SBORNÍK NÁRODNÍHO MUZEA V PRAZE
Řada B – Přírodní vědy • sv. 72 • 2015 • čís. 3–4 • s. 293–300

ACTA MUSEI NATIONALIS PRAGAE
Series B – Historia Naturalis • vol. 72 • 2015 • no. 3–4 • pp. 293–300

FILOGRANULA CINCTA (GOLDFUSS, 1831), A SERPULID WORM (POLYCHAETA, SEDENTARIA, SERPULIDAE) FROM THE BOHEMIAN CRETACEOUS BASIN

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Kočí, T., Jäger, M. (2015): *Filogranula cincta* (GOLDFUSS, 1831), a serpulid worm (Polychaeta, Sedentaria, Serpulidae) from the Bohemian Cretaceous Basin. – Acta Mus. Nat. Pragae, Ser. B Hist. Nat., 72(3-4): 293–300, Praha. ISSN 1804-6479.

Abstract. Tubes of the serpulid worm *Filogranula cincta* (GOLDFUSS, 1831) were found in several rocky coast facies and other nearshore / shallow water localities in the Bohemian Cretaceous Basin ranging in geological age from the Late Cenomanian to the Late Turonian. A morphological description, discussion regarding systematics and taxonomy and notes on palaeoecology and stratigraphy are presented.

■ Late Cretaceous, Polychaeta, Filogranula, Serpulidae, Palaeoecology

Received April 24, 2015
Issued December, 2015

Introduction

Filogranula cincta (GOLDFUSS, 1831) is a small and inconspicuous but nevertheless common serpulid species in the Bohemian Cretaceous Basin (BCB). Earlier Reuss (1845, 1846) described and figured tubes of this species from localities in the BCB (Jäger 1983, p. 68, Kočí 2007, p. 112), although under different names such as "*Serpula cristata* DUJARDIN" from Želenice ("Schillinge") and "*Serpula fluctuata* SOWERBY" from Novosedlice ("Weisskirchlitz"), a site situated in the northwestern part of the city of Teplice. Frič (1869) also mentioned these two species names and localities.

Conversely, Geinitz (1875) described and figured tubes under the species name "*Serpula cincta* GOLDFUSS" from the Saxon portion of the BCB, however, these specimens belong to different genera (Jäger 1983, 2014). Wegner (1913) introduced the new name "*Serpula pentastemma*" for the species which Geinitz (1875) had erroneously described under the name "*Serpula cincta*". However, the situation is confused by the fact that the drawing provided by Wegner shows a true *Filogranula cincta* from the Cretaceous of Opole ("Oppeln") in Poland instead of Geinitz's species! Among the three localities where "*Serpula pentastemma*" occurs, Wegner also mentioned the Late Turonian of Strehlen which today is part of the city of Dresden. This is the only suggestion that *Filogranula cincta* might perhaps occur in the Saxon part of the BCB. However, in the collection of the Senckenberg Naturhistorische Sammlungen at Dresden, there is no *Filogranula cincta* from Strehlen.

It is surprising that in his monograph on the serpulids of the BCB Ziegler (1984) neither mentioned *Filogranula cincta* nor any of its synonyms, nor has the systematic-taxonomic revision of Ziegler's original specimens by the authors of the present paper resulted in the reappearance of any *Filogranula cincta* specimen. It seems that, apart from the vague mention from Strehlen by Wegner (1913), for more than a hundred years no additional finds of *Filogranula cincta* from the BCB had been published until the present authors began collections and study.

Material and methods

Since the year 1960, many additional specimens of *Filogranula cincta* have been collected by the authors from several rocky coast facies and other nearshore / shallow water localities in the BCB, some directly from the outcrops and some from picking through residues produced by washing and sieving large amounts of friable sediments taken from the outcrops. The geological age of the finds covers the time-span from Late Cenomanian to Late Turonian, with the majority of localities and specimens from the Early Turonian.

