Coexistence of symbiotic hydroids (*Protulophila*) on serpulids and bryozoans in a cryptic habitat at Chrtníky (lower Turonian, Czech Republic)

Kamil Zágoršek, Paul D. Taylor & Radek Vodrážka

This study provides the first record and description of the hydroid *Protulophila gestroi* Rovereto, 1901 from the Bohemian Cretaceous Basin (Czech Republic). The hydroid colony was bioclaustrated by a serpulid tube on the underside of a platy sponge, which is also encrusted by three species of bryozoans and an oyster. The Bohemian specimen differs from previously described specimens of *P. gestroi* in having zooidal orifices with broad sinuses. • Key words: Hydrozoa, *Protulophila*, Turonian, Bohemia.

Zágoršek, K., Taylor, P.D. & Vodrážka, R. 2009. Coexistence of symbiotic hydroids (*Protulophila*) on serpulids and bryozoans in a cryptic habitat at Chrtníky (lower Turonian, Czech Republic). *Bulletin of Geosciences 84(4),* 631–636 (5 figures). Czech Geological Survey, Prague. ISSN 1214-1119. Manuscript received May 7, 2008; accepted in revised form September 9, 2008; published online October 29, 2008; issued December 31, 2009.

Kamil Zágoršek, National Museum, Department of Palaeontology, Václavské náměstí 68, CZ-115 74 Praha; kamil.zagorsek@nm.cz • Paul D. Taylor, Natural History Museum, Department of Palaeontology, London SW7 5BD, United Kingdom; pdt@nhm.ac.uk • Radek Vodrážka, Czech Geological Survey, Klárov 13/3, CZ-118 21 Praha, and Charles University, Faculty of Science, Institute of Geology and Paleontology, Albertov 6, 128 43 Praha 2; Radek.Vodrazka@seznam.cz

Cretaceous deposits at Chrtníky (eastern Bohemia, Czech Republic) infill a V-shaped depression in Palaeozoic diabase. The richness of the fossil fauna is unique for the Bohemian Cretaceous and therefore this outcrop has been studied for more than 60 years. The first to describe briefly the sediments and faunas from Chrtníky was Zázvorka (1946). He was followed by Žítt & Nekvasilová (1991), Vlačiha (2002) and Žítt *et al.* (2004). Detailed palaeontological and sedimentological research on the Chrtníky locality was made by Žítt *et al.* (2006). The bryozoans were studied in detail by Zágoršek & Vodrážka (2006).

One of us (RV) has collected mainly sponges from the outcrop and found many epibionts cemented to their skeletons. Among these are a serpulid worm containing an embedded symbiotic hydroid – *Protulophila gestroi* Rovereto, 1901 – interacting with bryozoans on the same substrate. A detailed description of this specimen is the main aim of the present study. We also take the opportunity to illustrate for the first time using SEM some of the British Cretaceous specimens of *P. gestroi* studied by Scrutton (1975) who gave a comprehensive account of the symbiosis between serpulid worms and this hydroid which becomes embedded (or bioclaustrated, see Taylor 1990) in the growing worm tubes.

Geographical and geological settings

The fossil locality is situated 0.5 km SE of the village of Chrtníky near Heřmanův Městec (eastern Bohemia), on the southern margin of the Bohemian Cretaceous Basin (Žítt *et al.* 2006). A Lower Palaeozoic diabase is here overlain by an upper Cenomanian–lower Turonian transgressive succession of conglomerates, limestones and siltstones. According to Čech *et al.* (1980), the upper Cenomanian conglomerates belong to the Korycany Member of the Peruc-Korycany Formation, whereas the limestone and siltstones represent the Bílá Hora Formation. Detailed descriptions of the section are given by Žítt *et al.* (2004, 2006) and Zágoršek & Vodrážka (2006).

