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The putative Ordovician annelid worm *Haileyia adhaerens* Ruedemann, 1934 is not a recognizable fossil

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Abstract.—A number of putative annelid worms have been described from Ordovician strata, and these records are included in large-scale compilations of paleontological data. If these fossils are worms, they may yield important phylogenetic information; conversely, if they are not worms, they should not be included in large-scale databases. In either case, restudy of the type material of these supposed annelids is useful. The type material (holotype and one paratype) of one of these putative annelids, *Haileyia adhaerens* Ruedemann, 1934, from the Middle Ordovician Normanskill Shale of Idaho, USA, is re-described and re-illustrated. The original description stated that the species is segmented, with parapodia, papillae, and setae, and lived attached to graptolites. Upon re-examination, the setae could not be detected, and the segmentation, parapodia, and papillae are herein re-interpreted as taphonomic, rather than biological, features. The supposed attachment of *Haileyia* to graptolites is likely to represent fortuitous bedding-surface associations. There is no evidence that *Haileyia adhaerens* is an annelid, or even a recognizable fossil.

Introduction

The fossil record of annelid worms is generally sparse because many annelids do not possess easily preservable tissues. The fossil record of annelids dates back to the early Cambrian, with complete worms being known from several Cambrian Konservat-Lagerstätten (Parry et al., 2014). Molecular clock evidence suggests that crown-group annelids arose during the late Cambrian–Ordovician interval (Parry et al., 2014); thus, the Ordovician annelid record is crucial to understanding the evolution of the group. The scolecodont record suggests substantial diversification of jawed polychaetes during the Ordovician Period (Hints and Eriksson, 2007). Machaeridians (now known to be annelids; Vinther et al., 2008) also appear to have diversified during the same interval (Hints et al., 2004). However, there are few annelid body fossils known from Ordovician rocks, making it difficult to assess the evolution of the group as a whole during this time.

A number of fossils identified as annelids or other types of worm were described from Ordovician strata in the nineteenth and earlier part of the twentieth centuries (e.g., Ulrich, 1878; Ruedemann, 1901, 1934; Moberg and Segerberg, 1906; Hadding, 1913). The majority of these fossils have never been restudied or adequately illustrated, and it is unclear whether they are indeed worms and, if they are worms, to which phylum they belong. Some of these fossils, such as those that are the subject of this paper, have been included in paleontological databases such as the Paleobiology Database (PBDB, source: fossilworks.org; search conducted 28 April 2019) and compilations (Sepkoski, 2002), at which point rare taxa in particular can influence perceived global patterns, even when not explicitly cited or discussed. For members of rare fossil groups, erroneous data points can become significant.

Rudolf Ruedemann (1864–1956) was an extremely prolific paleontologist, with more than 140 publications during his lifetime (Rodgers, 1974). Much of his work has stood the test of time; however, in some cases he described structures in fossils that, upon subsequent examination, are not present (e.g., Simonetta, 1961; Maletz, 2015), and it appears that many of his specimens are of inorganic origin (Tollerton, 2006). One of Ruedemann's putative worms is *Haileyia adhaerens* Ruedemann, 1934, from the Ordovician Normanskill Shale of Idaho, USA. Herein we re-describe and illustrate photographically the type (and only known) material of *Haileyia adhaerens* and assess its interpretation.

Materials and methods

The type material of *Haileyia adhaerens* Ruedemann, 1934 consists of two specimens: the holotype (USNM PAL 90853; Fig. 1) and the paratype (USNM PAL 706443; Fig. 2), both of which lack counterparts. Both specimens are from the Normanskill Shale (upper Middle Ordovician), near the head of Fall Creek, Idaho, USA. We could find no references to additional material of *Haileyia adhaerens* in the literature, so the re-description is based solely on the type series. The specimens were examined both dry and wet under both low- and high-angle light. Photographs were obtained with a Nikon D80 camera and a Maozua 5 MP USB microscope.

Repository and institutional abbreviation.—The specimens are housed in the National Museum of Natural History, Washington DC, USA (NMNH).

