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Naming trace fossils

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Abstract

A different approach to the naming of trace fossils is advocated. The primary ichnotaxobase should be the form of the burrow actually occupied, and the secondary ichnotaxobase should be the morphology of the structure that reflects the manner in which this burrow has been displaced and/or extended. Only by attempting to name trace fossils in this way will it be possible to eliminate features due to sedimentological factors that took place on termination of the animal's activities, including passive infill and diagenesis. To discriminate between different preservational states the citation should include both the taxonomic and preservational aspects.

1. Introduction

Since the latest revision of the International Code of Zoological Nomenclature (Ride *et al.* 1985) much confidence has been given to trace fossil nomenclature and towards the stabilization of trace fossil names. How the naming of trace fossils is governed by the Code has been discussed by Bromley (1990, 1996), Rindsberg (1990), Magwood (1992) and Pickerill (1994). As Bromley (1990) put it, the 'Dark Age', when names for trace fossils were to all intent invalid, was ended by the 1985 Code. There are still some relatively minor problems to be resolved (Rindsberg, 1990).

Publication of the 1985 Code has almost certainly led to the increase of papers dealing with ichnotaxonomic revision and re-examination of type material, for instance Wetzel & Bromley (1994, 1996) on *Phycosiphon* and *Helminthopsis*, respectively. But the question may be posed: whether this is in itself sufficient and in the best interests of ichnology. Why should trace fossil taxonomy be considered in the same way as plant and animal taxonomy? Is not a different approach to naming required? As Sarjeant & Kennedy (1973) noted 'Conceptually, trace fossils have no place in the Linnaean system and its present-day derivatives'. However, it is not our aim to depart from the 'Rules'.

While for probably most workers the ultimate aim of body fossil taxonomy is to further understanding of evolution and biostratigraphy, the information that trace fossils can provide is much wider, and though including aspects of evolution, centres on sedimentology (including sequence stratigraphy) and palaeoecology. The objectives of naming trace fossils are to provide stability and to maximize their information potential. Whereas the morphology of body fossils is due to inherent genetic factors the morphology of a trace fossil, although in many cases due to a genetically determined function, is at least as much, if not more, due to external factors, including stratal level, substrate type and consistency, grain size, type of infilling, and penecontemporaneous erosion. It is the information that trace fossils provide related to these factors that makes them so useful. Seilacher (1964) recognized the three aspects in the sedimentological classification of trace fossils: taxonomic, behavioural and preservational. Trace fossils, like body fossils, undergo taphonomic and diagenetic modification. Features due to these processes can play no part in taxonomy. But such processes can either enhance a burrow, leading to an *elite* trace fossil (Bromley, 1990), or render the structure less discernible. The latter led MacNaughton & Pickerill (1995) to propose *taphoseries* for ichnotaxa that have the potential to be misidentified for each other following taphonomic loss. For instance, with poor preservation it may not be possible to distinguish between *Planolites* and *Palaeophycus*, if the diagnostic lining of the latter is uncertain.

2. Ichnotaxobases

This leads to the question as to what are the bases for naming: the ichnotaxobases (Bromley, 1990). Bromley (1990, 1996), Magwood (1992) and Pickerill (1994) have discussed these in detail. Their approach is basically objective and includes general form, type of branching, burrow boundaries, and nature and structure of the burrow fill. Fürsich (1974a,b) extended morphological analysis to assessing which features were of significance and which were accessory: the former being applicable at the ichnogeneric level, the latter at ichnospecific level. In practice his scheme is not easy to apply because of its inherent subjectivity. For instance, Fürsich (1974b) regarded the expanded base of the U-burrow as the diagnostic feature of *Diplocraterion helmerseni*. But Osgood (1970, p. 322) explained that the deformation was due to the animal coming up against a relatively firm, concealed substrate.