The studied samples came from a wall forming the southeastern part of the quarry (GPS location: 49° 58.640´ N, 15° 36.427´ E) in the 'Giant Channel' (*sensu* Žítt *et al.* 2006) in the middle part of a two metre-thick sequence of siltstones containing sponges (Fig. 1; unit 8 *sensu* Žítt *et al.* 2006). The lower Turonian siltstones of unit 8 (*sensu* Žítt *et al.* 2006) at Chrtníky contain a low-diversity fossil assemblage when compared with underlying and overlying strata (Žítt *et al.* 2006). The most abundant component of the taphocoenosis are sponges which bear numerous encrusters represented mainly by

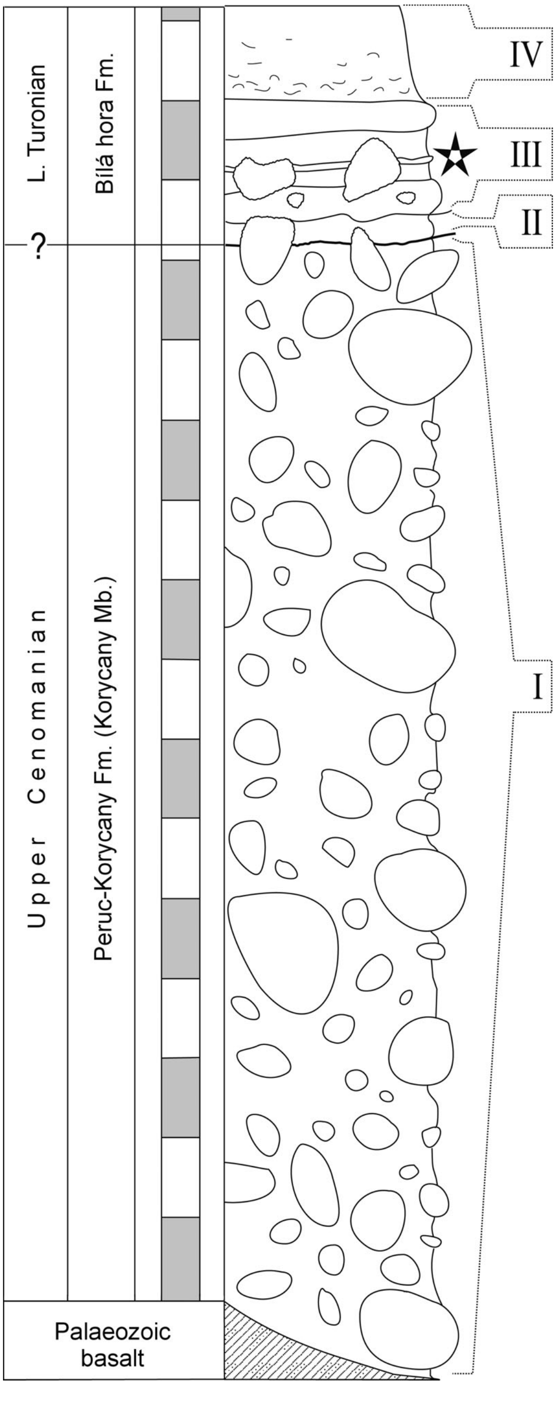

Figure 1. Simplified lithological profile of the studied Chrtníky section (modified after Žítt *et al.* 2006). I – conglomerates; II – clayey limestone; III – siltstones with sponges; IV – clayey siltstone. Stratigraphic position of the *Protulophila* specimen in the section is indicated by an asterisk.

bryozoans, bivalves, serpulids, brachiopods and agglutinated foraminifera (for some examples see Žítt *et al.* 2006). According to Žítt *et al.* (2006), the early Turonian age of this part of the section is demonstrated by the presence of *Inoceramus* ex gr. *labiatus* (Schlotheim, 1813).

