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THE OPHIUROID *AMPHIURA*? *PLANA* IN NEARSHORE SETTINGS OF THE BOHEMIAN CRETACEOUS BASIN (CZECH REPUBLIC)

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Abstract: Comparatively common lateral arm plates from Turonian strata in the Czech Republic are assigned to the amphiurid brittlestar species *Amphiura*? *plana* Kutscher et Jagt *in* Jagt, 2000, which is also known from the Campanian and Maastrichtian of northern Germany, southern Sweden, Denmark, the Netherlands and Belgium. This species appears to represent an evolutionarily conservative lineage with extensive paleogeographical and stratigraphic ranges, in excess of 20 or 25 million years. The abundance of *Amphiura*? *plana,* based on lateral arm plates, amounts to about 5 % at Velim, where three other species are commoner still.

Key words: Cretaceous–Turonian, Bohemian Cretaceous Basin, nearshore, evolutionary conservatism, Ophiuroidea.

Introduction

Originally only the lateral arm plates of the present taxon (see Štorc 1996) were known, which explains why its systematic position was not quite clear. Recently, Jagt (2000a) and Kutscher & Jagt *(in* Jagt 2000), have recorded arm fragments preserving spines as well as ventral arm plates, dissociated vertebrae, dorsal arm plates, radial shields and possibly even other skeletal elements from arms and disc. Those authors also shed more light on the taxonomic position of the species. The present study of the Upper Cretaceous material from the Czech Republic furnishes additional data.

Stratigraphic and geographical settings

All remains of *Amphiura*? *plana* collected come from nearshore depositional settings in the Bohemian Cretaceous Basin (Czech Republic), at two localities (see Fig. 1) exposing nearshore facies (Korycany Member of the Peruc-Korycany Formation (KM), Bílá hora Formation (BHF), Lower Turonian), namely Velim — pocket Václav (grey and greenish claystone, KM, *Whiteinella archaeocretacea* Zone — see Fig. 2), and Kutná Hora-Kaňk (marls overlying conglomeratic limestone, BHF). For details of localization and lithology see Žítt (1992), Žítt et al. (1997a,b, 2001) and Fig. 2.

Material and methods

The material was collected by Jiří Žítt (Institute of Geology ASCR, Prague) between the 1970s and 1990s and by the author in the 1990s. The Bohemian Cretaceous sediments were washed and dissociated ophiuroid ossicles were handpicked. On the whole, more than 170 ossicles of the present species were found. Several dissociated lateral arm plates were coloured or photographed with the help of a scanning electron microscope (SEM) at the Institute of Geology ASCR. The relatively large number of lateral arm plates from Velim locality also permitted a quantitative evaluation of the abundances of individual ophiuroid species.

Systematic description

Class: **Ophiuroidea** Gray, 1840
Subclass: **Ophiuridea** Gray, 1840
Infraorder: **Gnathophiurina** Matsumoto, 1915
Superfamily: **Gnathophiuridea** Matsumoto, 1915
Family: **Amphiuridae** Ljungman, 1867
Genus: *Amphiura* Forbes, 1843
Type species: *Amphiura chiajii* Forbes, 1843

Amphiura? *plana* Kutscher et Jagt *in* Jagt, 2000
Fig. 3

1996 type R — Štorc, pp. 204–210, figs. 84, 137–141.
1998 sp. 14 = *Amphiura*? n. sp. 1 — Jagt et Kutscher, fig. 2f.
1999 *Amphiura*? n.sp. — Jagt, p. 200, pl. II, fig. 4.
2000 *Amphiura*? *plana* Kutscher et Jagt, sp.nov. — Jagt (a), p. 21, pl. 10, fig. 11; pl. 11, fig. 1.
2000 *Amphiura*? *plana* Kutscher et Jagt *in* Jagt, pp. 71–72, pl. 29, figs. 1–5; pl. 33, fig. 3.
2002 *Amphiura*? *plana* Kutscher et Jagt *in* Jagt, 2000 — Štorc, pp. 394–397, figs. 196, 206–210.

