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A Recent redirected boring, *Gastrochaenolites ornatus* Kelly and Bromley, in the Upper Cretaceous chalk of south-east England

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Abstract

Space may be a limiting factor for boring organisms. A cobble of Upper Cretaceous chalk collected from float at Margate, north Kent, England, UK, is infested by two distinct morphologies of borings; slender, U-shaped *Caulostrepsis taeniola* Clarke and clavate *Gastrochaenolites ornatus* Kelly and Bromley, produced by polychaetes and bivalves, respectively. One *G. ornatus* boring is redirected (branched), a rare feature in *Gastrochaenolites*, suggesting that the borer changed direction to permit it to bore deeper.

Key words: beachcombing, palaeoecology, taphonomy, *Caulostrepsis*

Introduction

Space is an important limiting factor in large and long borings, and may be a decisive influence on the boring trajectory and lifespan of many boring organisms (see, for example, Savrda and Smith, 1996). *Gastrochaenolites* Leymerie, 1842, is an ichnogenus of clavate (club-shaped) borings commonly produced by bivalves (Bromley, 2004, p. 462) in lithic substrates such as limestones and thick shells such as oysters and strombid gastropods (Kelly and Bromley, 1984; Pickerill and Donovan, 1997). Under crowded conditions *Gastrochaenolites* can be curved and overlapping (Kelly and Bromley, 1984, text-fig. 4B; Donovan, in review).

Different considerations apply to the perforation of lithic and shelly substrates by the boring bivalves which produce *Gastrochaenolites*. If a suitable rock substrate such as a limestone is thick and laterally extensive, one or more borers can generate *Gastrochaenolites* that are discrete, do not interfere with each other and grow more or less perpendicular to the bed's surface. In contrast, a loose cobble which may be rolled about on the seafloor does not provide a consistent orientation to the surfaces of the clast, will have its surface area reduced by corrosion and abrasion, and will be weakened by borings, resulting in a loss of substrate volume and area (Bromley, 1975, p. 418, fig. 18.15). Herein, we describe an unusual boring in a chalk cobble and discuss how substrate has influenced boring morphology.

Material

This cobble was collected from float by F.E.F. on the sea front at Margate, north Kent coast, south-east England, UK, in June 2013. It was found behind the beach huts, but had been densely bored by marine organisms. The rock is Upper Cretaceous chalk which outcrops extensively in this area (Peake, 1967; Robinson, 1986). The specimen is now registered in the collection of the Naturalis Biodiversity Center, Leiden, RGM (= Rijks Geologische Museum) 791 630. The boring documented herein was discussed, briefly, as part of a broader study by Donovan and Fearnhead (2016).

Description

The cobble, RGM 791 630, is an irregularly shaped clast of chalk about 76 x 49 x 47 mm. Invertebrate borings are prominent. Small, elongate apertures, slot-shaped to weakly figure-of-eight, are *Caulostrepsis taeniola* Clarke, 1908, produced by boring annelids (Donovan and Fearnhead, 2016, fig. 1A–C). The larger, more prominent boring form is referred to *Gastrochaenolites ornatus* Kelly and Bromley, 1984. There are six specimens, two seen in longitudinal section and four recognized as conical tubes through the chalk (Donovan and Fearnhead, 2016, fig. 1; Fig. 1 herein). All specimens of *G. ornatus* in RGM 791 630 are curved. The opening at the narrower end of each is the aperture or,

Fig. 1. Cobble of chalk from Margate, north Kent coast, south-east England, RGM 791 630, *Gastrochaenolites ornatus* Kelly and Bromley (*Caulostrepsis taeniola* is not apparent in this view). The broken surface of the cobble shows rounded sections through *G. ornatus* showing, prominently, longitudinal sections of two geniculated borings (centre) and curved specimens (top right). The former is bifurcated and possesses a bioglyph in each branch. Specimen uncoated. Scale bar represents 10 mm.

at least, the remnant of the neck at the apertural end. The sides of the boring are smooth, but unlined, except at the base of the chamber (compare with Kelly and Bromley, 1984, pp. 801–802, text-fig. 7), where it bears a distinctly corrugated sculpture or bioglyph generated by the borer; the largest specimen appears to be branched and have a bioglyph in each branch (Fig. 1). The apertures of five of these borings is at the same surface infested by *Caulostrepsis*; the sixth perforates the wall of a *G. ornatus* boring (Donovan and Fearnhead, 2016, fig. 1F). *Gastrochaenolites ornatus* is the spoor of the oval piddock, *Zirfaea crispata* (Linné) (Donovan, 2011), and other boring bivalves (Kelly and Bromley, 1984, pp. 801–802).

Discussion

Presumably, RGM 791 630 was carried onshore during a storm or by human activity. Both of the ichnogenera found in this cobble, *Caulostrepsis* and *Gastrochaenolites*, are common borings in chalk and limestone clasts on the beaches of south-east and eastern England (see, for example, Donovan and Lewis, 2011; Donovan, 2013a). A qualitative observation is that *Gastrochaenolites* are typically more or less straight and, inferentially, are commonly (but not invariably; Kleemann, 2009, fig. 4) curved or geniculated in substrates where they are limited by space (for example, contrast most of the specimens illustrated in Kelly and Bromley, 1984; Donovan and Hensley, 2006, with borings in small clasts such as Donovan, 2013b, fig. 2). Features such as the irregular and fragmented shape of the cobble RGM 791 630, and the longitudinal sections of two and missing bases of four other *Gastrochaenolites*, demonstrate that this is a fragment of a clast that was not very much larger than it is now when infested by borers. Presumably, it was the borings themselves that weakened the cobble and facilitated its breakdown.

Most peculiarly, one of the *G. ornatus* borings (Fig. 1) appears redirected, but *Gastrochaenolites* do not branch in the strict sense (Kelly and Bromley, 1984; Kleemann, 2009). This specimen is interpreted as recovery by the producing bivalve after a 'failed' boring that originally moved to the left and redirected to the right. Both branches show the serrated, ornate sculpture which is a diagnostic feature of the deepest parts of this ichnotaxon. As the right boring extends deeper into the cobble, this is interpreted as the later 'branch'. Thus, RGM 791 630 does not preserve a branched *Gastrochaenolites sensu stricto*; rather, it is two overlapping borings, albeit probably produced by a single bivalve that was tightly constrained by its small substrate. Similar readjustments have been noted in the clavate borings generated by Gastrochaenidae, Lithophaginae, Pholadidae and Teredinidae (K. Kleemann, written comm. to SKD, 3 December 2015). Savrda and Smith (1996) have eloquently argued that such branching behaviour in *Teredolites longissimus* Kelly and Bromley in wood is a response to boring in a crowded substrate, a deduction which resonates with our observations of RGM 791 630. In conclusion, the branched *G. ornatus* is unusual and is interpreted as the result of limitations of space.

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