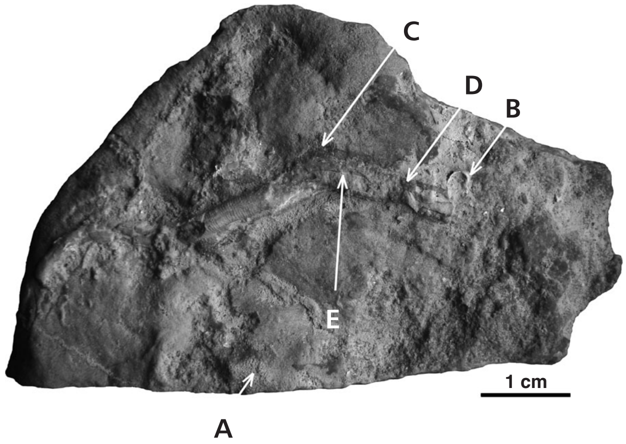

Figure 2. Part of the encrusted sponge *Verruculina phillipsi* (Reuss) indicating positions of serpulid, bryozoans and hydroid. • A – bryozoan *Onychocella novaki* (Brydone, 1910). • B – oyster. • C – bryozoan *Onychocella reussi* Prantl, 1938. • D – bryozoan *Marginaria elliptica* Roemer, 1841. • E – position of hydroid *Protulophila gestroi* Rovereto, 1901 on serpulid.

Material and methods

The studied samples were boiled in soda for several hours and briefly macerated in 38% sulphuric acid (Vodrážka in press). The encrusted sponge was then cleaned with a high-pressure water stream (water-blasting technique) and in an ultrasonic bath. Micrographs were made in the Institute of Palaeontology, Vienna University, using a Jeol JSM-6400 high-vacuum scanning electron microscope. Comparative British material was scanned uncoated at the Natural History Museum, London (NHM), using a LEO 1455VP low-vacuum scanning electron microscope.

Described material from Bohemia is stored within the Cretaceous collection of the National Museum, Prague, and numbered NM-P2 O 6658. The British material is in the collections of the Department of Palaeontology, NHM, London.

Description

The fragment of the platy sponge *Verruculina phillipsi* (Reuss, 1846) is about 80 mm long by 50 mm wide (Fig. 2). The inhalant (lower) skeletal surface is encrusted by one oyster (Fig. 2B), three bryozoan colonies, and the serpulid *Neovermilia ampullacea* (Sowerby, 1829) containing the symbiotic hydroid *Protulophila gestroi* Rovereto, 1901 (Fig. 2E).

The oyster and a colony of the bryozoan *Onychocella novaki* (Brydone, 1910) (Fig. 2A) are isolated and do not interact with any of the other encrusters. Colonies of the other two bryozoans, *Marginaria elliptica* Roemer, 1841 (Fig. 2D) and *Onychocella reussi* Prantl, 1938 (Fig. 2C), are partly overgrown by the serpulid.

