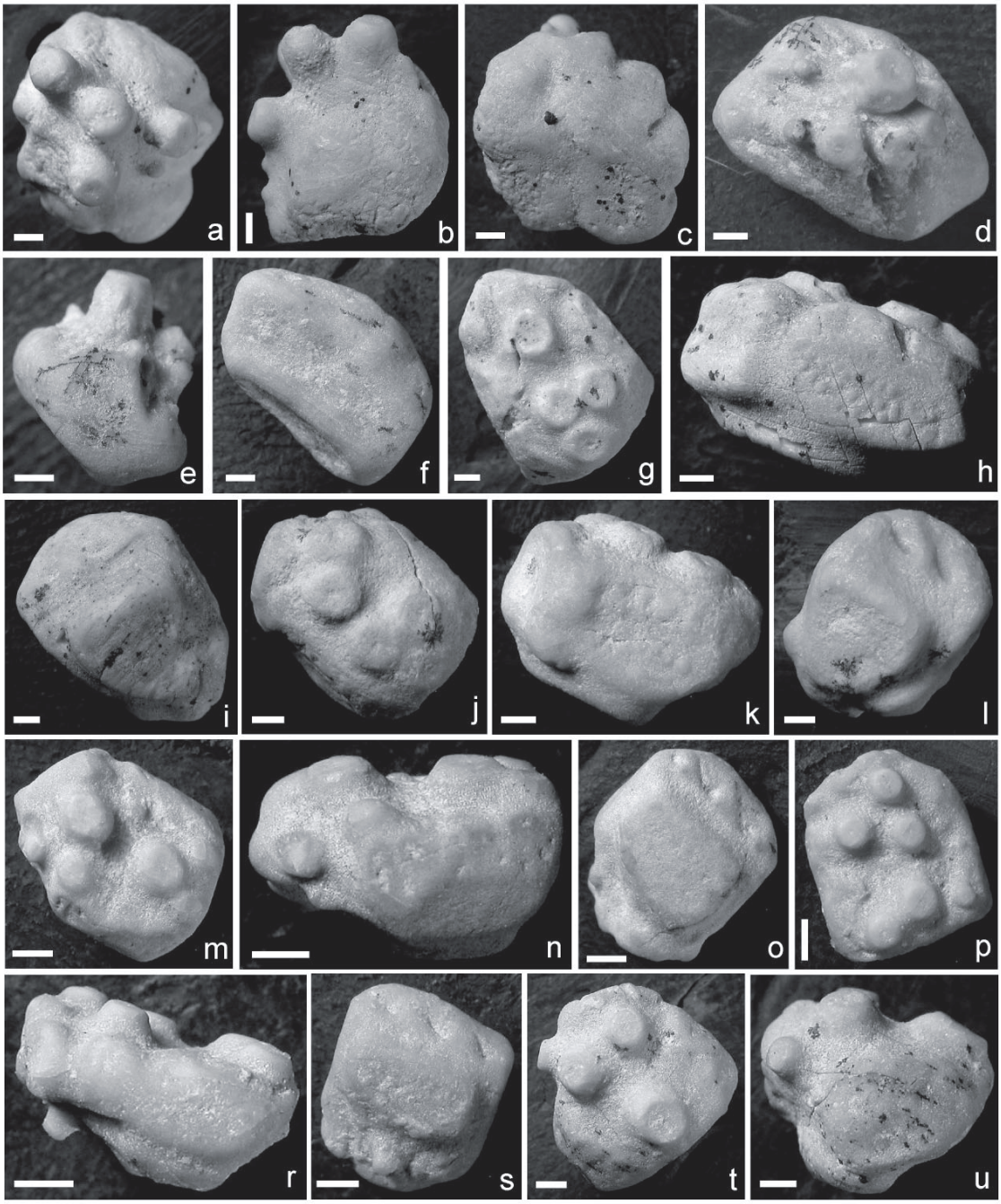


**Fig. 6.** *Geinitzaster decoratus* (Geinitz). **a–c** — ossicle of type D, No. O 6351 (a — distal view), Předboj; **d–f** — ossicle of type F, No. O 6352 (d — distal view), Předboj; **g–i** — ossicle of type H, No. O 6353 (g — outer view), Předboj; **j–l** — ossicle of type H, No. O 6354 (j — outer view), Kuchyňka near Brázdim; **m–o** — ossicle of type I, No. O 6355xxx (m — outer view), Předboj; **p–s** — ossicle of type I, No. O 6356 (p — outer view), Předboj; **t, u** — ossicle of type F(?), No. O 6357 (t — outer view), Předboj. All specimens are housed in the National Museum, Prague. Scale bars represent 1 mm.

