Late Cretaceous bourgueticrinid crinoids from southern Poland – preliminary observations

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Dissociated skeletal elements of bourgueticrinid crinoids, comprising mostly columnals, radicular cirri, a few cups and some brachials, are recorded from Turonian-Maastrichtian strata of southern Poland (Miechów Trough, Kraków-Częstochowa Upland, Holy Cross Mountains and Opole Trough). Published records of bourgueticrinids from Poland are surprisingly few; only specifically indeterminate columnals, radicular cirri and a sole proximale, plus a single cup of *Bourgueticrinus utriculatus* have been noted. The present material, although limited, clearly demonstrates that these crinoids must have been less rare than anticipated and are, in fact, distributed throughout the entire Upper Cretaceous sequence in this area. The majority of bourgueticrinids had an extensive root system (radicular cirri) and their presence thus allows some conclusions regarding substrate consistency (softground) to be drawn. A striking feature of the present faunules is the small cup size in comparison to material from elsewhere in northern Europe, possibly an ecophenotypical expression. Species distinction within the genus *Bourgueticrinus* is still contentious and we refer to our material in open nomenclature.

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Introduction

Subsequent to Rasmussen's (1978) classification of post-Palaeozoic (articulate) crinoids, the higher-level placement of bourgueticrinids has varied to some extent. Simms (1988) referred them to the suborder Bourgueticrinina within the order Isocrinida. Simms *et al.* (1993) went much further, and proposed to unite the families Bathycrinidae, Phrynocrinidae and Porphyrocrinidae with the Bourgueticrinidae, and place them in the superfamily Solanocrinitacea (infraorder Comatulidia, order Comatulidina). This classification has not generally been accepted; the revised *Treatise* volume on crinoids (Hess and co-workers, research in progress) adopts Simms's (1988) scheme of a suborder Bourgueticrinina within the order Comatulida, a view also favoured here.

In general, bourgueticrinids have rather small, simple, cylindrical or conical cups and proximalia, and stems of variable length which are attached by an irregular terminal

plate (disc) or by branched radicular cirri borne by some distal columnals, and lack genuine cirri. Columnal articulations are synarthrial, a characteristic feature which unites them with the pentacrinoid larval stage of isocrinids and comatulids. In fact, bourgueticrinids appear to have been derived from an isocrinid or comatulid stock through paedomorphosis (Simms, 1988) and their similarity to thiollericrinids accounts for the assignment to the order Comatulida. This view is adopted here.

In Europe and in the former Soviet Union (now Ukraine, Georgia, Kazakhstan, Uzbekistan and Turkmenistan), bourgueticrinids are widely distributed in strata of Late Cretaceous (Turonian-Maastrichtian) and early Paleogene age (Rasmussen, 1961; Klikushin, 1982b; Jagt, 1999), but preservation varies widely. The best material is from obrution deposits of Maastrichtian age in the southeast Netherlands (Jagt *et al*., 1998), comprising numerous more or less fully articulated specimens and closely comparable to 'populations' from the Maastrichtian of Mississippi (Moore, 1967). The youngest representatives of the genus *Bourgueticrinus* are known from the Lellinge Formation in Denmark and are late Paleocene (Rasmussen, 1972). Associated with species of *Bourgueticrinus* in the uppermost Cretaceous and lower Paleogene are members of *Dunnicrinus*, '*Democrinus*' and *Paleobathycrinus*, but the relationships and status of these genera still need to be determined. This peculiar group of articulate crinoids survives to the present day in deep-water settings (Clark, 1973, 1977, 1980; Macurda & Meyer, 1976; Roux, 1976, 1977; Améziane-Cominardi *et al*., 1990; Améziane & Roux, 1997; Donovan, 1997; Mironov, 2000; Roux *et al*., 2002).

In comparison to elsewhere in Europe, records of bourgueticrinids from Poland are surprisingly scanty. Kongiel (*in* Kongiel & Matwiejewówna, 1937) briefly noted and illustrated a handful of columnals and radicular cirri, plus a single proximale from the uppermost Cretaceous (upper Maastrichtian) in the Puławy area (Wisła [Vistula] River valley). Merta (1972) recorded a single cup assigned to *B. utriculatus* (Valette, 1917) from lower Campanian marls exposed at Zabierzów (Kraków-Częstochowa Upland). We concur with that identification, having had the opportunity to examine numerous specimens from the lower Campanian of the Hannover area (northern Germany; see also Jäger, 1979, 1980; Amme, 2005). The most recent account of specifically indeterminate bourgueticrinids is that by Niedźwiedzki & Salamon (2005), who recorded isolated columnals from the upper middle Turonian (*lamarcki* Zone) of Długopole Górne, Sudetes (southern Poland).