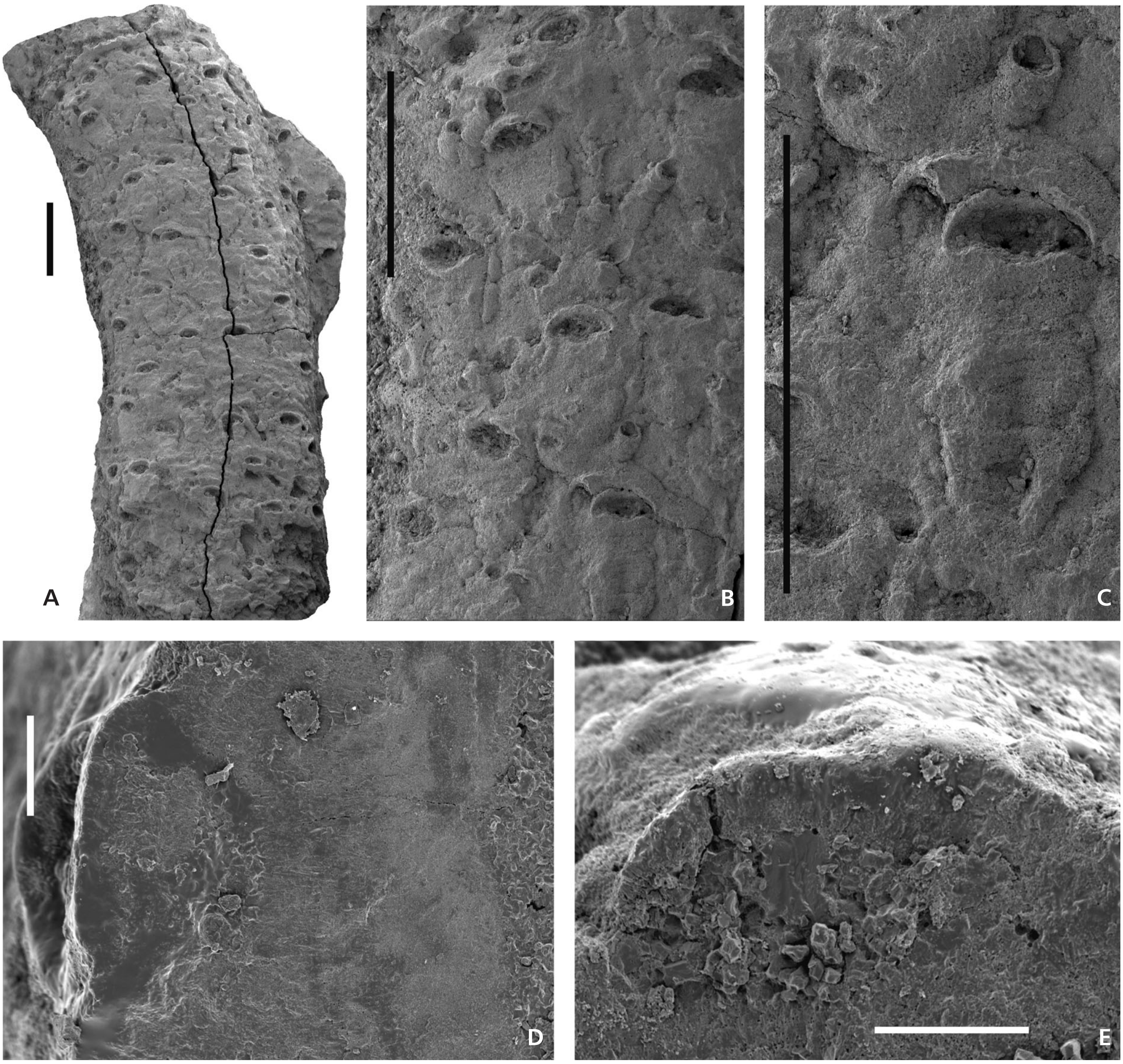

Figure 3. SEM images of *Protulophila gestroi* Rovereto, 1901 from Chrtníky, specimen NM-P2 O 6658. • A – general view of the studied specimen. • B – detail showing chaotic arrangement of the hydroid zooids and stolons. • C – detail showing shape of the zooids, orificial sinuses and stolons. • D – cross-section showing hydroid orifice (left), hydroid chamber incorporated into the serpulid skeleton (centre), and the inner margin of the serpulid tube (right). Note clear outline of the rounded triangular hydroid chamber. • E – detail of cross-section showing that the diagenetic calcite crystals filling the hydroid chamber are much larger than those forming the serpulid tube. • Scale bars: A–C = 1 mm; D, E = 100 µm.

The tube of the serpulid *Neovermilia ampullacea* (Sowerby, 1829) is infested by *Protulophila gestroi* Rovereto, 1901 (Fig. 3) which appears as a chaotically arranged colony embedded within the surface layers of the worm tube. Exposed zooids of *P. gestroi* have rectangular chambers, approximately 680–755 µm long by 337–460 µm wide, tapering slightly at their proximal ends. The frontal surfaces of the zooids are transversely wrinkled. Apertures are semicircular (approximately 290–340 µm wide by 101–159 µm high), always with a shallow sinus situated in the middle of the proximal margin. Small accessory tubes approximately 80–181 µm in diameter and opening distally (in the direction of growth) are visible between the zooids. These probably represent stolons. Cross-sections through hydroid chambers show their deep incorporation into the serpulid skeleton. The chambers in cross-section are sometimes rounded, sometimes more oval. They always exhibit a different structure than the serpulid skeleton, being infilled by larger calcite crystals than those making up the serpulid tube.