Though we will mostly never be sure what the maker of a trace was, indeed in many instances its phylum may remain enigmatic, surely we should try to determine what was the form of the burrow occupied by the producer. This was an aspect emphasized by Seilacher (1957) (Fig. 1b) when demonstrating the difference between the burrow as observed in modern sediments and the fossil analogue that displayed evidence of former positions. In arriving at the basis for a burrow name we should first ask the question: what was the morphology of the burrow that was occupied at a particular stage of its construction (Table 1)? Secondly, how was the burrow displaced and/or extended? In a simple U-burrow (*Arenicolites*) there is no displacement whereas *Diplocraterion*, though also having a U-form, displays evidence of upward or downward displacement which is so widespread in the geological record that we can be certain that it was formed under genetic control.

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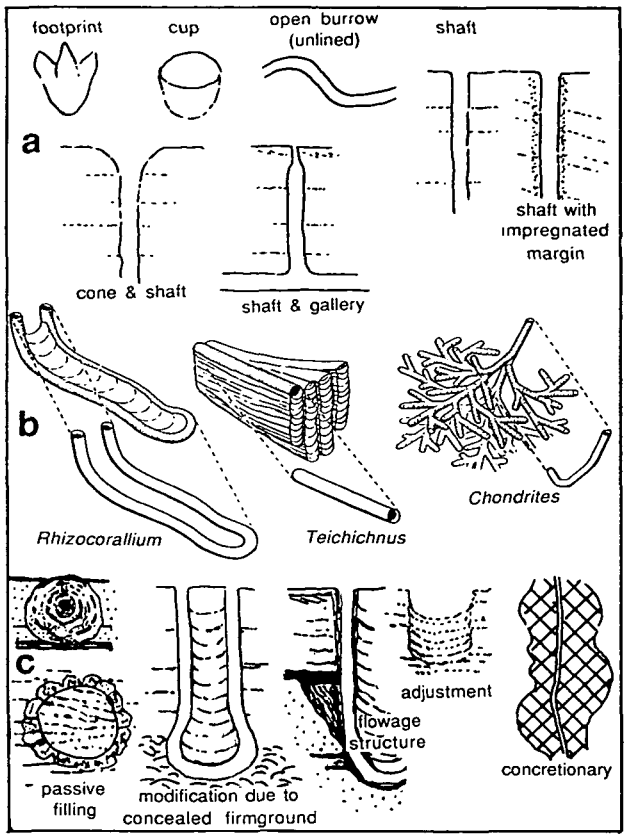


Figure 1. (a) Some simple primary ichnotaxobases. (b) Three burrows and their displacement or extension (secondary ichnotaxobase). Adapted from Seilacher (1957) who drew these for a different purpose. (c) Some common features of trace fossils which may not serve as ichnotaxobases.

