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The earliest bryozoan parasite: Middle Ordovician (Darriwilian) of Osmussaar Island, Estonia

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ABSTRACT

The earliest known macroscopic endobiotic symbionts are described from Middle Ordovician bryozoans of Osmussaar Island, Estonia. The bryozoan symbionts represent a new ichnospecies and ichnogenus, *Anoigmaichnus odinsholmensis* ichnosp. nov., which occurs only in *Mesotrypa bystrowi*. It most likely represents a parasite. The shape of the trace is consistent with a worm-like animal, making the annelids likely candidates for the trace maker. The increase in predation pressure may have been among the direct causes leading to the appearance of various macroscopic endobiotic symbionts in the Ordovician.

1. Introduction

Bryozoans have hosted various endobiotic symbionts in their evolutionary past (Voigt, 1955; Elias, 1966; Palmer and Wilson, 1988; Ernst et al., 2014). Bryozoan symbionts have previously been unknown from the Ordovician of Baltica, but they occur in the Ordovician of North America (Palmer and Wilson, 1988). Symbionts also occur in recent bryozoans; some of them are parasitic (Hill and Okamura, 2007; Tamberg et al., 2013). Symbiotic endobionts are usually completely embedded in the tissues of a host bryozoan, except for an opening on the host surface for feeding (Ernst et al., 2014). Macroscopic endobiotic symbionts are also known from other Ordovician invertebrates, such as tabulates and rugosans (Tapanila, 2004, 2005). Their previously known earliest representatives occur in the Late Ordovician of North America and Baltica (Elias, 1986; Tapanila, 2005; Dixon, 2010; Vinn and Mõtus, 2012a,b). Hard substrate fossils are among the best examples of symbiotic interactions in the geological past because non-mineralized symbionts can leave a living cavity within the host skeleton (Taylor, 1990; Taylor and Wilson, 2003). Such cavities left by embedment are termed bioclaustrations (Palmer and Wilson, 1988). Most of these traces have recently been interpreted as being parasitic in nature (Zapalski, 2007, 2009, 2011; Zapalski and Hubert, 2011).

Bioclaustrations and skeletal symbiotic endobionts have previously been described from the Late Ordovician and Silurian of Baltica (Vinn and Mõtus, 2012a,b; Vinn et al., 2014). However, no bioclaustrations or other endobiotic symbionts have previously been reported from the Middle Ordovician of Baltica or any other paleocontinent. Thus, the Middle Ordovician may have been the time of first appearance of macroscopic endobiotic symbionts. It is possible that the appearance of macroscopic endobiotic symbionts could be a function of the Great Ordovician Biodiversification Event (GOBE).

The aims of this paper are to: (1) determine whether the endobiotic cavities in the bryozoan *Mesotrypa bystrowi* belong to bioerosional trace fossils or bioclaustrations; (2) determine the taxonomic affinity of the trace maker; (3) discuss the ecology of bryozoan–worm associations; (4) discuss the occurrence of endobiotic symbionts in the bryozoans, and (5) discuss the possible influence of the GOBE on the appearance of macroscopic endobiotic symbionts.

2. Materials and methods

A total of 71 bryozoans from Uhaku Stage were collected from Osmussaar Island by Ralf Männil from 1971 to 1986 (Figs. 1, 2). The collection contained six specimens of the trepostome bryozoan *Mesotrypa bystrowi*. The apertures constructed by endobiotic symbionts were discovered on the surface of colonies using a binocular light microscope Leica S8APO. The diameters of these apertures were measured under the microscope using calipers. Four specimens with endobiotic

