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Rotularia (Annelida: Sabellida: Serpulidae) attached to the mid-Cretaceous Burmese amber

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Abstract

Rotularia Defrance is a common extinct genus of planispirally coiled fossil polychaete worms in the family Serpulidae from shallow marine environment. Here, we describe a large collection of *Rotularia* specimens attached to mid-Cretaceous Burmese amber. The fossil record of *Rotularia* serves as a valuable tool for calibrating polychaete evolution and suggests that the Burmese amber forest was likely situated not far from the seashore.

Keywords: Serpulidae, coiled polychaeta, marine environment, mid-Cretaceous

Introduction

Rotularia is a genus of polychaetes that constructed remarkably regular calcareous tubes, either planispiral or trochospiral in shape. The earliest known records of *Rotularia* date back to the Upper Jurassic, with their major diversification occurring during the Cretaceous (Ball, 1960; Stevens, 1967; Müller, 1980). During the Eocene, *Rotularia* reached its peak distribution. It is a common component of shallow-water marine faunas, with several species having notable local significance for biostratigraphic studies (Macellari, 1984). The taxonomic position of *Rotularia* was historically confused with certain gastropods. Interpretations alternated between *Rotularia* being a vermetid gastropod (Bronn, 1827; Schauroth, 1865; Stoliczka, 1868; Whitfield, 1890; Rovereto, 1899; Cossmann, 1912; Rutsch, 1939; Wenz, 1943) and a serpulid polychaete (Simonelli, 1887; Gardner, 1939; Wrigley, 1950) throughout the literature. This debate continued into the mid-20th century, as reflected in the work of Karagjuleva (1964). Ultimately, *Rotularia* has been widely accepted as a serpulid polychaete, based on the microstructure of its calcareous tube.

Mid-Cretaceous Burmese amber has yielded over a thousand species of organisms, including plants, fungi, mollusks, onychophorans, vertebrates, nematodes, diverse arthropods, and various marine animals preserved in amberground, since the first discoveries approximately a century ago (Mao et *al*., 2018; Ross, 2019, 2024). Although an increasing number of species have been consistently described over the past years, only a few tube-dwelling polychaetes have been reported from Burmese amber (Zhang & Huang, 2024), and no coiled polychaetes have been described to date. Herein, we report the first record of *Rotularia* attached to Burmese amber.

Material and methods

This study was based on 80 specimens from the mid-Cretaceous Burmese amber, which originated from a locality near Noije Bum (26°20′ N, 96°36′ E), Hukawng Valley, Kachin State, northern Myanmar. All studied specimens are housed in Nanjing Institute of Geology and Palaeontology, CAS, Nanjing, China (Figs 1–4). Photographs of Recent *Rotularia* specimens were taken from the Field Museum and the private collection of D.Y.H. (Fig. 5).

Photographs were taken using a Zeiss Axio Zoom V16 stereo microscope and a Zeiss Axio Imager 2 light microscope with a digital camera attached. Microtomographic data were acquired using a Zeiss Xradia 520 Versa 3D X-ray microscope at the micro-CT laboratory of NIGPS and analyzed with VGStudioMax 3.0.