face (Figs. 4m, 6t). Some of these bases are, however, longer (Fig. 6e). Ossicles bear partly lateral, partly adradial (?) and partly proximal facets. Lateral subvertical facets are 1–3 in number, situated on opposite ends of ossicles (Figs. 4n,o, 6e,u). They are sometimes indistinct and obscured (Fig. 6e,u). The most proximal facets are well defined and concave (positioned downwards in Figs. 4p, 5p, 6f, 7f). The adradial (?) facet is in fact formed by 2–3 smaller facets which resemble those on, e.g. the adradial part of median marginals in *Metopaster* (Figs. 4p, 6f).

G-type is based on one figured ossicle. Massive, bilaterally symmetrical ossicle with the outer surface bearing one large and one small side bases for spines. Four large lateral facets, two lying on opposite sides, are oriented obliquely downwards (Figs. 8b, 9b) but do not intersect. The remaining two facets are smaller and subvertical (Figs. 8a, 9a).

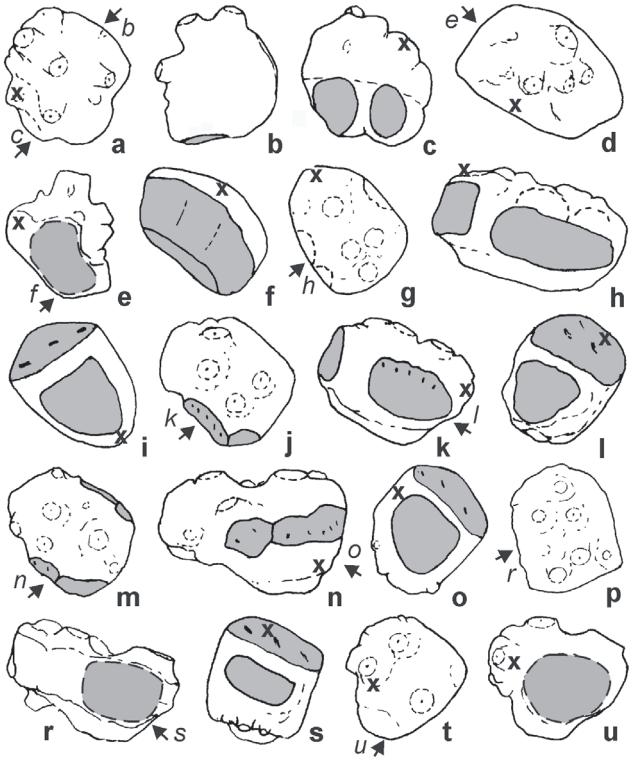

**Fig. 7.** A sketch complementing Fig. 6 in showing simplified morphology, location of articulation facets (shaded), position and orientation of different views (arrow with the respective letter; x placed inside some drawings). For data on specimens including their dimensions, see Fig. 6.

H-type is based on two figured and two unfigured (Předboj) ossicles. Elongated ossicles with very low bases for spine articulation. The narrower end is cut in a wedge-like manner (much like in A-type ossicles), with two facets (Figs. 6g,h,j,k, 7g,h,j,k).

I-type is based on 2 figured ossicles. They have only an outer surface on their narrower end, with bases for spines. This surface passes up to the opposite side of this ossicle part. The ossicle extremity thus bears no articulations with other ossicles (Fig. 6n,o,r,s).

All ossicles of H and I-types bear long subvertical facets laterally, with distinct articulation structures (tubercles, granules). Several (possibly 5–6) smaller facets are situated above one long facet (Fig. 7k,n; unclear situation in Fig. 7g,h — probable facet outlines are dashed). The obliquely oriented adradial (?) surface bears one (Fig. 6i) to three facets, which are obliquely orientated with respect to the outer ossicle faces (Fig. 6l,o,s). The proximal facet is flat and lies on a socket-like elevation, thus separated from the adradial (?) facet (Figs. 6l,o,s,u, 7l,o,s,u).

J-type is based on one figured and one unfigured (Radim) ossicles. Small ossicles of irregular shape with outer face bearing several small and low bases for spines (Fig. 8f,h). The articulation facets are not clearly developed but at least one small facet seems to be present. Large basal face (marked by grey fill together with a small facet separated by a dashed line in Fig. 9g) may in fact be an inwardly directed ossicle face without articulatory function.

