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First fossil soldier beetles (*Coleoptera Cantharidae*) from Bitterfeld amber, Germany

Fabrizio Fanti

Via del Tamburino 69, I-53040 Piazze (SI), Italy

E-mail: fantifab@alice.it

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Abstract

Two new taxa with affinities to the family Cantharidae (soldier beetles), are described and illustrated here for the first time from Bitterfeld amber (Germany, Middle Eocene). *Malthodes andreasi* sp. nov. is characterized by the last sternite that is distinctly elongated, strongly curved and apically forked to form kind of a fin, whereas *Malthodes neumanni* sp. nov. is characterized by the last abdominal segments (both tergites and sternites) little developed and by its diminutive size. The genus *Malthodes* appears to have been widespread in the forests and undergrowth from which the Bitterfeld amber originated.

Key words: Bitterfeld amber, Middle Eocene, Cantharidae, new taxa

Zusammenfassung

Zwei neue Taxa aus der Familie der Cantharidae aus dem Bitterfelder Bernsteins (Deutschland, mittleres Eozän) werden hier erstmals beschrieben und illustriert. *Malthodes andreasi* sp. nov. ist dadurch gekennzeichnet, dass das letzte Sternit sehr lang, stark gekrümmt und apikal flossenartig gegabelt ist, während *Malthodes neumanni* sp. nov. durch die letzten schwach entwickelten abdominalen Segmente (sowohl Tergite als auch Sternite), und eine sehr winzige Größe charakterisiert ist. Die Gattung *Malthodes* scheint in den Wäldern und im Unterholz des Bitterfelder Bernsteinwald-Ökosystems weit verbreitet gewesen zu sein.

Schlüsselwörter: Bitterfelder Bernstein, mittleres Eozän, Cantharidae, neue Taxa

1 Introduction

Bitterfeld amber (= Saxonian amber) was first discovered in the mid-17th century (1669) near Bad Schmiedeberg, east of Bitterfeld (Henkel 1744; Krumbiegel 1991, 1997; Fuhrmann 2005), and subsequently (since 1848) in the mine Golpa and (in the following decades) in the mine Goitsche (= Goitzsche), both near the town of Bitterfeld in Upper Saxony. The latter mine, active from 1974 to 1993 but now closed and flooded, was an important open-cast mine of lignite extending over an area of 5 km^2 (Priese 1977; Krumbiegel 1991, 1997; Liehmann 1997; Dunlop & Giribet 2003; Fuhrmann 2005; Standke 2008; Dunlop 2010; Wolfe et al. 2015). The amber was produced primarily by the Tertiary conifers *Cupressospermum saxonicum* Mai, 1960 and *Geinitzia formosa* Heer, 1871, but probably also by several other families such as Pinaceae Lindley, 1836 (Barthel & Hetzer 1982; Fuhrmann & Borsdorf 1986; Poinar 1992; Krumbiegel 1997; Knuth et al. 2002; Yamamoto et al. 2006; Rappsilber 2008; Krumbiegel & Kosmowska-Ceranowicz 2007; Dunlop 2010). It was formed in a river valley west of Leipzig and accumulated in a swamp forest on the delta of a river called Saxonian Amber River (Fuhrmann 2005, 2008; Yamamoto et al. 2006; Standke 2008; Dunlop 2010). The age of the amber has been the subject of controversy: It was initially considered early Miocene, roughly 22 Ma old (see also: Rikkinen & Poinar 2000), based on regional geology and microbotany (Barthel & Hetzer 1982) and on physico-chemical analysis (Fuhrmann & Borsdorf 1986). However, it was subsequently interpreted as late Oligocene (Chattian, 23.8-25.3 Mya) based on sediments, palynology and inclusions (e.g., Knuth et al. 2002; Yamamoto et al. 2006; Dunlop & Mitov 2009). Comparing Bitterfeld and Baltic ambers (as was done, e.g., by Wunderlich 1983; Röschmann 1997; Hoffeins & Hoffeins 2003; Vitali 2011; Sodhi et al. 2013) and taking into account that many species included are similar, if not the same, the two types of amber appear to have

originated from forests of a similar age (Eocene). Recently, a middle Eocene age has been confirmed by Wolfe et al. (2015), who found that the two ambers are coeval, but with different geological origins, compositions and paleogeographic provenances.