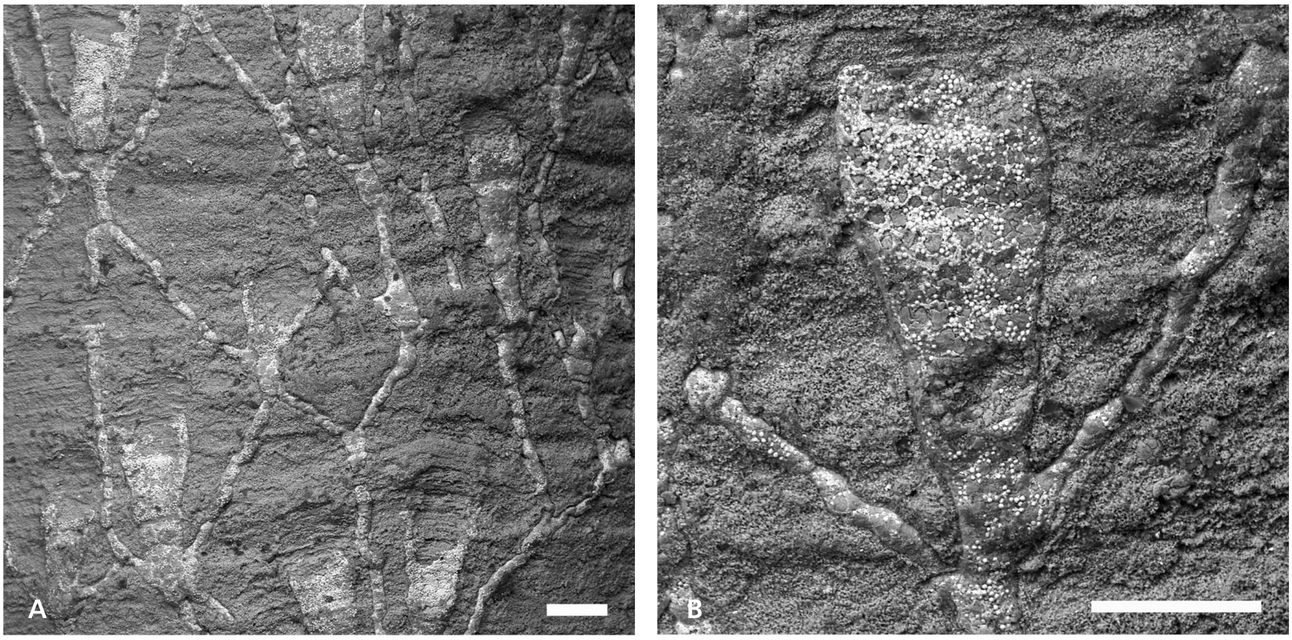

Figure 4. SEM images of natural casts of zooids and stolons of *Protulophila gestroi* Rovereto, 1901 in an exfoliated tube of the serpulid worm *Parsimonia*. Albian, Gault Clay, Kent, England, NHM A10932. • Scale bars: A = 100 μm, B = 200 μm.