Although the present spot samples are limited in scope and content, they do demonstrate that there is far more potential as far as Polish Late Cretaceous bourgueticrinids are concerned. In the near future, specific portions of the sequence will be targeted for bulk sampling, in an attempt to obtain more material, in particular of cups and proximal brachials. Descriptions below are thus preliminary.

Localities and geological setting

The crinoid specimens described herein are derived from comparatively small samples (up to a few tens of kilogrammes), taken more or less at random from a number of outcrops in the Miechów Trough, the Kraków-Częstochowa Upland, the Holy Cross Mountains and in the Opole Trough (Fig. 1). With the exception of the last-named region, all sections sampled are situated in the southeasterly part of the Szczecin-Łódź-

Fig. 1. Map of Poland, showing distribution of Cretaceous strata and locations of sections sampled.

Miechów Synclinorium, the main Alpine (Laramide) tectonic element in extra-Carpathian Poland. In the Miechów Trough and Kraków-Częstochowa Upland, the Cretaceous sequence is divided into two parts, a lower portion comprising Albian to Santonian strata, and an upper comprising the upper Campanian and lower Maastrichtian. In the southwesterly part of the Holy Cross Mountains, the sequence consists of the upper Coniacian, Santonian and lower Campanian (Remin, 2004).

In contrast, the Opole Trough formed the Circum-Sudetic Trap Basin which surrounded the Sudetic Islands, and as such it was genetically connected to the Bohemian, Saxonian and northern Sudetic basins. The Cretaceous sequence here comprises the uppermost Cenomanian, Turonian and Coniacian (Niedźwiedzki & Kalina, 2003; Niedźwiedzki & Salamon, 2005).

In total, twenty-eight localities exposing Cenomanian to Maastrichtian strata were sampled. Samples were washed and residues hand picked; only seven (Fig. 2) of these

yielded crinoid material in the Turonian-Maastrichtian interval, as follows.

Zabierzów – Less than 10 m of section are exposed; upper Turonian strata (thickness 2 m) consist of grey limestones, unconformably overlying Upper Jurassic deposits. Upper Santonian-lowermost Campanian glauconitic marls reach a maximum thickness of *c*. 8 m (see Merta, 1972). Samples were taken from all intervals.

Wierzchowisko – The section exposed, not exceeding 6 m, consists of siliceous chalk (opoka in Polish literature) intercalated with lower Campanian marls (Jagt *et al*., 2004). Samples were collected from a marly intercalation in the uppermost part of the section (Fig. 2).

Rzeżuśnia – A total of 20 m of upper Campanian opoka with flints and intercalated with marls are exposed (Jagt *et al*., 2004). Samples were taken from the middle part of the section, where most of the marly intercalations occur (Fig. 2).

Podlesie – A <3 m thick sequence of white and grey opoka of the lower Campanian, intercalated with marls and exposed along a steep slope at the northern end of the village. A thin hardground level (0.4 m) is observed at the bottom of the section exposed (Fig. 2).

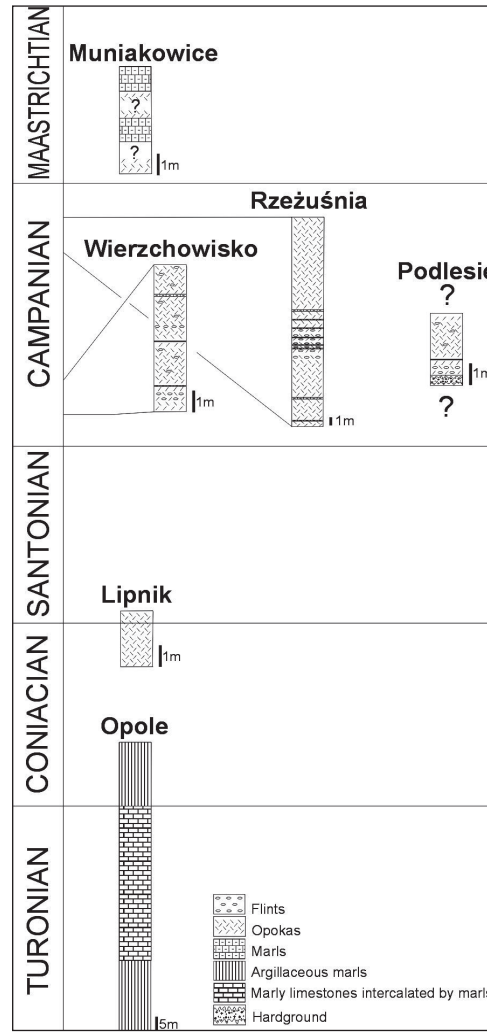

Fig. 2. Lithologs and stratigraphy of sections studied (after Niedźwiedzki & Kalina, 2003; Jagt *et al*., 2004; Remin, 2004).

