FAVREINA BABAI ISP. NOV., A NEW ANOMURAN MICROCOPROLITE FROM THE UPPER CRETACEOUS OF SOUTHEASTERN SPAIN

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Abstract: The new anomuran microcoprolite *Favreina babai* isp. nov. is described from the Late Cretaceous La Cañadilla Formation of the Southern Iberian range. Among the ichnogenus *Favreina*, the new ichnospecies is characterized by rod-shaped bodies with numerous (> 100) laterally grouped longitudinal canals of rounded transverse sections within the symmetry plane. The high number of these canals represents an unique feature within the (late) Cretaceous record. The new microcoprolite occurs in wackestones with miliolids (among *Vidalina hispanica* Schlumberger) and ostracods of shallow-water carbonates ascribed to a near-coastal facies.

Keywords: Crustacean, ichnotaxon, Upper Cretaceous.

INTRODUCTION

Internally structured crustacean microcoprolites are widely reported from Cretaceous shallow-water carbonates (Brönnimann & Masse, 1969; Vialov, 1978; Senowbari-Daryan & Grötsch, 1992; Fenninger & Hubmann, 1994; Blau et al., 1997; Senowbari-Daryan et al., 2009; Kietzmann & Palma, 2014; Schlagintweit et al., 2016). Although the ichnotaxonomy and glossary of terms for description are well established (Brönnimann & Norton, 1960; Knaust, 2020), the stratigraphic ranges of the individual ichnospecies remain poorly constrained. Most records are from the Lower-mid-Cretaceous whereas findings from the Upper Cretaceous are rarer (e.g., Senowbari-Daryan & Kuss, 1992). A new ichnotaxon of crustacean microcoprolite, *Favreina babai* isp. nov. is described here from the Upper Cretaceous of southeastern Spain.

GEOLOGICAL SETTING

Geological Overview

The Iberian Basin was a NW-SE trending extensional basin located in the eastern Iberian Plate during the Mesozoic (Salas et al., 2001; Sánchez-Moya & Sopeña, 2004) (Fig. 1A). During the Late Cretaceous, sea-level fluctuations played a crucial role in controlling sedimentation processes within this extensional basin (e.g., Segura et al., 2001; Gil et al., 2004; Torromé et al., 2022). Three second-order transgressive-regressive (T-R) cycles have been identified for the Late Cretaceous (Gil et al., 2004; Segura et al., 2004) (Fig. 2A). During the first (late Albian–middle Turonian) and second (middle Turonian–early Campanian) cycles, the Iberian Basin was dominated by shallow-marine carbonates, with a connection between the Atlantic and Tethys Oceans during the Cenomanian (Gil et al., 2004) (Fig. 1A).
In the Maestrazgo Domain, an eastern sector adjacent to the Ebro Massif (Fig. 1A), extensive rudist prairies developed in coastal settings during the Santonian, forming the La Cañadilla Formation (Torromé et al., 2022). This unit is of particular relevance for its marine paleontological content; for instance, a new species of dasycladalean green alga was recently described in the Valdeconejos locality (Torromé & Schlagintweit, 2023). The subsequent regressive trend of the second T-R cycle started a transition from shallow-marine environments to wetlands with marine influence in many parts of the Iberian Basin (Martín-Chivelet et al., 2019), including the Maestrazgo Domain (Torromé et al., 2023). During the third T-R cycle, the overall regressive trend, coupled with the initial stages of tectonic inversion driven by the convergence of the European and African plates, led to the establishment of continental settings in certain areas of the basin (Martín-Chivelet et al., 2019). In the Maestrazgo Domain, this shift is reflected in the Allueva Formation (Fig. 2A), a continental alluvial unit that marked the definitive end of marine influence in this sector (Aurell et al., 2022). The main stages of compressional tectonics (Eocene-early Miocene), followed by post-orogenic erosion during the Neogene, ultimately shaped the present-day configuration of the Maestrazgo Domain (Casas et al., 2000; Liesa et al., 2018) (Fig. 1B).

