Not just hyphae — the amber mite Glaesacarus rhombeus as a forager on hardened resin surfaces and a potential scavenger on trapped insects

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Not just hyphae – the amber mite *Glaesacarus rhombeus* as a forager on hardened resin surfaces and a potential scavenger on trapped insects

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Abstract

The former Königsberg collection of Baltic amber, currently stored in the Georg-August-Universität Göttingen, contains an amber specimen showing a group of *Glaesacarus rhombeus* (KOCH & BERENDT, 1854) (Acari: Glaesacaridae) on or close to an inclusion of the tettigonid *Eomortoniellus handlirschi* ZEUNER, 1939 (Orthoptera: Tettigonidae). One adult female's mouthparts are in direct contact with the main inclusion's leg, appearing to have fed from the stuck orthopteran at the moment of trapping. The conserved behaviour as well as the frequency of *G. rhombeus* and its syninclusions point towards this mite species not just being a mycetophagous borehole dweller that was flushed out by resin flows, but rather having a more diverse lifestyle that involved foraging on hardened resin surfaces and possibly feeding on carrion.

Keywords: Baltic amber, Eocene, Acari, *Glaesacarus rhombeus*, Tettigonidae, palaeoethology.

1. Introduction

Amber is well-known as a fossilization medium capable of conserving animals and plant parts as well as their interactions with great fidelity. Less known is the fact that the amber resin itself had been interacted with by the animals as well, like bees and ants collecting resin to use it as a disinfectant in their hives (LARSSON 1978; CHAPUISAT et al. 2007).

As the resin trap did not always cover the entire animal with one flow, leaving exposed areas, predators and scavengers were using the hardened resin for easy meals. In Baltic amber, this behaviour has been particularly shown by ants, which are sometimes conserved together with large, partially eaten arthropods; much more often, the partially eaten arthropods are conserved alone, which led to the initial assumption that the culprits were birds rather than ants, until inclusions with the ants present have been discovered (LARSSON 1978).

The Astigmata mite *Glaesacarus rhombeus* (KOCH & BERENDT, 1854) is one of the most common inclusions in the Upper Eocene Baltic amber, making up about 15% of the amber inclusions and often appears in great numbers in a single amber piece. Inclusions of this mite species are also known from the contemporary Rovno amber, but there it is much rarer (PERKOVSKY et al. 2007). It is assumed to be associated with the tunnels created by wood-boring insects in the amber tree, as it is often found together with wingless Psocoptera and frass (LARSSON 1978).

The unusual anatomy of *Glaesacarus rhombeus* and the vague original description made it hard assigning properly the species to a higher taxon; the original classification placed them in the Sarcoptidae (KOCH & BERENDT 1854). During the whole history of investigation, it had been assigned to 5 different families (Sarcoptidae, Acaridae, Cryptognathidae, Erythraeidae, Glycyphagidae), both inside as well as outside of the Astigmata. Currently, *Glaesacarus* is included in its own family Glaesacaridae (Astigmata), with a possible relation to the Lemanniellidae (SIDORCHUK & KLIMOV 2011). As a unique morphological feature the females of this species possess a pad-like structure at the end of their hysterosoma, which is assumed to have been used to hold onto the male during mating, like the very similar structures present on males of many different Astigmata taxa (SIDORCHUK & KLIMOV 2011).

Other cases of interactions between mites and other arthropods usually fall within phoresy or parasitism. The former is often seen performed by deutonymphs of Uropodidae (Mesostigmata) in Baltic amber, but also known from Astigmata (presumably Histiostomatidae) (DUNLOP et al. 2013, 2014). The most common parasitic mites preserved in Baltic amber are Erythraeidae of the genus *Leptus* (Prostigmata), which parasitize a variety of insect clades, and an as-of-yet unidentified mite specialized to ants (EICHMANN 2002; own observations).

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2.1. Material and methods

The amber piece has the inventory number GZG. BST. 06700, its old number is G1653. It is clear and dark yellow in colour. It is cut and polished into a rectangular shape, with the face to the left side of the main inclusion being oblique and having three faces. The corner close to the main inclusion's right side is broken off, and the eye was damaged. The piece is 15 mm long, 8 mm wide and 7.5 mm deep.

The examinations were predominantly done with a 'Zeiss Stemi 2000' stereoscopic microscope. The measurements and photographs were taken with the microscope 'Zeiss Discovery V12 Stereo' and the program 'AxioVision 4.8'. The post-processing of the photographs and the illustrations were done with the image manipulation program ''GIMP 2.6.7''.

