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VERMIFORICHNUS (POLYCHAETA) BORINGS IN *PARASPIRIFER BOWNOCKERI* (BRACHIOPODA: DEVONIAN)[1]

R. D. HOARE and R. L. WALDEN, Department of Geology, Bowling Green State University, Bowling Green, OH 43403

ABSTRACT. Shells of *Paraspirifer bownockeri* (Stewart) from the Silica Formation, Middle Devonian of northwestern Ohio, commonly contain numerous borings of a polychaete worm forming the endolithic trace fossil *Vermiforichnus clarki* Cameron (1969a) which can be exposed by acidizing the specimens. The borings are most abundant on the brachial valve, and their surface openings tend to be concentrated along major growth lines thence extending dominantly in the general direction of the beaks of the valves. Infestations of the polychaete occurred at 2 different time intervals as indicated by the spacing of the borings on 2 major growth lines with renewed shell growth between them. Growth of the host was severely reduced immediately following the infestation and in some areas damage to the mantle caused deformation in the shell of the host.

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INTRODUCTION

Previous interpretations of the larger borings commonly seen in the brachiopod *Paraspirifer bownockeri* (Stewart) from the Silica Formation in northwestern Ohio have been alluded to as sponge borings, *Clionoides thomasi* Fenton and Fenton (1932) by Hoare and Steller (1967) (fig. 1), as boring sponges by Kesling and Chilman (1975) and as "*Clionoides*" sp. by Steller (1965), Kesling et al. (1980) and Sparks et al. (1980). These interpretations were based on the external configuration of the surface opening of the boring only. Subsequent investigation, brought about by the accidental over-acidization of a specimen, has provided us with the determination that these features are borings within the

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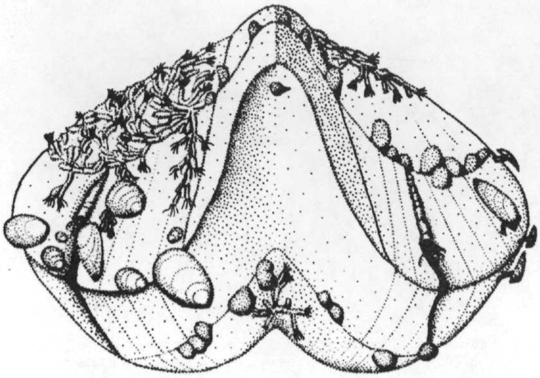


FIGURE 1. Anterior view of *Paraspirifer bownockeri* (Stewart) showing reconstruction of epizoans. Small, rounded structures concentrated along the major growth line were designated as the sponge *Clionoides thomasi* Fenton and Fenton, thought to be the cause of the large borings in the shell of the host, Silica Formation, BGSU-3765, 1×. (From Hoare and Steller 1967, used by permission of the Ohio J. Sci.)

shell and not borings through the valves. Cameron (1969b), using acidized specimens of *P. bownockeri*, described such burrows and related them to the endolithic trace fossil *Vermiforichnus clarki* Cameron.

Assignment of borings, of the type now referred to *Vermiforichnus,* can be found in Häntzschel (1975) and are well summarized by Cameron (1969b) who also describes probable architects, orientation, distribution and abundance of the borings (1967, 1969a,b). Substrate specificity of *Vermiforichnus* is discussed by Thayer (1974) and ecological relationships by Watkins (1979, 1981).

The specimens of *Paraspirifer bownockeri* are from the Silica Formation, exposed in an abandoned quarry, now owned by the France Stone Co., 4.9 km southwest of Sylvania, SE¼ sec. 7, T. 9 S., R. 6 E., Lucas Co., Ohio. Some of the specimens were collected by Anthony Zalinski who donated them for study. The specimens are in the repository of Bowling Green State University (BGSU).

METHODS AND MATERIALS

Several specimens of *Paraspirifer bownockeri*, both with and without surface evidence of borings, were selected, photographed, and emersed in a 30% solution of HCL to dissolve most of the shell material. Duration of time to accomplish the shell removal depended upon the degree of pyritization of the shell material, but averaged approximately 5 min. This exposed many of the borings which are preserved to a large extent by an internal filling of fine-grained pyritized sediment. Some of the borings can be seen still embedded within shell material.

