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A group of wax-bearing coccomorphans preserved together with a rove beetle and an aphidlion-like larva represents a possible case of predator-prey interaction in 100 million years old Kachin amber

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Abstract

We here report an amber piece from Kachin amber, Myanmar, Cretaceous, about 100 million years old. It includes a group of 17 immatures of coccomorphans (scale insects) displaying wax, most likely for defensive purposes. In the same piece we found two possible predators of the coccomorphans: an adult rove beetle and an aphidlion-like larva with a fully assembled camouflaging cloak. Both possible predators are positioned very close to some of the coccomorphans, and no separate flows of amber seem to separate them. It therefore seems likely that this is a case of predators preserved together with their prey. Such cases of predator-prey interaction are still rare in amber, while other interactions, such as mating or parasitism, have been increasingly reported. A comparable case of aphids preserved together with an aphidlion has so far only been known from significantly younger Baltic amber. The here reported case seems to be the first one in which an aphidlion-like larva is preserved together with potential prey in Kachin amber, although quite a large number of such larvae have already been reported.

Keywords: Neuroptera, Staphylinidae, Coccomorpha, Burmese amber, Cretaceous

Introduction

Reconstructing interactions of extinct organisms is always challenging. Yet, for understanding the evolution of the more complex aspects of palaeobiology, such as predator-prey interactions and further ultimately reconstructing entire food webs, it is crucial to find access to this type of information. The challenge is that direct predator-prey interactions are rarely preserved in the fossil record (and even rarely observed in the modern fauna, *e.g.*, Maritz & Maritz, 2020; Hu *et al.*, 2025), most likely coupled to a rather short time of interactions, which reduces the chances of preserving this very moment. This is quite different from other types of interactions, such as mating or parasite-host interactions, which are more long-lasting, compared to predator-prey interactions.

Our best chance for a rather direct preservation is fossil resin, known as amber. Here we have indeed quite a number of cases of preserved mating events (Weitschat, 2009; Fischer & Hörnig, 2019; Fu *et al.*, 2024) and parasite-host interactions (Weitschat, 2009; Arce *et al.*, 2024a, b, 2025). Yet, when it comes to predator-prey interactions, amber is rather disappointing, but at least some cases can be mentioned: an ant in Cretaceous amber is known to have prey in its mandibles (Barden *et al.*, 2020). The chances of preserving this case were likely higher, as it probably carried the prey to its nest, which took a while. So it is likely not the direct predator-prey interaction, but close to it.

Some cases remain unclear concerning whether they indeed represent predator-prey or parasite-host interactions, either due to an unclear status of the exact role (Hörnig *et al.*, 2020) or simply due to a conceptual challenge coupled to animals that catch other animals for their parasitic (or parasitoid if you consider that not part

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of parasitism) offspring (Kiesmüller *et al*., 2022; Haug *et al*., 2024a).

Haug *et al*. (2023b) reported a case of a piece of Eocene Baltic amber in which some aphids were preserved together with a possible predator, an aphidlion, hence a predator preserved together with its possible prey. Although this was not a perfect case, *i.e*., there is no direct interaction between the predator and the possible prey, their very close co-occurrence in a single type of amber (micro-taphocoenosis; Haug *et al*., 2020b), seemingly in the same layer (see Solórzano-Kraemer *et al*., 2023), gives a good hint for a possible interaction. The interesting aspect of this piece is that aphidlions are relatively rare in Eocene ambers (Haug *et al*., 2022). In Cretaceous ambers there are significantly more aphidlions or, better, aphidlion-like larvae known (Haug *et al*., 2022). We therefore should also expect cases in which such aphidlion-like larvae are preserved together with possible prey items, especially as we have other rare events preserved such as larvae hatching from their eggs (Pérez-de la Fuente *et al*., 2019; Haug *et al*., 2023a). Still, the only case so far is one that falls into the unclear-if-predator-or-parasite category (Kiesmüller *et al*., 2024).