Bitterfeld amber, although less known and studied than Baltic amber, is rich in inclusions (see, e.g., Barthel & Hetzer 1982; Schumann & Wendt 1989a, 1989b; Krumbiegel 1991, 1997; Krumbiegel & Krumbiegel 1996; Krumbiegel & Kosmowska-Ceranowicz 2007; Rappsilber 2008, 2016; Weitschat 2008; Dunlop 2010; Wichard 2013), but soldier beetles have not been described to date. There is present in literature only a generic citation of a cantharid housed in the "Museum für Naturkunde", Berlin, (Hieke & Pietrzeniuk 1984). This specimen was later studied by Schumann & Wendt (1989a) and Rappsilber (2016) who stated that it probably represents a "*Malthodes* sp./spec. (?)". This same specimen was mentioned only at a family level by Schumann & Wendt (1989b), Krumbiegel (1997), Dunlop (2010) and Fanti (2017a). By comparison, various *Malthodes* fossils have been reported from Baltic amber (Kuśka & Kupryjanowicz 2005; Kuśka & Kania 2010; Fanti 2017b, 2018; Fanti & Vitali 2017; Fanti & Damgaard 2018; Fanti & Michalski 2018; Fanti & Pankowski 2018), Rovno amber (Kazantsev 2010; Kazantsev & Perkovsky 2014) and Oligocene brown coals of Brunstatt, Alsace (Förster 1891). This study describes, for the first time, soldier beetles (two different species of *Malthodes*) from Bitterfeld amber based on specimens from the holdings of the Museum für Naturkunde, Berlin, Germany, and already partially studied by the authors mentioned above.

2 Materials and methods

The specimens described here have been kept at the Museum für Naturkunde (MfN), Leibniz-Institut, Berlin (Germany) for approximately 40 years. They come from the Goitsche mine near Bitterfeld (Germany). The amber pieces have been cleaned and polished, and the inclusions examined with a Carton stereoscopic microscope 0.8-40x and photographed with a Nikon D80 camera mounted on a Nikon SMZ-U zoom 1:10 microscope. Images have been processed with PhotoImpact Viewer SE software. Drawings were made by free-hand with China ink. In addition to the two specimens described here, six other inclusions are housed in the same Museum under accession numbers MB.I.7307, MB.I.7309, MB.I.7310, MB.I.7311, MB.I.7312, MB.I.7313 ("MB.I." = Museum Berlin, Insecta), all of which are believed to be females of *Malthodes sp.* (although, for some, characters may not be well visible). They have not been identified at the specific level because female *Malthodes* usually cannot be described unless they are associated with males.

3 Systematic palaeontology

Family Cantharidae Imhoff, 1856 (1815)
Subfamily Malthininae Kiesenwetter, 1852
Tribe Malthodini Böving & Craighead, 1931
Genus *Malthodes* Kiesenwetter, 1852
Subgenus *Malthodes* Kiesenwetter, 1852

Malthodes (*Malthodes*) *andreasi* sp. nov.
Fig. 1

Type material: Holotype: Male, in Bitterfeld amber; Museum für Naturkunde (MfN), Leibniz-Institut, Berlin (Germany), accession MB.I.7308 (an additional label states "Cantharidae//aff. *Malthinus*//Deutschland Sachsen-Anhalt Bitterfeld//Bitterfelder Bernstein// Serie 8").

Type horizon: Middle Eocene (47.8-38 Mya).

Type locality: Germany, Sachsen-Anhalt, Bitterfeld, Goitsche open-cast mine (southeast of Bitterfeld).

Etymology: The new species is named in honor of Andreas Abele (Museum für Naturkunde Berlin) to acknowledge his help with writing this paper.