The specimen from Předboj (Late Cenomanian) was collected by Dr. Olga Nekvasilová during her field work between 1960–1968, and was deposited in the National Museum in Prague (NM-O7549). Other material was found at the rocky coast locality Plaňany (Late Cenomanian to Early Turonian). During an excursion of a party from the Paläontologische Gesellschaft in September 1993 to the large boulder at Karlov (see Žítt and Nekvasilová 1989, Early Turonian), a small fragment of a *Filogranula cincta* tube was found in the loose rubble below the large boulder. Most of the *Filogranula cincta* specimens described in the present study were found during 10 years of field work on sediments of the rocky coast facies / shallow water of the locality Skalka near Velim (pocket Václav, Early Turonian by Žítt et al. (1997)). The specimens were isolated by washing and sieving (using a meshscreen with a 1 mm grid) more than 100 kg of bioclastic rubble within grey claystones situated below

Text-fig. 1. Simplified map of the Bohemian Cretaceous Basin (BCB, the Czech Republic), showing the occurrence of *Filogranula cincta* (Goldfuss) in the Bohemian Cretaceous Basin: Předboj, Plaňany, Velim-Skalka, Kutná Hora-Karlov, Chrtníky, Novosedlice ("Weisskirchlitz"), Želenice nad Bílinou ("Schillinge") and Klokočské Loučky.

pocket Václav. This *Filogranula cincta* material from Velim-Skalka has already been published (Kočí 2007). The material (NM-O7619 – NM-O7621) from the locality Chrtníky (Early Turonian) was collected from the "western depression" 8a/b sensu Žítt et al. (2006) by Dr. Radek Vodrážka, and some more tube fragments were found in layer 8f. A single tube fragment of *Filogranula cincta* attached to a gastropod was found during an excursion to the Bohemian Paradise in the locality Klokočské Loučky (earliest Late Turonian, NM-O7612). All the aforementioned sites are shown in the map (Text-fig. 1).

Systematic Palaeontology

Classification of the genus *Filogranula* Langerhans, 1884 and of the species *Filogranula cincta* (Goldfuss) follows that of Goldfuss (1826–1833), Reuss (1845, 1846), Regenhardt (1961), Zibrowius (1968, 1972), Lommerzheim (1979), Jäger (1983, 1987, 1991, 2005), Radwańska (1996), ten Hove and Kupriyanova (2009), Ippolitov et al. (2014) and Serpulidae Rafinesque, 1815 (by H. A. ten Hove) in WoRMS (http://www.marinespecies.org (last accessed on November 21st, 2015).

Class **Polychaeta Grube, 1850**
Subclass **Sedentaria Lamarck, 1818**
Infraclass **Canalipalpata Rouse et Fauchald, 1997**
Order **Sabellida Fauchald, 1977**
Family **Serpulidae Rafinesque, 1815**

Genus ***Filogranula* Langerhans, 1884**
(non **Brünnich Nielsen, 1931**)