We report here an amber piece from Cretaceous Kachin amber, Myanmar, with a group of hemipterans together with two possible predators. One of them is an adult rove beetle, the other one is an aphidlion-like larva. We discuss the implications of this finding concerning organismic interactions.

Material and methods

Material

The single amber piece of this study is Kachin amber from Myanmar and therefore of late Cretaceous age (Shi *et al*., 2012; Yu *et al*., 2019). The specimen was legally purchased on the trading platform ebay.com from the trader burmitefossil. It has been deposited in the Palaeo-Evo-Devo Research Group Collection of Arthropods, Ludwig-Maximilians-Universität München (LMU Munich), Germany, under repository number PED 4035. Fossils in Myanmar amber have caused discussions about ethics in paleontological research (*e.g*., Haug *et al*., 2020a; Dunne *et al*., 2022). One strategy to improve the situation is to collaborate with colleagues in Myanmar (for our first steps in this direction, see *e.g*., Haug *et al*., 2023a).

Documentation methods

The amber piece was documented on a Keyence VHX-6000 digital microscope. The specimen was covered by glycerol and a coverslip to even out the surface. Different light settings were used to optimally visualise all structures (ring illumination, coaxial illumination, transmitted illumination, white or black background). All images were recorded as compound images (fused stacks of images, merging of adjacent image details, HDR).

Results

The amber piece includes 19 major inclusions (Fig. 1A, B). Of these, 17 appear similar to each other and are interpreted as hemipterans (Fig. 2A–D). One of the other two is interpreted as a rove beetle (Fig. 3E). The last one is a camouflaged larva of a lacewing, more precisely an aphidlion-like larva (Fig. 3A, B).

The sub-similar appearing specimens are roughly in the same size range; they mostly carry a prominent wax tail on their posterior abdomen, but they also have wax strands on other body regions (Fig. 2A–D). The rove beetle is significantly larger than the other specimens (Fig. 1A, B). The aphidlion-like larva can easily be (and initially has been) overlooked as it is strongly covered by debris (Fig. 3A). Only after inspecting the piece, the structures protruding from under the debris could be identified as processes of an aphidlion-like larva. It was not possible to visibly access this larva from the other side as it is concealed by one of the hemipterans.

Discussion

Identity of the specimens

The majority of the specimens preserved in the amber piece, 17 in total, are similar in overall appearance. They are wingless with a pair of antennae with six to seven elements each; the antenna is longer than the central body; each of the six walking-type legs is longer than the central body (Fig. 2A–D). There are no cerci or other protrusions. In some specimens it is apparent that the mouthparts form an elongate beak (Fig. 2C). The central body is ovoid in dorsal view, slightly more extruding posteriorly and bearing numerous setae and especially prominent structures interpreted as wax strands. In some cases, these are also longer than the central body. Overall shape, mouthparts, and wax indicate that these are immature representatives of Coccomorpha. Representatives of Coccomorpha have been reported repeatedly from Myanmar amber (Vea & Grimaldi, 2015) including numerous examples of individuals carrying wax structures (*e.g*., Vea & Grimaldi, 2012; Poinar *et al*., 2020; Poinar & Vega, 2023). Possibly they are immatures (cf. Shcherbakov, 2022) of the group Ortheziidae (Wang *et al*., 2015). The observed characters are most compatible with them representing stage 2 and/or 3 immatures (Kozár, 2004). The legs