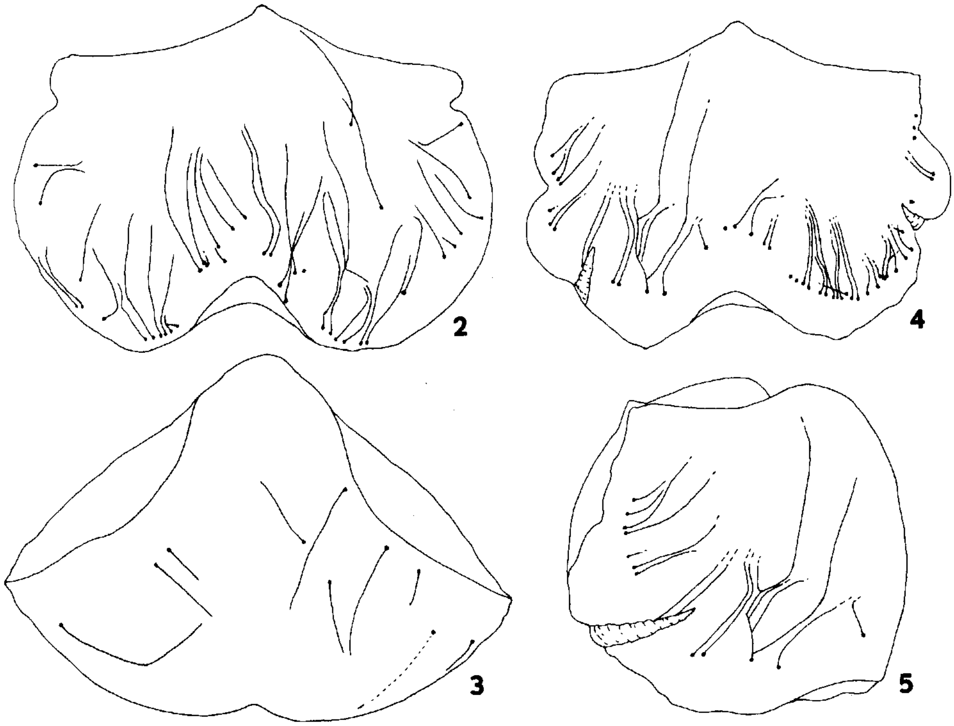
Measurements of the fillings of the borings were made under a microscope using an occular micrometer. Characteristics and location were noted at the same time for each. The specimens were whitened with MgO and rephotographed. Distribution and extent of the borings, as shown in figures 2–5, were made by inking enlarged photos in comparison with the specimens.

Of the 6 specimens acidized, borings were exposed on 4, all of which showed surface openings. Two specimens, lacking surface evidence, were confirmed as having no borings.

We measured boring length (BL), boring diameter (BD) and boring opening diameter (BOD). The length of boring, as given, is in part a reconstruction, since portions may have been acidized away or since the distal end may not be completely exposed. Boring diameter is an average figure based upon at least 2 measurements of the same structure since the borings are variably exposed in terms of depth. The diameter of the boring opening was measured prior to acidization but was impossible to determine in several instances because of preservation of the brachiopod host. Characteristics noted were whether borings branched or not, whether borings were essentially straight or strongly curved, whether borings followed the ornamentation or not, whether borings crossed one another and in which valve the boring was located.

RESULTS

As can be seen in figures 6, 8, 9, 12, the openings of the borings tend to be concentrated along major growth lines on both the pedicle and brachial valves. This indicates an infusion of the polychaete into the habitat at a particular time, infesting the brachiopod primarily along the anterior edge, or line of commissure, and possibly causing a decrease in growth activity by the host. A second infestation can be seen in figures 2, 3, 9–12 after renewed growth of the host had occurred. In some instances the action of the polychaete was detrimental to the host by injuring the mantle, causing shell deformation as seen in figures 1, 4–8. Such deformations are commonly occupied by tubes of the worm *Cornulites*, the borings extending posteriorly from the area of deformation (figs. 4–8).