Muniakowice – A number of working quarries are situated east of the village. These expose dark grey clays and opoka of the lower Maastrichtian, with a maximum thickness of 5 m (Fig. 2; see Kraus & Rutkowski, 1962, for details).

Lipnik – Two localities expose upper Coniacian-lower Santonian strata. The thickness does not exceed 3 m, in a sequence comprising of opoka, marly limestones and marls. Samples were taken from the lowermost Santonian (Fig. 2; see also Remin, 2004, fig. 4).

Opole – Cenomanian sandstones (< 3 m thick) are exposed in a quarry in the northern outskirts of the city. Overlying these are Turonian argillaceous marls, marls and

marly limestones (*c*. 50 m), with at the top Coniacian argillaceous marls (*c*. 25 m) (Fig. 2; see also Walaszczyk, 1992; Niedźwiedzki & Kalina, 2003).

Systematic palaeontology

Material described and illustrated herein is housed in the collections of the Nationaal Natuurhistorisch Museum (Naturalis), Leiden (abbreviation RGM). Morphological terminology follows Ubaghs (1978).

Family Bourgueticrinidae de Loriol, 1882

Remarks – As noted above, we prefer listing our bourgueticrinid material in open nomenclature. Over twenty-five 'species' have been recorded to date (see Table 1), but quite a number of these are based on single cups or proximalia, or a few specimens at best. Hence, almost nothing is known about the range of variation of the various species (see, e.g., Roux, 1987), although many authors agree that certain cup morphologies are typical of particular stratigraphic intervals (see Smith & Wright, 2002). In this respect, there is a close similarity to the way the various 'species' of the holasteroid echinoid genus *Echinocorys* have been treated. The only way out of this taxonomic mess would be to revise type material of the various forms, include newly collected material (wherever possible), analyse this biometrically and in this way determine which particular features of cup morphology are useful for classification. Some authors have already demonstrated or hinted at the importance of pera- and paedomorphic processes (heterochrony) acting on crinoid evolution (not yet fully understood; see Améziane-Cominardi & Roux, 1994; Roux *et al*., 1997; Kjaer & Thomsen, 1999), and noted that groups (families, genera) recognised to date may turn out to be paraphyletic. Here we use the prefix 'ex gr.' to denote that a certain specimen is close to a 'species' identified in the literature, but need not necessarily be conspecific.

Genus *Bourgueticrinus* d'Orbigny, 1841

Type species – *Apiocrinites ellipticus* Miller, 1821, by original designation.

Bourgueticrinus ex gr. *fischeri* (Geinitz, 1872)

Pl. 1, figs. 1, 2.

cf. *1872 *Antedon fischeri* Geinitz, p. 18, pl. 6, figs. 9-12.
cf. 1961 *Bourgueticrinus fischeri* (Geinitz); Rasmussen, p. 185, pl. 27, figs. 12-14.
cf. 1982b *Bourgueticrinus fischeri* (Geinitz); Klikushin, p. 818, pl. 3, figs. 1-8; text-fig. 4G-I.

Material – A single cup (RGM 211 410) from the lowermost Santonian (*Cladoceramus undulatoplicatus* Zone) of Lipnik (see Remin, 2004, fig. 4).

Description – Cup diminutive (height 1.25 mm, lower and upper diameters 0.85 mm and 1.35 mm, respectively), with discrete basal and radial rings; basal height *c*. 73% of radial height; cup markedly conical, sutures well developed and outer surfaces of basals

Table 1. Bourgueticrinid 'species' recorded to date from the Turonian-Maastrichtian (Upper Cretaceous) of Europe and the former Soviet Union, based on literature data and personal observations.