To determine the interrelation between inclusions of *Glaesacarus rhombeus* and wood remains, detritus or psocopterans, the former amber collection of Königsberg and the Bitterfeldian amber collection of M. Kutscher (both stored in the Georg-August-University of Göttingen) were examined for their main inclusion and syninclusion contents.

2.2. Preservation

The as a main inclusion assigned tettigonid nymph lies close to a face and is nearly complete except for the missing antennae and damaged eye. The front legs appear to be bloated. There is one crack indicating the position of a layer visible close to the main inclusion's left hind tibia. Aside from the tettigonid, the amber piece contains 13 specimens of *Glaesacarus rhombeus*, 2 Diptera (1 Sciaridae ♀ and 1 Chironomidae ♀) (Fig. 1). Furthermore, there are hyphae, arthropod hairs (possibly from the main inclusion), stellate hairs, fine detritus and air bubbles. The main inclusion and the sciarid fly are covered with white emulsion on their right sides. The hyphae are in contact with the tettigonid's left foreleg.

3. Results

The tettigonid nymph can be identified as *Eomortoniellus handlirschi* Zeuner, 1939 by the spine configuration on the tibiae, missing external spine on the middle tibia and the size and shape of the head (Zeuner 1939).

Due to their characteristic body shape and proportions the mites can be assigned to *Glaesacarus rhombeus* (Koch & Berendt, 1854).

Out of the 13 *Glaesacarus* specimens, 5 individuals are positioned close to the main inclusion's hind left femur and were very likely sitting on the leg when they were engulfed by resin. Furthermore, 3 individuals are close to the main inclusion's tarsi of the same leg. The remaining mites are further away from the main inclusion, but generally close to the leg, with one specimen being close to the main inclusion's left eye.

The chelicerae of one adult female mite have direct contact with the distal third of the femur. At the point of contact there is a dark spot visible (Figs. 2–4).

In all, there were 248 amber pieces examined containing specimens of *G. rhombeus* in the two examined collections. 21 of them (8.5%) had wood as syninclusions and 54 (21.8%) had detritus. In the entire collections, 3.5% contained wood and 7% contained detritus.

4. Discussion

It cannot be said with certainty that the mite attached to the tettigonid's femur fed on the insect, since there is no damage visible on the cuticle and the dark spot is hard to interpret, but because this is the only mite in direct contact to the main inclusion while the other specimens had been loosened by the resin flow, it is very likely the mite interacted with its mouthparts with the main inclusion. It is possible that the mite fed on bacteria or hyphae growing on the cuticle; there are hyphae present on the left foreleg, but the hindleg with the mites has no visible growths and it is more likely the hyphae have grown after the tettigonid had been submerged in resin.

Other possible interpretations of this inclusion are phoresy or parasitism. The former is very unlikely, as phoretic astigmatan mites attach themselves with suckers on their hind bodies and act so only as deutonymphs (Walter & Proctor 2013). The latter can be excluded by the sheer amount of *G. rhombeus* inclusions found in Baltic amber, which indicates a close connection of this mite species to the amber tree.

The Baltic and Bitterfeld amber collections of the Georg-August-University in Göttingen contain a few other examples of *G. rhombeus* being on larger inclusions, among them GZG. BST. 29103 (on Machilidae) and GZG. BST. 28297 (on Ceratopogonidae), showing that the conserved behaviour in the examined amber piece is rare, but not a single occurrence. However, none of the mites was conserved in a position that suggests feeding on the trapped insects.

Among the closest living relatives and unrelated Astigmata with a similar anatomy, such behaviour is not known. Lemanniellidae, assumed to be the closest recent relatives of Glaesacaridae, feed on hyphae within insect nests, which coincides with the proposal of *G. rhombeus* being a fungus eater in wooden burrows (Wurst 2001). Algophagidae, an astigmatan with a similar outward appearance to

