

Short communication

Juvenile snail with preserved soft tissue in mid-Cretaceous amber from Myanmar suggests a cyclophoroidean (Gastropoda) ancestry

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ABSTRACT

Gastropods are generally rare in amber. In this paper we describe an example of exceptional soft-bodied preservation in a fossil terrestrial mollusk—a snail shell with some tissue, including part of the cephalic region (head) with a tentacle and inferred eye stalk, and potentially part of the foot and operculum. The snail, a probable juvenile, is preserved in Burmese amber (Burmite) from Myanmar, of earliest Cenomanian age. Morphological evidence suggests a cyclophoroidean ancestry and a possible attribution to the family Cyclophoridae; members of this superfamily are widespread today in Asia, thus indicating a long geological history in the region. This specimen constitutes the first confirmed and oldest record of soft-bodied preservation of a snail in Cretaceous amber.

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1. Introduction

Konservat-Lagerstätten (exceptional preservation) in amber deposits worldwide enable soft-part anatomies to be preserved that are otherwise unknown in the usual fossil record; thus, they offer more complete records of palaeontological diversity and behaviour. Amberization can preserve fine structures such as barbules of feathers, external opening of the ear, the eyelid, and fine details of tarsal scutellation in vertebrates (Xing et al., 2016a,b, 2017); hairs, eye-facets and genitalia of insects and soft-bodied organisms in 3D such as worms and fungi (Grimaldi and Ross, 2017).

Here we describe a new Burmese amber piece (a.k.a. Burmite), DIP-Y-0909 (Dexu Institute of Palaeontology, Chaozhou, China), containing a complete gastropod with soft tissue, which is

exceptional in the fossil record. Based on biostratigraphical evidence (ammonites and pollen) Burmese amber from the Hukawng Valley, Myanmar (see Guo et al., 2016, for recent map) has been dated as late Albian–Cenomanian (~105–95 Ma) (Cruikshank and Ko, 2003), supported by radioisotopic data (U–Pb) from volcaniclastic zircons indicating an age of 98.8 ± 0.6 Ma for the amber-bearing bed (Shi et al., 2012). Ross (2015) considered Burmese amber was most likely to be late Albian because some of the amber pieces were bored by pholadid bivalves which suggested the resin was already hard when deposited; however, a recent study has demonstrated that the bivalves were boring into the resin while it was still soft, and thus, is contemporaneous with the age of the bed, i.e. early Cenomanian (Smith and Ross, 2018).

2. Methods and materials

Burmese amber piece DIP-Y-0909 is 19.77 mm × 17.02 mm × 8.26 mm, and it weighs 1.65 g (Fig. 1). It was scanned with a Nikon

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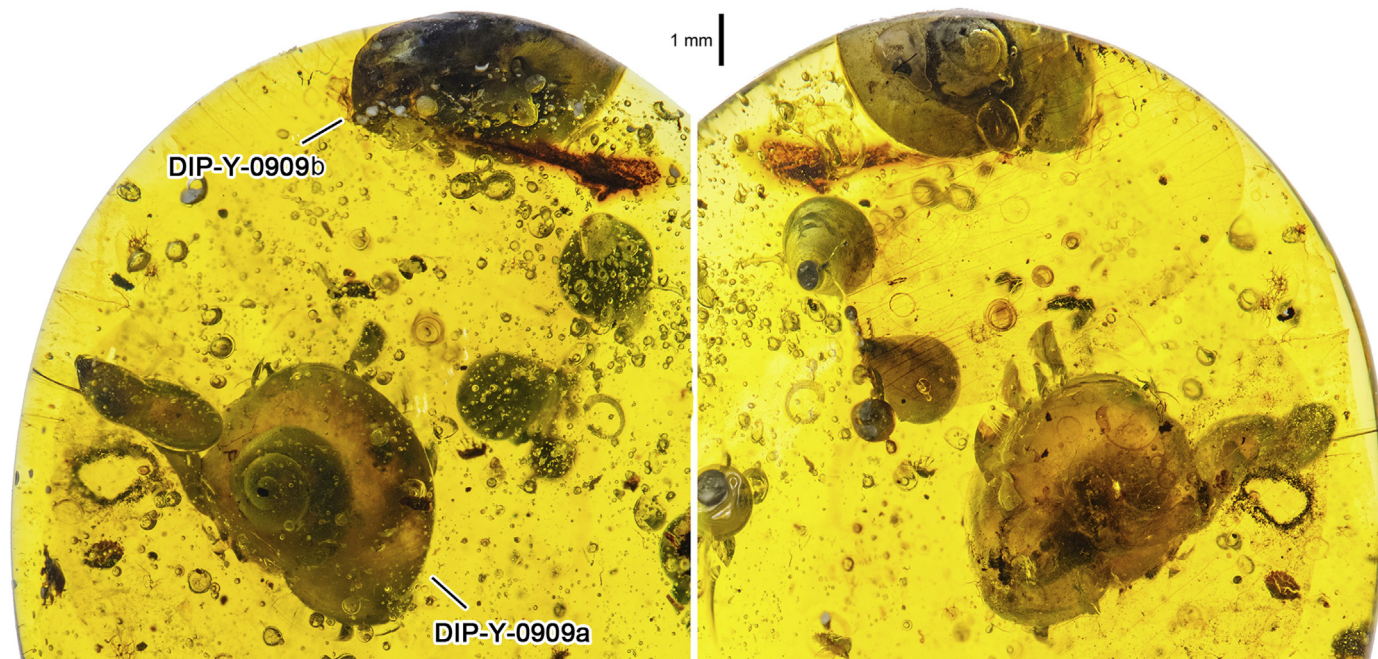