Type: Holotype is a lateral arm plate FGWG 112/17 (Collections of Institut für geologische Wissenschaften, Ernst-Moritz-Arndt Universität Greifswald, Germany) — see Kutscher & Jagt *(in* Jagt 2000, pl. 29, fig. 2).

Type horizon and locality: White chalk facies of the upper Lower Maastrichtian (Sumensis, Cimbrica and Fastigata Zones), Rügen, NE Germany.

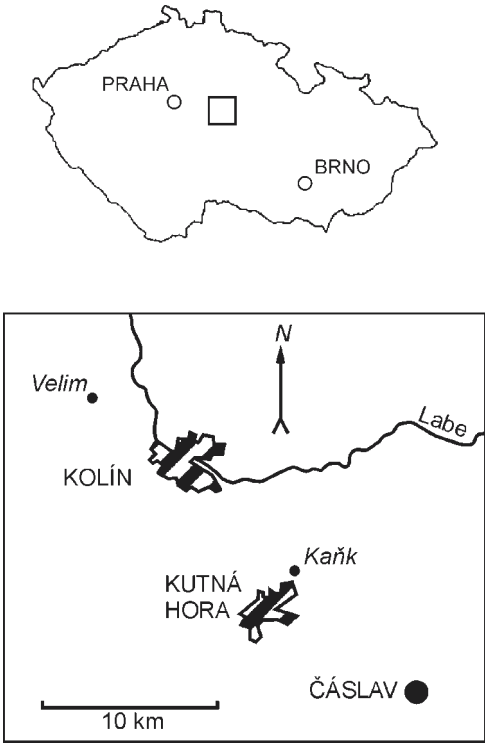

Fig. 1. Location of Velim and Kutná Hora-Kaňk within the Bohemian Cretaceous Basin.

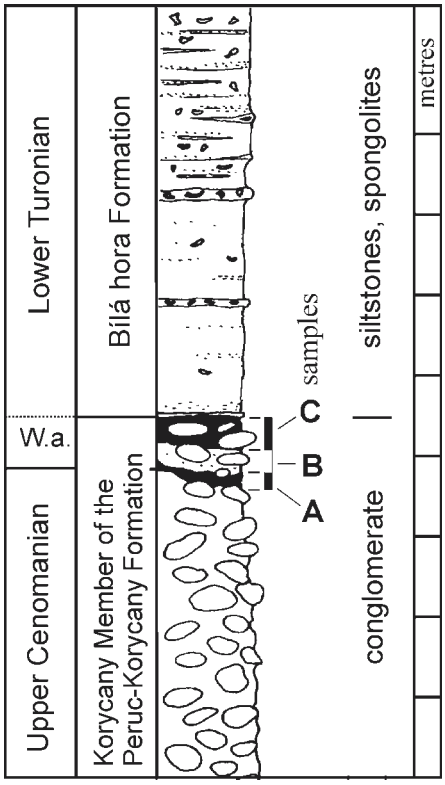

Fig. 2. The Velim-Václav section, Czech Republic. **A, C** — grey, echinoderm-rich calcareous claystone matrix of conglomerate, **B** — light-greenish echinoderm-rich calcareous claystone to clayey limestone matrix of conglomerate. W.a. — *Whiteinella archaeocretacea* Biozone. Modified after Žítt et al. (1997a).

Material: 172 dissociated lateral arm plates (and probably also a few rare vertebrae) from Velim — pocket Václav (Nos. O 6329, O 6330, Os 521, Os 522 and Os 523), and a single lateral arm plate from Kutná Hora-Kaňk (No. O 6337). All specimens are housed in the National Museum, Prague.