Description: Adult, slender, winged with short elytra, male (because of the modified last abdominal segments). Body length 3.0 mm; antennae approximately 2.4 mm; elytra approximately 1.3 mm. Entirely dark brown without yellow spots on elytral apex. Head completely exposed, slightly elongated, narrower than pronotum, rounded back toward the eyes, integuments with shallow punctation. Eyes rounded, convex. Maxillary palpi four–segmented, palpomeres unequal in length, terminal one globular and distally pointed. Labial palpi three–segmented with the terminal one globular and pointed. Antennae filiform, 11–segmented, rather long, reaching elytral apex; antennomere I elongated, club-shaped, not particularly robust; antennomere II filiform and shorter than scape; antennomeres III–X filiform, elongated, subequal in length, very long and thin; antennomere XI filiform, rounded at apex, slightly sturdier than previous; all antennomeres covered with setae. Pronotum nearly square-shaped, flat, with deep and sparse punctation, straight and not bordered on lateral sides, anterior margin straight, posterior one slightly expanded in the middle. Scutellum triangular-shaped. Elytra clearly wider than pronotum, parallel-sided and short so to leave several abdominal segments uncovered, apex rounded, surface slightly rugose with deep and dense punctation. Metathoracic wings slightly darkened, and when folded, exceeding elytra and reaching (or very slightly exceeding) the last abdominal segment. Legs long; coxae stout; trochanters elongated; femora enlarged particularly in the middle, very slightly bent; tibiae cylindrical,