Fig. 1. Two views of Burmese amber specimen DIP-Y-0909, showing the positions of the two potential cyclophoroidean snails.

Metrology XTH 225/320 LC dual source industrial micro-computed tomographic scanner, housed in the China University of Geosciences, Beijing (CUGB), China. The specimen was scanned with beam strength of 120 KV, and an absorption contrast with a spatial resolution of 10.96 μm (Fig. 2).

DIP-Y-0909 contains two snails catalogued as DIP-Y-0909a and b. The former exhibits soft tissue, while the latter is incomplete. They are morphologically similar, and possibly conspecific. The shell of DIP-Y-0909b appears to be empty.

3. Description

Morphological characteristics: DIP-Y-0909a has a smooth, weakly calcified, translucent, low conical helicoid shell of approximately three to three and a half whorls, which are slightly shouldered towards the moderately impressed sutures (Fig. 3). Growth lines are well developed and equally and closely spaced. The lower part of the body whorl is incomplete and the bottom is concave. The subcircular aperture of the shell is inclined. The outer lip is thickened on the margin. The phaneromphalus umbilicus is covered by soft tissue and is not clearly visible. The shell is 2.08 mm high with a last whorl diameter of 4.88 mm. The aperture is 1.13 mm high with a diameter of 2.10 mm. DIP-Y-0909b is not well preserved though is morphologically similar to DIP-Y-0909a and may be conspecific. Its shell is 1.54 mm high with a diameter of 2.46 mm. Its aperture cannot be measured due to poor preservation.

The visible soft parts are challenging to discern, except that part of the cephalic region of the snail is preserved with paired ommatophores, comprising one complete ocular-tentacle with eye stalk (tentacle pair 1; tentacle pair 2 not visible or complete) along with the base of the other tentacle and possibly part of the foot. The observed tentacle is continuous and arises from the dorsal surface of the head region. It is relatively long, thin and darkened with a slightly bulbous, blackened, eye stalk, as opposed to a caudal horn, which is more robust in nature and has a distinct morphology. The

small darkened spot at the base of the tentacle, may be the vestige of an eye (Fig. 4), a common and well known position in cyclophoroidean snails. The head and foot of the snail is somewhat distorted, compounded by the optical effects of the fossil resin, but the characteristic discoidal feature could well represent an operculum, which is covered and mostly obscured by resin and some tissue. The inferred part of the foot is stretched and partially obscured by resin and an air bubble which is also concealing other features of the head. It cannot be discounted entirely that the discoidal, bubbly blob represents the operculum, a key feature in Cyclophoroidea, but this feature is masked by the bubble and resin. In life, the snail would have sat on the operculum and foot, as it progressed along in the tropical forest habitat(s). The soft parts of the snail are very stretched, and this could represent a final attempt at escape to no avail. Given that the snail was seemingly entombed in tree resin while alive, this could account for the pronounced distortion in the preserved soft tissues.