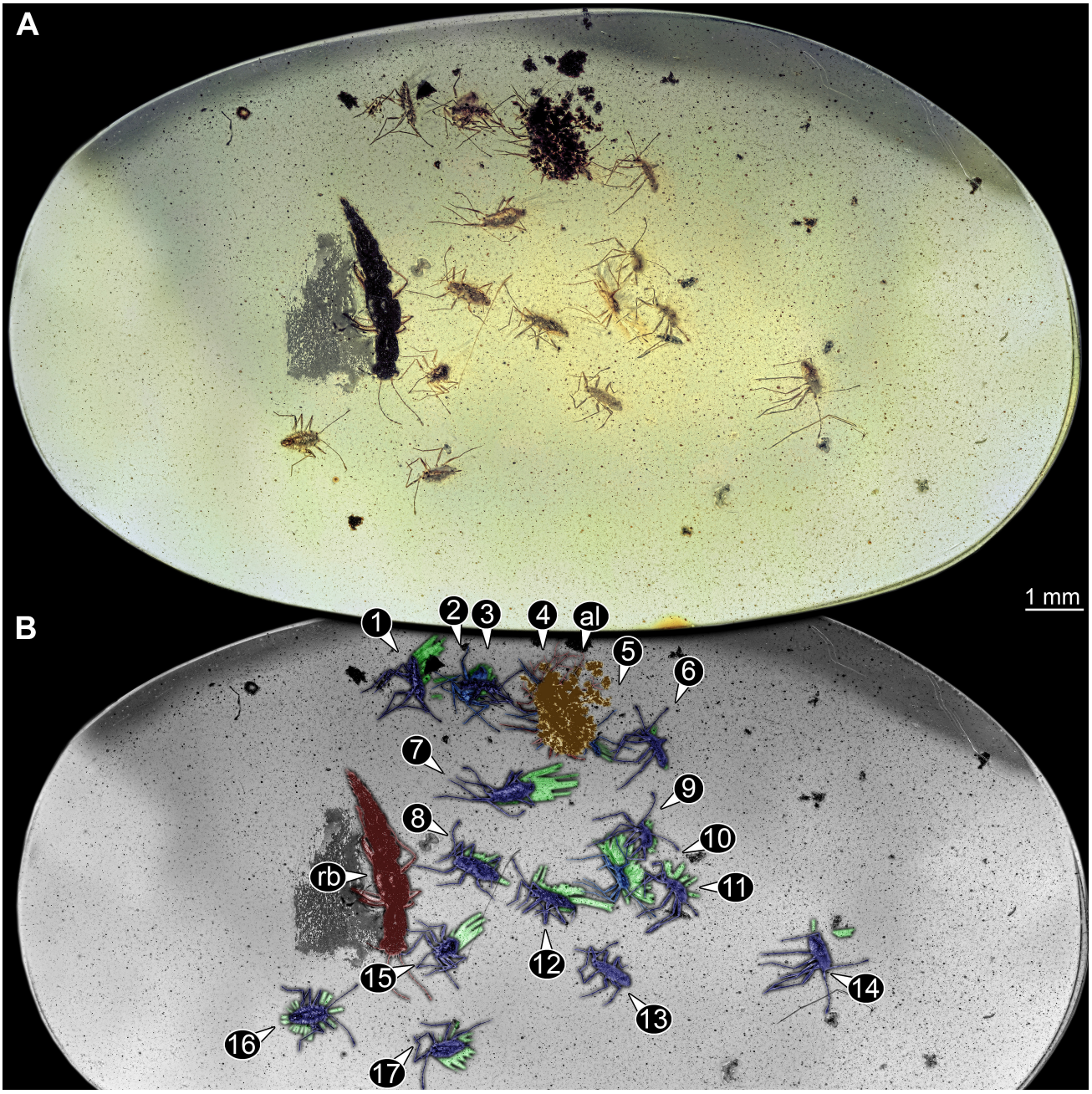

FIGURE 1. New amber piece, PED 4035, of 17 coccomorphans with two possible predators. **A**, Overview of the amber piece. **B**, Colour-marked version of **A**. Abbreviations: 1–17 = coccomorphan specimens; al = aphidlion-like larva; rb = rove beetle.

exhibit clear differentiation between the trochanter and femur, as well as between the tibia and tarsus, and the claw has no denticles. The eyes seem to be separated from the insertion of the antenna.

Burmorthezia insolita Vea & Grimaldi, 2012, *Burmorthezia kotejai* Vea & Grimaldi, 2012, and *Arctorthezia baltica* Vea & Grimaldi, 2012 are species from Kachin amber of which immature individuals have been reported, and these have a general morphology similar to the specimens studied here. However, even allowing for potential variation associated with immature stages, including in wax configuration and antenna subdivision, the wax in the mentioned species is of the cottony type, distributed as wide plates over the dorsal surface, plus the number of antenna elements is six. In contrast, the present specimens have a glassy wax organised as strands extruding posteriorly, each strand apparently bearded by a marginal seta, and the antenna elements vary between six and seven.

