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REGULAR RESEARCH ARTICLE

A new ichnogenus for *Teredolites longissimus* Kelly and Bromley

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Abstract Ichnotaxobases that provide internally consistent classification schemes for trace fossils such as burrows and borings include general form, branching, orientation, ornamentation, internal structure and fill, and boundaries. Substrate is a poor ichnotaxobase but it has been widely used for some ichnogenera, most notably the clavate (club-shaped) borings commonly produced by bivalves. The ichnogenus *Teredolites* Leymerie includes only two ichnospecies, both limited to xylic (woody) substrates; *Teredolites clavatus* Leymerie, the type species; and *Teredolites longissimus* Kelly and Bromley. *Teredolites clavatus* are club-shaped and short, whereas *T. longissimus* are long and straight to sinuous to worm-like. Although both are (commonly) bivalve borings in wood substrates, they are morphologically highly dissimilar. *Teredolites longissimus* Kelly and Bromley is made the type ichnospecies of *Apectoichnus* igen. nov. herein. *Apectoichnus* includes elongate borings, commonly circular in section, smooth-sided, sinuous to contorted and intertwined, and with or without a calcareous lining; they are found in wood.

Keywords Ichnosystematics · *Teredolites* · *Apectoichnus* · *Gastrochaenolites* · Ichnotaxobases

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Introduction

Trace fossils are sedimentary structures and not organisms. This simple fact has repeatedly caused confusion when trace fossils and their purported producing organisms have been used interchangeably; it is wrong to think of a trace as a 'beast', as it is nothing more than a beast's mark. We may know the beast only from its mark, that is, we may know more of its ecology than of its systematic position. This may lead to further confusion and a difficult case of identity to unravel (Donovan 2015).

Other causes of idiosyncratic ichnosystematic confusion concern the importance, or otherwise, of substrate. I am not aware that any modern author has suggested that identical trails in, for example, mudrocks and sandstones should be anything but members of the same ichnotaxon. Yet substrate is regarded as of primary importance to many workers on borings. Some might regard essentially identical pits as *Oichnus* Bromley, 1981, when they occur on a mollusc shell or *Tremichnus* Brett, 1985, when they occur on an echinoderm, although I do not (Donovan and Pickerill 2017).

One group of borings in which substrate has been widely accepted as an ichnotaxobase are the clavate (club-shaped) structures commonly generated by several genera of bivalves. These borings are referred either to *Gastrochaenolites* Leymerie, 1842, if penetrating a rocky or shelly substrate, or *Teredolites* Leymerie, 1842, if the structure is in wood. Partly, this separation is based on our conception of the producing organisms; the bivalve *Gastrochaena* Spengler (and others) produces clavate borings in rocky and shelly substrates (although identical borings may be generated by certain gastropods and sipunculans; Bromley 2004, p. 462), whereas *Teredo* Linné (and others; see, for example, Gale 1995) generates clavate borings in

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wood. This distinction has been widely accepted, particularly since the publication of the elegant exposition of Kelly and Bromley (1984), and, hitherto, it has certainly been used without question by the present author and many others. Herein, I contest one widely used aspect of this scheme of classification; the inclusion of two ichnospecies in *Teredolites* which show strong contrasts in gross form.

The terminology of borings used herein follows Häntzschel (1975) and Kelly and Bromley (1984). Specimens discussed herein are deposited in the Naturalis Biodiversity Center, Leiden (RGM) and the Natuurhistorisch Museum Maastricht, Maastricht (NHMM), both in the Netherlands.

Systematic ichnology

Ichnogenus *Teredolites* Leymerie, 1842.

Type species. *Teredolites clavatus* Leymerie, 1842.

Holotype of type species. Untraced (Kelly and Bromley 1984, p. 804).

Diagnosis. (Slightly modified after Kelly and Bromley 1984, p. 804.) "Clavate borings in woody substrates, acutely turbinate, evenly tapered from aperture to base of main chamber; neck region not separated from main chamber; cross-sections at all levels more or less circular; short."

Discussion. The only necessary change made to the original diagnosis of Kelly and Bromley, now *T. longissimus* is type ichnospecies of *Apectoichnus* igen. nov., was to change "… elongate and short" to simply "short".