4. Identification

The inferred juvenile nature of the gastropod shell of only three to three and a half whorls renders a firm taxonomic identification uncertain. Nevertheless, there are potential contenders with comparable morphologies in both extant and fossil Cyclophoroidea. The most significant aspect of this paper is to bring to light the first and oldest confirmed soft tissue preserved in a gastropod from 99 Ma, rather than to confirm an affinity taxonomically. As reviewed by Zhang (2017) and Yu et al. (2018), architaenioglossan caenogastropods are rare in Burmese amber, let alone with any soft part preservation, with few taxa recorded: two genera in the Cyclophoroidea, *Euthema* (Diplommatinidae) and *Cretatortulosa* (Pupinidae), and undescribed snails belonging to the Clade Stylommatophora in the families Valloniidae and Subulinidae (Zhang, 2017) being the most common. Many gastropod taxa in Burmese amber await description, but thus far,

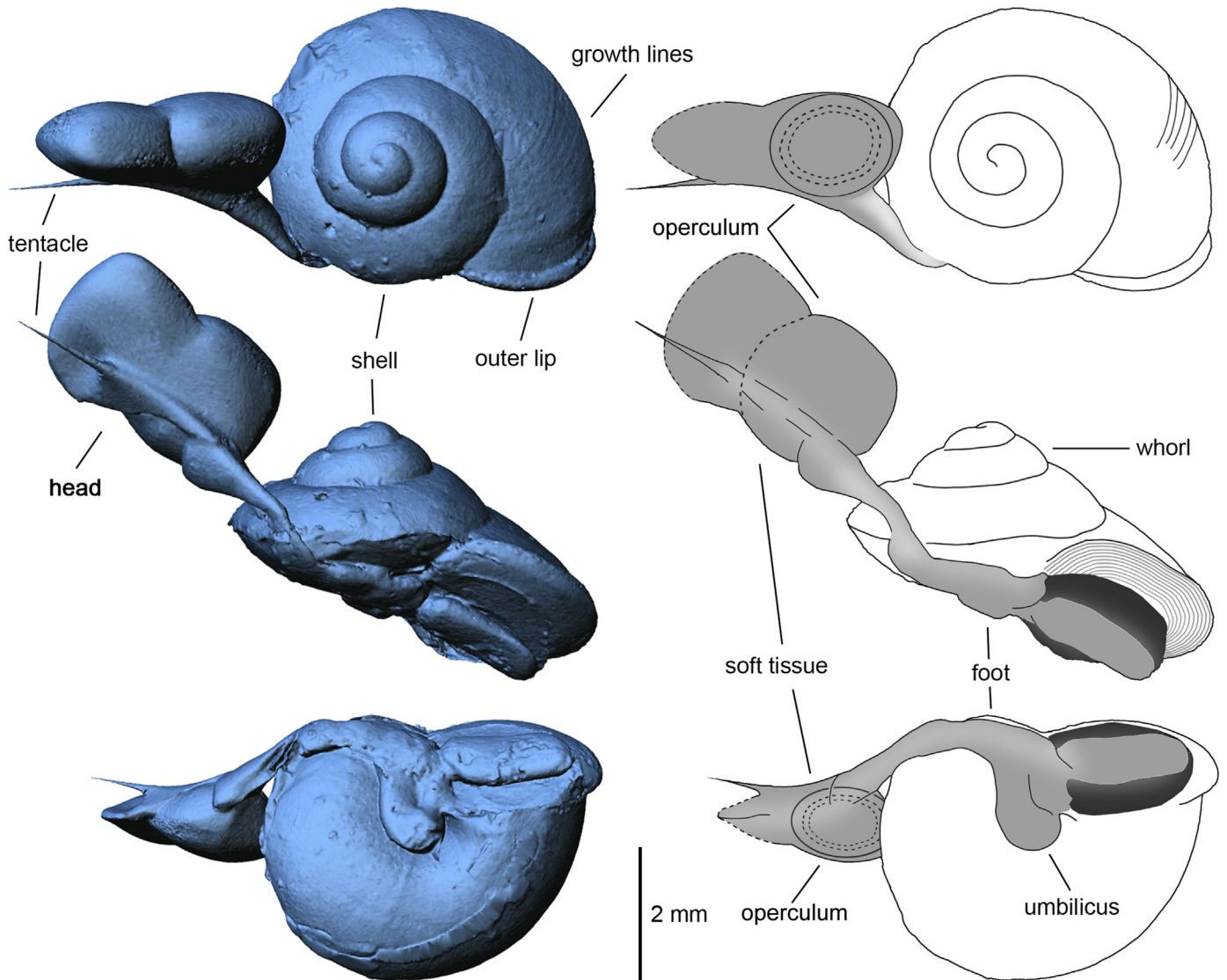


Fig. 2. Micro CT reconstructions and line drawings (dorsal, lateral and ventral views) of snail DIP-Y-0909a showing details of the shell and soft tissue.