***Filogranula cincta* (Goldfuss, 1831)**

Text-fig. 2, Text-fig. 3, Pl. 1, Fig. 1–5

1831 *Serpula cincta* nobis – Goldfuss, p. 237, pl. 70, fig. 9a–c.
1837 *Vermilia cristata*, Duj. – Dujardin, p. 233, pl. 17, fig. 17.
1840 *Serpula undulata* nob. – von Hagenow, p. 668.
1845 *Serpula cristata* Dujardin – Reuss, p. 18, pl. 13, fig. 92a–c.
1846 *Serpula fluctuata* Sow. – Reuss, p. 106, pl. 24, fig. 10a–b.
1869 *Serpula fluctuata*, Sow. – Frič, p. 220.
1869 *Serpula cristata*, Duj. – Frič, p. 221.
1870 *Serpula fluctuata*, Sow. – Frič, p. 197.
1870 *Serpula cristata*, Duj. – Frič, p. 198.
non 1875 *Serpula cincta* Goldf. – Geinitz, p. 286, pl. 63, fig. 18a–c.
1913 *Serpula pentastemma* nov. nom. – Wegner, p. 200, text-fig. 12.
1961 *Flucticularia flucticularia* n. sp. – Regenhardt, p. 57, pl. 9, fig. 2.
1961 *Flucticularia undulata* (Hagenow, 1840) – Regenhardt, p. 57, pl. 6, fig. 6.
1961 *Flucticularia trilix* n. sp. – Regenhardt, p. 58, pl. 5, fig. 5.
1961 *Flucticularia calamistrata* n. sp. – Regenhardt, p. 59, pl. 6, fig. 5.
1961 *Vepreculina plumosa* n. sp. – Regenhardt, p. 68, pl. 6, fig. 4.
1979 *Filogranula fluctuata* (Sowerby 1829) – Lommerzheim, p. 155.
1983 *Filogranula cincta* (Goldfuss, 1831) – Jäger, pp. 68–71, pl. 8, figs 8–13.[with a long synonymy list]
1987 *Filogranula cincta* (Goldfuss, 1831) – Jäger, p. 39, pl. 1, figs 11–16.
1991 *Filogranula cincta* (Goldfuss 1831) – Jäger, pp. 148–149, pl. 5, figs 1–5.
1996 *Filogranula cincta* (Goldfuss, 1831) – Radwańska, p. 71, pl. 8, figs 1–6.
2005 *Filogranula cincta* (Goldfuss, 1831) – Jäger, p. 151, pl. 2, figs 10–13.
2007 *Filogranula cincta* (Goldfuss) – Kočí, pp. 112–113, figs 1–2.
2011 *Filogranula cincta* (Goldfuss, 1831) – Jäger, p. 686, pl. 4, fig. 1.
2012 *Filogranula cincta* (Goldfuss) – Kočí, p. 122, fig. 1F.
2012 *Filogranula cincta* (Goldfuss, 1831) – Jäger, p. 51, pl. 1, figs 13–14.
2014 *Filogranula cincta* (Goldfuss, 1831) – Ippolitov et al., p. 142, fig. 8C–D.

Stratigraphical range. Early Hauterivian to Late Maastrichtian.

Material. Two near-complete specimens from locality Velim-Skalka are deposited in the National Museum Prague (NM-O6396 and NM-O6397). From the same locality, forty-one incomplete specimens and tube remains were studied. One near-complete specimen is from Předboj (NM-O7549), another complete specimen is from Plaňany. Seven specimens (two of them free and five attached to sponges; NM-O7619 – NM-O7621) are from the locality Chrtníky, layer 8a/b after Žítt et al. (2006), and three from

the same locality, layer 8f. One small fragment comes from the large boulder at Karlov (see Žítt and Nekvasilová 1989). One specimen (NM-O7612), attached to a sculptured core of a gastropod, is from the locality Klokočské Loučky.

Description. The tube consists of an attached posterior portion and often, depending on individual age and ecological conditions, a short or long free anterior portion. The attached portion may be straight, curved, irregularly serpentine, or may form a loop, whereas the free portion is straight or slightly curved. The tube increases in diameter only gradually and may reach a few centimetres in total length, although mostly only fragments are found. The two near-complete specimens from Velim-Skalka are 6.7 and 7 mm long, respectively, and the longest specimen from Chrtníky is 19.5 mm long. The anterior free portion which is 2.9 mm and 3 mm long in the two complete specimens, respectively, ascends obliquely upward; it rises at angles of 30°, 43°, 60° and 86° in four specimens. The cross-sections of broken tubes, mostly from the attached posterior tube portions, range from 0.9 to 2.3 mm in diameter, respectively from 1.8 to 2.8 mm if measured at the base of the trapezoidal cross-section. Outside the Bohemian Cretaceous Basin, the largest specimens may reach up to 3 mm in diameter (Jäger 1983). In several tubes which possess a peristome at the transition from the attached to the free portion, the free portion has a somewhat smaller diameter compared to the anterior part of the attached portion. The tube diameter at the aperture ranges from 1.2 to 1.9 mm.