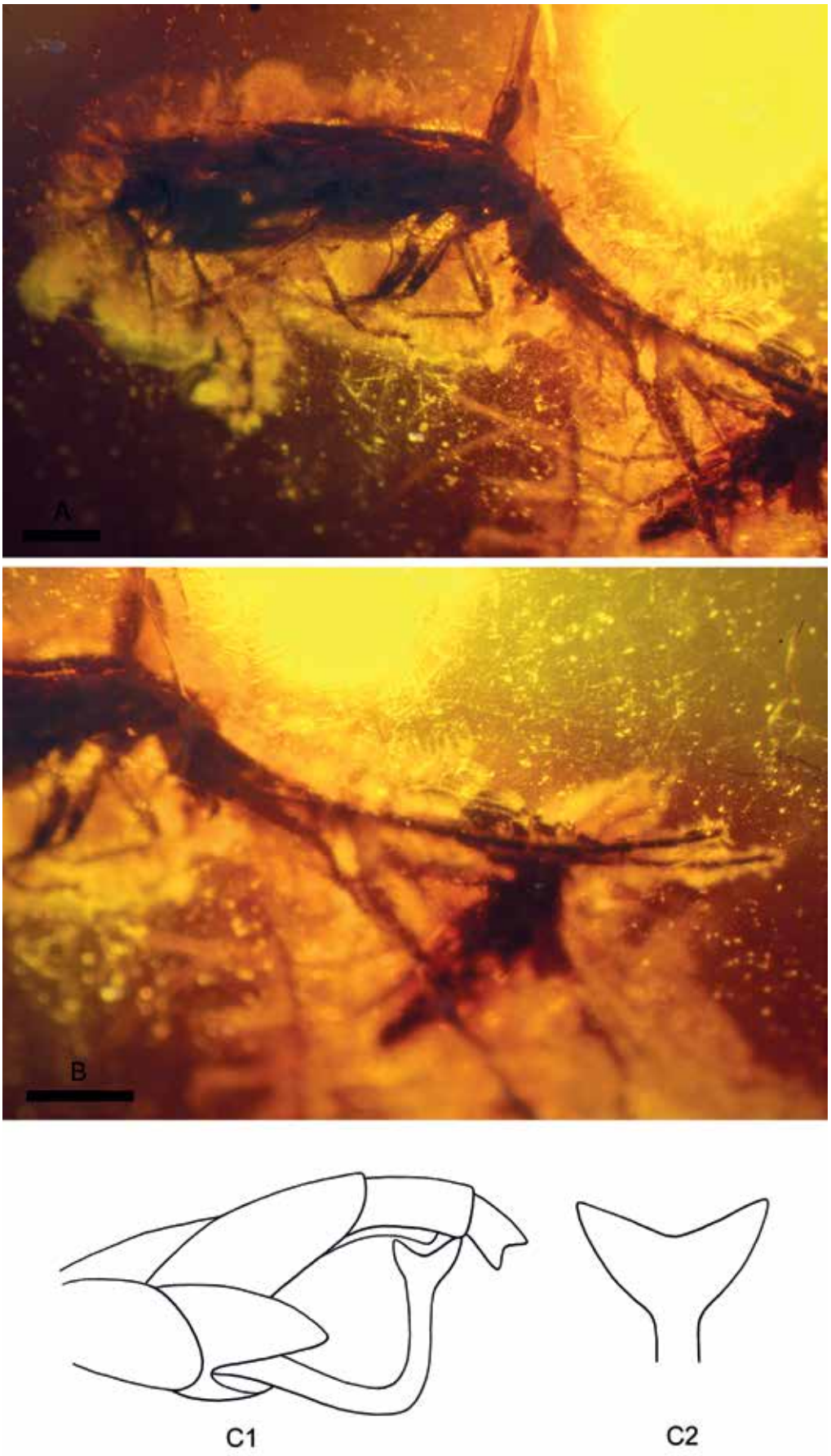

Figure 1: *Malthodes andreasi* sp. nov. in Bitterfeld amber (MB.I.7308). A: Holotype, dorso-lateral view, scale bar = 500 µm; B: Holotype, detail of antennae, scale bar = 500 µm; C1: Line drawing of the last abdominal segments; C2: Line drawing of the apex of the last sternite.