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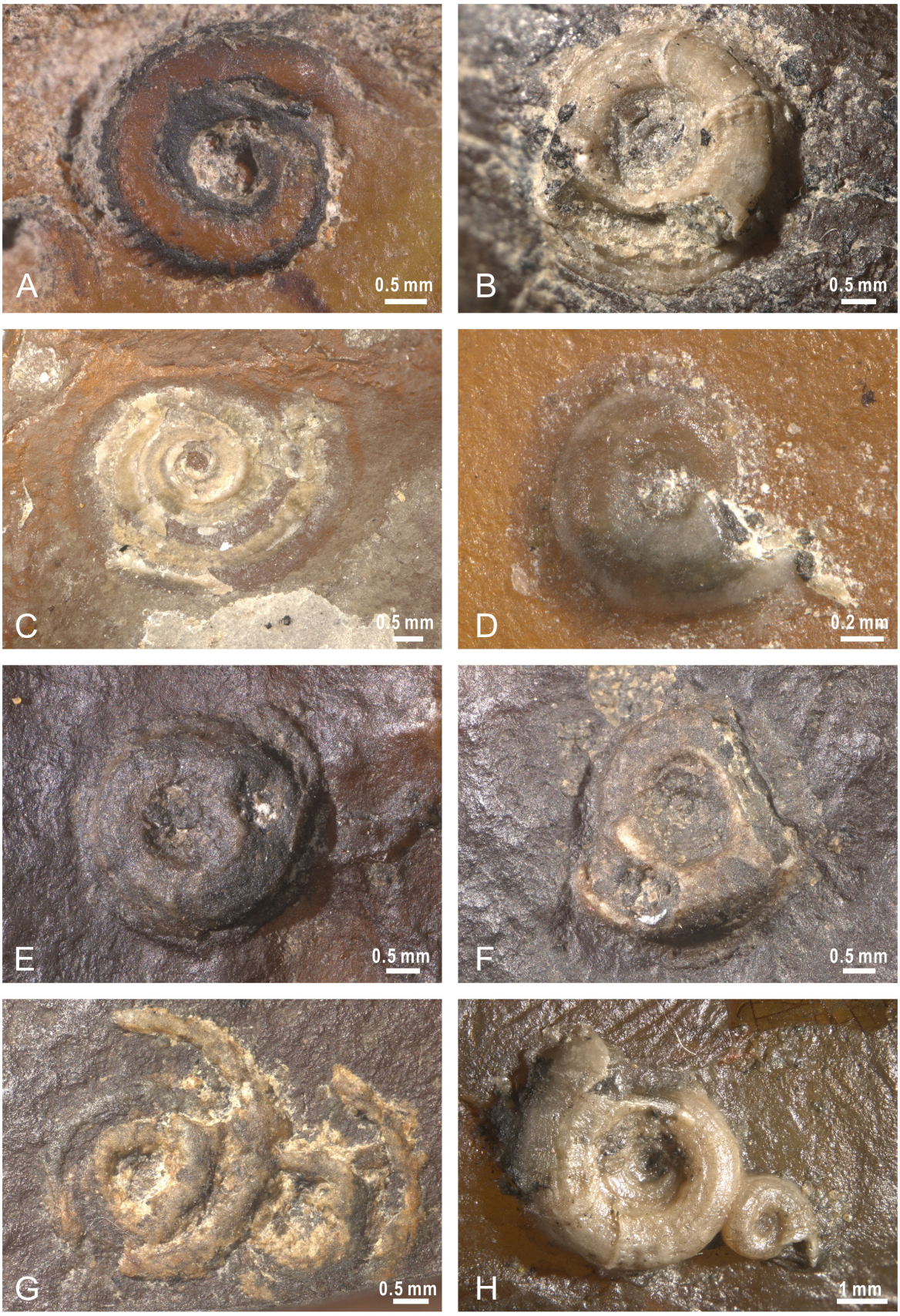

FIGURE 1. Microfacies of *Rotularia* attached to Burmese amber. **A**, Densely spaced delicate striation, NIGP206584. **B**, Several conspicuous annular rings, NIGP206585. **C**, Horizontal view of *Rotularia*, NIGP206586. **D**–**F**, NIGP206587, NIGP206588, NIGP206589. **G**, Slightly curved free anterior tube portion is present, NIGP206590. **H**, Aggregated specimens with longitudinal keels, NIGP206591.