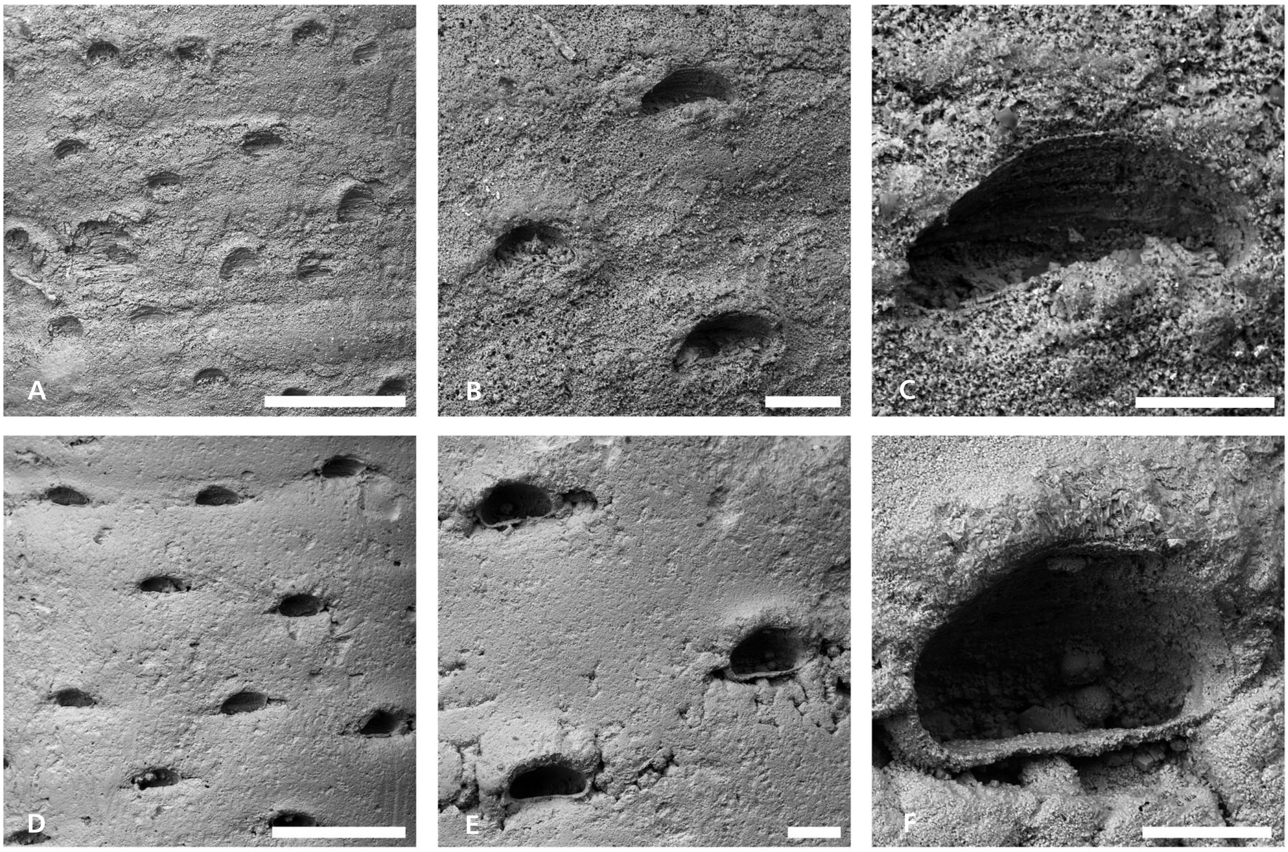

Figure 5. SEM images of external surfaces of serpulid tubes infested by *Protulophila gestroi* Rovereto, 1901 showing details of the zooidal orifices. • A–C, Albian, Gault Clay, Kent, England, NHM A10889. • D–F, Albian, Red Chalk, Norfolk, England, NHM A7625. • Scale bars: A, D = 1 mm; B, E = 200 μm; C, F = 100 μm.