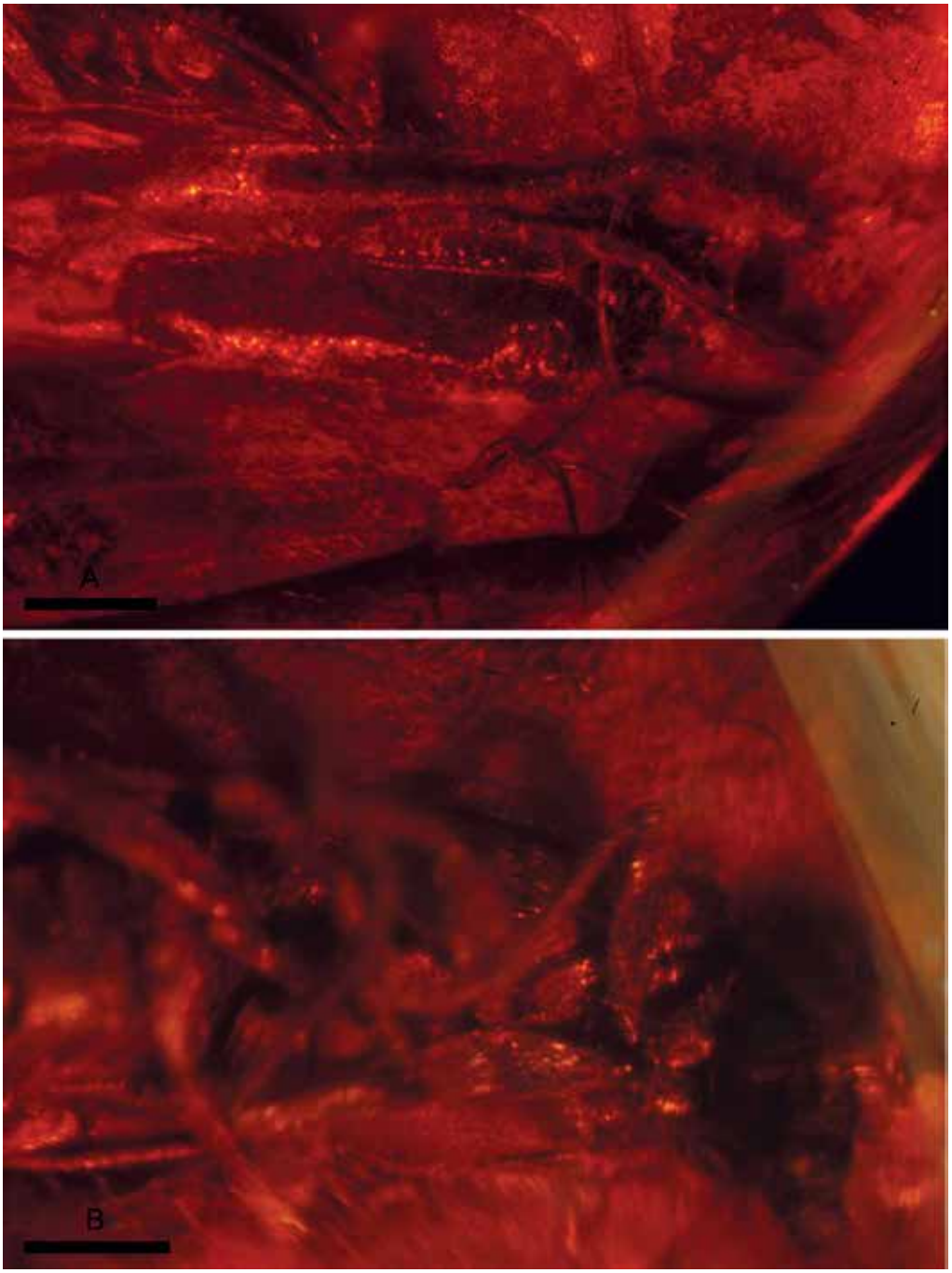

Figure 2: *Malthodes neumanni* sp. nov. in Bitterfeld amber (MB.I.7306). A: Holotype, dorsal view, scale bar = 400 µm; B: Holotype, detail of sternum and legs, scale bar = 200 µm.

longer than femora. Tarsi five–segmented; tarsomere I elongated; tarsomere II about 1.7 times shorter than first; tarsomere III short, globular; tarsomere IV bilobed; tarsomere V slender; claws simple. Penultimate tergite (tg9) sub-trapezoidal, wide, slightly folded on sides; last tergite (tg10) narrower and shorter than penultimate, apically forked; last sternite (st9) very long, cylindrical, stout, strongly curved, apically forked in a kind of robust fin. Metasternum trapezoidal. Abdominal segments transverse.

Syninclusions: Plant remains, stellate hairs (trichomes), pollen grains and air bubbles. Also present are a well-preserved dipteran and a disarticulated arthropod with only the head, antennae and several legs well preserved.

Remarks: The amber piece measures approximately 15.5 x 9 x 6 mm and is red in colour. The inclusion is complete, with the upper part of the body somewhat flattened. Present on the surface are also a few fractures.

Differential diagnosis: *Malthodes andreasi* sp. nov. shows characters that cannot be found in any of the known fossil or extant representatives of *Malthodes* from north and central Europe. Finding the precise affinities is therefore difficult. For example, the last sternite ends in a sort of fin that might be associa-

