Phoretic springtail (Collembola: Sminthuridae) on a false blister beetle (Coleoptera: Oedemeridae) in Eocene Baltic amber

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Phoretic springtail (Collembola: Sminthuridae) on a false blister beetle (Coleoptera: Oedemeridae) in Eocene Baltic amber

MARGARITA GRÜNEMAIER

Abstract

A fourth specimen of a fossilized phoretic springtail has been observed in Baltic amber. Since the host is a false blister beetle of the genus *Oedemera* OLIVIER, 1789, there are implications about the preferred habitat of the phoretic springtail and the preservation allows new insights into the grasping mechanism used by springtails for phoresy.

Keywords: Baltic amber, Eocene, Collembola, Coleoptera, phoresy.

1. Introduction

Amber is well-known for preserving organisms with life-like fidelity, including evidence of behavioural interactions (ARILLO 2007). One such behaviour is phoresy, whereby a smaller organism uses a larger and more mobile organism for dispersal. In the Eocene Baltic amber it is predominantly seen in pseudoscorpions and the deutonymphs of several mite taxa (Uropodidae and Anoetidae) (WEITSCHAT & WICHARD 1998; DUNLOP et al. 2012, 2013). Among extant springtails, phoresy has not been observed thus far, and only three cases of this behaviour are known to be preserved in fossils: one specimen on a mayfly in Dominican amber, five specimens of *Sminthurus longicornis* WOMERSLEY, 1932 on the leg of the opilionid *Dicranopalpus ramiger* KOCH & BERENDT, 1854 and two specimens on a not further determined opilionid, both in Baltic amber (POINAR 2010; PENNEY et al. 2012). In this paper, a fourth case of phoresy by springtails is described in which a false blister beetle was used as a host.

Springtails are small hexapods with a size range of 0.12 to 17 mm. The oldest fossils are known from the 400 million-years-old Rhynie Chert of Scotland (HIRST & MAULIK 1926). They are defined by the presence of a ventral tube or collophore and a furca, which consists of three segments and is used predominantly to escape predation. It can be reduced in some cases (HOPKIN 1997; JANSENS 2012). The Collembola suborders are the elongate Arthropleona with a visible abdominal segmentation, the round-bodied Symphypleona with unclear abdominal segmentation and the similar but not directly related, minute Neelipleona, which includes only a few species (HOPKIN 1997). They are mostly known as inhabitants of dark and damp environments like leaf litter or soil, where they can be found at depths exceeding 105 cm, but they inhabit a wide range of habitats, like animal burrows and nests, caves, buildings, trees, flowers, shores of lakes and rivers, coasts, mountains, water surfaces, and excrement (HANDSCHIN 1929; HOPKIN 1997; JANSENS 2012). Fungi, microorganisms, algae, detritus, pollen, excrement and carrion are used as food sources, occasionally other springtails are consumed (HANDSCHIN 1926).

While there are no cases of phoresy using winged insects known in extant springtails, the males of the families Sminthurididae, Coenaletidae and Mackenzellidae possess grasping organs on the 2nd and 3rd segments of their antennae, which grasp forwards-upwards. The males attach themselves with the grasping organs to the antennae of the female during mating; there is no relationship between this mechanism and the use of the antennae during phoresy, in which non-modified antennae grasp downwards-backwards and the jaws might play a role as well (Fig. 1) (HANDSCHIN 1926; HOPKIN 1997; JANSENS 2012).

Most of the amber Collembola can be assigned to moss and bark dwellers because of their well-developed furca, while the springtails that inhabit gaps in the bark and have a reduced furca are rare (LARSSON 1978). Although inclusions of Collembola are common in Baltic amber, only 19 species can be recognized, which are included in the 10 extant genera *Allacma* BORNER, 1906, *Entomobrya* RONDANI, 1861, *Hypogastrura* BOURLET, 1839, *Isotoma* BOURLET, 1839, *Lepidocyrtus* BOURLET, 1839, *Orchesella* TEMPLETON,

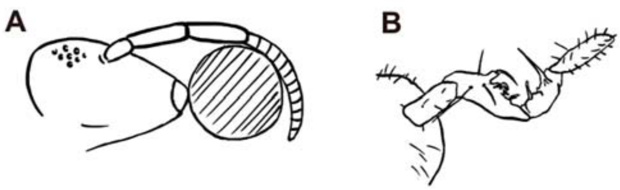

Fig. 1. The grasping mechanisms of springtails, the method used for phoresy (**A**: the leg is depicted as a hatched cross-section) and the grasping antenna of a male *Sminthurides aquaticus* (**B**: after an illustration by HOPKIN 1997).