Discussion

Serpulid tubes infested by the hydroid *Protulophila gestroi* Rovereto, 1901 are common in the Jurassic and Cretaceous of Europe (see Jäger 1983, Niebuhr & Wilmsen 2005), and the association apparently ranges up to the Pliocene (Rovereto 1901, Carboni *et al.* 1982, Scrutton 1975). The specimen described here from the Turonian of Chrtníky in Bohemia shows several unusual features, at least some of which may be due to the method of sample preparation that entailed boiling in soda and macerating in sulphuric acid. This procedure removed the outer parts of the serpulid tube and exposed the zooidal chambers of the hydroid. In contrast, most of the specimens studied by Scrutton (1975) and subsequent authors (*e.g.*, Radwanska 2004, Niebuhr & Wilmsen 2005, Wilmsen *et al.* 2007) preserve the outer layers of the serpulid tubes with only the orifices of the hydroids being apparent. Exceptions are some exfoliated serpulids exposing casts of the zooidal chambers that were figured by Scrutton (1975, pl. 42, figs 1–10). One of these specimens is refigured here (Fig. 4). The hydroid is cast in part by framboidal pyrite, which appears bright in back-scattered electron images. The reticulate network of stolons lining the zooids is clearly visible.

Unlike some previous examples of *P. gestroi,* which typically occur in the upper parts of serpulid tubes close to the aperture (Walter 1965, Scrutton 1975, Radwanska 1996), the Chrtníky example infests the skeleton of the serpulid only in its middle part. The lack of prominent hoods in the Chrtníky specimen is probably a result of dissolution of the outer part of the serpulid tube. More significant is the different shape of the proximal edge of the orifice, which is straight or slightly concave in previously described examples of *P. gestroi* but has a broad sinus in the specimen from Chrtníky.

A feature evident in some British examples of *P. gestroi*, but seemingly not remarked upon previously, is the presence of a thin, apparent calcareous layer around the inside of the zooidal orifices (Fig. 5). This is particularly prominent in a specimen from the Albian Red Chalk of Norfolk (Fig. 5F). It may represent an initial layer of serpulid tube deposited in response to the presence of the hydroid.

Conclusion

The Chrtníky colony of *Protulophila gestroi* was bioclaustrated by a growing serpulid tube, the hydroid and serpulid living in symbiosis on the underside of a platy sponge also encrusted by three species of bryozoans and an oyster. The fact that the hydroid is only visible in the middle part of the serpulid tube suggests that it may have ceased growth before the host serpulid died. Compared with specimens of *P. gestroi* described previously, the Bohemian specimen differs in having zooidal orifices with broad sinuses. Whether or not this indicates the existence of more than one species of hydroid will only become apparent with further detailed studies of *Protulophila* across its broad stratigraphical and geographical range.

Acknowledgements

This work was supported by a project of the Ministry of Culture, Czech Republic (DE06P04OMG009) and by GAČR Project 205/06/0842. We express our thanks also to Tomáš Kočí who kindly determined the hydroid-infested serpulid. We are grateful for the valuable comments and remarks of the reviewers, Manfred Jäger and Markus Wilmsen.

References

CARBONI, M.G., MATTEUCCI, R. & SCHIAVINOTTO, F. 1982. Aspetti paleoecologici dell' associazione *Protula firma* Seguenza/*Protulophila gestroi* Rovereto nei Pliocene della cava Marco Simone (Roma). *Atti della Società Toscana di Scienze naturali, Memorie A88*, 51–81.

ČECH, S., KLEIN, V., KŘÍŽ, J. & VALEČKA, J. 1980. Revision of Upper Cretaceous stratigraphy of the Bohemian Cretaceous Basin. *Věstník Ústředního ústavu geologického 55(5)*, 277–296.

JÄGER, M. 1983. Serpulidae (Polychaeta sedentaria) aus der norddeutschen höheren Oberkreide – Systematik, Stratigraphie, Ökologie. *Geologisches Jahrbuch A 68*, 3–219.

NIEBUHR, B. & WILMSEN, M. 2005. First record of the hydroid *Protulophila gestroi* Rovereto, 1901, a serpulid symbiont, from the Middle Cenomanian *primus* Event, northern Germany. *Neues Jahrbuch für Geologie und Paläontologie, Monatschefte 2005*, 219–232.

RADWANSKA, U. 1996. Tube-dwelling polychaetes from some Upper Cretaceous sequences of Poland. *Acta Geologica Polonica 46*, 61–80.