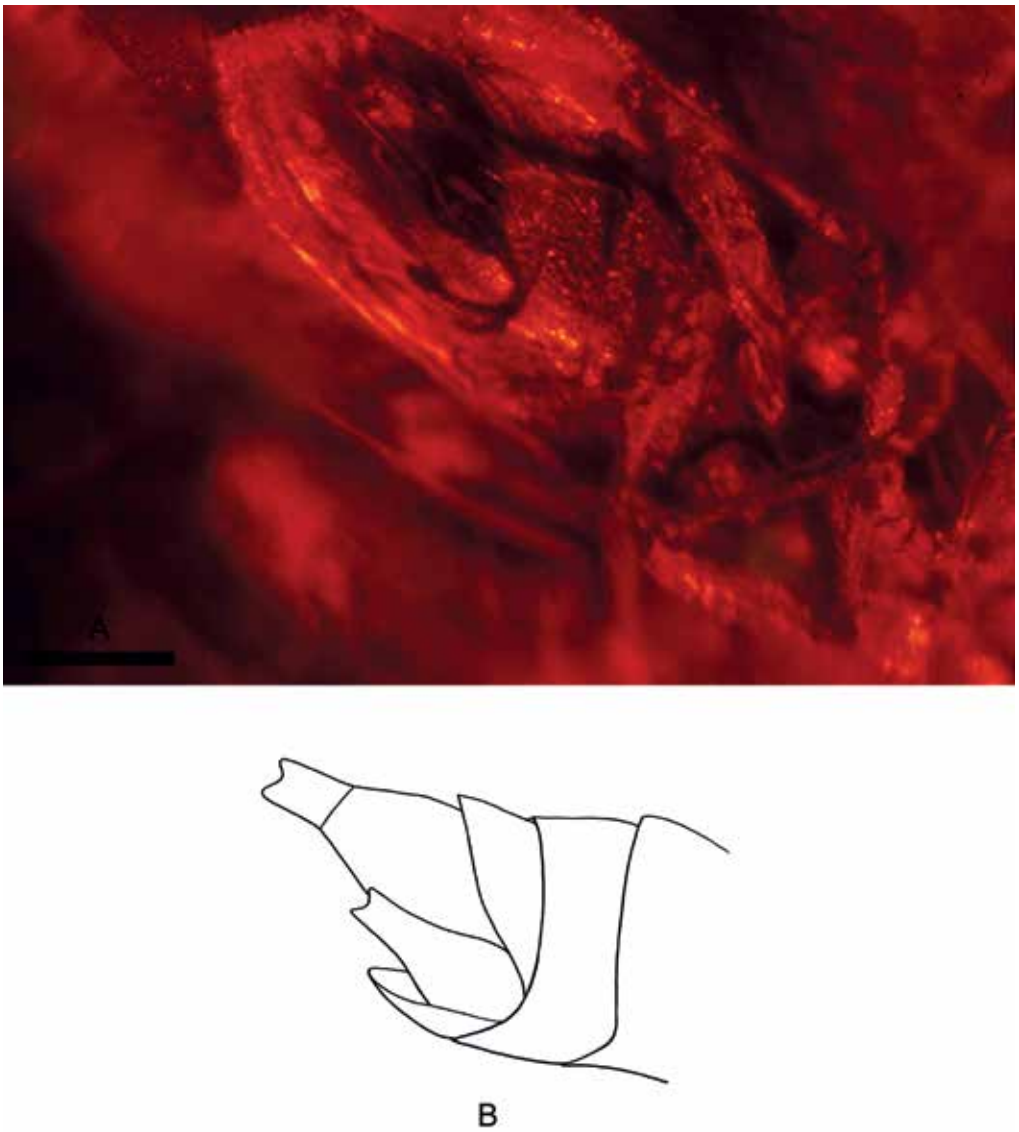

Figure 3: *Malthodes neumanni* sp. nov. in Bitterfeld amber (MB.I.7306). A: Holotype, detail of the last abdominal segments, scale bar = 200 µm; B: Line drawing of the last abdominal segments.

ted with a few species in Peninsular Italy such as *Malthodes latialis* (Fiori, 1906), *Malthodes latistylus* Liberti, 2017, *Malthodes murgianus* Pic, 1914, and *Malthodes pinnatus* Kiesenwetter, 1871. All of these taxa, however, have the last tergites (tg9 and tg10) modified, at times with urophysis (Liberti 2017). The new species also shares some similarities with *Malthodes siculus* Kiesenwetter, 1852. However, *M. andreasi* sp. nov. differs from *M. siculus* in that its last sternite is more pinnate and much more curved, and by the absence of urophysis at the apex of the penultimate tergite (Liberti 2015).

Malthodes (*Malthodes*) *neumanni* sp. nov.
Figs. 2, 3

Type material: Holotype: Male, in Bitterfeld amber; Museum für Naturkunde (MfN), Leibniz-Institut, Berlin (Germany), accession MB.I.7306 (an additional label states “Cantharidae//aff. *Malthinus*//Deutschland Sachsen-Anhalt Bitterfeld//Bitterfelder Bernstein”).

Type horizon: Middle Eocene (47.8-38 Mya).

Type locality: Germany, Sachsen-Anhalt, Bitterfeld, Goitsche open-cast mine (southeast of Bitterfeld).

Etymology: The new species is named in honor of Christian Neumann (Museum für Naturkunde Berlin) to acknowledge his help with writing this paper.