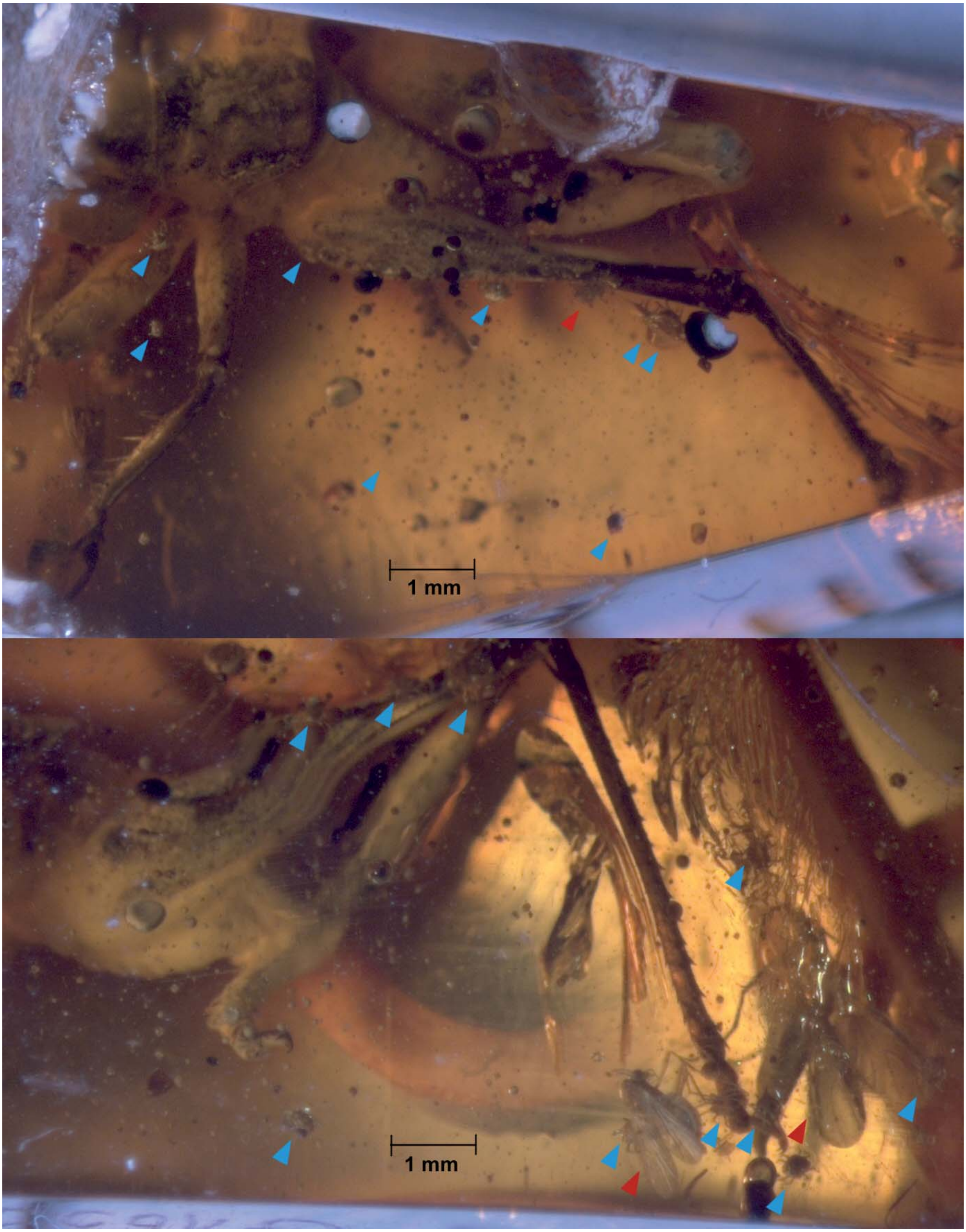

Fig. 1. Overview of the GZG. BST. 06700 amber specimen, stored in the collection of the Georg-August-University, Göttingen, showing the top view of the tettigonid *Eomortoniellus handlirschi* (positions of *G. rhombeus* specimens marked in blue, the attached female in red) and a side view with a focus on the hind leg (*G. rhombeus* specimens marked in blue, syninclusions of Sciaridae (small) and Chironomidae (large) marked in red).