K-type is based on one figured and one very poorly preserved unfigured ossicle (Kuchyňka). Enigmatic, small but massive ossicles, preserved fragmentarily. One low cylindrical base for a spine occurs on the small outer face (directed downwards and to the right in Fig. 8e). The element is elongated (viewed axially in Fig. 8e), bounded by poorly defined faces, bearing depressed articular facet-like areas on the extremities (see Fig. 8e for one of them).

**Remarks and relations:** The ossicles described by Geinitz as *Oreaster decoratus* and restudied by the present author at the Staatliches Museum, Dresden, belong to two of the ossicle types defined herein. The lectotype (SAK 6454) in the Dresden collection, is of H-type but is very large (length 10.6 mm, width 6.8 mm, height 5.6 mm) and differs in having ridge-like articulation structures on the abradial part of the proximal facet. Paralectotype SAK 6455 is similar to the lectotype but somewhat smaller (length 9.6 mm, width 6.8 mm, height 4.3 mm). Paralectotypes SAK 6456–6458 are of C-type with several lateral subvertical facets around. The paralectotypes are, however, larger (6456 — length 9 mm, width 7.3 mm, height 3.5 mm; 6457 — length 6.2 mm, width 6.2 mm, height 2.3 mm; 6458 — length 6.2 mm, width 6.2 mm, height 2.4 mm; compare with Fig. 4r,s,t,u here) than the Bohemian specimens.

The ossicles figured by Frič (1911, p. 76, Fig. 320) coming from his locality Kamýk and referred to as *Oreaster decoratus* could not be traced in the collections of the National Museum, Prague. Because of the poor quality of the illustrations, their systematic affinity remains questionable.

Although not described in detail, Jagt (2000, p. 489, Pl. 20, Figs. 21,22) illustrated two dissociated ?marginals from the lower Upper Campanian of Benzenrade-de Wingerd (the Netherlands) that bear a certain resemblance to the Bohemian material. Closer comparisons are, however, needed.

## Notes on skeletal structure

Ossicles of A-type articulated to unknown ossicles along their paired facets. Because all the lateral portions of these ossicles are formed by outer structures, that is by outer surface with cylindrical bases for spines, the ossicles must have been oriented from the body outwards. This orientation is confirmed by the slightly oblique (as if directed slightly upwards) position of bases for spines. Ossicles of A-type were occasionally tall, also comprising some additional, yet more distally articulated ossicles. Ossicles of A-type probably formed part of the dorsal skeleton of the disc or proximal arm portions.

Ossicles of B-type, which have lateral facets around the whole base, must have been surrounded by smaller plates all around. This is possible only on the aboral disc surface (primary plates?) or in aboral (upper) arms. If the asteroid had more heavily plated arms, these ossicles could have been located even in their more distal parts. The more or less well-developed radial symmetry of the ossicle shows a central position (i.e. in the plane of arm symmetry).

Ossicles of C-type are rather small and flat and may represent a type of abactinal. The position and orientation of the

