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Ichnology of Late Cretaceous echinoids from the Maastrichtian type area (The Netherlands, Belgium)—3. *Podichnus* Bromley and Surlyk and a crinoid attachment on the echinoid *Echinocorys* Leske from the Lixhe area, Belgium

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Abstract

The tests of large Late Cretaceous holasteroid and spatangoid echinoids provided hard substrates that could become infested, both before and after death, by a range of invertebrates. Specimens of *Echinocorys* gr. *conoidea* (Goldfuss) from the Lixhe 1 Member (Gulpen Formation) of north-east Belgium are well-known as bored and encrusted benthic islands. A brachiopod pedicle attachment, *Podichnus* sp. cf. *P. centrifugalis* Bromley and Surlyk, is located on the apical system of a strongly-infested test; this was the highest point of the echinoid even after death. This would have favoured the brachiopod feeding in clean water. A bourgueticrinid crinoid attachment at mid-height on the test is conical, but lacks encrusting radices. Such a brachiopod-crinoid association is, perhaps, more typical of the Palaeozoic than of the latest Mesozoic (i.e., Maastrichtian).

Key words: hard substrates, episkeletobionts, benthic islands, palaeoecology

Introduction

Holasteroid echinoids in the Upper Cretaceous of northern Europe and elsewhere preserve ample evidence of attack by a diversity of invertebrate organisms, both borers and encrusters, that infested the test both pre- and, mainly, post-mortem (see Donovan *et al*., 2010 and references therein). Most notably, the large and robust tests of locally common taxa such as *Echinocorys* Leske and *Hemipneustes* L. Agassiz may have acted as benthic islands (*sensu* Taylor and Wilson, 2003, p. 4) after death. Dead, robust echinoid tests on a soft lime bottom would have provided hard substrates for those benthic invertebrates that were obligate encrusters or borers, such as certain bivalves, serpulid and sabellid worms, articulate and inarticulate brachiopods, and bryozoans, but would have been of no interest to, for example, parasitic invertebrates and predatory vertebrates. Herein, we describe a test of the common holasteroid *Echinocorys* from the Upper Cretaceous (upper Maastrichtian) which was densely infested post-mortem by encrusting organisms. Of particular note is the evidence that episkeletobionts (*sensu* Taylor and Wilson, 2002) included a brachiopod and a crinoid. The specimen discussed herein is deposited in the collections of the Natuurhistorisch Museum Maastricht, Maastricht, The Netherlands (NHMM).

Material and methods

The echinoid is identified as *Echinocorys* gr. *conoidea* (Goldfuss, 1829), a species abundant in the upper third of the Lixhe 1 Member of the Gulpen Formation (Felder and Bosch, 2000, fig. 3.33; Jagt, 2000). NHMM JJ 14717 comes from the CBR-Lixhe quarry (Lixhe, province of Liège, north-east Belgium; see Fig. 1). It was collected from the uppermost 1 m (= *Echinocorys* level) of the Lixhe 1 Member of the Gulpen Formation (Upper Cretaceous, upper Maastrichtian; *tegulatus*/*junior* Zone [*sensu germanico*]). As we noted previously (Donovan *et al*., 2010, p. 52), flint-filled tests of *Echinocorys*, such as NHMM JJ 14717 (Fig. 2C), are common in quarries in the Haccourt-Lixhe area of Belgium.

Description

Test largely complete apart from breakage left posteriorly and ambitally, approximately symmetrical about ambulacrum

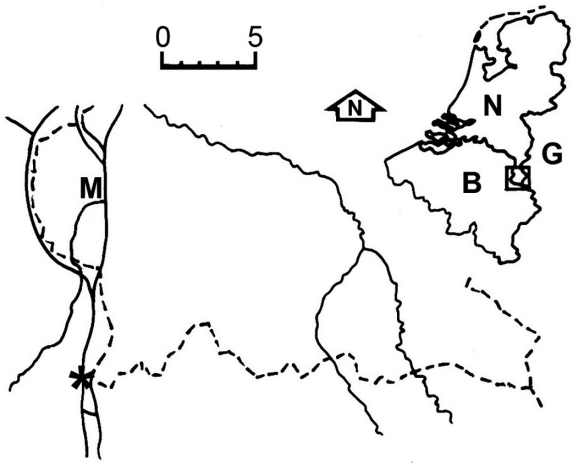

Fig. 1. Outline map of study area (redrawn after Jagt, 1999, fig. 1; Donovan and Jagt, 2004, fig. 1), showing political boundaries (dashed lines), rivers and canals (solid lines), the city of Maastricht (M) and the CBR-Lixhe quarry (*). The inset map of the Netherlands (N), Belgium (B) and Germany (G) shows the approximate position of the main map (box).