Sample locality

The studied area is located in the Berge Subbasin (Teruel, Spain; Fig. 1B), a compressional intramountain subbasin developed during the tectonic inversion period (Liesa et al., 2018; Aurell et al., 2022). The samples containing the studied fossils were collected from the lowermost levels of the La Cañadilla Formation near the locality of Molinos (Fig. 2B; UTM coordinates: 30T 715363 4522858). This geological unit is dated to the middle Santonian-earliest Campanian based on biostratigraphy and Sr-isotope analysis (Torromé et al., 2022). Therefore, it is likely that *Favreina babai* isp. nov. belongs to the middle Santonian.

An initial sample was taken during a logging campaign; however, the potential identification of a new ichnospecies required the collection of additional samples, which were subsequently obtained from both the original layer and the overlying strata, that exhibits similar facies (Fig. 2C). At this outcrop, the lithostratigraphic unit is 30 meters thick and comprises a well-stratified alternation of marlstones and limestones (Fig. 2D; Torromé et al., 2022). The upper boundary of the La Cañadilla Formation at this location is marked by an erosional unconformity overlain by Cenozoic rocks.

MATERIAL, METHOLOGY AND REPOSITORY

The material containing *Favreina babai* isp. nov. consists of five different thin sections from the sample M2 (M2: second sampled bed from the Molinos log). Three of them (M2_0, M2_1, M2_2) were taken from the original rock sample, one (M2_7) was collected from a different sample from the same original bed, and the remaining sample (M2_3) was collected from the overlying strata (Fig. 2C).

Thin section images were captured using an Olympus BX53M petrographic microscope equipped with an Olympus DP27 digital camera, housed at the "Instituto Universitario de Ciencias Ambientales (IUCA)" of the University of Zaragoza. All thin sections are curated at the "Museo de Ciencias Naturales de la Universidad de Zaragoza" (MPZ; Canudo, 2018), with inventory numbers provided in Table 1.

SYSTEMATIC DESCRIPTION

Ichnofamily Favreinidae Vialov, 1978

Ichnogenus *Favreina* Brönnimann, 1955

Type species *Coprolithus salevensis* Paréjas, 1948

Favreina babai isp. nov.

Figs. 3-4.

Derivatio nominis: The name is dedicated to the late Baba Senowbari-Daryan in recognition of his numerous contributions to the study of fossil crustacean microcoprolites.

Holotype: Transverse section in Fig. 3A, sample M2_0_2 stored in the "Museo de Ciencias Naturales de la Universidad de Zaragoza" under the depository number MPZ 2024/323.

Stratum Typicum: Santonian La Cañadilla Formation (Fig. 2A).

Type locality: Section exposed near to the locality of Molinos (Fig.

Diagnosis: Rod-shaped coprolite, rounded to slightly oval in transverse sections (without any depression or cap), displaying a bilateral symmetric pattern of rounded shaped canals. In the symmetry plane, a comparably thick longitudinally furrow, cylindrical to claviform in section, is present. Interconnecting lines or fissural spaces between canals or connections between the latter and the median furrow are absent.

Description: *Favreina babai* represents a rod-like microcoprolite handed down in the form of different random sections. Transverse sections are rounded to slightly oval without any depression ("ventral groove", e.g., Brönnimann and Masse, 1969). Rare ellipsoidal specimens are due to vertical compression/compaction and do not reflect the original morphology (Fig. 3K). The microcorpolite itself is homogeneous micritic without showing any differentiation of the material/texture (e.g., "ventral cap"). It is traversed by numerous longitudinal canals running parallel to each other as discernible in longitudinal sections (Fig. 3E-F). As displayed in transverse sections, the canals are rounded in outline and display a bilateral symmetric arrangement forming two groups which in turn are separated by a homogeneous median zone that lacks canals. The arrangement of the canals allows a differentiation between a longitudinal straight row parallel to the median axis (median canals), canals at the periphery forming a semicircle that follows the outline of the microcoprolite (peripheral canals) and internal canals between the two former groups. The latter are forming two loops or arches (Fig. 4). Interconnecting lines or fissural spaces between canals are poorly constrained to absent. The peripheral canals are slightly offset from each other without forming a zigzag-pattern that is known from other *Favreina* ichnospecies.