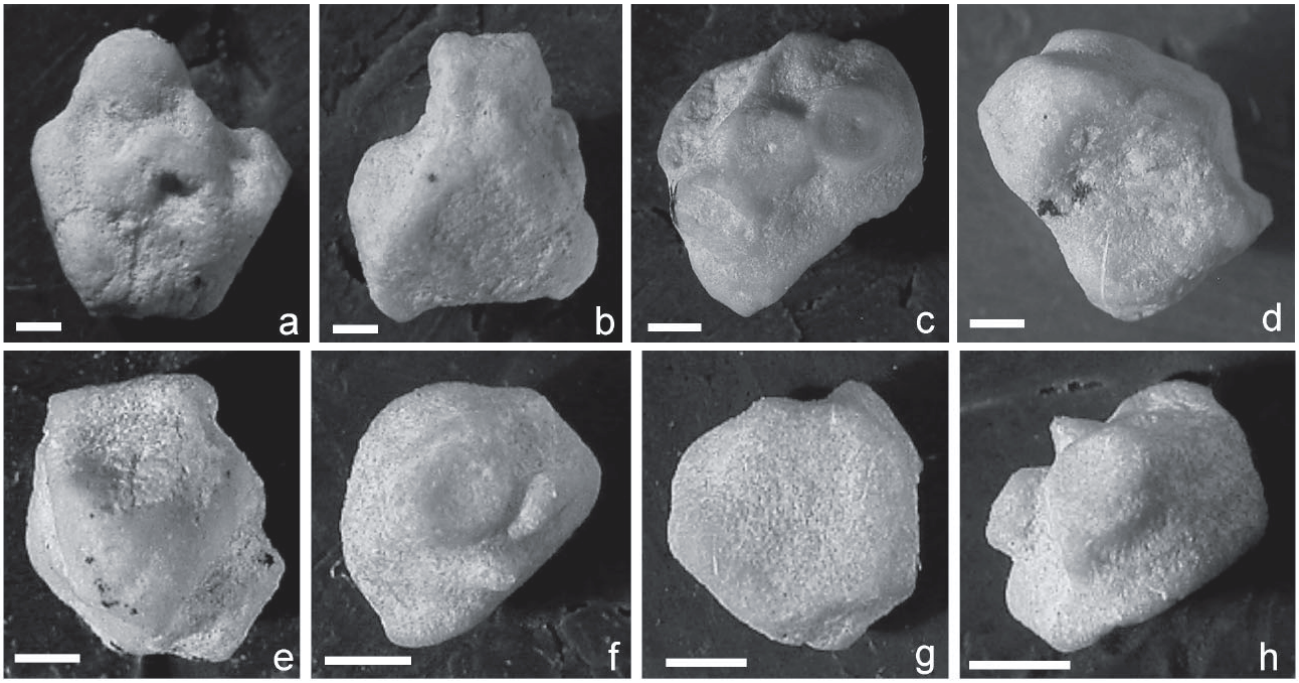


**Fig. 8.** *Geinitzaster decoratus* (Geinitz), ossicles from Kuchyňka. **a, b** — ossicle of type G, No. O 6358 (lateral views); **c, d** — fragmentary ossicle of indeterminate type, No. O 6359 (c — distal view); **e** — ossicle of type K, No. O 6360; **f–h** — ossicle of type J, No. O 6361 (f — distal view). All specimens are housed in the National Museum, Prague. Scale bars represents 1 mm.

facets is, however, close to that of B-type, which indicates possibly a similar position in the skeleton.

Ossicles of D-type, as indicated by the type of their two facets and bilateral symmetry, could have belonged to the marginal disc structure.

Ossicles of E-type, as indicated by their large lateral facets and their wedge-like shape, could have formed part of the marginal structure probably lying interradially in a superomarginal position. They probably occurred as solitary elements between the laterally positioned smaller elements of variable size. The narrowed part of the ossicle onto which the outer ossicle face continues was directed outwards, because the wider side bears facets for articulation with some small elements (another type of abactinals?).

Ossicles of F-type formed part of the marginal frame, most probably superomarginal, of the arms. Their clearly defined adradial (?) facets probably articulated with small abactinals in the arms. The facet referred to as proximal in this paper may in fact be the intermarginal facet, to which the inferomarginal articulated. The lateral small facets of one ossicle (Fig. 4n,o), however, show that the lateral contact between these large superomarginals was only weak and that additional small plates were present here. The other ossicle of F-type laterally has only one large, albeit indistinct, facet (Fig. 6e). Nevertheless, the orientation of the bases for spines (obliquely upwards) seems to confirm the superomarginal position of this element (the orientation of ossicle in Fig. 6e corresponds to this position in the skeleton).

Ossicles of G-type have features of A-type (two obliquely oriented facets lying on opposite sides) but there are two other smaller facets in 90° position relative to the above ones. The

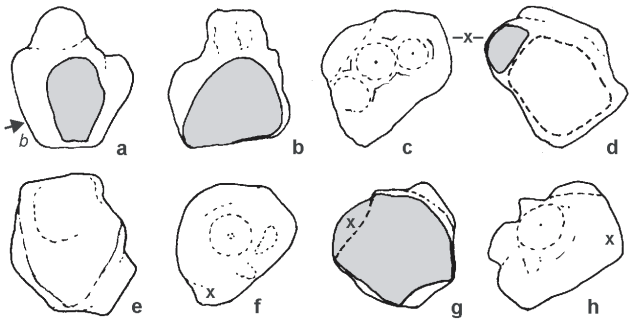


**Fig. 9.** A sketch complementing Fig. 8 in showing simplified morphology, location of articulation facets (shaded), position and orientation of different views (arrow with the respective letter; letter x placed inside some drawings). For data on specimens including their dimensions, see Fig. 8.

facets all around the base thus indicate a position among several other ossicles, similar to the ossicles of B and C-types.