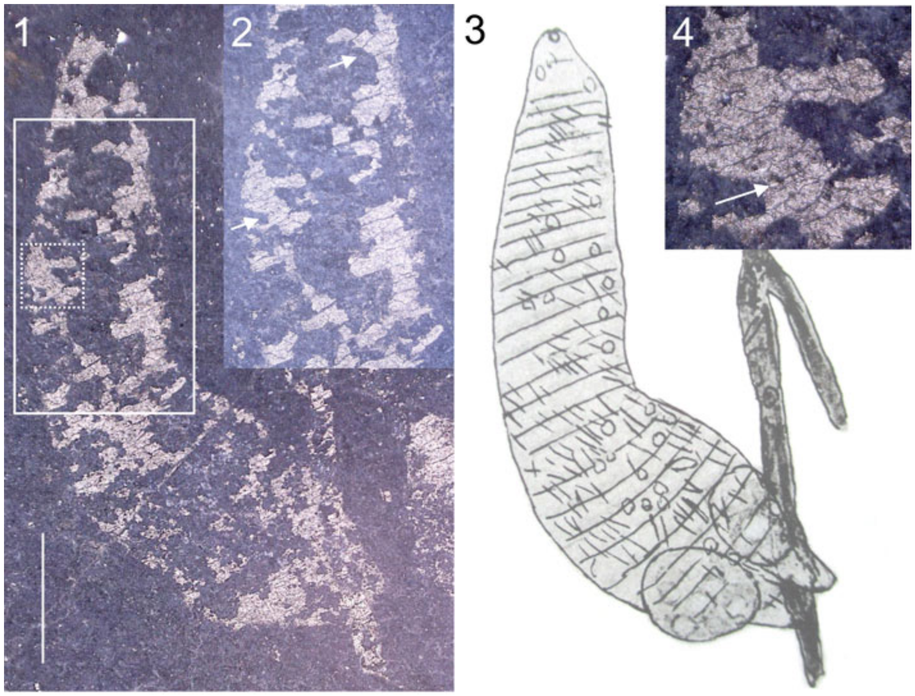

Figure 1. *Haileyia adhaerens* Ruedemann, 1934. (**1, 2, 4**) Holotype, USNM PAL 90853, entire specimen, photographed under water; (**2**) same, enlargement of the area indicated by the dashed white rectangle in (**1**), photographed under water, scattered bumps on film indicated by white arrow; (**4**) same, enlargement of the area indicated by the solid white rectangle in (**1**), photographed under water, showing the transverse structures on the specimen; the white arrows in (**2, 4**) indicate irregular cracking; (**3**) reproduction of the original illustration of the holotype (Ruedemann, 1934, pl. 21, fig. 11). The original illustration has been rotated to match the orientation of the photograph. Original image is copyright Geological Society of America and used with permission. Scale bar represents 2 mm.

Description of material

The *Haileyia* material is preserved as reflective films (presumed to be carbonaceous, perhaps with minor iron mineralization) on shale bedding planes, broadly similar in appearance to graptolites on the same slabs.

The holotype specimen tapers in both directions (abruptly in one direction) and is slightly curved (Fig. 1.1). It is ~10 mm long and ~3 mm wide at the widest point, tapering to a blunt point at the thin end; the wider end has a blunt termination (Fig. 1.1). Transverse structures extend across part of the width of the specimen, but are not entirely parallel and show irregularity typical of taphonomic cracking of a brittle sheet (Fig. 1.2). The surface of the specimen is irregular, and bears minute scattered bumps (Fig. 1.4). No other structures are visible within or around the margin of the specimen. The wider end of the specimen underlies a graptolite stipe.

The paratype (Fig. 2) is ~13 mm long and irregularly cylindrical, with a width of ~2 mm over most of its length. No structures are visible within or around the specimen, and the margins are diffuse. One end of the specimen is overlain by a graptolite stipe and the other is in contact with a dicellograptid graptolite.