1836, *Paidium* KOCH, 1840, *Podura* LINNAEUS, 1758, *Sminthurus* LATREILLE, 1842, and *Tomocerus* NICOLET, 1841 (POINAR 1992; WEITSCHAT & WICHARD 1998).

The Oedemeridae are small beetles with a size range of 5 to 16 mm that live almost exclusively as pollen eaters, while the larvae mostly feed on decaying, wet wood. The genus *Oedemera*, which is known from Baltic amber, develops in dry plant stems and the adults predominantly inhabit flowers and grasses (KOCH 1989; WATSON & DALLWITZ 2003; KRISKA 2007). They are soft-bodied and produce cantharidin for defense, similar to the related Meloidae. Recently, there are roughly 1.500 species known, which belong to 115 genera. The family consists of the subfamilies Oedemerinae, Calopodinae and possibly the Nacerinae, the further systematics are uncertain due to the lack of comprehensive cladistic analyses (WATSON & DALLWITZ 2003; KRISKA 2007).

So far, Oedemeridae have been mentioned to be present in Baltic amber as a family, but no species have been described. Older literature sources (BACHOFEN-ECHT 1949; SPAHR 1981) mention up to three species of *Oedemera* being described, but they seem to be misidentifications. However, *Eumecolus tenuis* HAUPT, 1950 has been described from the contemporary Geiseltal site (HAUPT 1950). Oedemeridae are rare in Baltic amber (POINAR 1992). Interestingly, the only genus known so far is a dweller of open spaces, while the taxa that develop in decaying wood seem to be absent. The Königsberg collection contains two specimens of this family, both male and belonging to different species of *Oedemera*.

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2. Material and methods

The amber piece with the inclusion is a part of the former amber collection of Königsberg and is tagged with the number GZG. BST 15174 (old number: G3893). It is about 10 mm long and has been cut into an approximately rectangular shape with a few slightly rounded edges. The beetle inclusion had been labeled as “Vesicantia/Meloidae” and is about 5 mm long, the springtail on its leg is about 1.1 mm long, its extended furca included. The back of the beetle is close to the edge of the amber piece. The right side is partially obscured by a fracture surface and emulsion on the right underside (Fig. 2C). A bubble is situated between the beetle’s front and middle legs; another bubble lying in a very similar position covers the coxal