On the upper side of the attached portion, the tube bears three longitudinal keels of which especially the two upper/lateral keels are usually strongly developed as more or less undulating, cockscomb-like ridges and/or bear tiny protruding spines. At the transition from the attached to the free portion, the two basal-lateral edges turn into two additional keels which may be sharp but small and straight or may be similar in shape to the other three keels. At each of the two latera, there is often a longitudinal furrow situated at half to three quarters of the height of the latera. Pentagonal stellate peristomes may occur, especially at or near the transition from the attached to the free portion, but also elsewhere, but most of them are relatively weak to moderately developed in the specimens from the Bohemian Cretaceous Basin when compared to some finds from other regions. Under the microscope, delicate transverse striation is visible. The striation, incremental lines and peristomes may be straight, but more often they are somewhat curved and protrude at the keels and at the edges of the tube's base.

The cross-section of the tube is most often trapezoidal but may also be quadrangular or pentagonal in the attached tube portion, whereas it is quadrangular or pentagonal in the free portion. A pentagonal cross-section is developed mainly at the peristome level and in the free portion of large specimens. The tube wall is moderately thick, but may be very thick near the peristomes. Neither tubulae nor tabulae are visible. The lumen is circular.

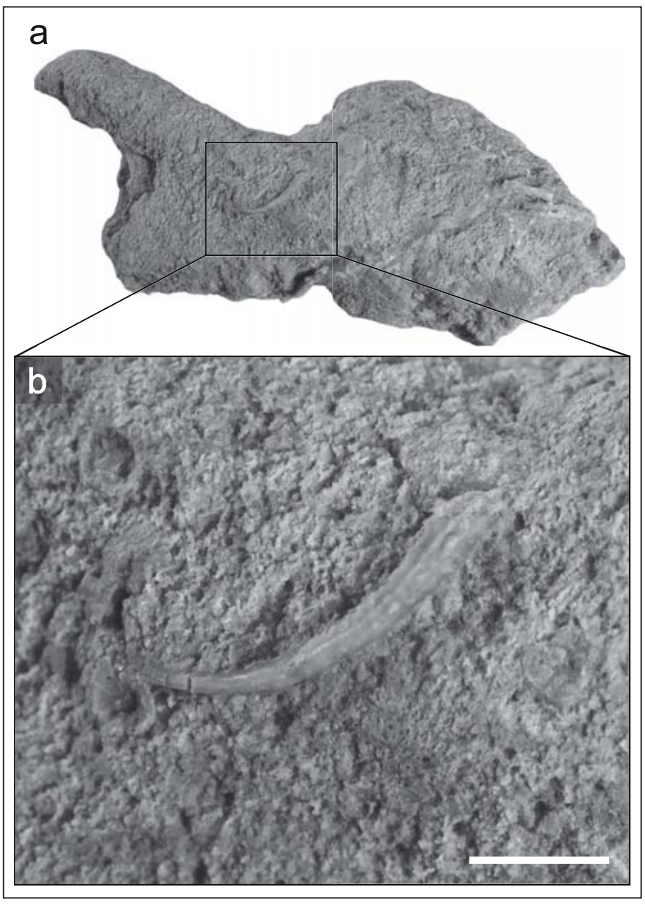
A small fragment from Chrtníky, layer 8f, which has only weakly developed keels but strongly developed transverse striation, is infested by the symbiont hydroid *Protulophila gestroi* Rovereto, 1901.

Remarks and relationships. In the Late Cretaceous, three species have tube morphologies relatively similar to *Filogranula cincta*: *Vermiliopsis fluctuata* (J. de C. Sowerby, 1829), *Metavermilia* (*Vepreculina*) *fimbriata* Regenhardt, 1961 and *Serpula*? *trilineata* Roemer, 1841. *Vermiliopsis fluctuata* is distinguished by possessing two additional longitudinal ornamental elements (altogether five keels plus two basal edges in the attached portion and seven keels in the free portion), by its heptagonal cross-section and by its flaring peristomes which protrude obliquely at the latera. In *Serpula*? *trilineata* the longitudinal keels are more weakly developed, and peristomes are absent, but there is delicate transverse ornamentation consisting of very small wrinkles. Moreover, the aperture does not ascend upwards, and there is no free tube portion known. *Metavermilia* (*Vepreculina*) *fimbriata* remains much smaller (tube diameter only 0.7–1 mm), only the free tube portion is known, and four to eight (usually five or seven) delicate longitudinal keels are situated all around the tube, whereas the lateral areas of *Filogranula cincta* tubes bear no keel.