Dimensions:

Diameter: 0.50-0.65 mm

Length: up to 1.20 mm

Number of median canals per side (*1*): 10-14 (= 20-28 in total)

Number of peripheral canals per side (*2*): 15-24 (= 30-48 in total)

Number of internal canals between (*1*) and (*2*): 18-25 (= 36-50)

Number of canals in total: ~88 to ~130

Diameter of canals: 0.014-0.022 mm

Width of homogeneous median zone: ~0.05 mm

Remarks: The arrangement and number of canals piercing microcoprolites in a longitudinal manner are used as the main distinguishing feature (Brönnimann, 1972). As the available transverse sections are not ideally cut and also not perfectly preserved, the reconstruction shown in Figure 4 is a combination obtained from various specimens (Fig. 3A-D). We differentiated three types of canals, (1) median canals, (2) peripheral canals and internal canals located between (1) and (2).

Comparisons: Senowbari-Daryan & Kuss (1992, tab. 1) provided a comparison table comprising the 19 different *Favreina* ichnospecies described up to this point in time. Later, the following 9 ichnotaxa were added: *Favreina prima* Herbig, 1993, *Favreina peruvensis* Blau et al., 1994, *Favreina belandoi* Fels in Schweigert et al., 1997, *Favreina omanensis* Senowbari-Daryan & Bernecker, 2000, *F. lahngangkogelensis* Schlagintweit et al., 2005, *F. fontana* Senowbari-Daryan et al., 2007, *F. tosaensis* Senowbari-Daryan et al., 2010, *F. carpatica* Senowbari-Daryan et al., 2013, and *F. iranensis* Dalvand et al., 2015. This amounts to a total of 28 ichnospecies of *Favreina*. *F. babai* is among those forms that may display more than 100 longitudinal canals comprising just one Cretaceous representative, *F. angulata* Senowbari-Daryan & Kuss, 1992 and is therefore compared with this group (Tab. 2; Fig. 5). Among these, we note that the three ichnospecies *F. prusensis* Paréjas, 1948 (Upper Jurassic of Switzerland), *F. lahngangkogelensis* Schlagintweit et al., 2005 (Upper Jurassic of Austria) and *F. iranensis* Dalvand et al., 2015 exhibit a striking correspondence between the pattern of the longitudinal canals in transverse section (Fig. 5A-E). They have several rows of zig-zag-running canals parallel to the median plane (the innermost row) and the lateral periphery. In addition, all three may reach diameters larger than 1 millimetre as a further characteristic while most others have diameters in a range between 0.50 mm and 0.80 mm. Here, we propose the synonymy of the three taxa with *F. prusensis* Paréjas, 1948 having priority. As another distinguishing criterion, *F. babai* shows a distinct and well-delimited median zone lacking any canals. These features distinguish *F. babai* from ichnotaxa such as *F. angulata* Senowbari-Daryan & Kuss, 1992 (Fig. 5G), *F. carpatica* Senowbari-Daryan, Lazăr & Bucur, 2013 (Fig. 5H), and *F. multicanalis* Förster in Förster & von Hillebrandt, 1984 (Fig. 5J). The diameter of the canals is not a practical feature to separate different *Favreina* ichnospecies. Most have diameters in a range between 10 and 30 µm. Just *F. cuvillieri* Brönnimann, 1955 and *F. radiata* Senowbari-Daryan & Kuss, 1992 have greater canal diameters with 40 and 50 µm respectively (Senowbari-Daryan & Kuss, 1992, tab. 1). The differences in the pattern of the canal arrangement in transverse section is evident from the provided reconstruction (Fig. 4) and the compilation shown in Figure 5. For example, some just have an indistinct grouping-arrangement (Fig. 5H, J-K) or others are lacking peripheral canals that run parallel to the external surface (Fig. 5I).

Palaeoenvironent: The La Cañadilla Formation represents a transitional setting (from shallow-marine to coastal) and can be subdivided into three distinct belts (Torromé et al., 2022): (1) a low-energy lagoon colonized by rudists, green algae (dasycladales), and foraminifera (mainly miliolids); (2) a transitional belt with a patchy distribution of carbonate mudbanks and ponds, featuring a variable proportion of charophytes, gastropods, and foraminifera; and (3) a vegetated coastal plain exhibiting intense brecciation and root bioturbation, primarily colonized by charophytes and gastropods (Fig. 6).
Evidence of crustaceans in the La Cañadilla Formation is scarce, with only fragmented crab claws identified in the more energetic areas of the lagoon, adjacent to the mudbanks of the second belt. Similarly, *Favreina babai* isp. nov. has only been recognized in the low-energy lagoon. Fossil remains from the original bed (M2_0, M2_1, M2_2, M2_7) are associated with wackestone accumulations, while remains from the newly sampled overlying bed (M2_3) are more characteristic of packstone accumulations.