	RASMUSSEN (1961)	**KLIKUSHIN (1975, 1980, 1982a, b, 1983)**	**other authors**
MAASTRICHTIAN	*B. aequalis*	*B. aequalis*	*Dunnicrinus aequalis* [3]
	B. alabamensis	*B. constrictus*	*B.* aff. *brydonei* [3]
	B. bruennichinielseni	*B. crassus*	*B. constrictus* [3]
	B. brydonei	*B. hagenowii*	*B. hagenowii*
	B. constrictus	*B.* sp.	*B.* cf. *utriculatus* [5]
	B. hagenowii	*B. succinctus*	
	B. tenuis		
CAMPANIAN	*B. alabamensis*	*B. baculatus*	*B.* aff. *baculatus* [3]
	B. brydonei	*B. bellus*	*B.* sp.[2]
	B. cylindricus	*B. constrictus*	*B. hureae* [3]
	B. elegans	*B. elegans*	*B.? suedicus* [3]
	B. ellipticus	*B. ellipticus*	*B. utriculatus* [4]
	B. fritillus	*B.* sp.	*B. fritillus*
	B. granulosus	*B. sulcatus*	*B.* sp.
	B. hureae	*B. utriculatus*	
	B. papilliformis		
	B. suedicus		
	B. utriculatus		
SANTONIAN	*B. alabamensis*	*B. brydonei*	*B. pockrandti* [1]
	B. cylindricus	*B. cylindricus*	*B. cylindricus*
	B. elegans	*B. elegans*	*B. ellipticus*
	B. ellipticus	*B. ellipticus*	
	B. fischeri	*B. fischeri*	
	B. fritillus	*B. granulosus*	
	B. globularis	*B.* cf. *maximus*	
	B. granulosus	*B. najdini*	
	B. hureae		
	B. maximus		
	B. papilliformis		
	B. suedicus		
	B. utriculatus		
CONIACIAN	*B. ellipticus*	*B. brydonei*	*B. tuberculatus* [2]
	B. fischeri	*B. cylindricus*	*B. cylindricus*
	B. granulosus	*B. fischeri*	*B. ellipticus*
	B. maximus	*B. hurae* [*sic*]	
TURONIAN	*B. ellipticus*	*B. fischeri*	*B. ellipticus*
	B. fischeri		
CENOMANIAN	-	-	-

[1] Jäger (1987), [2] Lee (1989), [3] Jagt *et al.* (1998) and Jagt (1999), [4] Merta (1972), [5] Jagt & Odin (2001)

and radials only slightly tumid; proximale not preserved. Lower facet of basals damaged; articular facets of radials well preserved with a medium-sized radial cavity, wide and medially deep dorsal ligament pit, and large and concave ventral muscle pits.

Discussion – This specimen is close to indeterminate juvenile bourgueticrinids from the lower upper Campanian of northeast Belgium illustrated by Jagt (1999, pl. 30, figs.

1-3), but has a less tall basal ring and lacks a 'constriction' halfway up that ring. It also resembles much larger material of *B. hureae* (see Jagt, 1999, pl. 29, fig. 3) and of *B.? suedicus* (see Jagt, 1999, pl. 31, fig. 2), both from the lower upper Campanian of northeast Belgium. The reason for placing it in the *fischeri* group herein is the general resemblance to material assigned to that group (see Rasmussen, 1961; Jäger, 1979, 1980; Klikushin, 1982a, b), the overall small size compared to other 'species' and the correspondence in stratigraphic range. Klikushin (1982b) recorded *B. fischeri* from the Coniacian-lower Santonian of western Ukraine, Turkmenistan and Mangyshlak (Kazakhstan), and noted that material from the Turonian-Coniacian of western Ukraine might also belong here. Jäger's (1979, 1980) records from the Hannover area (northern Germany) are younger (early Campanian).

***Bourgueticrinus* sp. 1**
Pl. 2, figs. 1, 3.

Material – A single cup/proximale (RGM 211 411) from the Turonian of Opole.

Description – Cup small, height 2.9 mm (inclusive of proximale), lower and upper diameters 1.4 and 1.9 mm, respectively; base of proximale damaged, of conical profile and more or less straight sides; sutures in basal and radial rings poorly discernible (only under low-angle light), height of basal ring equalling *c.* 160% of radial ring; greatest diameter of cup at mid-basal height; radials slightly constricted proximally; articular facets of radials abraded, but apparently originally rather depressed, almost 'inturned' and not projecting outwards; radial cavity narrow.

Discussion – This specimen cannot be compared with any other form recorded in the literature; the comparatively tall basals and the 'inturned' nature of the radial articular facets are conspicuous features. *Bourgueticrinus baculatus* Klikushin, 1982b (p. 820, pl. 4, figs. 7-11; text-figs. 6D-I, 7A), from the lower and upper Campanian of Akhchakuima and western Kopet-Dagh (Turkmenistan), also has tall basals and a much lower, constricted radial ring, but shows a tall, stick-shaped proximale.