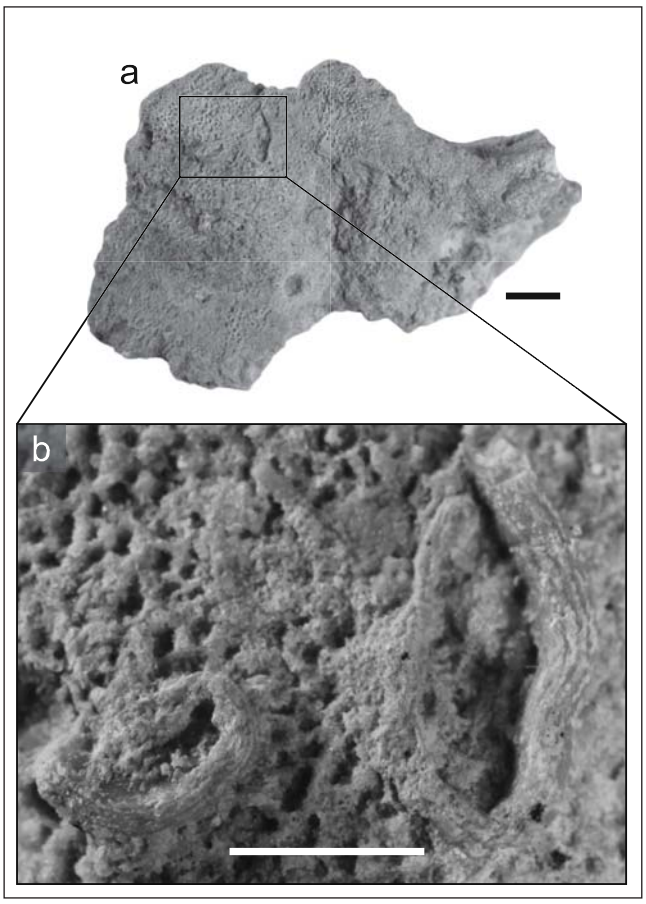
The recent species *Crucigera websteri* Benedict, 1887 has three irregularly undulating longitudinal keels that may reach 1.4 mm in height; the width of the tube may reach 5.5 mm including the keels. In juvenile specimens the base of the keels may be perforated. Sometimes there is a pair of faintly developed longitudinal ridges near the base of the tube. Terminal flaring peristomes or collar-like rings have not been observed (ten Hove and Jansen-Jacobs 1984).

Phylogeny. Species similar to *Filogranula cincta* in tube morphology were already common in the Jurassic: "*F.*" *tricristata* (Goldfuss, 1831) in the Late Toarcian and Early Aalenian of Germany and France (Jäger 1983, p. 68; Ippolitov et al. 2014, p. 146), and "*F.*" *runcinata* (J. de C. Sowerby, 1829) in the Kimmeridgian of Great Britain and in the Callovian and Oxfordian of Russia, Poland and Germany and even mass-occurrences in the Oxfordian of Russia (Ippolitov 2007, pp. 263–264, pl. 7, figs 7–12; Ippolitov et al. 2014, p. 146, fig. 7K). However, the tubes occurring in the Oxfordian ("Malm alpha") of southern Germany, mentioned by Jäger (1983, p. 69), may represent a different species or even a different genus. However, the problem exists that Recent and presumably also Late Cretaceous tubes of *Filogranula* sensu stricto belong to Clade BI (Ippolitov et al. 2014, fig. 1 including Recent genera closely related to *Filogranula* sensu stricto, and fig. 8C–D), whereas at least the well preserved tubes of "*F.*" *runcinata* from the Oxfordian of Russia are transparent and therefore should be related to the transparent tubes of Recent representatives of the genus *Placostegus* which belong to Clade AII (Ippolitov et al. 2014, p. 146, fig. 7K). In other words, it may be possible that the Jurassic and the Cretaceous to Recent tubes, in spite of similar shape and ornamentation, belong to different clades.