CONCLUSIONS

The occurrence of the new microcoprolite *Favreina babai* represents a further record of an ichnospecies displaying a high number of longitudinal canals (up to >100). With regard to this criterion, it is the first record of such a type in the Upper Cretaceous. Beyond that, *F. babai* is the second ichnotaxon of microcoprolites that has been described from the Upper Cretaceous of Spain besides *Sulcusina iberica* Schlagintweit et al., 2016.

ACKNOWLEDGEMENTS

Reviewer

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Captions

Fig. 1. (A) Palaeogeography of the Iberian Basin during the Cenomanian (modified from Martín-Chivelet et al., 2019); (B) Geological map of the Maestrazgo Domain in the Iberian Range (modified from Torromé et al., 2023). A red star marks the location of the Molinos outcrop.

Fig. 2. A) Synthetic stratigraphic log of the uppermost Cretaceous of the Maestrazgo Domain (Modified from Torromé et al., 2023). A red star indicates the approximate stratigraphic position of *Favreina babai* isp. nov. **B)** Aerial image showing the upper boundaries of the Organos de Montoro Fm (Mon) and the La Cañadilla Fm (Ca). The location of the studied samples is marked by a red star. **C)** Field view of the sampled beds. The red star marks the original sampled bed (M2_0, M2_1, M2_2, M2_7), and the pink star marks the overlying strata (M2_3). **D)** Panoramic view of the Molinos outcrop.

Fig. 3. Crustacean microcoprolite *Favreina babai* isp. nov. from the Santonian of southeastern Spain. **A-D, G-H, J-K)** Transverse sections, partly slightly oblique. Not the secondary vertically compression in K. **E-F)** Longitudinal sections. **I)** Calcareous benthonic foraminifera (discorbid?) co-occurring with the micropcoprolites. For MPZ-Depository numbers see Table 1.

Fig. 4. Reconstruction and interpretation of *Favreina babai* isp. nov. composed from several transverse sections (left) with some nomenclatural explanations and ichnospecies characteristic features (right). The example consists of two groups of 11 median canals, 16 peripheral canals and 22 inner (arched) canals amounting to 49 each side and a total of 98 canals.

Fig. 5. Comparison with *Favreina* ichnospecies characterized by high number of longitudinal canals (> 100). **A)** *F. prusensis* (from Parejas, 1948, fig. 42, Upper Jurassic of Switzerland), **B-C**) *F. lahngangkogelensis* (from Schlagintweit et al., 2005, fig. 85a, fig. 86, Upper Jurassic of Austria) and **D-E**) *F. iranensis* (from Dalvand et al., 2015, fig. 3a, Upper Jurassic-lowermost Cretaceous of Iran). **F**) *F. omanensis* (from Senowbari-Daryan & Bernecker, 2000, fig. 4A, Upper Triassic of Oman. **G**) *F. angulata* (from Senowbari-Daryan & Kuss, 1992, fig. 3C, upper Albian of Egypt. **H**) *F. carpatica* (from Senowbari-daryan et al., 2013, fig. 2B, Middle Jurassic of Romania). **I**) *F. peruvensis* (from Blau et al., 1994, fig. 4, Liassic of Peru). **J-K**) *F. multicanalis* (from Förster & Hillebrandt, 1984, fig. 8, Kimmeridgian of Chile). **L**) *F. fendiensis* (from Brönnimann & Zaninetti, 1972, fig. 2A-B, Middle Jurassic of Algeria).

Fig. 6. Simplified depositional model of the La Cañadilla Formation (modified from Torromé et al., 2022). Red stars indicate areas in which *Favreina babai* isp. nov. has been identified.

Tab. 1. MPZ-Depository numbers, sample (thin-section) numbers, and referenced illustration. MPZ = Museo de Ciencias Naturales de la Universidad de Zaragoza.

Tab. 2. Compilation and comparison of *Favreina* ichnospsecies displaying more than 100 longitudinal canals in transverse sections.