As ichnologists gradually appreciate how trace fossils were formed and their subsequent taphonomy, it is clear that many ichnotaxa are no more than special preservations of other taxa. The paradox is that it is often useful to retain such names because they carry important sedimentological and palaeoecological information. For instance work on *Scolicia* group traces (Fig. 2) (Smith & Crimes, 1983; Plaziat & Mahmoudi, 1988; Uchman, 1995; Uchman & Krenmayr, 1995) has led to a better understanding of the form of these complex back-filled burrows. The impression of the resting trace of an irregular echinoid (*Cardioichnus* Smith & Crimes, 1983) (Fig. 2) confirms that, in the Cretaceous and Cenozoic, the associated burrows are the work of burrowing echinoids, at different depths of penetration, some shallowly ploughing and referred to *Scolicia*. Uchman (1995) placed the interface trace *Subphyllochorda* into synonomy with *Scolicia* (as *S. prisca*) because he considered *Subphyllochorda* to be no more than a toponomic variant. But toponomic position (here referring to depth below the substrate surface) provides important clues for substrate tiering, and ethological interpretation (Bromley, Jensen & Asgaard, 1995), and other workers may not follow Uchman. The semi-relief cast of a washed out burrow (typical as a turbidite sole trace), for which the name *Taphrhelminthopsis* has been used, was also placed into synonomy as *Scolicia strozzii*. (Morphological variation here may reflect depth of erosion.) *Bichordites* Plaziat & Mahmoudi, 1988 was originally applied to a tube, now recognized as no more than the diagenetically enhanced drainage tube of an echinoid. (The producer had a single drainage tube – *Echinocardium* type – in contrast with the paired drainage tubes represented by *Scolicia* – *Spatangus* type.) It is surrounded by the back-filled burrow of the advancing animal, i.e. it represents a burrow within a burrow. The ichnotaxon has beeen revised (Uchman, 1995) to include the whole structure. Uchman (1995) also showed that biserial menisci seen in bedding-parallel section represent a preservational expression that can often be tentatively attributed to burrowing echinoids. But rather than referring such incomplete preservation to *Laminites* Ghent & Henderson, 1966, he used *Scolicia prisca* var. *laminites*, an unacceptable combination. This example of trace fossil taxonomy indicates the taxonomic problems posed by the nature of the substrate, toponomy and taphonomy: problems that do not affect body fossil taxonomy. Much remains to be done with *Scolicia* group traces.

Table 1. Primary and secondary ichnotaxobases.

Primary Ichnotaxobase
Morphology of the original burrow, burrow segment or trace e.g. open U-burrow, ± lining, segment of burrow containing animal, footprint set (Fig. 1a).

Secondary Ichnotaxobase
Extension and/or displacement of the primary ichnotaxobase by normal physiological processes, including branching, back-filling, lateral displacement, active lining (Fig. 1b).

Not Available as Ichnotaxobases
Diagenetic processes (which may nevertheless enhance or diminish ichnotaxobases), passive infilling, size, substrate effects during construction (including penecontemporaneous erosion, aggradation and lithification), taphonomic aspects (Fig. 1c), stratigraphic age and geographic location.

3. Citation of ichnotaxa

Retaining distinct ichnogenera is one way of emphasizing the preservational information. Alternative methods of indicating toponomy and taphonomy are to cite both names. For example:

Ichnogenus *Scolicia* de Quatrefages, 1849
Toponomic expression *Subphyllochorda* Götzinger & Becker, 1932

However, as understanding of preservational effects advance, it would be logical to use:

Ichnogenus *Scolicia* de Quatrefages, 1849
Toponomic expression: convex (interface) hypichnion

instead of a relegated ichnotaxon, the nature of which the reader may be uncertain. This was Seilacher's (1964) proposal e.g. '*Cruziana furcifera* D'Orbigny – (trilobite burrows in) endogenic convex hyporelief (preservation)' (our brackets).

Other examples are:

Ichnogenus ?*Scolicia* de Quatrefages, 1849
Taphonomic expression *Laminites* Ghent & Henderson, 1966

or

Ichnogenus ?*Scolicia* de Quatrefages, 1849
Taphonomic expression: bisymmetrical, probably meniscate burrow

and

Ichnogenus ?*Scolicia* de Quatrefages, 1849
Taphonomic expression: *Taphrhelminthopsis* Sacco, 1888

or, Taphonomic expression: convex hypichnial (turbidite) cast

Goldring & Jensen (1996) referred to *Plagiogmus* Roedel, 1929 as:

Psammichnites Torell, 1870
Taphonomic expression: *Plagiogmus* Roedel, 1929

This would be more clearly expressed by adding 'lower, concave surface of endichnial burrow'.