Description: *Lateral arm plates*: Figures 3.1 and 3.2 illustrate the outer surface of a distal (or median) plate (No. O 6329), while Figures 3.3, 3.4 and 3.5 represent a median (or proximal) lateral arm plate (No. O 6330). The plates are relatively thin, with an almost flat and smooth outer surface and a dorsally receded distal margin. Plate thickness is more or less constant in all places; in cross-section the plate is semicircular. The ventral side is slightly flattened. The proximal part of the outer surface shows a fine but poorly developed striation, which is mostly horizontally or subhorizontally directed, and articulation elements are not visible here (see Figs. 3.1,3,4). Very typical is the ornament consisting of a fine granulation. The small, equal-sized granules are best preserved in sample O 6329 (see Figs. 3.1 and 3.2), where little pores can be recognized between the granules. The granules in No. O 6330 are abraded or otherwise damaged in the distal part of the plate base (see Fig. 3.5), but the pores between them are easily seen. The ornament covers the rest of the outer surface (except for the proximal part, which has fine striation), and runs to the distal margin between the tubercles. The horseshoe-shaped tubercles are almost of equal size, positioned directly on the distal margin. Interspaces between the tubercles correspond to tubercle width and are not morphologically separated from the rest of the outer surface. The inner surface shows only a curved element for vertebral articulation; no pegs or other marked articulation elements are visible. Tentacle pore indentation is relatively large and well developed in all plates. Plates of the present species are relatively small; for example, in O 6330 the height of the plate is 0.73 mm and its maximum length is 0.80 mm; in O 6329 it is 0.73 mm and 0.86 mm, respectively.

The relatively large collection of lateral arm plates of "type R" (= *Amphiura*? *plana*) in the Bohemian material allows a reconstruction of morphological variation from proximal and median plates to distal ones. Fig. 3.1 illustrates, for example, a distal (or median) plate with 4 tubercles, while Fig. 3.3 shows a median (or proximal) plate with 5 tubercles.

Discussion

Lateral arm plates of the present species were originally described by Štorc (1996, p. 204–210) as "type R" from the Turonian strata of the Bohemian Cretaceous Basin. The plates studied here correspond completely to examples illustrated by Jagt (1999, 2000a) and by Kutscher & Jagt (*in* Jagt 2000) and are assigned to *Amphiura*? *plana* without any doubt.

Type R lateral arm plates are fairly small (see above), on average even more so than those of the Upper Cretaceous *Ophiocoma*? *senonensis* (Valette, 1915) and must have formed comparatively narrow arms. These arms were most likely fairly smooth too. The highly typical lateral arm plates of the present species are easily distinguished from those of all co-occurring