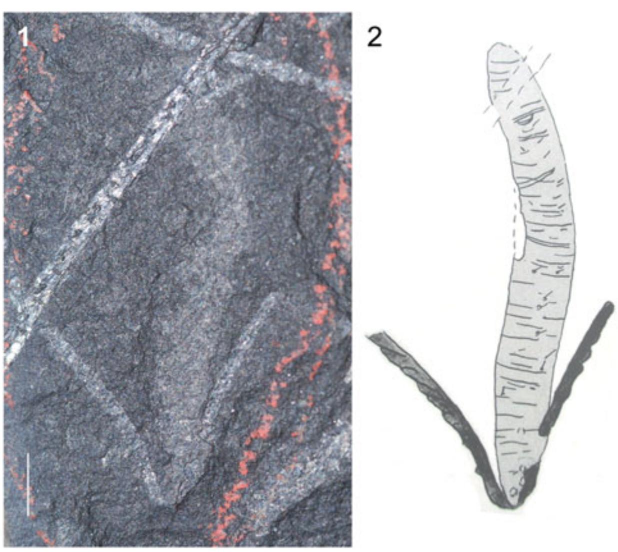

Figure 2. *Haileyia adhaerens* Ruedemann, 1934, paratype, USNM PAL 706443. (**1**) Photographed dry; note that the contrast has not been digitally enhanced, so that the image accurately reflects the actual appearance of the fossil; (**2**) reproduction of the original illustration of the paratype (Ruedemann, 1934, pl. 21, fig. 10). The original illustration has been rotated to match the orientation of the photograph. Original image is copyright Geological Society of America and used with permission. Scale bar represents 2 mm.

Discussion

In the original description, *Haileyia* is stated to possess segmentation, parapodia, setae, and papillae (Ruedemann, 1934). Transverse structures visible on the holotype were interpreted by Ruedemann (1934) as sutures separating segments; however, the transverse structures are not parallel (Fig. 1.2), as would be expected for the boundaries of annuli/segments, the dark lines are visible rock between broken plates of the organic film, and

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there are numerous oblique and perpendicular structures that indicate abiological cracking rather than original structure. Accordingly, these features are reinterpreted as cracks in the thin film that constitutes the specimen, and not as biological features. The putative parapodia illustrated by Ruedemann (1934) on the wider end of the holotype (Fig. 1.3) are not visible. Ruedemann (1934, p. 86) stated that “minute papillae and delicate setae are irregularly distributed over the body.” The ‘setae’ could not be detected under the microscope, but the ‘papillae’ are probably a reference to minute, scattered bumps on the film that appear to be impressions of pyrite framboids (Fig. 1.4). The surface of the film that forms the specimen is markedly irregular, but there is no suggestion that this indicates the presence of original structures.

Ruedemann (1934) stated that the putative worms were attached to graptolites and hypothesized that this was their mode of life. Both specimens are overlain by planktonic graptolites (Figs. 1.1, 2.1), and there is no sign of any parts of the putative worms overlying the graptolites, as would be expected if the worm had been clasping the graptolite. We interpret these associations as having arisen by chance because graptolites are very abundant on the bedding surfaces. For example, on the paratype slab, which measures 55 mm by 50 mm, there are at least 20 graptolites and at least 10 pieces of reflective film similar to those forming the type material of *Haileyia*. It is thus not surprising that some of these films are in contact with graptolites.

Haileyia adhaerens was identified by Ruedemann (1934) as a worm, but not firmly assigned to any group; nor was it assigned to a phylum, class, order, or family by Howell (1962, p. W170), although it is listed as a polychaete annelid by the PBDB (source: fossilworks.org; search conducted 28 April 2019). The PBDB lists 22 Ordovician polychaete genera (source: fossilworks.org; search conducted 28 April 2019, search terms Polychaeta and Ordovician), including *Haileyia*. Thus, this occurrence forms part of (and biases) our knowledge of large-scale patterns in the fossil record. Although this is only one record, it is not known how many other records are also erroneous, and so the re-interpretation of *Haileyia* serves as a reminder that data should not be used uncritically.

Conclusions

The type material of *Haileyia adhaerens* does not show any features that allow identification as a worm. Although the specimens probably represent organic remains, it is not possible to tell what type of organism may have produced them; such organic debris is extremely common in Ordovician black mudstone sequences, and is typically rejected as being undeterminable. As a result, both the generic and specific names should be abandoned, and the record should be rejected as evidence for any taxonomic group.

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