nearly all recovered are empty shells, apart from specimen DIP-Y-0909a described herein. As the shell shape, growth lines, whorl number, suture, inclined aperture, and open umbilicus of DIP-Y-0909a align with morphologic features within the Cyclophoroidea, all of which have an operculum; we identify the two new specimens tentatively as belonging to an early member of this superfamily with possibilities of an attribution to the Cyclophoridae or other group within this superfamily (see Egorov, 2009). The lack of further features hinders further identification of the specimen, which has a defect on the lower part of the body whorl, making the aperture appear to be more inclined. DIP-Y-0909b has similar morphological features with DIP-Y-0909a, so it may be attributed to Cyclophoroidea and perhaps even conspecific despite its incomplete nature. In apical view, whole profile and sculpture, DIP-Y-0909 is strongly reminiscent of the Late Cretaceous probable cyclophoroidean, *Strophostomella cretacea* (Tausch, 1886) (see review by Bandel and Riedel, 1994, Plate 4, figs. 5–8) from Hungary, but again, the juvenile nature of the new

material described here makes it nearly impossible to confirm an affinity. Most described Cretaceous cyclophoroidean gastropods are based on adult shells. Given the difficulties in attributing this juvenile group to a specific superfamily or even family, there are also some superficial similarities with the Valloniidae, so this possibility cannot be entirely discounted, except for the potentially preserved operculum precluding its affinity with Valloniidae. These evidence presented herein points more to a cyclophoroidean ancestry. Cyclophoroidean gastropods have an extensive geologic record, extending back to the Late Jurassic of Europe with both fossils and extant taxa recorded from tropical habitats (Raheem et al., 2017), and new evidence this year in the Asian region reaching back into mid-Cretaceous in Burmese amber (Yu et al., 2018). There is no close, allied relationship between the newly described specimens here and new cyclophoroidean genera described by Yu et al. (2018). This also indicates a probable higher diversity of terrestrial gastropods, than currently recorded.