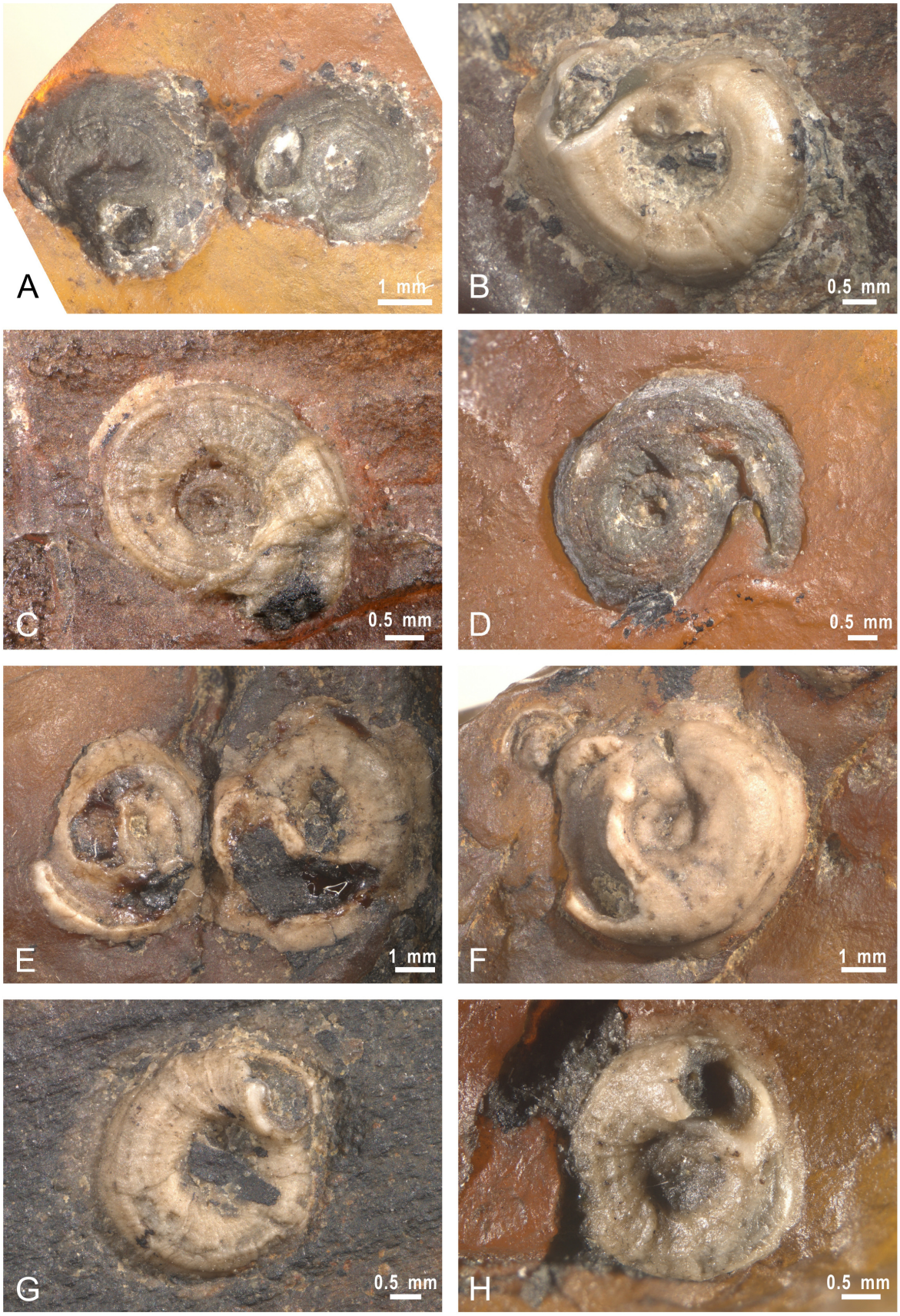

FIGURE 2. Microfacies of *Rotularia* attached to Burmese amber. **A**, Aggregated specimens with longitudinal keels, NIGP206592. **B**, Relatively weaker longitudinal keels, a small individual overgrows on the other one, NIGP206593. **C**, Conspicuous annular rings of *Rotularia*, NIGP206594. **D**, NIGP206595 showing longitudinal keels; **E**, NIGP206596. **F**, Aggregated specimens, side by side, NIGP206597. **G**, NIGP206598. **H**, Densely spaced delicate striation and longitudinal keels, NIGP206599.