***Bourgueticrinus* sp. 2**
Pl. 2, figs. 2, 4.

Material – A single cup/proximale (RGM 211 412) from the lower Campanian (correlatives of the *pilula* Zone, *sensu germanico*) of Wierzchowisko.

Description – Cup small, height *c.* 2.3 mm (inclusive of proximale), lower and upper diameters 1.4 mm and *c.* 1.7 mm, respectively; base of proximale near circular, flat and synostosial; proximale slightly conical, widening markedly along contact with basal ring; greatest diameter in lower portion of basal ring; sutures well visible, but shallow; height of basal ring equalling 147% of radial ring; diminishing in diameter proximally; radials constricted in lower third and with straight sides proximally; articular facets of radials low, with well-developed, deep dorsal ligament pits and small, yet deep ventral muscle pits; radial cavity medium sized.

Discussion – In having the height of the basal ring clearly exceeding that of the radials and a constriction at some point along the radial ring, the present specimen recalls *B. baculatus* Klikushin, 1982b, but that form has a much taller, stick-shaped proximale (see above). From correlative levels in England, *B. fritillus* Griffith & Brydone, 1911 (p. 30, pl. 4, figs. 14-17), is known. Rasmussen (1961) indicated the range of this form to be upper Santonian-lower Campanian, while Smith & Wright (2002, p. 257, pl. 50, figs. 8, 9) recorded it from the lower Campanian (*Offaster pilula* and *Gonioteuthis quadrata* zones). However, *B. fritillus* has a peculiar proximale shape, basal and radial rings of near-equal height, and lacks the constriction of the radial ring.

Bourgueticrinus sp. 3

Pl. 3, figs. 1, 2.

Material – A single cup/proximale (RGM 211 413) from the lowermost Santonian (*Cladoceramus undulatoplicatus*) of Lipnik (see Remin, 2004, fig. 4).

Description – Cup small, height 4.75 mm (inclusive of proximale), lower and upper diameters 2.4 and 1.9 mm, respectively; base of proximale near circular, but abraded, synostosial(?); proximale cylindrical, with more or less straight sides, but slightly constricted at junction with basal ring; basal and radial rings much narrower, probably the result of regeneration following injury (compare Jagt, 1999, p. 118, fig. 29B); sutures poorly visible, but basal ring apparently much taller (*c*. 250%) than radial circlet, with irregular outer surfaces (stereom irregularities) and constricted proximal end of radial ring; articular facets of radials small and inconspicuous, but worn; radial cavity much enlarged through abrasion.

Discussion – The fact that this specimen shows sublethal damage and regeneration means that it cannot be identified to 'species'; significant, yet again, is the fact that the height of the basal circlet clearly exceeds that of the radials.

Bourgueticrinus ex gr. *constrictus* (von Hagenow *in* Quenstedt, 1876)

Pl. 3, figs. 3, 5.

cf. *1876 *Apiocrinus constrictus* von Hagenow *in* Quenstedt, p. 368, pl. 104, figs. 64-66.
cf. 1961 *Bourgueticrinus constrictus* (Hagenow); Rasmussen, p. 175, pl. 29, figs. 1-7.
cf. 1999 *Bourgueticrinus constrictus* (von Hagenow *in* Quenstedt); Jagt, p. 126, pl. 32, figs. 5-9, 11; pl. 36, fig. 7 (uncertainly pl. 33, figs. 7-10).

Material – Two cups/proximalia (RGM 211 414, 211 415), both from the lower Maastrichtian of Muniakowice.

Description – Cup diminutive; height of RGM 211 414 is 4.6 mm, inclusive of proximale, the upper diameter being 1.36 mm; height of RGM 211 415 is 2.7 mm (inclusive of proximale), and lower and upper diameters are 0.4 and 0.75 mm, respectively. Proximale in RGM 211 414 with constricted subelliptical base (possibly due to damage), with a poorly developed synarthry, a constricted lower half and greatest diameter in upper third; irregular stereom structure in upper third; slight constriction at junction

with basal ring; basal and radial rings near equal in height, with a slight constriction in lower third of radial ring; articular facets of radials low, but poorly preserved, more or less 'inturned'. Proximale in RGM 211 415 with subelliptical base and apparently widened axial canal.