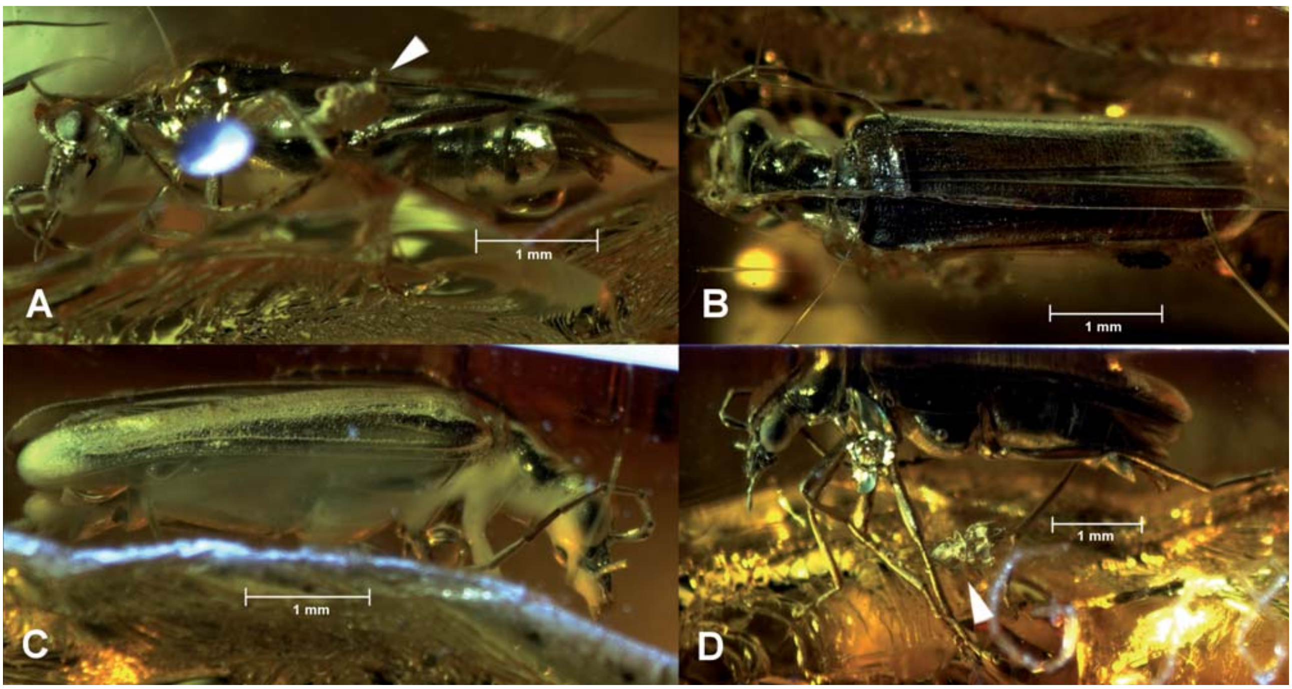

Fig. 2. The oedemerid beetle from different angles. **A**: Bottom view. **B**: Top view. **C**: Right side, partially covered by emulsion. **D**: Left side. Arrows indicate the position of the springtail.

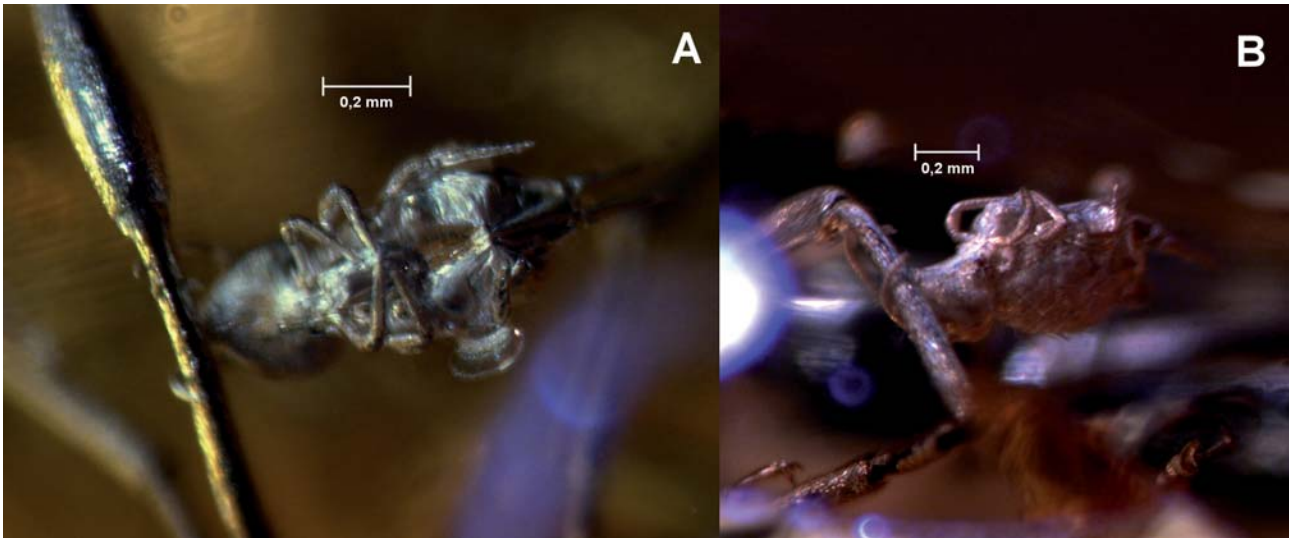

Fig. 3. The phoretic sminthurid springtail from different angles. **A**: Bottom view, showing the contact of the mouthparts to the oedemerid beetle's leg. **B**: Right side.

area of the springtail. Other syninclusions are a few stellate hairs.