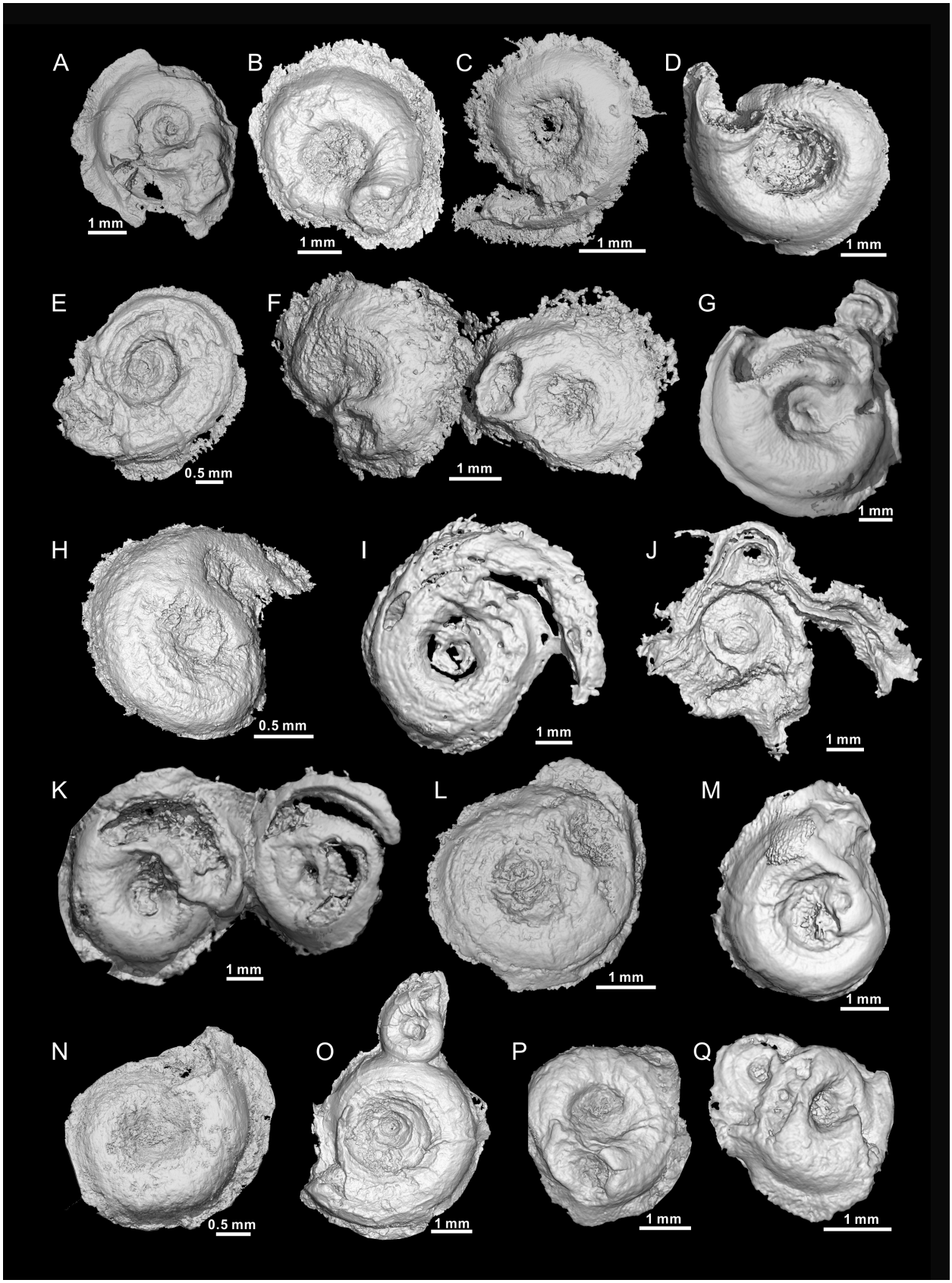

FIGURE 3. *Rotularia* attached to Burmese amber, under micro-CT. **A**, NIGP206600, **B**, NIGP206598, **C**, NIGP206595, **D**, NIGP206601, **E**, NIGP206594, **G**, NIGP206597, **H**, NIGP206584, **I**, NIGP206602, **J**, NIGP206603 (with an uncoiled serpulid tube preserved together, see Zhang & Huang, 2024), **L**, NIGP206604, **N**, NIGP206605, **P**, NIGP206599, solitary individuals. **F**, NIGP206592, **G**, NIGP206597, **K**, NIGP206596, **O**, NIGP206591, **Q**, NIGP206606, aggregated individuals, side by side. **M**, NIGP206593, aggregated specimens, a small individual overgrows on the other one.