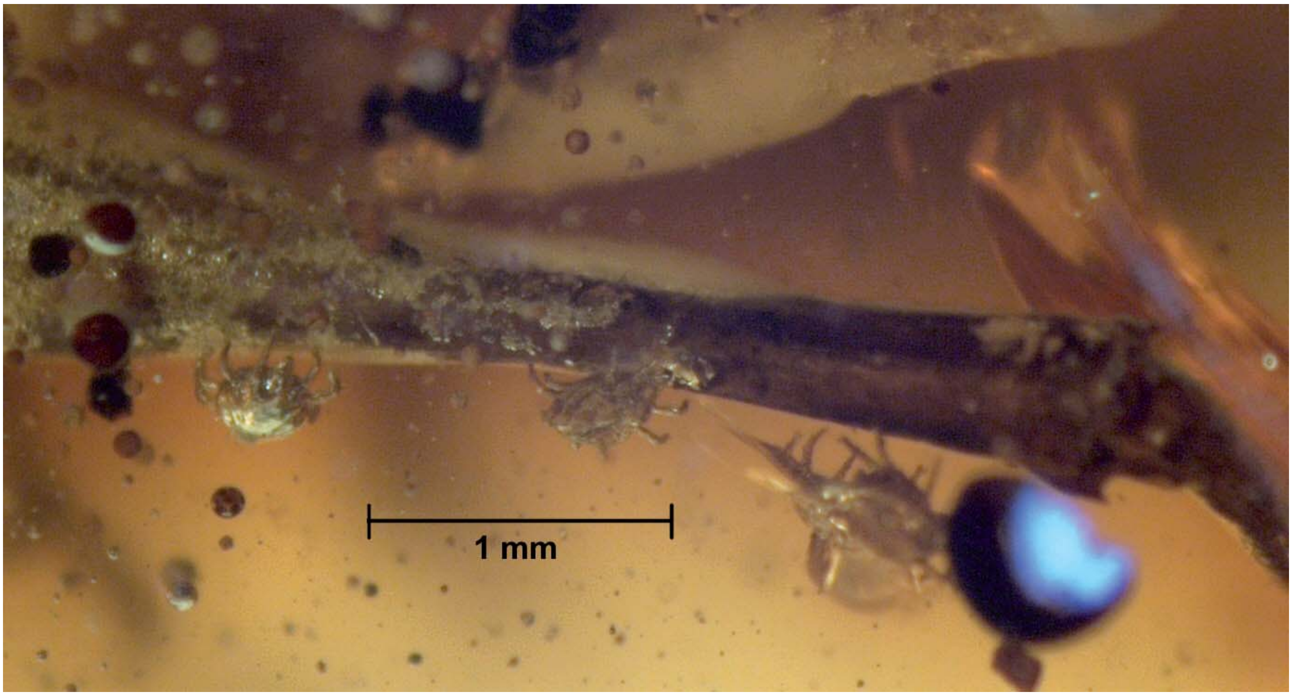

Fig. 2. The main inclusion's left femur with the mite having its mouthparts in contact.