Ossicles of H-type are somewhat enigmatic because the wedge-like lateral and the adradial (?) facets are both developed (see e.g. Fig. 7j–l). This ossicle may be tentatively interpreted as a special type of superomarginal, which adradially articulated with smaller, possibly abactinal plates, and was directed abradially (to the margin of the disc or arm) with the wedge-like articulation of opposite ossicle side. If two such elements were present next to each other, a small (unknown) adjacent superomarginal or other plate could have articulated in a triangular wedge-shaped gap. The ossicle in Fig. 6t–u slightly differs in having one larger facet abradially and one smaller asymmetrically positioned facet.

Ossicles of I-type, similar to H-type but having an outer surface instead of roof-like articulation (Fig. 7p–s), could well represent a type of marginal element (possibly inferomarginal). The adradial facet articulated with actinolaterals and that designated here as proximal may in fact be the intermarginal one. Low bases for spines indicate a possible ventral (adoral) position for this ossicle type. Up- and outwardly directed bases for spines (see Fig. 7r, the element is inversely oriented here) on the free end of the ossicle could have served for defence of lateral portions of the marginal frame.

The small ossicles of J-type probably functioned as plates filling irregular spaces between larger ossicles.

Ossicles of K-type are poorly preserved but their function as adambulacrals should be considered. A large, probably short tubercle articulated on the oral side of the element.

## Conclusion

On the basis of study of rich Bohemian material (Upper Cenomanian) and in part on Geinitz's original type series of *Oreaster decoratus* (Upper Cenomanian, Germany), the new genus *Geinitzaster* gen. n. is erected. In spite of detailed morphological study, there are many uncertainties regarding ossicle types and their position in the skeleton. The immense morphological variability of these ossicles (i.e. practically no element is exactly identical with any other, in contrast to the pronounced and clearly differrentiated ossicle types in the majority of, e.g. goniasterids), points to rather wide variation in the skeleton composition if viewed in detail (irregularities in the size and shape of plates and their mutual articulations) while the body appearance was generally identical. The body could have possessed massive arms with small ossicles irregularly filling the gaps between the large ones. The high tufts of spines dispersed on the body gave the asteroid the appearance of a rough and uneven object. The overall aspect could well have served for protection against predation and for masking on the uneven rocky bottom or on coarse-grained clastic stretches.

The results of the present study of *Geinitzaster* ossicles call for future comparative studies of all materials known in the world. The author hopes that the illustrations and descriptions of the Bohemian material will be of use for such future revisions.

**Acknowledgments:** The author is indebted mainly to Loïc Villier (Marseille) for ideas on the species studied. Hannes Löser (Dresden, presently in Mexico) is thanked for his help during visits to the Staatliches Museum, Dresden. The author is also grateful to O. Nekvasilová (Prague) for providing the Předboj specimens from her collection and to Č. Nekovařík (Prague) for his assistance during excavations at Kuchyňka near Brázdim. The *Geinitzaster* study is a substantial part of the Project No. 206/01/1580 supported by the Grant Agency of the Czech Republic and within the Research Programme Z3 013 912 of the Institute of Geology AS CR, Prague.

## References

Blainville H.M. de 1830: Zoophytes. *Dictionnaire des Science Naturelles*, Paris, 60.

Breton G. 1992: Les Goniasteridae (Asteroidea, Echinodermata) jurassiques et crétacés de France: taphonomie, systématique, biostratigraphie, paléobiogéographie, évolution. *Bull. Trim. Soc. Géol. Norm. Amis Mus. Havre*, hors série, suppl. 78, 4, 1–590.

Fisher W.K. 1911: Asteroidea of the North Pacific and adjacent waters. *U. S. Natl. Mus. Bull.* 76, pt. 1, 1–419.

Forbes E. 1848: On the Asteriadae found fossil in British strata. *Mem. Geol. Surv. Gr. Br.* 2 2, 457–482.

Frič A. 1911: Studies of the Czech Cretaceous strata. Illustrated list of fossils of the Korycany Member (Cenomanian). *Arch. Přírodověd. Výzk. Čech* 15, 1, 1–101 (in Czech).

Gale A.S. 1987: Goniasteridae (Asteroidea, Echinodermata) from the Late Cretaceous of north-west Europe. 1. Introduction. The genera *Metopaster* and *Recurvaster*. *Mesozoic Res.* 1, 1, 1986, 1–69.