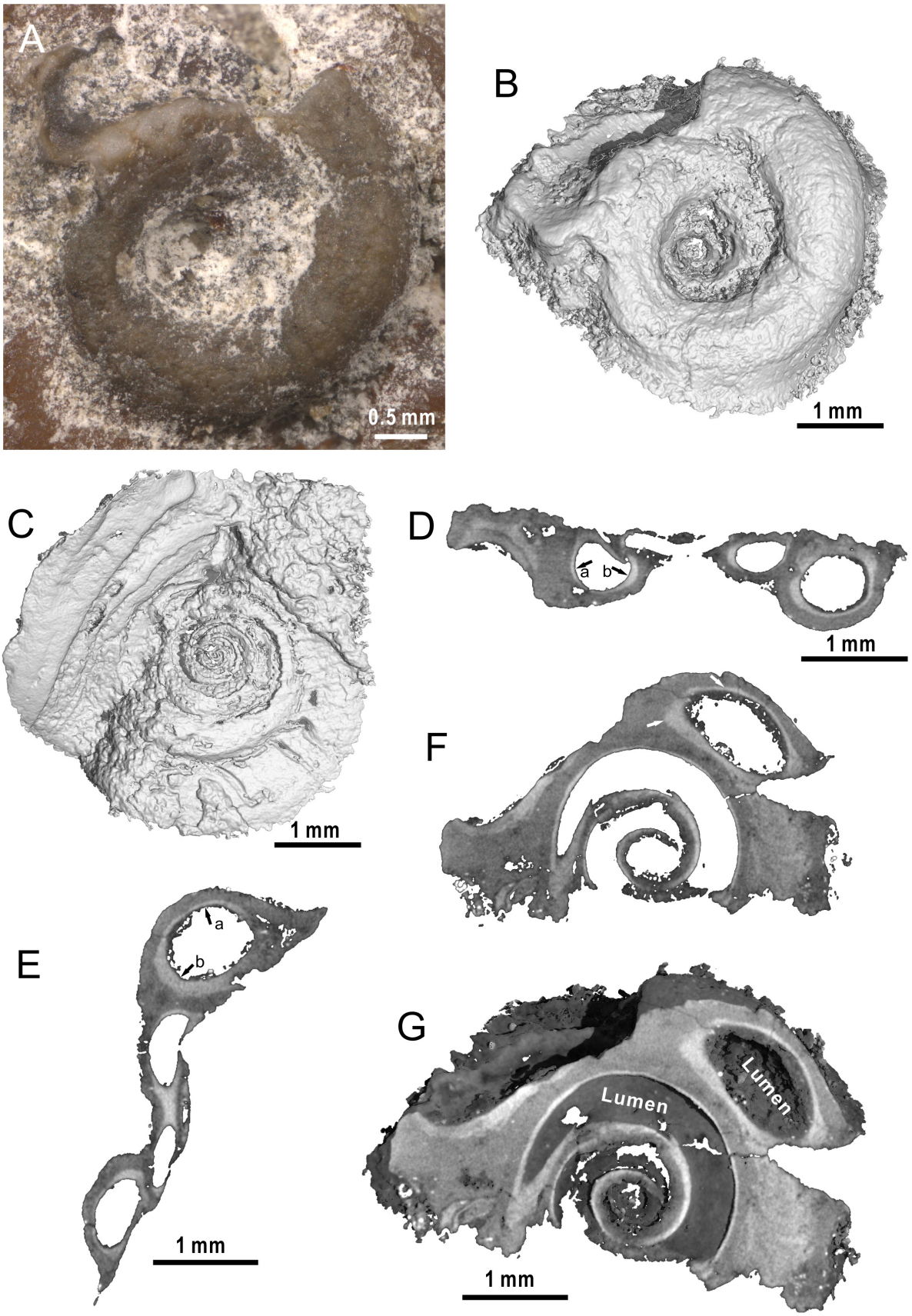

FIGURE 4. Different views of *Rotularia* by SEM, NIGP206607. **A**, Microfacies of *Rotularia*. **B**, Micro-CT view. **C**, Back plane showing the whorls. **D**–**E**, Section in median transverse plane of a form with round-shaped tube, the lumen is not in the central, the wall of the tube wall is thin on one side (a) and thick on the other (b). **F**–**G**, Horizontal view of *Rotularia*.