Relatively little is known of the genus' occurrence in the Early Cretaceous: *F. cincta* from the Early Cretaceous is mentioned by Ippolitov (2007, p. 263), and a few specimens of *F. cincta* are known from the Early Hauterivian of northern Germany (Jäger, personal observation) and one specimen from the Barrêmian of southeast France, where a second species presumably belonging to *Filogranula* is common at



Text-fig. 2. ***Filogranula cincta*** **(GOLDFUSS), locality Chrtníky (Early Turonian), no. NM-O7619, a – general view of a specimen attached to a lychniscosan sponge** ***Diplodictyon heteromorphum*****. Length of the sponge is 98.2 mm. b – detail of the tube. Length of the tube is 19.5 mm. The diameter of the aperture is 1.5 mm. Scale bars are 5 mm.**



Text-fig. 3. ***Filogranula cincta*** **(GOLDFUSS), locality Chrtníky (Early Turonian), no. NM-O7620, a – general view of two specimens attached to a lychniscosan sponge** ***Diplodictyon heteromorphum*****. Length of the sponge is 60 mm. b – detail of the tubes. Length of the left tube is 5.4 mm. The diameter of the aperture is 1.2 mm. Length of the right tube is 6 mm without the looped posterior portion. The diameter of the aperture is 1.4 mm. Scale bars are 5 mm.**

the same site (Jäger 2011, pp. 686–690). Ware (1975) introduced a new species, *Flucticularia sharpei*, from the Aptian of southern England and mentioned additional specimens presumably belonging to the same species from the Albian of southern England; these Aptian and Albian tubes are very similar to *F. cincta* and may belong to this species.

In the Late Cretaceous, the genus *Filogranula* is again common, with the species *F. cincta* being widespread in different facies, from the earliest Cenomanian (Lommerzheim 1979, p. 155, described as *Filogranula fluctuata* (SOWERBY, 1829)) until latest Maastrichtian (up to only 0.7 – 1.2 m below the Cretaceous/Palaeogene boundary at the locality Rødvig / Stevns Klint, Denmark; Jäger 2005, p. 151).

Very little is known about *Filogranula* in the Cenozoic. Ippolitov (2007, p. 263) listed *Serpentula alata* BRÜNNICH NIELSEN, 1931 from the Danian of Denmark as a species of the genus *Filogranula*; however, Jäger (1993), when studying serpulids from the Danian of the Netherlands and Belgium, described this species as *Placostegus alatus*.

In the seas of today, several living species of this genus are known (ten Hove and Kupriyanova 2009). In older literature, they are usually described under *Omphalopoma* MØRCH, 1863, until Zibrowius (1972) recognized *Omphalopoma* to be a nomen dubium and replaced it with the junior but valid genus name *Filogranula* LANGERHANS, 1884 (see, for example , Southward 1963, Zibrowius 1968, 1972, ten Hove and Kupriyanova 2009). In the Late Cretaceous and especially in the Recent species, peristomes, especially in the free tube portion, are more common, more strongly developed and morphologically more diverse, compared to the Jurassic representatives.

P a l a e o e c o l o g y a n d e c o l o g y. Jurassic *Filogranula* specimens are often found in condensed layers of sediment (Jäger, personal observations in the Late Toarcian; Ippolitov 2007, p. 260). Similarly, Early Cretaceous specimens are found in shallow marine deposits (Jäger 2011). However, in the Late Cretaceous, the species *Filogranula cincta* is euryecologic and common in many different fully marine facies (Jäger 1983, p. 71, 2011, p. 686). Lommerzheim (1979, p. 156) assumed that this species (as *Filogranula fluctuata*) lived from the littoral down to a depth of circa 200 m where it was attached to various substrates (shells, remains of corals and rock fragments). It seems