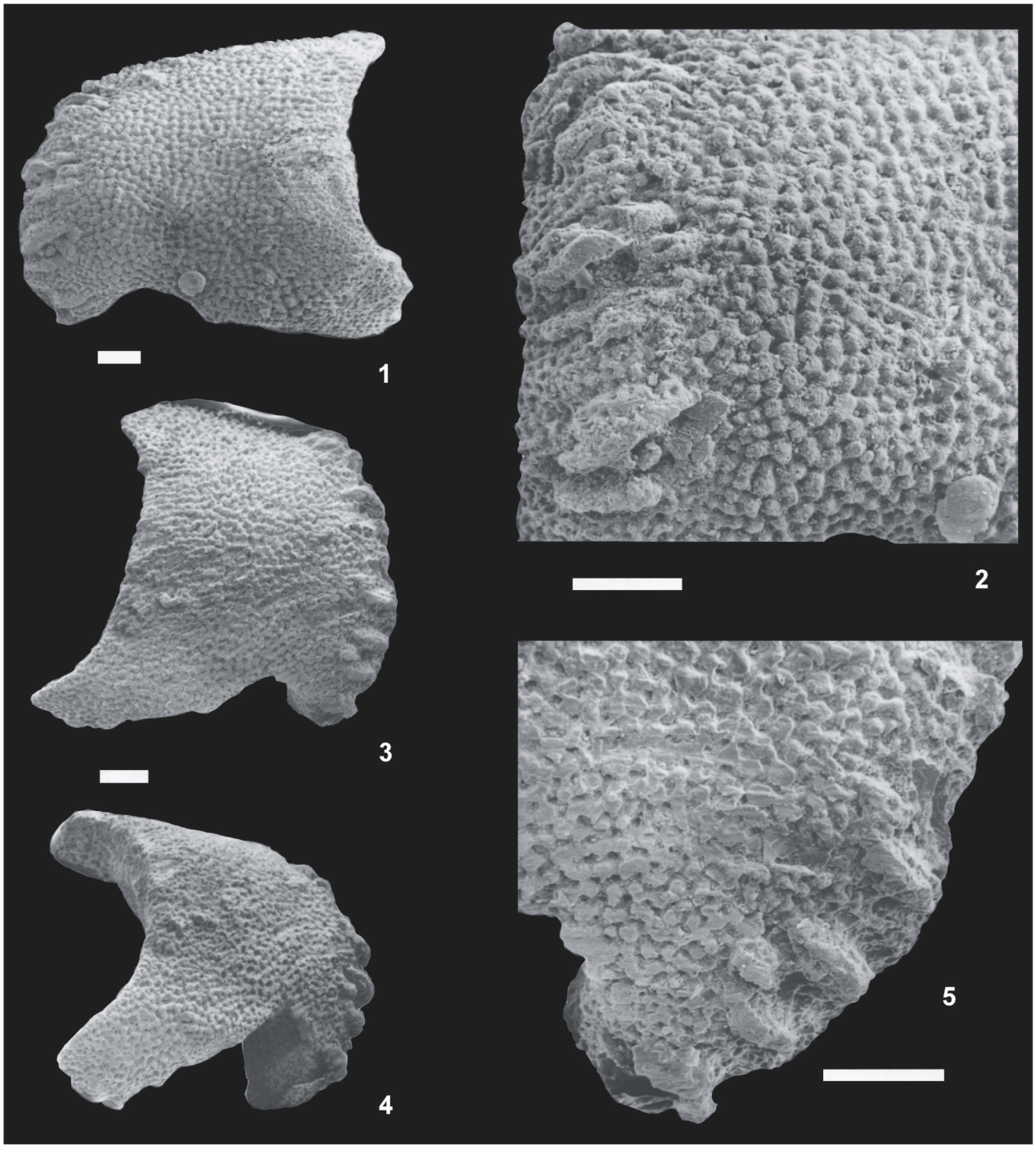

Fig. 3. Scanning electron micrographs of lateral arm plates of *Amphiura*? *plana*. Velim — pocket Václav locality. **1** — Outer surface of distal (or median) lateral arm plate (No. O 6329), distal left. Scale bar = 100 μm. **2** — Detail of distal part of the same plate. Scale bar = 100 μm. **3** — Outer surface of median (or proximal) lateral arm plate (No. O 6330), distal right. **4** — Outer surface of same plate in proximal-ventral view, distal right. Scale bar for figures 3 and 4 = 100 μm. **5** — Ventral portion of distal end of the same plate, distal right. Scale bar = 100 μm.

brittle stars. Only *Ophiothrix*? *bongaertsi* Kutscher et Jagt *in* Jagt, 2000 has comparable lateral arm plates, which are also present in the material from Kutná Hora-Kaňk. Lateral arm plates of *Ophiothrix*? *bongaertsi* (also see Jagt (2000a, p. 25); and Kutscher & Jagt *(in* Jagt 2000, p. 72) are reminiscent of *Amphiura*? *plana*, from which it differs in having even more clearly scythe-shaped lateral arm plates (thin dorsal portion), and more numerous and more close-set spine tubercles at the distal margin (9–11 in number).

Kutscher & Jagt *(in* Jagt 2000, p. 71) noted that, "Higher magnification reveals a fine granulation of the outer surface which, however, may be nothing more than a rather coarse

stereom structure since the same structure is seen at the proximal margin and in the tubercles." The present author, however, assumes that the fine granulation is a highly typical ornament, not just a coarse stereom structure. This is demonstrated by the fact that among various lateral arm plates of this species, the size of the granules is basically the same. The size of the granules is also an important taxonomic feature in the present species. It is also important that this granulation is replaced by a weak striation in the proximal part on the outer surface.