Description: Adult, winged, very small, elytra wide and rather elongated, male (because of the modified last abdominal segments, both last tergites and sternites). Body length 2.2-2.4 mm; antennae approximately 1.7 mm; elytra 1.2-1.3 mm. Entirely dark brown without apical yellow spots on elytra. Head rounded, narrower than pronotum, integuments with shallow punctation. Eyes rounded, convex. Maxillary palpi four–segmented, with terminal palpomere globular and distally pointed. Labial palpi three–segmented with last one globular and pointed. Antennae

filiform, 11–segmented, long, exceeding the elytral middle and almost reaching the apex; antennomere I stout, elongated, club-shaped; antennomeres II–IV filiform but robust; antennomeres V–X elongated, filiform, subequal in length, slightly thinner than antennomeres II–IV; antennomere XI longer than previous one, apically rounded; all antennomeres robust and covered with thin and short setae. Pronotum strongly transverse, slightly narrower than elytra, surface flat, margins bordered. Scutellum short, rounded at apex. Elytra elongated, wide, parallel-sided, leaving the last abdominal segments uncovered, apex rounded, surface pubescent with shallow punctation. Metathoracic wings transparent. Legs short and robust; coxae very stout; trochanters elongated; femora robust, slightly curved and flattened; tibiae cylindrical, with setae, shorter than femora, thin basally and widened apically. Tarsi five–segmented; tarsi short; tarsomere I robust, elongated; tarsomere II robust, shorter and around half length than first; tarsomere III very short; tarsomere IV bilobed; tarsomere V slender; claws simple. Last two tergites elongated, thin, lobe-shaped; penultimate (tg9) elongated and wide; last one (tg10) narrower and shorter than the previous, trapezoidal, apical margin slightly concave, fitted with long setae; last sternite (st9) small, basally cuneiform and then narrower, apically forked, fitted with pubescence on the sides. Metasternum subtrapezoidal. Abdominal segments strongly transverse and covered with pubescence.

Syninclusions: A few plant remains, two stellate hairs (trichomes) and air bubbles.

Remarks: The amber piece measures approximately 13 x 9 x 5 mm and is red in colour. The inclusion is complete with the legs curled up and the head slightly folded. The antennae are aligned with the body (along the elytra). The surface of the amber is transparent with only a few small fractures far from the inclusion.

Differential diagnosis: Its wide pronotum and elongated broad elytra place *M. neumanni* sp. nov. close to genus *Macrocerus* Motschulsky, 1845, of which only one species is known from Baltic amber (Kuśka & Kania 2010; Kazantsev 2013), although other specimens are known at the generic level (Fanti 2017). However, the last abdominal segments of the new species are modified, and thus leave no doubt that it belongs to the genus *Malthodes* Kiesenwetter, 1852. No fossil representative is similar to it, while for living species, it shows clear affinities with the *M. brevicollis* group of species (Liberti 2016, 2017). The new species has the same minute size, the same uniform blackish coloration and elongated elytra and similar abdominal segments. *Malthodes brevicollis* (Paykull, 1798) clearly differs from *M. neumanni* sp. nov. based on the former's last sternite (st9) evidently forked, penultimate tergite (tg9) shorter and fitted with short urophysis and the last tergite deeply emarginated apically. *Malthodes conicus* Wittmer, 1970 has the last tergite (tg10) more elongated and thin, not trapezoidal, and its last sternite (st9) shorter, not cuneiform basally (Liberti 2011, 2016).

4 Discussion

The presence of several species of the soldier beetle genus *Malthodes* Kiesenwetter, 1852 in Bitterfeld amber is certainly due, at least in part, to their small size and, consequently, the easier preservation of these animals in amber. It also suggests, based on extant species, that they lived in a rather heterogeneous and diversified forest environment, possibly characterized by open spaces within the forests themselves or by ecotonal zones with bushes and abundant undergrowth, where they could prey on aphids and other arthropods (Fanti & Michalski 2018). The lack of pollinivore and nectarivore genera in the same amber might suggest a scarcity of open spaces and meadows with flowers, although obviously a simple lack of conservation of the finds cannot be excluded. *Malthodes andreasi* sp. nov., with its short elytra, highly modified *terminalia*, and elytra with impressed punctation (an unusual character in this genus), certainly appears as an evolved species, while *Malthodes neumanni* sp. nov. with its small size, rather elongated elytra (a character still present in few extant *Malthode*s) and poorly developed last abdominal segments (both tergites and sternites) could might represent a primitive species. Summing up, the genus *Malthodes* appears to have been extremely abundant in Eocene forests, with a surprising biodiversity and number of interesting forms.

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