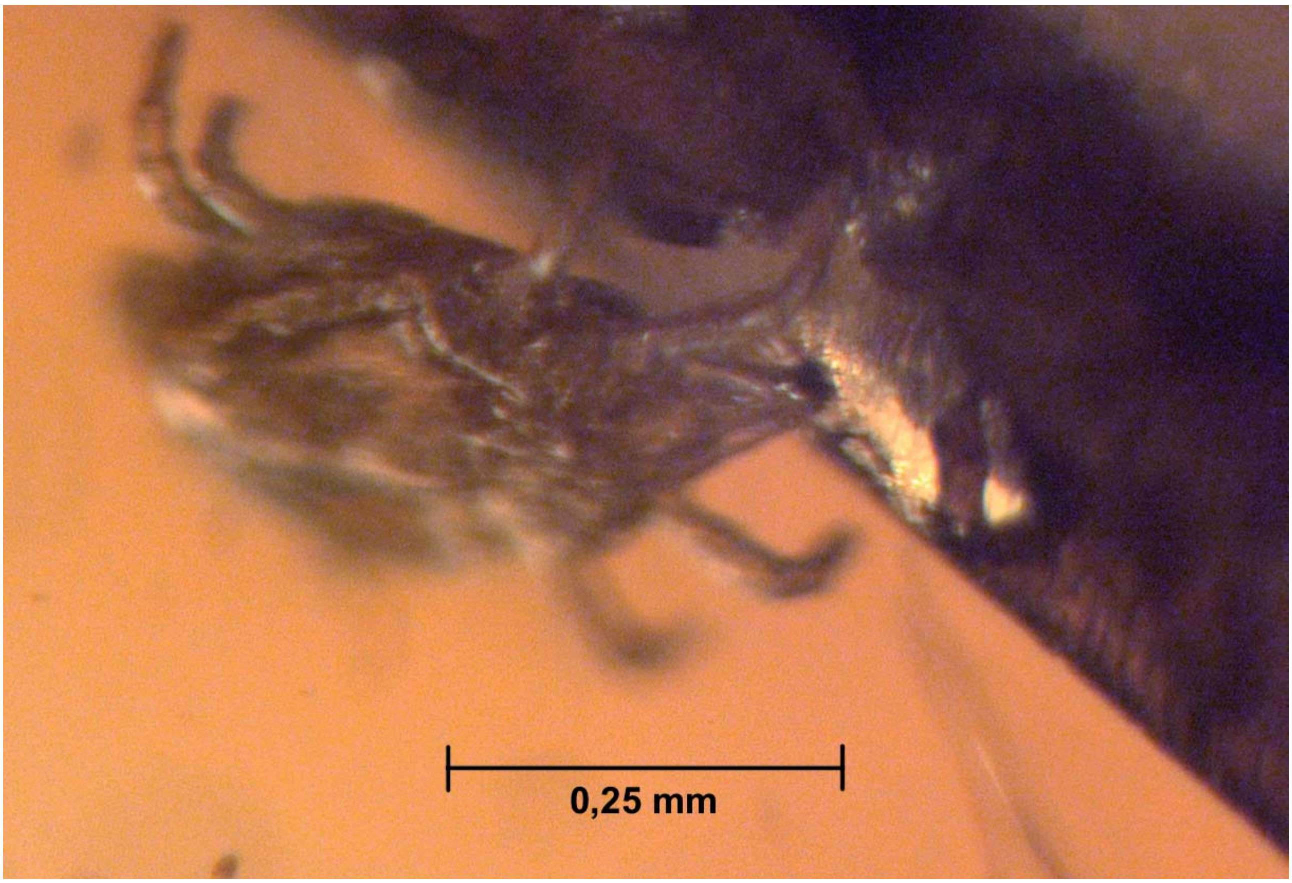

Fig. 3. Close-up of the mite.

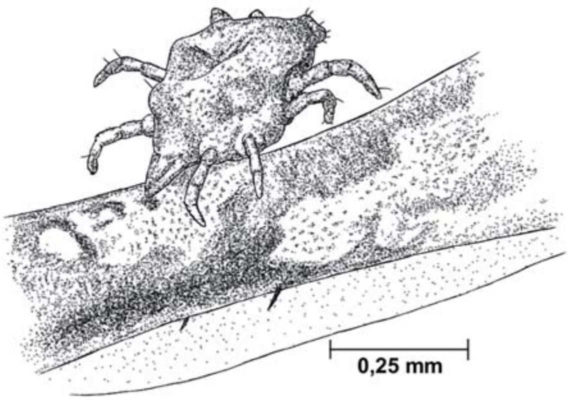

Fig. 4. Drawing of the mite on the leg.

Glaesacaridae, lives in water and other liquid media like tree sap; the diet of most species is unknown (FASHING & CAMPBELL 2009). Generally, Astigmata have a very diverse diet. Feeding on fungal spores, hyphae, bacterial mats, algae and detritus is common, with the mites living in boreholes, animal nests or on the animals themselves; particularly the diversity of feather mites is notable. Various Astigmata live as parasites and commensals of vertebrates, insects or land annelids; unusual habitats include nasal cavities, corneas and gastric mucus of bats (Gastronyssidae), hair follicles of rodents, primates and bears (Rhyncoptidae, Audycoptidae, Listrophoridae, Atopomelidae), or burrowing inside skin (Sarcoptidae, Hypoderatidae) (WALTER & PROCTOR 2013).

However, no close relatives or modern representatives of Glaesacaridae are known, therefore the behaviour of modern mites can only tentatively be used to reconstruct the mode of life of this unique family (SIDORCHUK & KLIMOV 2011). Since *G. rhombeus* is an extremely common species in Baltic amber, making up to 15% of the arthropod inclusions (PERKOVSKY et al. 2007), it must have had a close association to resin that went beyond being a borehole dweller.

Fig. 5. Illustration depicting the possible behaviour of *Glaesacarus rhombeus* on the bark of *Pinus succinifera* with a trapped clubionid spider.

Among common syninclusions with *G. rhombeus* are the bark lice of the family Liposcelidae and Sphaeropsocidae (especially the genus *Sphaeropsocus*) (Larsson 1978). However, bark lice are generally much rarer preserved than inclusions than *G. rhombeus* and there is no strong correlation between bark lice in general and *G. rhombeus* in the two examined amber collections (out of the 34 amber pieces containing psocopteran inclusions there were only three with *G. rhombeus* as syninclusions). Furthermore, in pieces with many specimens of *G. rhombeus* they are often arranged in layers on or close to the boundary layer of a previous resin flow, which also implies a lifestyle that included the hardened surface of resin flows on trees as foraging grounds.

Together with the behaviour shown in the described amber piece, it is safe to assume that *G. rhombeus* did not only live in wooden insect burrows to feed on fungal hyphae, but actively moved over hardened resin surfaces to either feed on the molds growing on the resin or trapped arthropods, or to feed on the arthropods themselves (Fig. 5).

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