The examinations were predominantly done with a stereoscopic microscope of the brand "Zeiss Stemi 2000". The measurements were taken with a "Keyence Digital Microscope VHX-500F", the photographs were taken with the microscope "Zeiss Discovery V12 Stereo" and the program "AxioVision 4.8". The post-processing of the photographs and the drawing of schematic illustrations based on freehand pencil sketches were done with the image manipulation program "GIMP 2. 6. 7".

3. Results

The springtail is a member of the Sminthuridae, as recognizable by the round-bodied shape and the annulated fourth antennomere (Fig. 3). The size of the fossil and its unfavourable position deep within the amber specimen don't allow a sure identification beyond the family with the available instruments. The seeming lack of a dentition of the mucro, antennal and furca proportions make it to be more likely a member of *Sminthurus* (Buitendijk 1941). Because of the relatively short antennae it can be excluded as a member of *Sminthurus longicornis*, the only phoretic springtail species known from the Baltic amber thus far (Poinar 2010).

The beetle had been previously identified as a blister beetle (Meloidae), but is in fact a false blister beetle (Oedemeridae) (Witautas 2015, pers. comm.), because of the bilobed fourth tarsal segment, the antennae reaching a length of over half the length of the body, the visible venation of the elytrae and the lack of a distinct constriction of the postorbital portion of the head (Fig. 2). The lack of an emargination of the eyes, two apical spurs on the tibiae and the number of 11 antennomeres in this male specimen group it into the subfamily Oedemerinae; the venation of the elytrae, the shape of the pronotum and the antennae make it identifiable as a member of the genus *Oedemera*. Its general shape is similar to the Recent species *Oedemera lurida* Marsham, 1802, but differs from it with a non-widened terminal segment of the palpus and an aedeagus bearing a terminal hook, similar to *O. laticollis* Seidlitz, 1899 or *O. subrobusta* Nakane, 1954 (Fig. 4) (Freude et al. 1969; Watson & Dallwitz 2003; Barševskis 2009).

The springtail is attached to the tibia of the beetle's left middle leg, with its body being aligned parallel to the beetle and its back facing to the right in relation to the beetle's body (Figs. 2D, 5).

In this inclusion it is obvious that not only the antennae, but also the mouthparts are in contact with the beetle's leg. The latter may have been pressed against the leg as an abutment for the antennae or were additionally grasping the leg's setae (Figs. 1, 3A). The use of the mouthparts in addition to the antennae for grasping is evident, since the antennae are not able to wrap around the comparably thick beetle leg and the use of antennae alone would work as hooking rather than real grasping.

4. Discussion

Oedemerid beetles mostly inhabit flowers, where they feed on the pollen, but they can also be found on plants,