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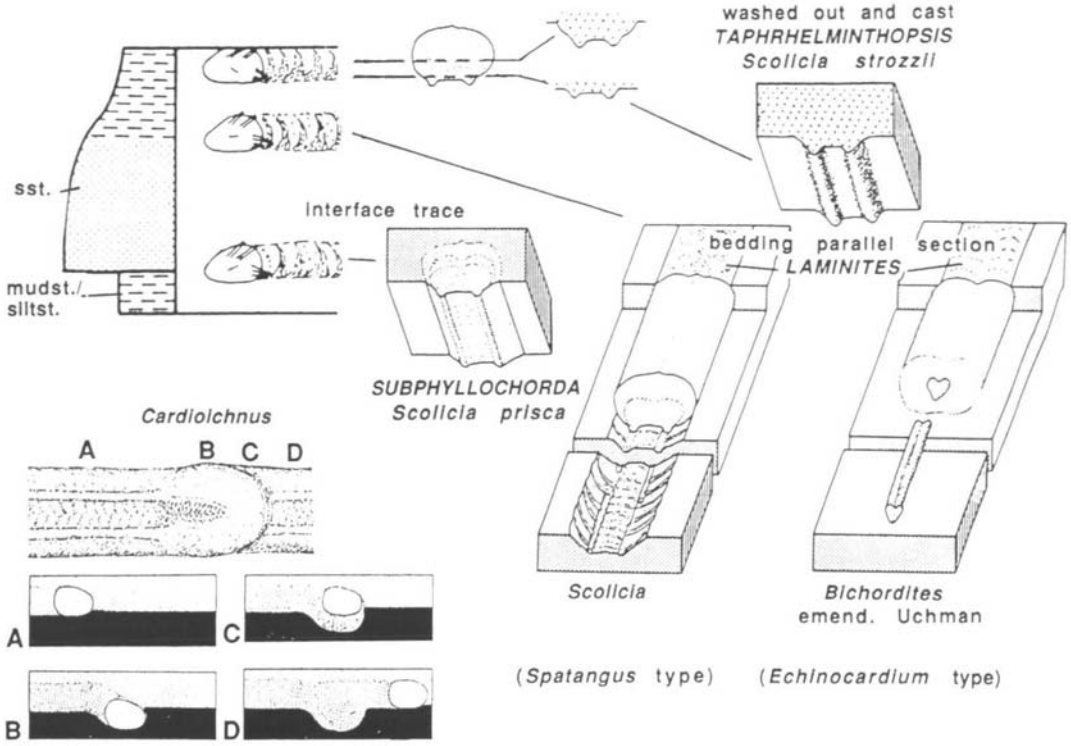


Figure 2. *Scolicia* group trace fossils attributed to burrowing echinoids, with toponomic and taphonomic expression. Names in capitals: those commonly used and indicating toponomy and taphonomy but rejected by Uchman (1995); names in italics: usage proposed by Uchman. Lower left: model for the formation of *Cardioichnus* (B), echinoid 'resting trace', linked to *Scolicia* (A, D). Adapted from Smith & Crimes (1983) and Uchman (1995).

The different levels along which many endichnial burrows may split along their length, each yielding a distinctive morphology, is analogous to the undertrack fallout of vertebrate and arthropod footprints (Goldring & Seilacher, 1971). Trewin (1994) recommended that the naming of the track (trackway) should refer to the 'highest (greatest) level of organization recognized'. Undertracks with only partial organization may be referred to as 'undertrack of ichnotaxon *A*'.

4. Conclusion

In conclusion, placing greater emphasis on the form of the primary burrow and its subsequent extension or dislacement as ichnotaxobases should lead to greater awareness of the limitations of the material being analysed, and indeed whether type material of existing ichnotaxa, including topotype material, has sufficient characters to warrant revision. Although we hold the view that trace fossil taxonomy is best governed by the International Code of Zoological Nomenclature, as awareness of the sedimentological and ecological aspects (including ichnofabrics) of trace fossil morphologies are better understood and ichnotaxa placed into synonomy, then citations must include the sedimentological aspect. To follow exactly body fossil procedure and not accept sedimentational effects results in information loss and often implies greater precision in naming than would be justified. Surely it is time to implement Seilacher's (1964) proposal.

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