strange that within the BCB, *Filogranula cincta*, in spite of its occurrence in at least eight different localities in the Czech portion of this basin, had not been detected yet, apart from the uncertain mention by Wegner (1913), in the Saxon portion of this basin, as the three-keeled tubes determined as "*Serpula cincta*" by Geinitz (1875) belong to different genera (Jäger 1983, 2014). Although being euryecologic during all of the Late Cretaceous, it seems that the main occurrence of *Filogranula cincta* may have slowly shifted from the littoral / shallow water realm to the offshore chalk facies during the Cenomanian until Coniacian times, because at least from the Coniacian onwards, this species is more common and widespread in offshore chalk facies than in nearshore shallow water facies (Jäger 1983, p. 71, and subsequent observations). Individuals of the extant species of the genus *Filogranula* live at depths of 15–1780 m (Zibrowius 1968, Southward 1963). In the Mediterranean Sea, they inhabit the deep sea as well as submarine caves in relatively shallow water (Zibrowius 1968). The extant species *Filogranula annulata* (O. G. Costa, 1861) is widespread throughout the Mediterranean in submarine caves as well as in "coralligenous" biota, from shallow water down to a depth of 100 m, and is found frequently together with the Red Coral (Zibrowius 1981).

Acknowledgements

We are grateful to Dr. H. A. ten Hove (Netherlands Centre for Biodiversity Naturalis, Leiden) and Associate Professor V. Ziegler from Prague for their references and discussions. We are indebted to Jan Sklenář PhD. (Palaeontological dept., National Museum, Prague) for his help with taking and improving all photographs and for his instructive remarks on this paper, and to Radek Vodrážka PhD. (Czech Geological Survey) for loaning material from the locality Chrtníky and leading the fieldtrip to this locality (October 14th, 2006). We are grateful to Dr. Stanislav Čech (Czech Geological Survey, Prague) for his very careful recommendations, notes and stratigraphical comments during his review, and to Dr. Alexei P. Ippolitov (Geological Institute of Russian Academy of Sciences, Moscow) who reviewed the manuscript and provided detailed comments, notes, recommendations and suggestions which greatly improved this paper. We greatly thank Gill Horalek for her helpful improvement of our English and Jan Wagner, PhD. (National Museum and Institute of Geology of the Czech Academy of Sciences) for his helpful comments which improved the manuscript. The research is supported by the grant project DRKVO 2015/06, National Museum, Prague.

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Explanation of the plate

PLATE 1

1. *Filogranula cincta* (Goldfuss), locality Velim-Skalka (Early Turonian), no. NM-O6396, a – oblique view to upper side/latus, b – oblique view to latus/underside. Scale bars are 2 mm.
2. *Filogranula cincta* (Goldfuss), locality Velim-Skalka (Early Turonian), no. NM-O6397, a – oblique view to latus/underside, b – oblique view to upper side/latus. Scale bars are 2 mm.
3. *Filogranula cincta* (Goldfuss), locality Předboj (Late Cenomanian), no. NM-O7549 (same specimen as in Kočí and Jäger 2015, pl. 1, fig. 6) from collection of Dr. Olga Nekvasilová (fieldwork carried out between 1960–68). Length of the tube is 6.7 mm. The diameter of the aperture is 1.2 mm. Scale bar is 1 mm.
4. *Filogranula cincta* (Goldfuss), locality Klokočské Loučky (Late Turonian), NM-O7612, a – general view of one specimen attached to a gastropod. The gastropod is 27 mm high. Scale bar is 10 mm. b – detail of the tube. Length is 2.8 mm. Diameter is 0.9 mm. Scale bar is 1 mm.
5. *Filogranula cincta* (Goldfuss), locality Chrtníky (Early Turonian), no. NM-O7621, a – general view of two specimens attached to a lychniscosan sponge *Diplodictyon heteromorphum*. Length of the sponge is 77.1 mm. Scale bar is 10 mm. Arrows show position of each specimen. b – detail of the tubes. Length of the left tube is 5.0 mm. Length of the right tube is 13.7 mm. The diameter of the aperture is 1.5 mm. Scale bar is 20 mm.

PLATE 1