A few vertebral ossicles in the Bohemian material also resemble the vertebra illustrated by Kutscher & Jagt *(in* Jagt 2000, pl. 33, fig. 3). In the present material, no dorsal or ventral arm plates or other skeletal elements other than lateral arm plates and vertebrae have been identified. Arm fragments with preserved spines and ventral arm plates as well as dissociated vertebrae, dorsal arm plates, radial shields and possibly even other skeletal elements from arms and disc have previously been recorded in material from the type area of the Maastrichtian Stage, as well as from Rügen and Møn (see Jagt 2000a; Kutscher & Jagt *in* Jagt 2000).

Kutscher & Jagt *(in* Jagt 2000, p. 72) provisionally assigned this species to the extant genus *Amphiura* (Amphiuridae), mainly on the basis of the structure of the radial shields, vertebrae and on the presence of large tentacle pore indentations, as well as on lateral arm plate structure.

Regarding the paleoecology of the present species, Jagt (1999, p. 200; 2000b, p. 530) noted that "Most amphiurids live buried at depths of ca.10 cm, with only the tips of arms protruding through mucus-lined channels, catching detritus, but also small animals such as worms and juvenile molluscs. Burrows are ventilated by undulations of the arms. Sometimes many individuals may form webs across the seafloor. Most extant forms live on muddy bottoms, some also under rocks in low water, but, unlike other ophiuroids, they do not move about freely.". This mode of life is illustrated by Fig. 4.

Quantitative analysis

The large number (3739 in total) of lateral arm plates from Velim allows a quantitative evaluation to be carried out (see Table 1). The locality Kaňk yielded fewer specimens (see above). The abundance of individual species as based on lateral arm plates are expressed in %. 3721 lateral arm plates (representing about 20 ophiuroid species) from samples A, B, and C of the Velim-Václav section (see Fig. 2 and right-hand column in Table 1), identified to species, were evaluated. This large statistical set offers relatively exact abundances of the individual species. The abundance of *Amphiura*? *plana* — based on lateral arm plates in this set — is 4.62 % (172 specimens). The most exact data on the abundance of this species were, however, obtained by a study of bulk samples (1.5 litre of rock) from horizon C (Fig. 2). This sample contains 2561 lateral arm plates which were identified to species, in which lateral arm plates of the present species constitute 5.19 % (133 specimens; see the left-hand column in Table 1).

Table 1: Abundance of *Amphiura*? *plana* based on lateral arm plates from Velim.

SAMPLES FROM VELIM-VÁCLAV			
The bulk sample (C)		**Samples A, B, C (including the bulk sample)**	
number of lateral arm plates	**%**	number of lateral arm plates	**%**
133	5.19	172	4.62

With about 5 % at Velim, *Amphiura*? *plana* seems to be the fourth most common ophiuroid species there. It is necessary to mention, that the quantitative ratios of the sceletal elements could be considerably changed by taphonomical processes (such as selective transport).

Paleogeographical and stratigraphic distribution

The present species is currently known from the Lower Maastrichtian of the isles of Rügen (formerly Rujana, Germany) and Møn (Denmark), the Lower Campanian of southern Sweden, as well as the Upper Campanian and Lower and Upper Maastrichtian of the Netherlands and Belgium (the type area of the Maastrichtian Stage) and the Lower Turonian (Bílá hora Formation) of the Czech Republic. In material from the Upper Cretaceous (Cenomanian, Turonian, Coniacian and Santonian) deposits of Tunisia *Amphiura*? *plana* is absent (Štorc 2002).