Discussion – These diminutive cups are very close to material generally referred to *B. constrictus*, of which *B. tenuis* Rasmussen, 1961 (p. 197, pl. 29, figs. 16-18) is a synonym, in having basal and radial rings of near-equal height, and a tall and slender proximale whose diameter generally increases proximally. This material is particularly well known from lower Maastrichtian strata in Denmark, northern Germany, southern Sweden and the extended Maastrichtian type area. As noted by Jagt (1999), *B. baculatus, B. constrictus* and *B. danicus* Brünnich Nielsen, 1913 (p. 53, pl. 2, figs. 49-51; pl. 3, figs. 1-58), might form a lineage extending from the lower Campanian to the lower Paleocene, with typically widened (figure 8-shaped, rhizocrinid type; see Roux, 1987, fig. 15) axial canals in columnals. The present collection contains quite a number of such columnals, which correspond closely to material illustrated by Rasmussen (1961, pl. 29, figs. 5-7; pl. 30, fig. 8; Klikushin, 1982b, pl. 1, figs. 6-11; see also Jagt, 1999, pl. 33, figs. 1-10).

Indeterminate bourgueticrinids

The present faunules also comprise some proximal (e.g., Pl. 4, fig. 5; RGM 211 421) and distal brachials, as well as isolated columnals (see Pl. 4, figs. 1-4; RGM 211 417-211 420). One of the columnals (Pl. 3, fig. 4; RGM 211 416), from the lower Maastrichtian of Muniakowice, is tall and slender, and compares well to material of *B. hagenowii* (Goldfuss, 1840) from the Maastrichtian of Denmark and Rügen (northeast Germany). It shows bite and/or scratch marks, closely comparable to those illustrated by Jagt (1999, pl. 35, figs. 6, 10, 11). It cannot be determined whether these marks were made when the crinoid was still alive (in which case the marks represent predation traces) or post-mortem. The former interpretation is favoured where regenerating cups are found associated (Jagt, 1999).

Distribution of bourgueticrinids in Poland

Although the present collection is rather limited and the material generally comparatively poorly preserved, it clearly demonstrates that there are several types of bourgueticrinid represented in the Upper Cretaceous of southern Poland. Our own recent collecting has shown that bourgueticrinids are indeed rare and that extensive bulk sampling is necessary if their taxonomic diversity is to be accurately determined. For some localities, but a single skeletal element was found per *c*. 30 kg of rock. The commonest finds are from Turonian and Coniacian deposits in the Opole area, while Campanian strata in the Miechów area have yielded little material to date (59 and seven specimens, respectively).

The first occurrence of bourgueticrinids in the Polish part of the mid-European Cretaceous Basin appears linked to the late Turonian maximum transgression (Jaskowiak-Schoeneichowa & Krassowska, 1988; Table 1 herein), occurring as they do in strata assigned to the *Mytiloides scupini* Zone in the Opole area (Niedźwiedzi & Kalina, 2003). In

pre-Maastrichtian strata, slight fluctuations in shoreline position and basin depth occurred (for details, see Jaskowiak-Schoeneichowa & Krassowska, 1988) and crinoids appear confined to clayey deposits where their extensive radicular cirral root system provided anchorage.

Our sampling has revealed mostly disarticulated skeletal elements, the commonest ossicles being columnals. None of the material is pristine; all ossicles show signs of abrasion and wear. The association at some localities of sturdier ossicles, such as cups and columnals, with more delicate brachials, suggests that post-mortem transport was limited. Only renewed bulk sampling may determine the ratio between columnal and brachial ossicles, compared to the number of cups, allowing estimation of population density. One more feature of these faunules is striking; their small size in comparison to bourgueticrinid material from elsewhere in Europe. This may be an indication of unfavourable ecological conditions, either related to water energy and/or turbulence or food availability. Here again, more material is needed.

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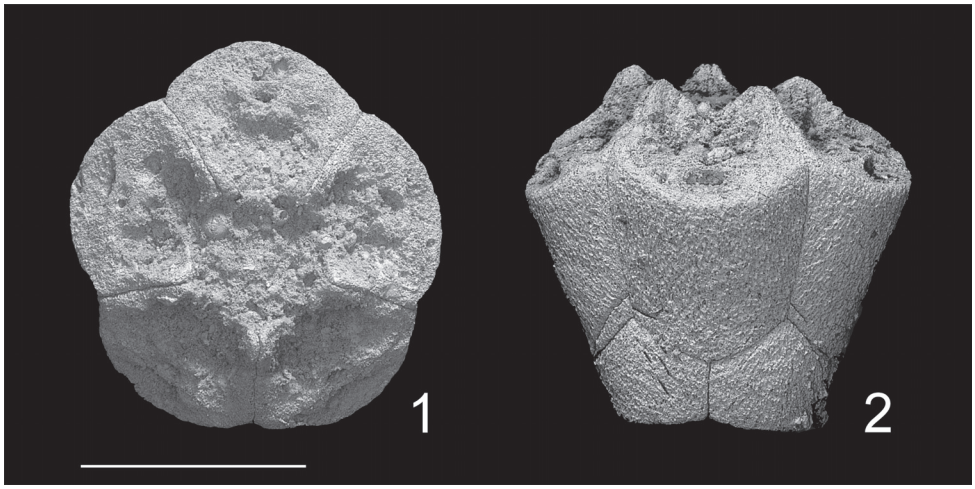