Ichnogenus *Apectoichnus* igen. nov.

Synonymy. Determining a comprehensive synonymy list of *Apectoichnus* and its type species would be a Herculean task, somewhat outside the intention of this short note. The ichnospecies *T. longissimus* Kelly and Bromley, 1984, was erected less than 35 years ago, yet, for example, the present author has published at least ten research papers discussing this ichnotaxon by name. Other authors have been at least as productive.

Kelly and Bromley (1984, pp. 803–804) compiled a synonymy list for the ichnogenus *Teredolites* Leymerie, but presumably most of these refer to specimens that we would now call *T. clavatus*. That this list is incomplete is undoubted. For example, Donovan and Isted (2014, p. 252, Table 1) noted an array of names given to borings in Cretaceous wood from the Isle of Wight, UK, but without supporting illustrations. The only modern reference is to *T. longissimus* by Donovan and Isted (2014), yet there is no guarantee that their material is conspecific with any of the previous records; they could all have referred to what we now call *T. clavatus*. Thus, a detailed synonymy of *Apectoichnus* since 1984 would include very many entries, all *T. longissimus*. A synonymy list pre-1984 would be a worthy research project but is beyond the scope of the present communication.

Etymology. From Greek, *apektos*, uncombed, dishevelled (Brown 1985, p. 273), referring to the gregarious, tangled form commonly taken by tube-formers (Fig. 1a).
Type species. *Teredolites longissimus* Kelly and Bromley, 1984 (Fig. 1). The only ichnospecies included in this ichnogenus.

Holotype of type species. BMNH 38019, Aptian (Lower Cretaceous), Kent, England (Kelly and Bromley 1984, p. 804, text-fig. 11).

Diagnosis. Elongate borings, commonly circular in section, smooth-sided, straight or sinuous to contorted and intertwined, with or without a calcareous lining. The boring may change direction and cause a constriction of the tube but tubes are commonly of more or less constant diameter. May be solitary or gregarious.

Discussion. For discussion of the relevance of calcareous lining to ichnotaxonomy, see Donovan (2002).

Discussion

The principal ichnotaxobase used for clavate borings has been substrate, either rocky/shelly (*Gastrochaenolites* Leymerie) or wood (*Teredolites* Leymerie); the importance of morphology has been at the level of ichnospecies. The diagnosis of *T. clavatus* is more concerned with substrate than morphological features: "Clavate *Teredolites* predominantly perpendicular to the grain in woody substrates having length/width ratio usually less than 5" (Kelly and Bromley 1984, p. 804). On the same page the diagnosis of the ichnogenus *Teredolites* is "Clavate borings in woody substrate …" and, thus, that of *T. clavatus* actually tells us little more.

Teredolites longissimus Kelly and Bromley, 1984, the only other nominal species attributed to this ichnogenus, is morphologically very distinct from the type ichnospecies and, indeed, from any other boring ichnotaxon. It is worthy of inclusion in a new ichnotaxon. That is, the club-shaped *T. clavatus* is very dissimilar in gross morphology from the worm-like *T. longissimus* (best shown by Kelly and Bromley 1984, text-fig. 9). Indeed, *T. longissimus* can be one of the most idiosyncratic of borings, varying from more or less straight to contorted and intertwined (Savrda and Smith 1996; Fig. 1a herein). The use of a woody substrate for the principal ichnotaxobase for *Teredolites* has resulted in two strongly dissimilar ichnospecies being