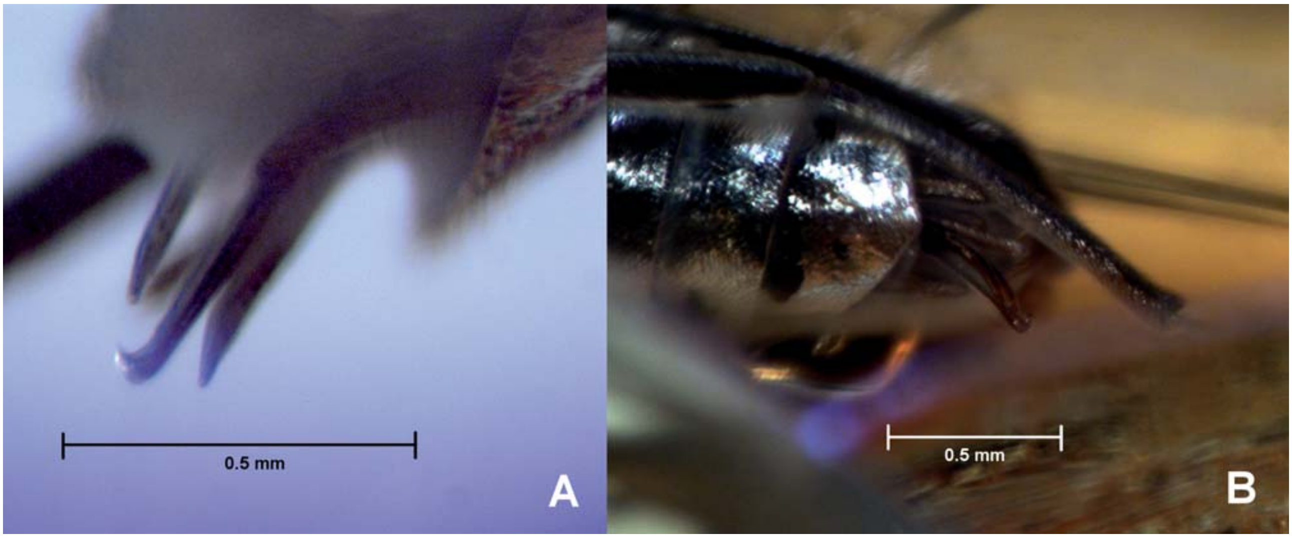

Fig. 4. Genital apparatus of the oedemerid beetle. **A**: Side view. **B**: Bottom view.

under pieces of driftwood or in other types of wet, decaying wood. Inland species develop more commonly in conifers, coastal species in driftwood (Kriska 2007). The genus *Oedemera* is predominantly found on or near flowers, or on grasses. Since Symphypleona populate open surfaces like plants, as indicated by their anatomy with the short, humpbacked body and the well-developed furca (Hopkin 2006; Christiansen et al. 2009), the springtail was probably picked up on or near a flowering plant, indicating that the amber tree the beetle was captured on was likely close to an open area.

The function of the grasping mechanism employed by phoretic Collembola has been barely considered in the papers by Penney et al. (2012) and Poinar (2010), except for the use of the antennae. The photographs in Penney et al. (2012) show no direct contact of the springtail to the phoresy host, since it apparently became detached in the resin. While several springtails in the photograph in Poinar (2010) actually imply a contact of the mouthparts to the leg, neither the angle nor the quality of the photograph allow for verification. The description only mentions the position of the antennae on the leg. With only the antennae being used for grasping, the danger of falling off or being brushed off by the host is much greater. Phoretic arthropods are often seen as a nuisance by their hosts, which will often attempt to rid themselves of the hitchhikers by increased cleaning, as observations of flies carrying pseudoscorpions have shown (Carl 1994). It is also possible that there are differences in grasping mechanisms between different springtail species or different techniques may be used in different situations. *Sminthurus longicornis* possesses relatively long antennae and has been found on a leg comparatively thin to its size, while the springtail studied herein has short antennae grasping a relatively thick leg.

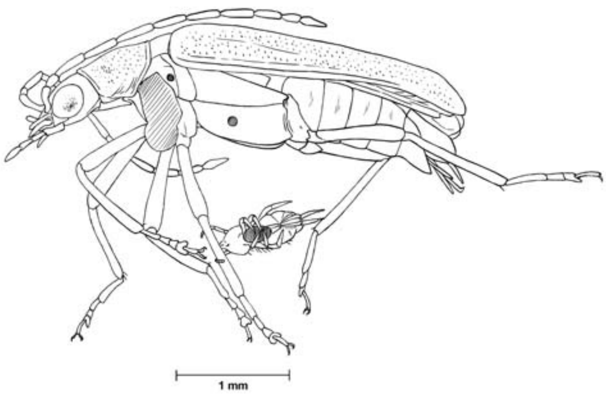

Fig. 5. Schematic illustration of the oedemerid beetle with the phoretic springtail. Hatched areas are bubbles and reflecting fracture faces.

The low number of phoretic springtail fossils and the lack of known modern cases of springtail phoresy do not allow a clear picture of the phoresy techniques employed by springtails and more specimens are required to give a conclusive insight into the details and variations of the grasping mechanism.

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