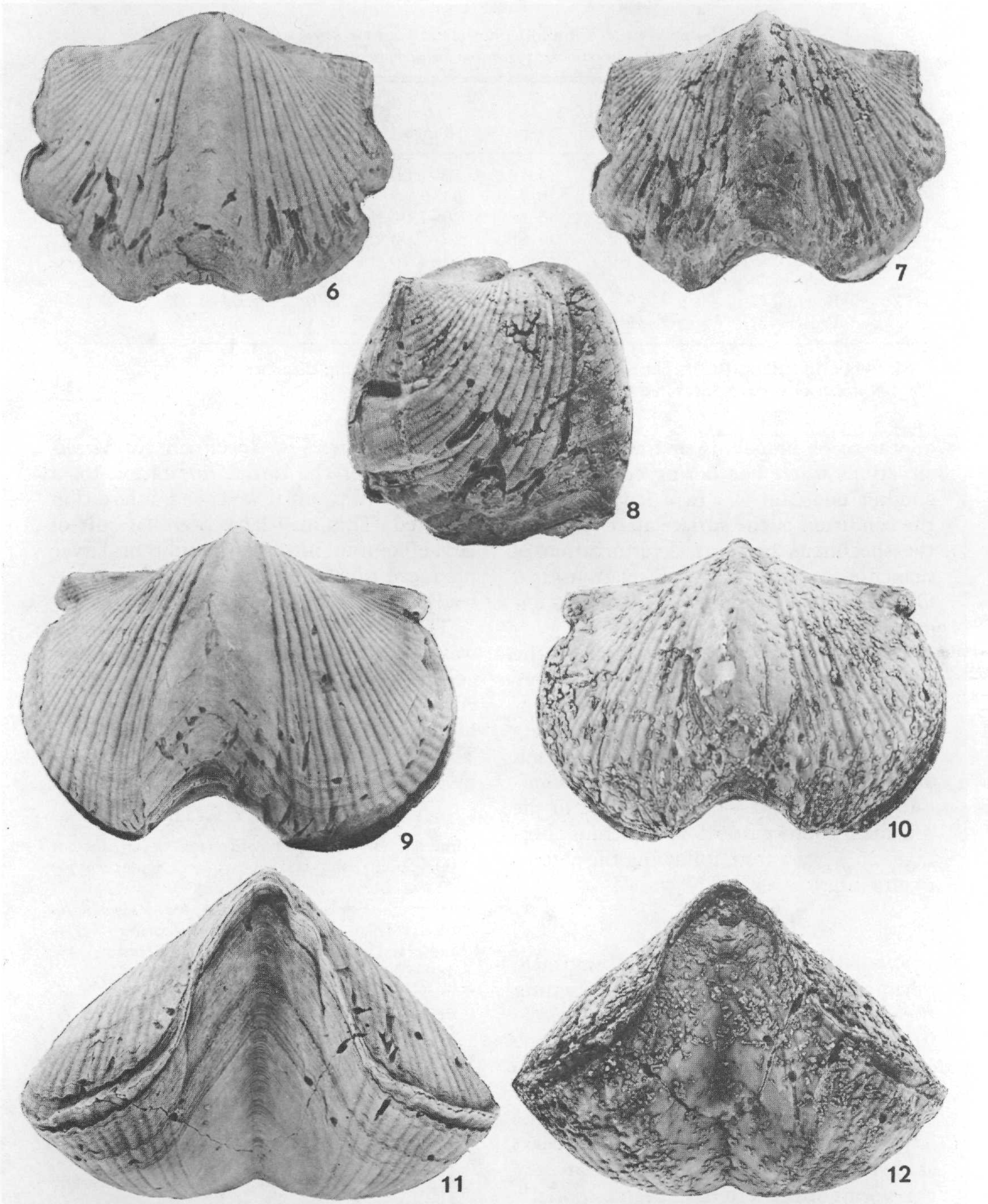


FIGURES 2–5. Diagrammatic representation of *Vermiforichnus clarki* Cameron borings in *Paraspirifer bownockeri* (Stewart). 2, 3, brachial and anterior views of BGSU-4197 showing concentrations of openings of borings along two major growth lines and at least two instances of crossing of borings. 4, 5, brachial and brachial lateral views of BGSU-4195 showing deformations of the host shell, occurrences of the worm tube *Cornulites* and crossing and branching borings of *Vermiforichnus clarki*. The second infestation of *Vermiforichnus* had not affected this specimen. Silica Formation, all 1×. Dots indicate position of surface openings of borings and dashed lines are reconstructions or assumption that the boring extended further than was preserved.