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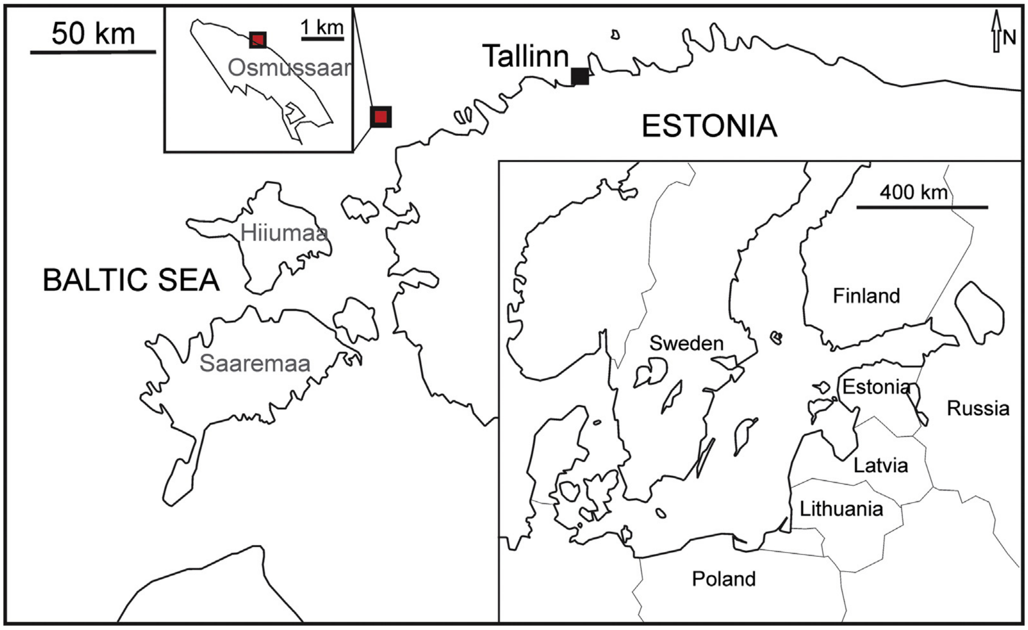

Fig. 1. The location of Osmussaar Island in Estonia and the bryozoan locality (red square). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

symbionts were longitudinally and transversely cut into multiple sections using a stone saw. Surfaces of these sections were polished, and the endobiont cavities digitally photographed using a Leica IC80 HD camera (Leica Microsystems GmbH, Germany) and scanned with an Epson perfection 4490 optical scanner. The studied specimens are deposited at the Institute of Geology, Tallinn University of Technology (GIT).

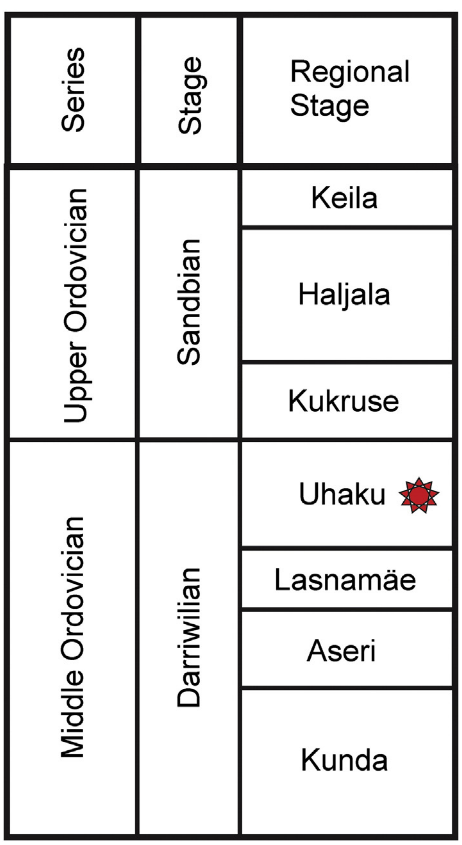

Fig. 2. The stratigraphy of the Middle Ordovician of Estonia. Location of the earliest bryozoan parasites marked with red asterisk. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Systematic ichnology

Anoigmaichnus ichnogen. nov.
(Fig. 3A–F)

Diagnosis. — Shafts perpendicular to host's growth surface or tilted (up to 45°); conical to cylindrical; circular to oval cross-sections; lacking separate wall. The shafts cut through host's skeleton throughout most of their length. The apertures are elevated above host's growth surface.

Etymology. — ἄνοιγμα (Greek) = opening, aperture; ἴχνους (Greek) = track.

Type species. — *Anoigmaichnus odinsholmensis* ichnosp. nov.

Anoigmaichnus odinsholmensis ichnosp. nov.

Diagnosis. — same as for genus.

Material. — Three *Mesotrypa bystrowi* colonies with two shafts and one colony with single shaft.

Locality. — Osmussaar, at the middle of the cliff on the eastern coast (Fig. 1).

Stratigraphy. — Uhaku Stage, Darriwilian, Middle Ordovician (Fig. 2).

Etymology. — After the local Swedish name of Osmussaar Island (Odinsholm).

Description. — Shafts perpendicular or at an oblique angle (up to 45°) to bryozoan host's growth surface; up to 3.0 mm deep. The shafts have conical to cylindrical cross-sections. They lack their own walls. The shafts cut through host's zooecia throughout most of their lengths. There are no tabulae or other internal structures within the cavity. Only in the apertural region are host's zooecial walls not cut; here the cavities have a smooth sheath made of bryozoan skeletal material. The