RADWANSKA, U. 2004. Tube-dwelling polychaetes from the Upper Oxfordian of Wapienno/Bielawy, Couiavia region, north-central Poland. *Acta Geologica Polonica 54*, 35–52.

REUSS, A.E. 1846. *Die Versteinerungen der böhmischen Kreideformation*. 148 pp. I.E. Schweizerbart, Stuttgart.

ROVERETO, G. 1901. Briozoi, anellidi e spugne perforanti del Neogene Ligure. *Palaeontographia Italica 7*, 219–234.

SCRUTTON, C.T. 1975. Hydroid-serpulid symbiosis in the Mesozoic and Tertiary. *Paleontology 18*, 39–42.

SCHLOTHEIM, E.F. VON 1813. Beiträge zur Naturgeschichte der Versteinerungen in geognostischer Hinsicht. *Leonhard's Taschenbuch für die gesammte Mineralogie 7(1)*, 3–134.

SOWERBY, J. DE C. 1829. *The mineral conchology of Great Britain. Volume 6*. 236 pp. Published privately, London.

TAYLOR, P.D. 1990. Reservation of soft-bodied and other organisms by bioimmuration – a review. *Palaeontology 33*, 1–17.

VLAČIHA, V. 2002. Macrofaunal taphocoenoses of the Peruc-

Korycany and Bílá hora Formations at Chrtníky near Přelouč (Bohemian Cretaceous Basin). *Acta Universitatis Purkynianae, Studia biologica 6*, 1–8.

VODRÁŽKA, R. 2005. *Rod* Hillendia *Reid, 1864 a* Guettardiscyphia *Fromental, 1860 (Porifera, Hexactinellida) z české křídové pánve*. 65 pp. Diploma thesis, Faculty of Science, Charles University, Praha, Czech Republic.

VODRÁŽKA, R. in press. A new method for the extraction of macrofossils from calcareous rocks, using sulphuric acid. *Palaeontology.*

WALTER, B. 1965. Un Bryozoaire perforant de l'Oxfordien. *Compte rendu sommaire des séances de la Société géologique de France 1965*, 286–287.

WILMSEN, M., NIEBUHR, B., WOOD, C.J. & ZAWISCHA, D. 2007. Fauna and palaeoecology of the Middle Cenomanian *Praeactinocamax primus* Event at the type locality, Wunstorf quarry, northern Germany. *Cretaceous Research 28*, 428–460. DOI 10.1016/j.cretres.2006.07.004

ZÁGORŠEK, K. & VODRÁŽKA, R. 2006. Cretaceous Bryozoa from Chrtníky. *Courier Forschungsinstitut Senckenberg 257*, 161–177.

ZÁZVORKA, V. 1946. Transgrese svrchní křídy v severozápadní části Železných hor. *Věstník Královské české společnosti nauk, Třída matematicko-přírodovědecká 1944*, 1–26.

ŽÍTT, J. & NEKVASILOVÁ, O. 1991. Epibionti přicementovaní k diabasovým klastům a skalnímu dnu ve svrchní křídě Železných hor a okolí. *Časopis Národního muzea*, *Řada přírodovědná 156(1)*, 17–35.

ŽÍTT, J., SVOBODOVÁ, M. & VODRÁŽKA, R. 2004. Příbřežní zóna českého křídového moře při hranici cenoman/turon; příklady vývoje tafocenóz a sedimentačního prostředí, 117–118. *In* ZLINSKÁ, A. (ed.) *5. Paleontologická konferencia, zborník abstraktov*. Bratislava.

ŽÍTT, J., VODRÁŽKA, R., HRADECKÁ, L., SVOBODOVÁ, M. & ZÁGORŠEK, K. 2006. Late Cretaceous environments and communties as recorded at Chrtníky (Bohemian Cretaceous Basin, Czech Republic). *Bulletin of Geosciences 81(1)*, 43–79. DOI 10.3140/bull.geosci.2006.01.043