Geinitz H.B. 1871–1872: Das Elbthalgebirge in Sachsen. Ester Theil. Der utere Quader. *Palaeontographica* 20, 1–319 Cassel.

Jagt J.W.M. 2000: Late Cretaceous-Early Palaeogene echinoderms and the K/T boundary in the southeast Netherlands and northeast Belgium — Part 5: Asteroids. *Scripta Geol.* 121, 377–503.

Klein V. 1952: Preliminary report on the investigation of the Cenomanian and Lower Turonian surf facies between Kladno and Brandýs n. L. *Věst. Ústř. Úst. Geol.* 27, 155–157 (in Czech).

Perrier J.O.E. 1884: Mémoire sur les étoiles de mer recueillies dans la Mer d'Antilles e tle Golf du Mexique. *Mus. Hist. Nat., Nouv. Arch., Paris* Ser. 2, v. 6, 127–276.

Spencer W.K. 1907: A Monograph on the British fossil Echinodermata from the Cretaceous Formations. Volume Second. The Asteroidea and Ophiuroidea, Part Fourth. *Palaeontographical Society,* London, 91–132.

Spencer W.K. 1913: The Evolution of the Cretaceous Asteroidea. *Phil. Trans. r. Soc. Lond.* B204, 99–177.

Svoboda P. 1986: Upper Cretaceous between Odolena Voda and Neratovice-Byškovice. *Zpr. Stud. Okres. Muz. Praha-východ* 1984**,** 36–44 (in Czech).

Záruba Q. 1948: Rocky coast of the Cretaceous sea near Prague. *Ochr. Přír.* 3, 121–124 (in Czech).

Ziegler V. 1982: Mineralogical, petrographic and paleontological characteristics of the Lom u Radimi protected nature monument. *Bohemia cent.* 11, 17–28 (in Czech).

Žítt J. 1992: A new occurrence of Upper Cretaceous epibionts cemented to the rocky substrates and bioclasts (locality Radim, Czechoslovakia). *Čas. Mineral. Geol.* 37**,** 145–154.

Žítt J. 1993: Regular echinoids from Předboj (Late Cenomanian). *Zpr. Geol. Výzk. v r. 1991*, 151–153 (in Czech).

Žítt J. in press a: Asteroidea in the Late Cretaceous taphocoenoses of Bohemia. *Proc. 11th IEC, Munich, 2003. Balkema/Swets & Zeitlinger Publishers.*

Žítt J. in press b: The asteroid genus *Haccourtaster* (Echinodermata, Goniasteridae) in the Bohemian Cretaceous Basin (Czech Republic). *Cretaceous Research.*

Žítt J. & Nekvasilová O. 1994: Orientation of *Spondylus* valves cemented to the hard-rock substrates (Bivalvia, Upper Cretaceous, Bohemia). *J. Czech Geol. Soc*. 39, 281–295.

Žítt J. & Nekvasilová O. 1996: Epibionts, their hard-rock substrates, and phosphogenesis during the Cenomanian–Turonian boundary interval (Bohemian Cretaceous Basin, Czech Republic). *Cretaceous Research* 17, 715–739.

Žítt J., Nekvasilová O., Bosák P., Svobodová M., Štemproková-Jírová D. & Šťastný M. 1997: Rocky coast facies of the Cenomanian–Turonian boundary interval at Velim (Bohemian Cretaceous Basin, Czech Republic). *Bull. Czech Geol. Surv.* 72, 83–102, 141–155.

Žítt J., Nekvasilová O., Hradecká L., Svobodová M. & Záruba B. 1999a: Rocky coast facies of the Unhošť–Tursko High (Late Cenomanian–Early Turonian, Bohemian Cretaceous Basin). *Acta Mus. Nat. Pragae, B, Historia Naturalis* 54, 1998, 79–116.

Žítt J., Nekovařík Č., Hradecká L. & Záruba B. 1999b: Late Cretaceous sedimentation and taphocoenoses on Proterozoic elevations near Brandýs nad Labem, with main emphasis on the Kuchyňka near Brázdim locality (Bohemian Cretaceous Basin). *Zpr. Stud. Okres. Muz. Praha-východ* 13, 189–206 (in Czech).

Žítt J., Kopáčová M., Nekovařík Č. & Peza L.H. 2002: New data on the Late Cenomanian taphocoenose at Kuchyňka near Brázdim (Bohemian Cretaceous Basin). *J. Czech Geol. Soc*. 47, 55–64.