The paleogeographical and stratigraphic distribution of the present species, as shown in Fig. 5, shows that *Amphiura*? *plana* is a widely distributed taxon ranging from the Lower

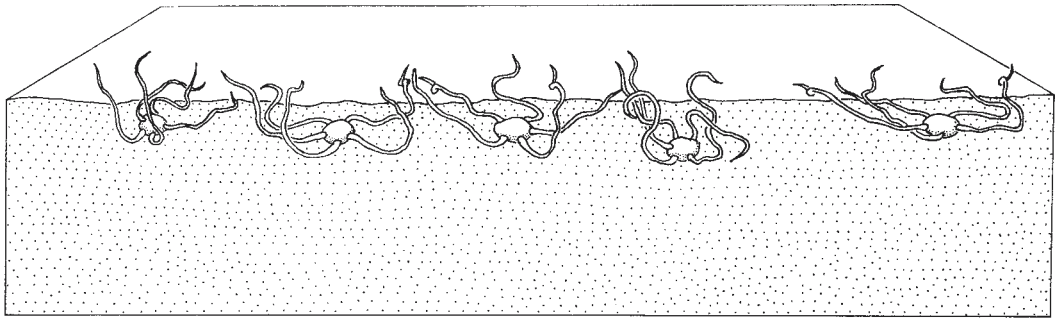

Fig. 4. Cross-section through seafloor showing individuals of the extant species *Amphiura filiformis* buried at depths of ca. 10 cm, with only the tips of arms protruding through mucus-lined channels. Modified after Blegvad (1915).

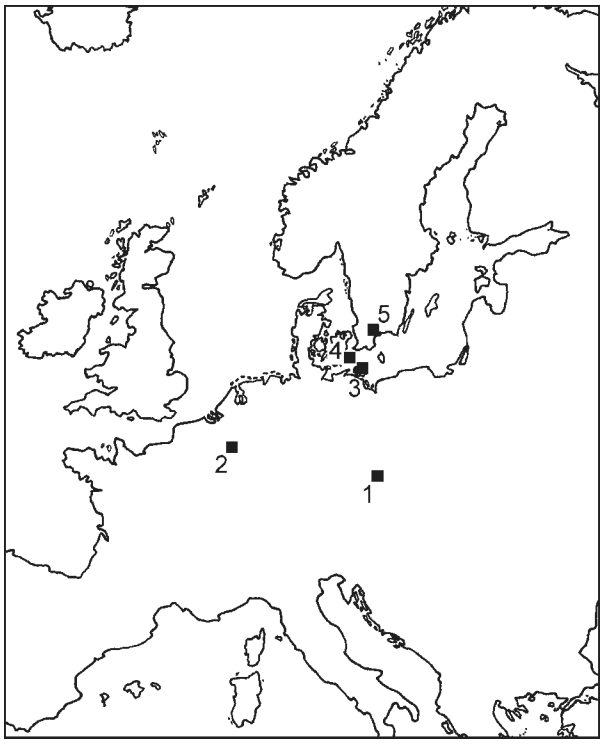

Fig. 5. Geographical distribution of *Amphiura*? *plana* in the Upper Cretaceous of Europe. **1** — Bohemian Cretaceous Basin (Czech Republic, Lower Turonian); **2** — type area of the Maastrichtian Stage (southeast Netherlands and northeast Belgium, Upper Campanian, Maastrichtian); **3** — Rügen (Lower Maastrichtian); **4** — Møn (Lower Maastrichtian); **5** — southern Sweden (Lower Campanian).

Turonian (?and Upper Cenomanian) to the Upper Maastrichtian. This species appears to represent an evolutionarily conservative lineage which existed for more than 25 million years (for geochronology see Gradstein & Ogg 1996).

Conclusion

In the course of detailed studies of the enormously rich Bohemian material (Turonian nearshore deposits, Korycany Member of the Peruc-Korycany Formation and Bílá hora Formation, Bohemian Cretaceous Basin), over 170 lateral arm plates of *Amphiura*? *plana* have been collected (Štorc 2002). The fine granulation and granule size of outer lateral arm plate surfaces seem to be important taxonomic features. The lateral arm plates of this species are quite small and light in construction and must have formed fairly narrow arms of circular or oval cross-section. The arms of *Amphiura*? *plana* were, moreover, most likely fairly smooth. The abundance of *Amphiura*? *plana* is, according to the lateral arm plates, about 5 % at Velim, with this species the fourth most common ophiuroid. This species appears to represent an evolutionarily conservative lineage with extensive paleogeographical and stratigraphical ranges.

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