V and removing the periproct. Test filled partially with chalk, but with chertified sedimentary rock adhering to external surfaces both orally, where it conceals the peristome, and suprambitally (Fig. 2C). Dimensions are length 83.0+ mm, width *c*. 69.9 mm and height *c*. 55.5 mm.

Test encrusted and bored on apical surface only. Episkeletobionts include numerous cheilostome (electrid) bryozoans, juvenile specimens of ostreid and dimyid bivalves (*Pycnodonte vesicularis* (Lamarck, 1806); *Atreta nilssoni* (von Hagenow, 1842); compare Hodges, 1991; Waller, 2012), a single individual of a sabellid polychaete (genus *Glomerula* Brünnich Nielsen; compare Jäger, 2012), a small cancellothyridine brachiopod, and a single crinoid (Fig. 2C–E). Borings are rare, including non-predatory *Oichnus simplex* Bromley, 1981 (Fig. 2C, a single boring and a cluster of three borings at '8 o'clock' to the crinoid attachment), including both penetrative and incomplete examples, and *Podichnus* isp. cf. *P. centrifugalis* Bromley and Surlyk, 1973.

Podichnus is found on the apical system (Fig. 2A, B), that is, the highest point of the test when in life position. Small, rounded, consisting of numerous fine pits/canals arrayed more or less radially. Some slender canals extend outside this central region and, although presumably largely internal, breach the surface of the test for short distances (best seen in Fig. 2A between '12 and 2 o'clock' to boring).

Crinoid attachment at about mid-height test, encrusting part of anterior plate column of right posterior ambulacrum I. Small, conical, with numerous small lobate overgrowths at circumference and a central, circular, concave articular facet at the apex. It was both overgrowing and was partly overgrown by cheilostome bryozoans.

Discussion

Podichnus has previously been recorded from the type area of the Maastrichtian encrusting *Echinocorys* gr. *conoidea* (Goldfuss) and belemnites (Jagt *et al*., 2007; Donovan *et al*., 2011). Although infestation, particularly by ostreid and dimyid bivalves and craniid brachiopods, of *Echinocorys* in the Lixhe 1 Member is already well known, the specimen described herein is of interest for its position, morphology and association. The trace fossil *Podichnus* is precisely situated at the highest point of the test. That the test was resting on the Maastrichtian seafloor in life position is indicated by the absence of encrusters and borers on the oral surface; in contrast, they are numerous and diverse on the apical surface. Thus, the brachiopod that produced this scar, which would have been further elevated by its pedicle, was raised well above the sediment surface and would have been feeding from particularly sediment-free water.

The morphology of the trace fossil is most similar to that figured by Donovan *et al.* (2011, fig. 3A) as *Podichnus* cf. *centrifugalis* and from the same locality. We reiterate our reasons for leaving these specimens in open nomenclature, "... at least one carefully oriented section cut through the substrate or the production of an epoxy cast would be required of each specimen to determine its precise morphology ... we refrain from such destructive preparation" (Donovan *et al*., 2011, p. 104). Certainly, the morphology of NHMM JJ 14717 differs from the pattern of holes commonly recognised as *P. centrifugalis* or the similar *Podichnus silesiacus* Małkowski, 1975 (Boucot, 1990, figs. 119, 121). It is very different from the more concentric structure of *Podichnus perpendicularis* Robinson and Lee, 2008. Another form, *Podichnus obliquus* Robinson and Lee, 2008, has a more oblique, radiating structure, but the holotype (Robinson and Lee, 2008, fig. 1E) shows rather loosely separated canals unlike NHMM JJ 14717 (see also Bromley, 2008). The pedicle trace of the Recent terebratelloid *Aerothyris macquariensis* (Thomson, 1918) (Robinson and Lee, 2008, fig. 1A) is perhaps closest, but this is included in *P. centrifugalis*. *Podichnus donovani* Breton, 2011, is the underside of a cyclostome bryozoan (P.D. Taylor, e-mail to S.K.D., 27 February 2013), rather than a brachiopod pedicle etching trace.

Crinoid attachments on *E*. gr. *conoidea* are well known, yet comparatively rare. The present specimen (Fig. 2C–E) is of interest in having a simple, conical structure without any radiating, encrusting radices. We deduce that this attachment may have been in an early stage of growth before radices were developed (contrast with Jagt *et al*., 2012, figs 1, 2); alternately, it may represent a different taxon. It was certainly produced by a bourgueticrinid. Further, the close association of a brachiopod attached by a pedicle and a cemented crinoid is unusual for the Late Cretaceous, being much more typical of the Palaeozoic.