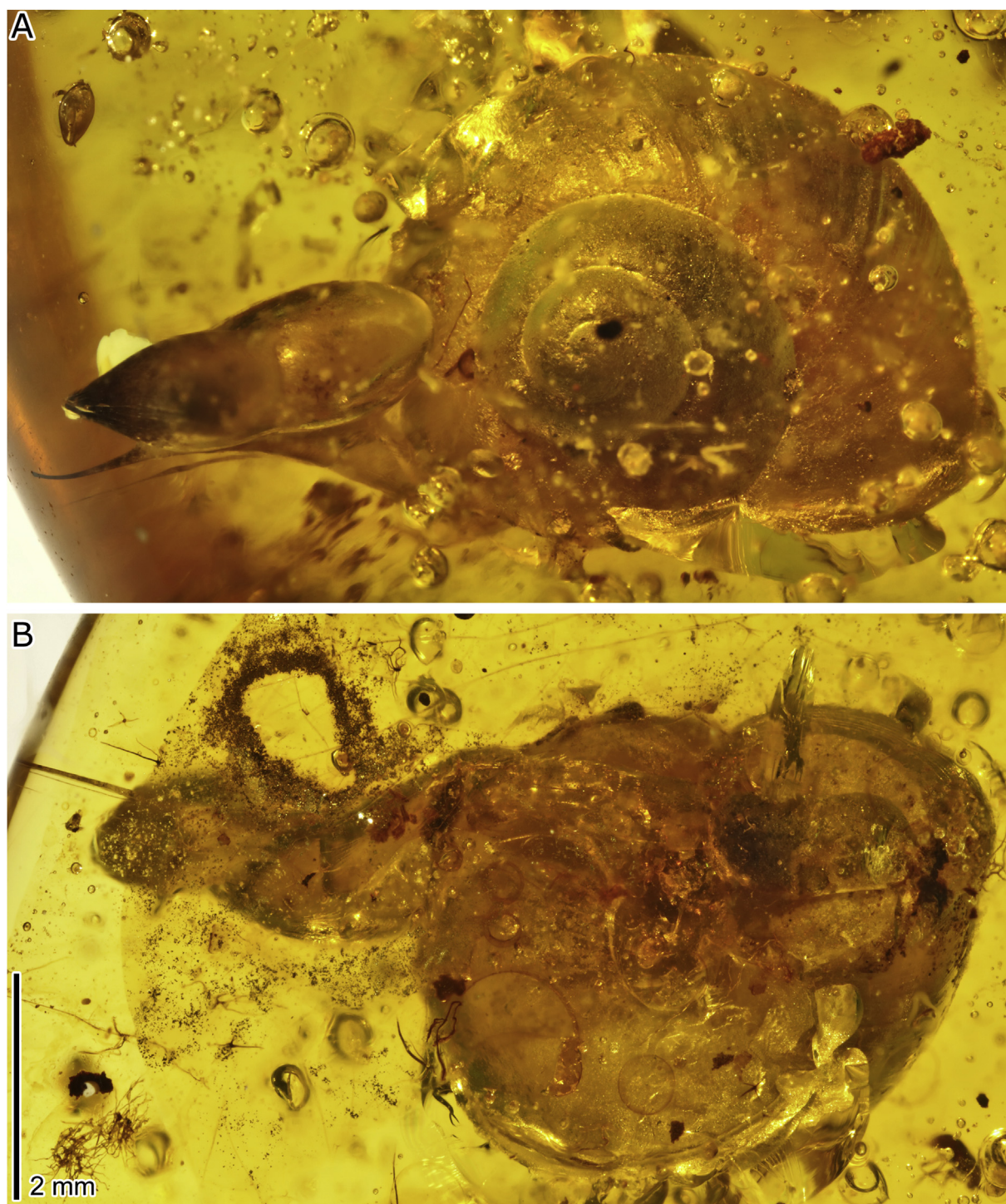


Fig. 3. The dorsal (A) and ventral (B) views of snail DIP-Y-0909a showing the shell and soft tissue details.

5. Preservation and palaeobehaviour

Resin can collect inside the void of a tree, drip off a branch or flow along the outer bark. Resin that accumulates on the outside of a tree can act as a trap for small invertebrates (Ross, 2010). Amber has preserved arthropods mating, laying eggs, carrying eggs, feeding, as well as various symbiotic relationships (Zhang, 2017). These suggest that they were trapped very quickly.

The soft tissue of snails has not been recorded before in Burmese amber; however, a reputed punctid snail in Burmite with possible soft parts was figured by Poinar and Poinar (2008, fig. 27). One snail figured in plate 16A appears to be empty, whereas the black and white photograph of another snail in figure 27 shows some material near the aperture but no discernible soft parts. A snail with a tentacle in Eocene Baltic amber was figured by Weitschat and Wichard (2002), and soft tissues of a helicimid and