The differences in antenna elements and wax secretions do not fully correspond to the immature morphology described for any of the already known species. These specimens thus contribute to the known morphological diversity of Cretaceous coccomorphans within Ortheziini.

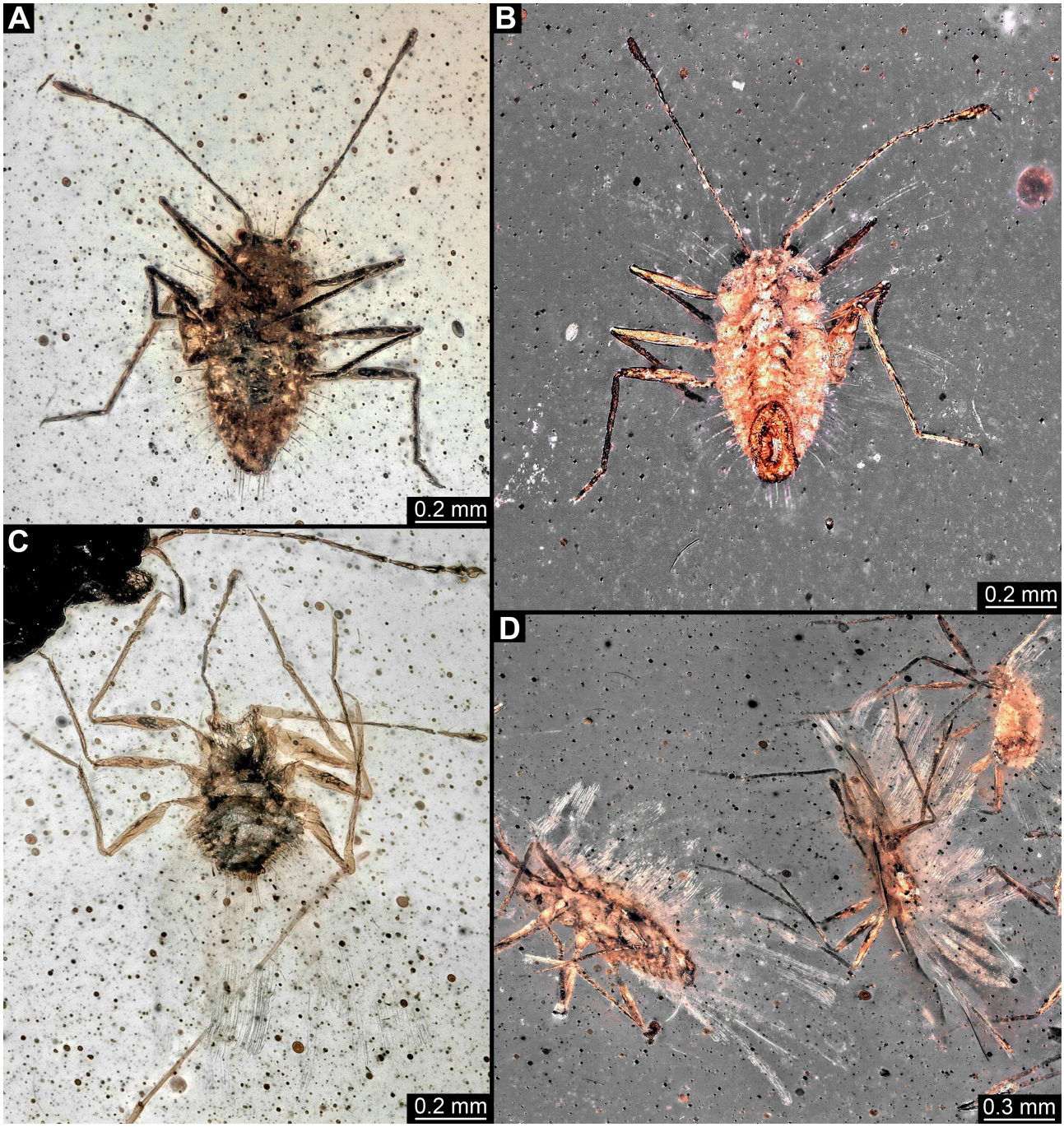

FIGURE 2. Details of coccomorphans from amber piece PED 4035. **A**, **B**, Specimen 16, ventral view. **A**, White background. **B**, Black background. **C**, Specimen 15, white background. **D**, Specimens 9, 10, 12, black background.

Only a few details are accessible of the larva with the camouflaging cloak, yet the distinct processes that carry this cloak immediately identify the larva as an aphidlion-like larva, in this case a lacewing closely related to the modern lineage of Chrysopidae (green lacewings). Such processes are well known in other larvae from Cretaceous ambers, including specimens from Lebanon (Pérez-de la Fuente, 2018, 2019) and Spain (Pérez-de la Fuente, 2012, 2016), yet especially many specimens are known from Myanmar amber (Fig. 3C; Wang *et al*., 2016; Haug *et al*., 2022). While such processes are also known in a single younger fossil aphidlion-like larva (from Ukrainian Rovno amber; Haug *et al*., 2024b), modern-day aphidlions have shorter and more robust appearing processes for carrying their camouflaging cloak (Fig. 3D; Mantoanelli *et al*., 2006; Tauber *et al*., 2011, 2013).

The third type of fossils has distinct hardened forewings, presumably covering the hindwings, also known as elytra (Fig. 3E), which are rather short and leave most of the abdomen exposed (while in many