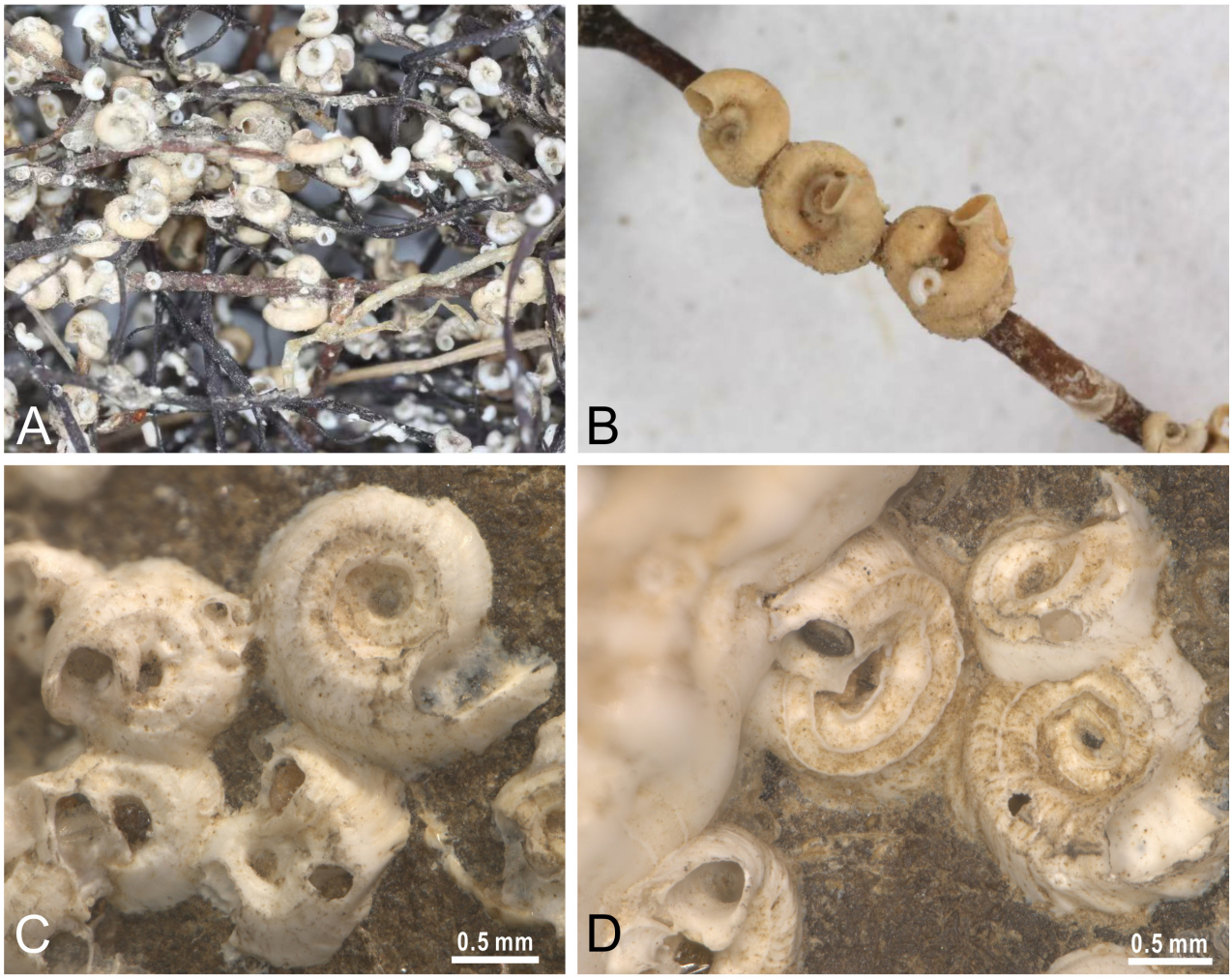

FIGURE 5. Recent *Rotularia*. **A**, **B**, Aggregate *Rotularia* attached on algae from collection of Field Museum, USA. **C**, **D**, Aggregate *Rotularia* attached on stone that collected from sea shore of Bilbao, Spain.