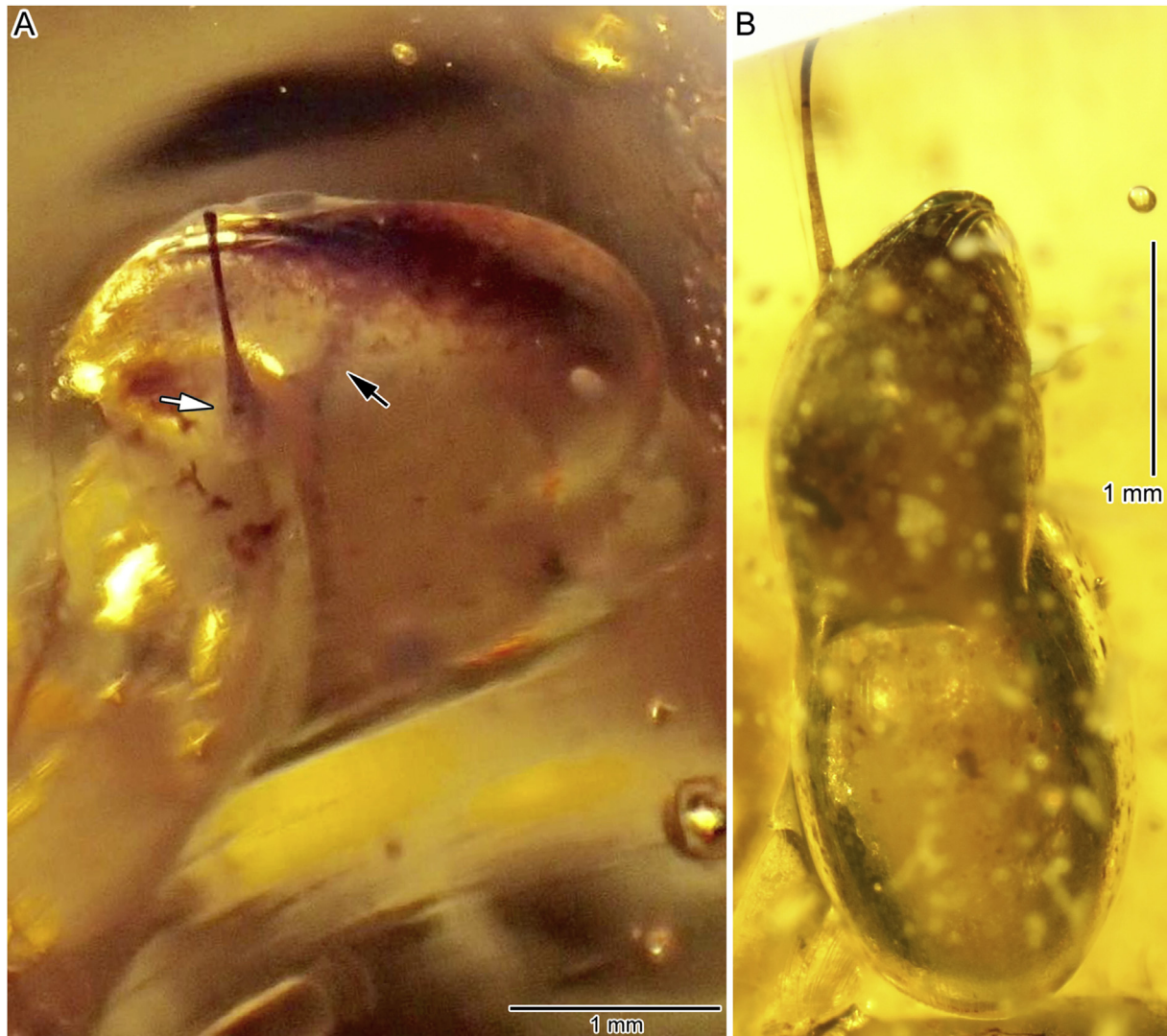


Fig. 4. Close-up photograph of snail DIP-Y-0909a (A: lateral view, B: ventral view) showing the extended aspect of the perceived eye (white arrow), eye tentacle and possible second tentacle (black arrow) projecting into an air bubble.

prosobranch were recorded in Miocene Dominican amber by Poinar and Roth (1991). Other snails in amber either do not demonstrate any preservation of soft-tissue, or darker areas visible through translucent shells may indicate tissue within the shell (see figures in Xia et al., 2015, Zhang, 2017). Since the usual defence of a snail is to retract effectively into its shell when threatened, it is conceivable that the same reaction would result when resin engulfs the hapless mollusk.

In this unusual example in Burmese amber, having soft tissues outside of the shell suggests the following possible series of events:

1. The snail was crawling along, with its tentacles outstretched.
2. Resin flowed around the shell of the snail first, which prevented the soft-part of the snail retracting.
3. The snail crawled forward to try to pull itself free of the resin but this only resulted in it stretching its foot.
4. The foot and tentacles of the snail were then engulfed by resin.
5. The snail then exuded air into the resin which partially obscured the head and foot; moreover, air could have been already been trapped in the shell.

6. Conclusion

The soft part preservation of a snail in mid-Cretaceous Burmese amber is recorded for the first time. The architaenioglossan caenogastropod, probably belonging to a juvenile of the superfamily Cyclophoroidea and perhaps the Cyclophoridae, exhibits an inferred eye tentacle (tentacle pair 1), as part of the cephalic region and possibly part of the foot. A discoidal-shaped feature and bubble at the aperture probably represents the operculum, but this is not certain. The position of the discoid shape, however, does fit well with members within the Cyclophoroidea. It is suggested that the shell of the snail was engulfed by resin first which prevented the soft-parts retracting into the shell.

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