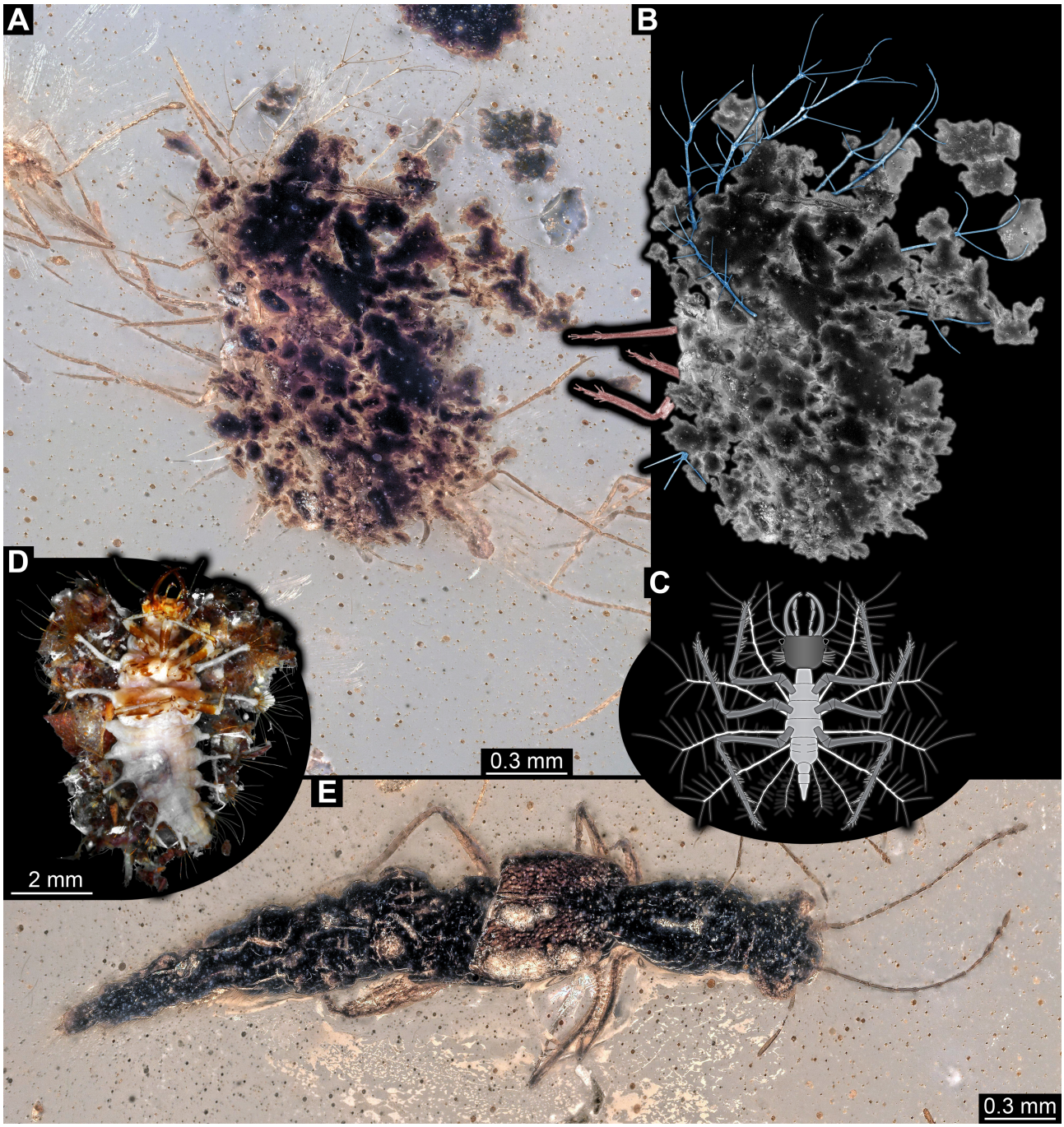

FIGURE 3. Details of possible predators in amber piece PED 4035 and comparative lacewing larvae. **A**, **B**, Aphidlion-like larva with camouflaging cloak, legs (red) and dorsal processes (blue) protruding from under the cloak. **C**, Restoration of a "naked" aphidlion-like larva exhibiting the dorsal processes (Haug *et al*., 2022). **D**, Extant larva of *Leucochrysa*? with prominent camouflaging cloak, note how also here the processes extend beyond the camouflaging cloak (reused from Haug *et al*., 2024b, CC-BY 4.0). **E**, Rove beetle.

cases the elytra conceal the entire abdomen). Such short elytra are well known in adult earwigs (Dermaptera) and rove beetles (Staphylinidae). The morphology of the head structures and the absence of cerci and associated structures indicate that the fossil is a rove beetle. Rove beetles are well known from Kachin amber (Jałoszyński & Peris, 2016; Yin *et al*., 2018; Yamamoto & Newton, 2021; Li *et al*., 2023; Yamamoto, 2024; Chen *et al*., 2025; Haug *et al*., 2025). The beetle resembles representatives of the group *Festenus* Żyła *et al*., 2017 known from amber from Myanmar with several species. For the species *Festenus microraptor* Mainda, 2024 (from Hkamti amber) its small size of about 1.6 mm was mentioned as a diagnostic character (Mainda, 2024: p. 133). The other

known species (from Kachin amber) are indeed larger; *F. annodutt* Mainda, 2023 measures over 5 mm (Mainda, 2023: fig. 1, p. 574), *F. robustus* Żyła *et al*., 2017 about 3 mm, and *F. gracilis* Żyła *et al*., 2017 slightly more than 3 mm (Żyła *et al*., 2017). The new specimen measures also a bit more than 3 mm and therefore is most similar in size to *F. gracilis*. The distal three antennal elements (antennomeres) are slightly more slender than in other species and resemble the condition in *F. gracilis* most closely. Also the overall slender appearance of the body resembles the condition in *F. gracilis*. We therefore see it as most likely that the new specimen is a representative of *F. gracilis*.

Ecological roles

Hemipterans fulfil various ecological roles, but representatives of Coccomorpha feed on plant liquids. The pronounced wax strands that all specimens show (at least to a certain degree) have likely functioned for defensive purposes.