Plate 1

Figs. 1, 2. *Bourgueticrinus* ex gr. *fischeri* (Geinitz, 1872), cup (RGM 211 410), from the lowermost Santonian (*Cladoceramus undulatoplicatus* Zone) of Lipnik, showing radial articular facets (1) and lateral aspect (2). Scale bar represents 1 mm.

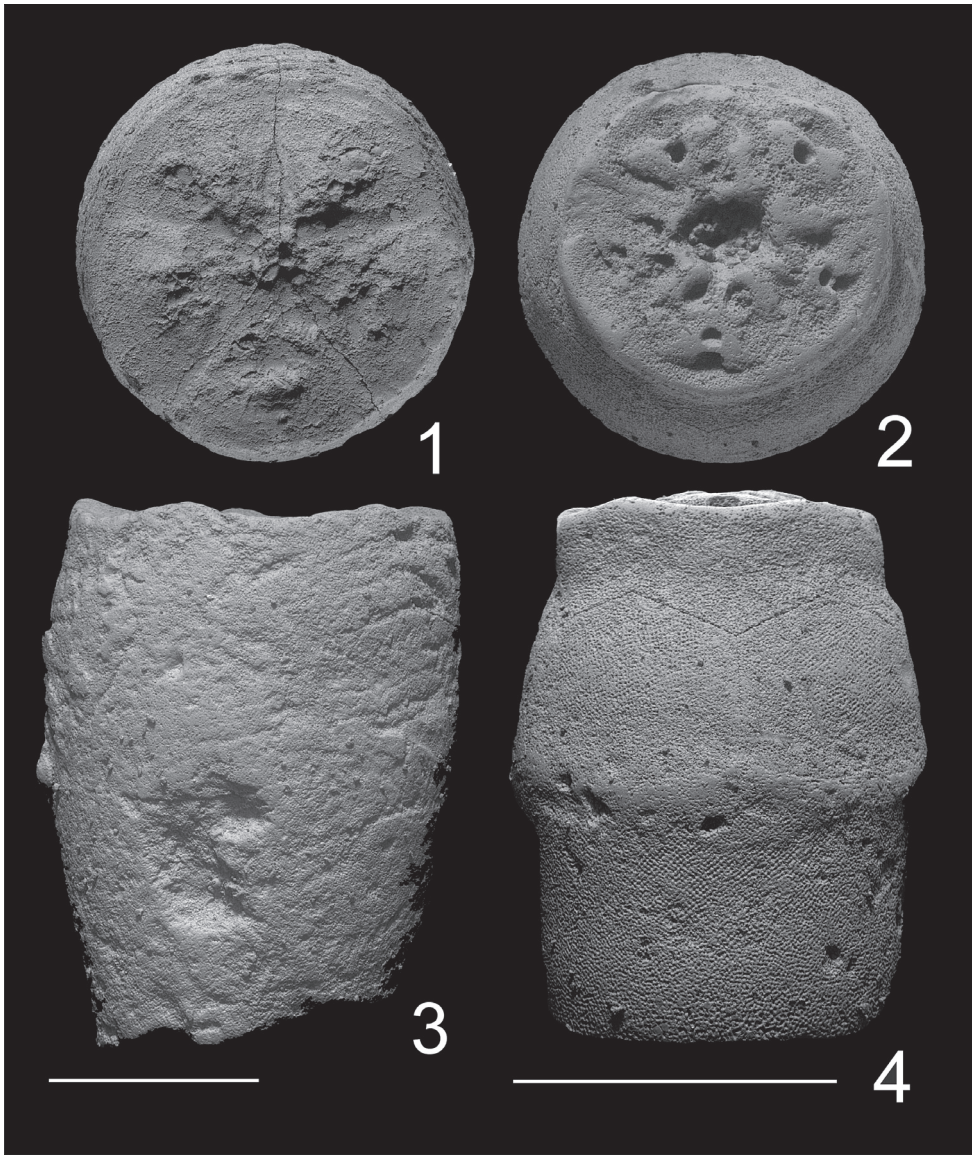

Plate 2

Figs. 1, 3. *Bourgueticrinus* sp. 1, cup/proximale (RGM 211 411), from the Turonian of Opole, in lateral view (3) and showing the radial articular facets (1).