Results

Specimens of *Rotularia* collected from Burmese amber are consistently small with diameter commonly around 1–3.5 mm (Figs 1, 2). In the spiral morphotype, the tube is tightly coiled, and generally forms a regular planispiral to low trochospiral with 2–3 turns and has a rather acute apical angle umbilicus (Figs 1, 2). The initial whorls are commonly eroded or broken off. The whorl profiles are mainly rounded partially or wholly overlapping each other, and the final whorl is the only one entirely visible. A non-coiled straight or slightly curved free anterior tube portion may be present (Figs 1G, 2D, 3C, D, I). The spiral tube portion bears three longitudinal keels which show considerable variations in relative size, shape and position (Figs 2A, B, G, H, 3E, I, M, O, P). The middle keel is generally more pronounced, two at upper and lower peripheral edges. The keels delimited by spiral depressions may form defined grooves on the outer tube wall (Fig. 2A). Some specimens possess additional weaker keels in the outer whorl and in the free tube portion (Fig. 3O). Densely spaced delicate striation may (Figs 1A, 2G, H) or may not be present, more conspicuous annular rings occur only in a few specimens, forming a reticular pattern together with the keels (Fig. 2G, H). Rounded conspicuous transverse ornament sometimes occurs in the outer wall (Figs 1B, H, 2B, 3M) but most of them are delicate. The cross section is rounded. Under micro-CT, the tube-wall is seen to consist of two layers (Fig. 4D, F), a thin, inner, bright layer surrounding the lumen (Fig. 4D–G), and a very thick outer layer. The lumen is often not central, but displaced towards one side of the tube (Fig. 4D–F). Both sinistrally and dextrally coiled spirals occur (Figs 3N, Q, 2G, H), and the proportion of dextral versus sinistral specimens were relatively even (sinistrally coiled/dextrally coiled = 22/28 in visible individuals).

Rotularia were attached directly to the Burmese amber by the whole spiral tube portion. The life position

of *Rotularia* has been discussed by many authors (*e.g*., Macellari, 1984); Savazzi, 1995, 1999; Seilacher *et al*., 2008). The spiral combined an uncoiled anterior tube portion constituted a stabilizing structure, increasing the effective area of contact with the substrate is very common in the sessile soft-bottom dwellers among polychaetes and gastropods (Savazzi, 1995). Very noticeable is the difference in the microstructures of their walls. In serpulids, a parabolic to oblique texture is visible in the equatorial cross-section, while in gastropod, parallel in the inner and transverse on the outer part of the wall. In cross-section, serpulids have a concentric increment on the outside and inside, in gastropods, there is a concentric increment on the inside, and a radial increment on the outside. The difference is also in the thickness of the inner sides of the wall of the tubes, in serpulids the inner part of the wall is thin, in gastropods, it is thicker (Schmidt, 1951; Müller, 1980).

Rotularia were found either aggregated or solitary on the Burmese amber. Aggregates include a few specimens more than two, and often growing side by side (Figs 1H, 2A, E, F, 3G, O, Q), sometimes overgrow on the other ones (Figs 2B, 3M). They are very similar with the extant polychaetes (Fig. 5). As shown in previous studies, *Rotularia* preferred fine-grained sediments, which offered suitable living conditions for this soft-bottom dweller. From this perspective, the fine-grained Burmese amber likely provided a relatively favorable and stable substrate for *Rotularia*.

Conclusion

The serpulid *Rotularia*, described here from mid-Cretaceous Burmese amber, represents the first record of marine coiled polychaetes preserved in amber. The relatively complete tube morphology, well-preserved outer-wall ornamentation, and the presence of a partially uncoiled, free anterior tube portion suggest that the Burmese amber-producing forest was likely near a shoreline. The amber pieces may have acted as hard substrates in a coastal environment, similar to gravels.

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