Evidence of 191 borings is present on the 4 host specimens. Of these, 112 (59%) occur on the brachial valves. One specimen (BGSU-4195) has a total of 90 borings present. Measurements on only 70 of the 191 borings present were made since the rest are too incomplete to give accurate data. Table 1 provides the data as to size, shape, orientation and location of the 70 borings measured. The borings range in length from 5.1 to 31.0 mm, averaging 14.7 mm. The exact length cannot be determined in many cases because of destruction during acidization or lack of exposure, but the measurements provide a fair estimate of this dimension.

Likewise, the diameter of the boring and of the surface opening of the boring may, in some instances, be misleading. The former ranges from 0.50 to 1.10 mm, averaging 0.72 mm, and the latter ranges from 0.50 to 1.01 mm, averaging 0.73 mm. At least 2 measurements of diameter were made on each boring and averaged for the diameter as given in table 1 and should present a close approximation of the true diameter. The size of surface opening is often more apt to be affected by external processes of weathering and diagenesis, and the exact margin of the opening may not be preserved. Most of the openings are subcircular; some are suboval. In some instances the proximal end of the boring appears to flare out slightly as if enlarged by activity of the occupant.

The borings rarely branch. In only 3% of the structures can branching be definitely seen (figs. 2, 4). Other instances of what



FIGURES 6–12 Unacidized and acidized views of *Paraspirifer bownockeri* (Stewart). 6–8, brachial unacidized, brachial acidized and brachial lateral acidized views, Silica Formation, BGSU-4195, 1×. 9–12, brachial unacidized, brachial acidized, anterior unacidized and anterior acidized views, Silica Formation, BGSU-4197, 1×.

TABLE 1

Measurements of Vermiforichnus clarki *Cameron borings in* Paraspirifer bownockeri *from the Silica Formation (mm).*

BGSU No.	Valve	BL* Range	BL* Aver.	BD* Range	BD* Aver.	BOD* Range	BOD* Aver.
4194	Brachial (9)**	7.2–25.2	14.1	.50–1.00	.59	.50–1.00	.56
	Pedicle (3)	7.3–16.2	10.9	.51– .80	.61	.55– .81	.65
4195	Brachial (9)	6.9–31.0	15.1	.70–1.00	.82	.73–1.00	.87
	Pedicle (2)	10.0–13.2	11.6	.62– .90	.76	.82–1.00	.91
4196	Brachial (9)	8.1–25.0	15.5	.51–1.10	.77	.61– .62	.61
	Pedicle (1)		11.3		.61		.62
4197	Brachial (29)	9.3–29.3	16.1	.50–1.00	.70	.62–1.01	.75
	Pedicle (8)	8.2–16.8	11.9	.56– .99	.71	.60– .65	.62

*BL = boring length; BD = boring diameter; BOD = boring opening diameter
**( ) Number of borings measured

appear to be branching at first glance are situations where one boring crosses below another one (fig. 2). In a few situations the condition of the surface after acidizing the specimens prevents determination of branching versus crossing relationships. Of the borings present, 13% do cross another burrow.

In terms of shape and orientation the borings tend to be straight to slightly curved and, more rarely, strongly curved. In most cases they generally approximate the orientation of the major ornamentation of the host. Fifty-three percent are essentially straight and 44% come close to the ornamentation pattern. Numerous borings, 26%, vary from following the pattern to crossing it.

DISCUSSION

Paraspirifer bownockeri was abundantly inhabited by the polychaete worm forming the trace fossil *Vermiforichnus clarki* Cameron during the deposition of the Middle Devonian Silica Formation. The brachial valve of the host was bored more commonly than the pedicle valve since the latter was lying on the substrate (Sparks et al. 1980). The infestation of the larvae of the worms appears to have been essentially instantaneous, attaching primarily along the line of commissure, most abundantly in the anterior region. Renewed growth by the host shows few specimens of *Vermiforichnus* after the initial infestation for a period of time until a second infestation occurred. This may have been a result of larvae coming into the habitat or larvae produced from the epizoan polychaetes already present on the host.

The activity of the epizoan polychaete was detrimental to the host causing a near cessation of growth. In some instances the edge of the mantle of the host may have been damaged causing shell deformation. These deformations often became occupied by the worm *Cornulites*.

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