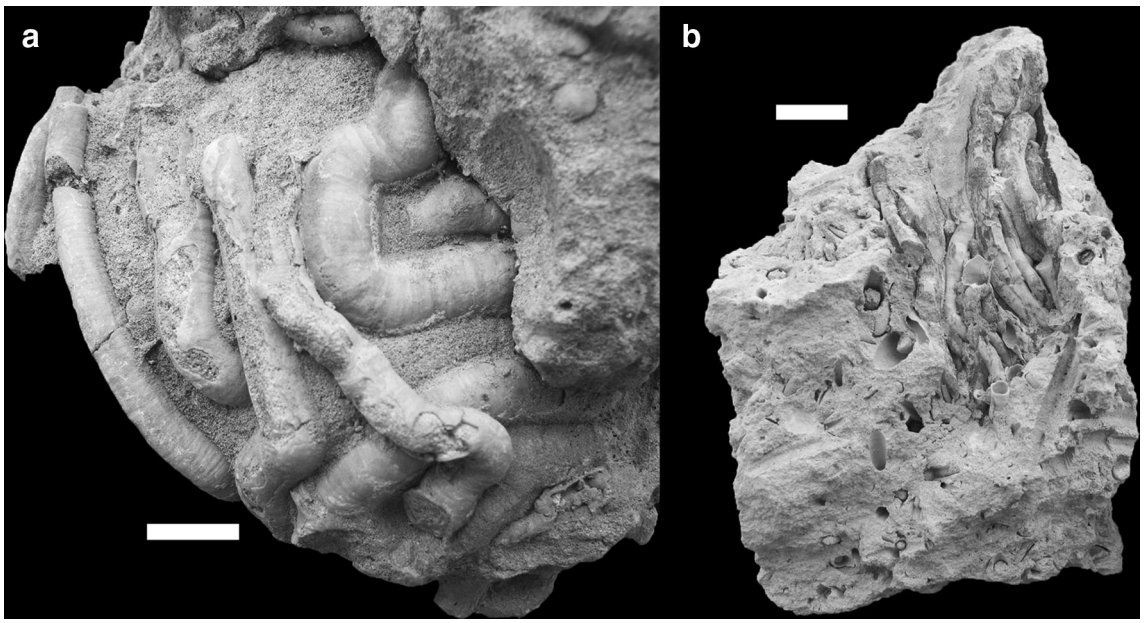

Fig. 1 *Apectoichnus longissimus* (Kelly & Bromley). **a** RGM 621 005, specimen preserved as calcareous tubes, and showing the contorted and gregarious association of individual borings common in this ichnospecies (after Donovan 2014, Fig. 2A). Specimen from the Eocene Ceru di Cueba Formation of Curaçao. **b** NHMM JJ 11884a, cluster of straight borings (after Donovan and Jagt 2013, Fig. 5E). Specimen from the uppermost Maastrichtian (Upper Cretaceous) Nekum Member, Maastricht Formation of the ENCI-HeidelbergCement Group quarry, St. Pietersburg, the Netherlands. In both specimens the woody substrate has decayed away. All scale bars represents 10 mm

lumped together. If the importance of a woody substrate is rejected as an ichnotaxobase, as it should be, then it is apparent that *T. clavatus* and *T. longissimus* need to be separated at the ichnogeneric level. Further, the ichnogeneric diagnosis of *Teredolites* (see above) as originally published by Kelly and Bromley stated "… acutely turbinate …", where turbinate is defined in a widely recognized reference as "Resembling a spinning-top in shape, conical" (Brown 1993, p. 3423). This describes *T. clavatus* admirably (e.g., Kelly and Bromley 1984, text-Figs. 9A, 10), but *T. longissimus* not at all (Kelly and Bromley 1984, text-Figs. 9B, 11; Fig. 1 herein).

Teredolites longissimus is much bigger in its length-to-width ratio than *T. clavatus* and it may be sinuous in a manner seen in no other clavate boring (Fig. 1a); indeed, it is not truly club-shaped. *Teredolites clavatus* and *T. longissimus* have been grouped together because they are borings in wood, not because they are close in form. Does substrate matter? Pickerill (1994, p. 10) followed Bromley (1990) in recognizing general form, branching, burrow fill and burrow boundaries as recognizable ichnotaxobases. Bertling et al. (2006, Table 2) summarized recommended ichnotaxobases as morphology (overall shape), orientation, ornamentation and internal structure. Note that none of these experts included substrate as an ichnotaxobase.

Teredolites longissimus is morphologically distinct from *T. clavatus*, the type ichnospecies of *Teredolites*. Therefore, these distinctive ichnospecies are separated at the level of ichnogenus herein and *T. longissimus* is named as the type ichnospecies of *Apectoichnus* igen. nov.

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Compliance with ethical standards

Conflict of interest The author declares that he has no competing interests.

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