Both of the other inclusions, the rove beetle and the aphidlion-like larva, are more likely predators and also potential predators of the coccomorphans. For rove beetles, the diversity of feeding modes is quite high (*e.g*., Stocker *et al*., 2022; Rojas *et al*., 2024); but for some ingroups, such as Steninae (of which the here presented specimen is a representative), it is well known that they feed on a variety of prey items, including aphids (Habibullah-Rana *et al*., 2010; Balog *et al*., 2013) and relatives, but it remains unclear whether among these are also coccomorphans (Krooss & Schaefer, 1998; Hu *et al*., 2025). Rove beetles are used as pest control against plant pests (especially fly larvae; *e.g*., Birken & Cloyd, 2007), therefore we further considered information from websites dealing with pest control. It has been stated there that rove beetles also consume (and hence are effective against) coccomorphans (*e.g*., https://cals.cornell.edu/integrated-pest-management/eco-resilience/biocontrol/biocontrol-agents/rove-beetle#:~:text=Pests%20Targeted%20by%20Rove%20Beetles%20Rove%20beetles,other%20adults%20when%20food%20supplies%20are%20low, accessed on 20.11.2025). There are also potential cases of this behaviour in the literature (Abd-Rabou *et al*., 2012; Whitehead, 2017).

For aphidlions (and most other lacewing larvae), this case is easier: all of them are known to be fierce predators using their compound jaws (each mandible forms with the corresponding maxilla a so-called stylet) for injecting first venom and then saliva into the prey to finally suck out the liquified tissues (MacLeod, 1964; Zimmermann *et al*., 2019). It is furthermore well established that aphidlions feed on aphids (as the name implies) but also on "small arthropods" or "soft bodied arthropods/insects" (Townsend, 1939; Oswald *et al*., 2002), without a clear specification of whether or not this also includes coccomorphans. Again, here we searched for pest control information, as aphidlions have also been successfully established as pest control agents (Oswald *et al*., 2002; Weihrauch, 2012). Indeed, some university-related publication organs (Pundt, 2019; Allsup, 2020) mention the consumption of mealybugs by aphidlions (Pseudococcidae, ingroup of Coccomorpha).

The case at hand

The occurrence of 17 coccomorphan immatures in close proximity suggests a local aggregation, as commonly observed in scale insects on host plants. Such aggregations may represent concentrated prey resources and may therefore attract multiple predators. For the amber piece we studied, we can recognise that a certain density of prey items (coccomorphans) and two potential predators (an aphidlion-like larva and a rove beetle) co-occur in close original proximity, constituting a micro-taphocoenosis (Haug *et al*., 2020b). No indication of amber flows separates the specimens from each other (cf. Solórzano-Kraemer *et al*., 2023), further suggesting a micro-event preserving a momentary ecological interaction. In addition, the possible predators are also very close to the possible prey items. Both potential predators are in a size range that would make it plausible that they could prey on the coccomorphans.

The coccomorphans display wax structures that are known to be used in defence, also against predators (Foldi, 1991: p. 178), underpinning the necessity to do so. While wax may have other functions, the fact that the wax protrudes sideways and backwards from the coccomorphans, but does not cover them, makes other functions, such as control of microenvironment, less prevalent.

The lacewing larvae display a fully developed camouflaging cloak. This structure not only helps the larva against predators, but also allows it to get closer to the prey, before being spotted. Overall, this amber piece is a good case for representing an interaction of predator and prey just before the actual moment of prey capture. Similar cases are rare. The famous case of an ant with prey between its mandibles (Barden *et al*., 2020) is likely not the very moment that the ant caught its prey, but depicts the transport of the prey item to the nest. Other cases involve more likely interactions between temporary parasites and their host. While these are, by some authors, considered micro-predators, the time of interaction is clearly longer than with a predator *sensu stricto* and therefore more likely to be preserved. We therefore are often bound to pieces such as the one reported here or the Baltic amber piece reported in Haug *et al*. (2023b), as these may not represent 100% definite cases of predator-prey interactions, but remain our best hints at such type of interaction (see also discussion in Haug *et al*., 2023b).

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