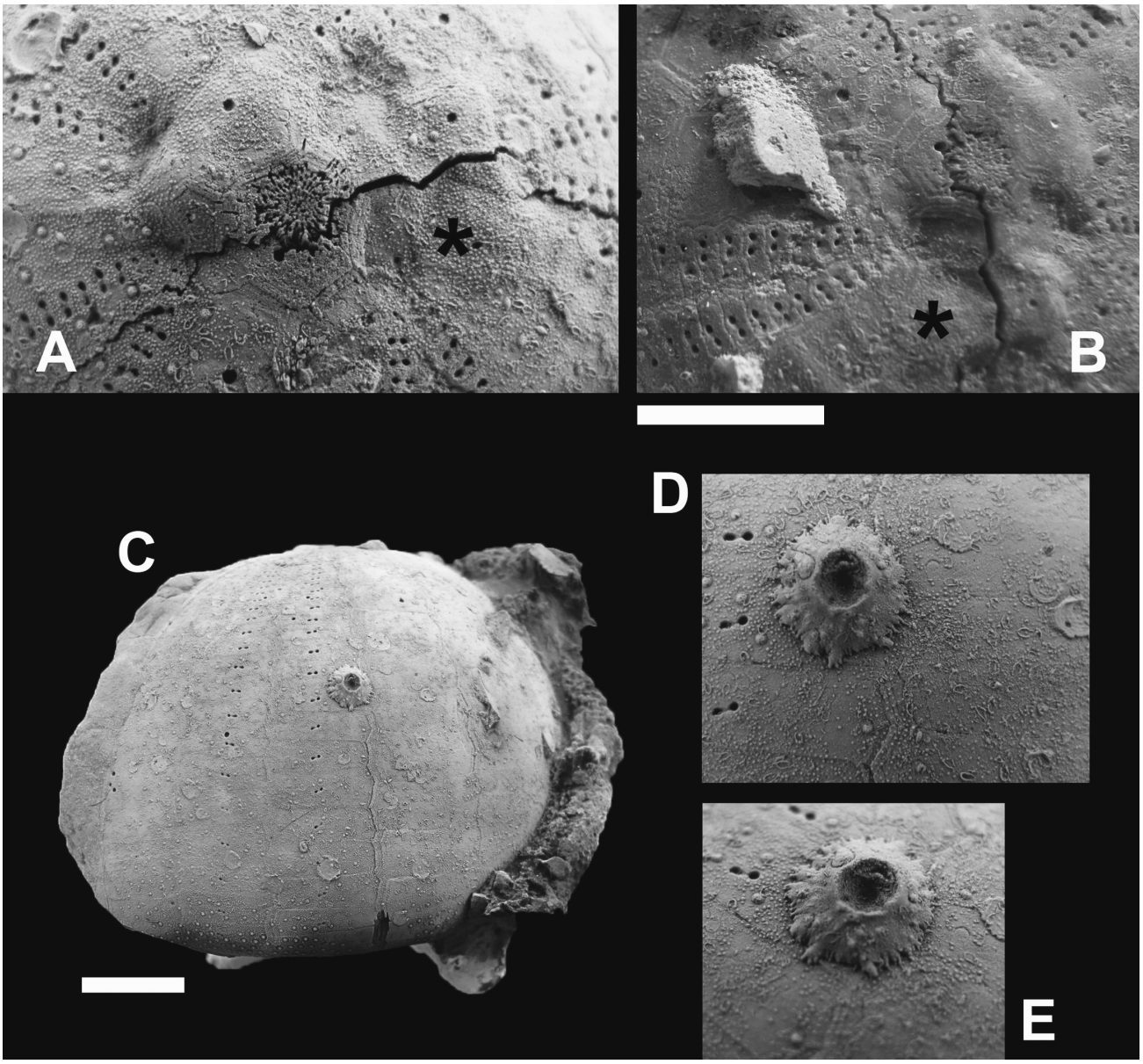

Fig. 2. *Echinocorys* gr. *conoidea* (Goldfuss) as a hard substrate, NHMM JJ 14717. A, B, *Podichnus* isp. cf. *P. centrifugalis* Bromley and Surlyk on the apical system; (*) marks the position of the madreporite. A, anterior to right, image slightly larger than (B). Note radial arrangement of canals. B, uncoated, anterior towards bottom of page. C, complete test in oblique right posterior view, crinoid attachment encrusting anterior plate column of ambulacrum I. D, E, crinoid attachment, 5.3 mm in diameter, (E) is a more oblique view. Apart from (B) (uncoated), all images show the specimens after painting with black food colouring and coating with ammonium chloride. Scale bars represent 10 mm.

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