Figs. 2, 4. *Bourgueticrinus* sp. 2, cup/proximale (RGM 211 412), from the lower Campanian (correlatives of the *pilula* Zone, *sensu germanico*) of Wierzchowisko, in lateral view (4) and showing radial articular facets (2).

Scale bars represent 1 mm.

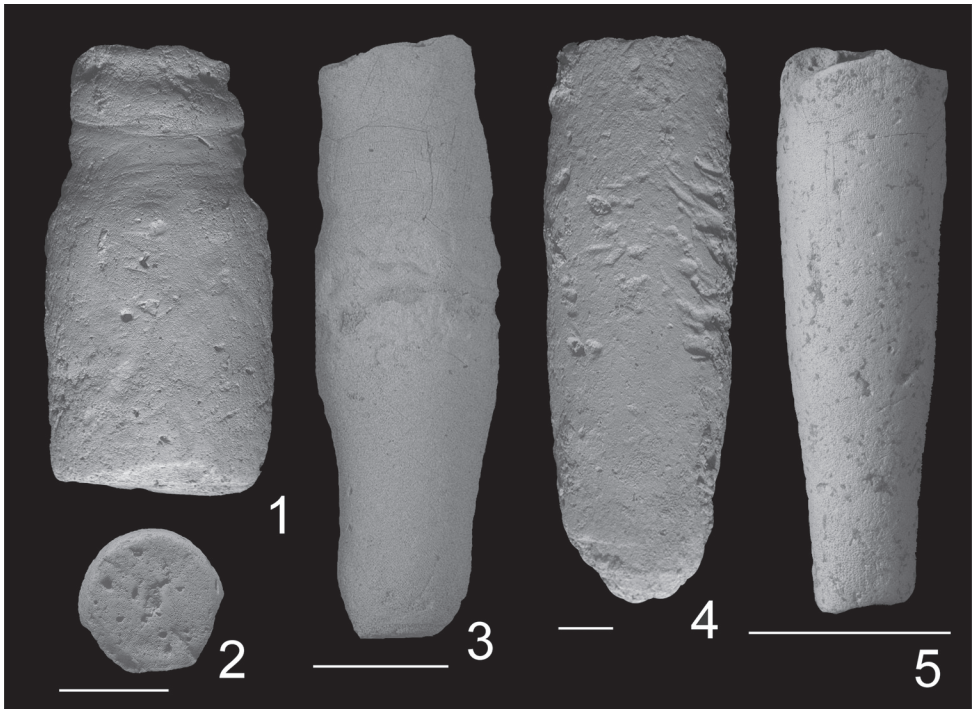

Plate 3

Figs. 1, 2. *Bourgueticrinus* sp. 3, cup/proximale (RGM 211 413), from the lowermost Santonian (*Cladoceramus undulatoplicatus* Zone) of Lipnik, in lateral view (1) and showing the radial articular facets (2).

Figs. 3, 5. *Bourgueticrinus* ex gr. *constrictus* (von Hagenow *in* Quenstedt, 1876), cups (RGM 211 414, 211 415), from the lower Maastrichtian of Muniakowice, both in lateral view.

Fig. 4. Columnal with bite/scratch marks (RGM 211 416), probably assignable to *B. hagenowii* (Goldfuss, 1840), from the lower Maastrichtian of Muniakowice, in lateral view.

Scale bars represent 1 mm.

Plate 4

Disarticulated bourgueticrinid ossicles.

Fig. 1. Lateral view of distal columnal (RGM 211 417), from the Coniacian of Opole.
Figs. 2, 3. Articular views of proximal/medial columnals (RGM 211 418, 211 420, respectively), from the lowermost Santonian (*Cladoceramus undulatoplicatus* Zone) of Lipnik.
Fig. 4. Articular view of distal columnal (RGM 211 419), from the lower Maastrichtian of Muniakowice.
Fig. 5. Lateral face of brachial 2 (RGM 211 421), from the Turonian of Opole.

Scale bars represent 1 mm.