Palaeoentomology 008 (3): 290–298
https://www.mapress.com/pe/

Article

ISSN 2624-2826 (print edition)
PALAEOENTOMOLOGY
ISSN 2624-2834 (online edition)

https://doi.org/10.11646/palaeoentomology.8.3.5
http://zoobank.org/urn:lsid:zoobank.org:pub:3EA08EB3-CC25-4A6A-97C6-0D901F438523

A new wireworm-like larva (Coleoptera, Elateridae *incertae sedis*) from about 100 million year-old Kachin amber with a very stout antenna

JOACHIM T. HAUG[1, 2], PATRICK MÜLLER[3] & CAROLIN HAUG[1, 2, *]
[1]*Ludwig-Maximilians-Universität München (LMU Munich), Faculty of Biology, Großhaderner Str. 2, 82152 Planegg-Martinsried, Germany*
[2]*GeoBio-Center at LMU, Richard-Wagner-Str. 10, 80333 München, Germany*
[3]*Kreuzbergstr. 90, 66482 Zweibrücken, Germany*
joachim.haug@palaeo-evo-devo.info; https://orcid.org/0000-0001-8254-8472
pat14789@web.de; https://orcid.org/0000-0001-5651-0470
carolin.haug@palaeo-evo-devo.info; https://orcid.org/0000-0001-9208-4229
**Corresponding author*

Abstract

Beetle larvae are ubiquitous in the modern-day fauna, and we can expect that this was not very different in many past ecosystems. Yet, the literature on fossil beetle larvae is still comparably scarce. Here we report a larva with a wireworm-like morphology from about 100 million years old Kachin amber, Myanmar. The larva represents the third type of larvae that shares characters with modern larvae of Elateridae, the group of click beetles. However, it also possesses an unusual feature, a bulbous trunk end. Such a structure is well known in modern larvae of some ingroups of Elateridae such as Cebrioninae, Elaterini, and Agriotini, and to a certain degree also Dicrepidiini, Physorhinini, and Ampedini. The new fossil is different in the morphology of the antennae and palps, which are short, rather stout, and cone-shaped, being broader than those of any of the modern counterparts.

Keywords: Coleoptera, Elateridae, Elaterinae, Elaterini, fossil larva, Cretaceous

Introduction

Amber preserves fossils of spectacular quality of details, but appears to have a certain bias in favour of some animal groups (*e.g.*, Weitschat & Wichard, 2002; Solórzano Kraemer *et al.*, 2018). Beetles are very common in the modern fauna, with a tremendous species richness (Zhang, 2011, 2013; McKenna *et al.*, 2015, 2019; Boudinot *et al.*, 2023) and beetles are also quite common in amber (Weitschat & Wichard, 2002; Gröhn, 2015; Peris & Rust, 2020). What seems much less common in amber are beetle larvae (see Haug, 2020 for term), or we should say, this is the impression provided by the literature. In the modern fauna, beetle larvae seem to represent quite a large share of the biomass in continental ecosystems (Husler & Husler, 1940: p. 344). We can assume that this was also the case in past ecosystems (Peris & Rust, 2020). The seeming rarity of fossil beetle larvae in the literature probably has different reasons. Difficulties may occur when trying to establish a differential diagnosis for species description, as larvae and adults from the same fauna may be conspecific (*e.g.*, Haug *et al.*, 2022). Also, larvae and adults do not evolve in the same pattern (Haug *et al.*, 2015). Larvae can, therefore, have quite unexpected structures (Haug *et al.*, 2021a), which hampers a taxonomic interpretation (Haug *et al.*, 2020). Some larvae are even interpreted as representatives of quite distantly related lineages by different researchers (*e.g.*, Schawaroch *et al.* 2005 *vs.* Beutel *et al.*, 2016; Zippel *et al.*, 2022 *vs.* Batelka & Engel, 2022 and Rasnitsyn & Müller, 2023), making it difficult to decide between the interpretations (contra Boudinot *et al.*, 2024). As the larval phase is an important period of ecological interaction in the lifetime of beetles, it is unfortunate that our knowledge of beetle larvae is so limited, especially also for understanding ecosystems of the past. We here report an unusual fossil from Kachin amber, Myanmar, representing a type of beetle larva newly recorded to the fauna known from this resource. The systematic interpretation is challenging, yet certain characters of Elateridae can be identified.

Material and methods

In the centre of the study is a single specimen preserved in a piece of about 100 million year-old Kachin amber,

Submitted: 20 May 2024; accepted by D.-Y. Huang: 11 Jun. 2025; published: 27 Jun. 2025

Myanmar (Cruickshank & Ko, 2003; Shi *et al*., 2012; Yu *et al*., 2019). It has been part of the collection of one the authors (PM) with the preliminary number BUB 1258 and is now deposited in the Staatliches Naturhistorisches Museum Braunschweig, Germany, under repository number SNHMB.G 8518. The specimen was documented on a Keyence VHX-6000 digital microscope with a composite image combining different focus layers, panoramas of adjacent image details, as well as HDR. Unpolarised low-angle ring light and cross-polarised co-axial light were used, each with black and white background; the best result was used for this publication. Further processing was pursued in Adobe Photoshop CS2 (*e.g*., Haug *et al*., 2021a). For a broader comparison, we measured certain lengths of SNHMB.G 8518 and of some modern-day larvae resembling it based on literature data (*e.g*., Hyslop, 1917; Husler & Husler, 1940; Buchholz, 1995) or bugguide.com. As many depictions lacked a scale, we used ratios of the length of the antenna vs. the length of the head capsule, as well as the width of the antenna (measured at the second element from proximal as this one can be seen on dorsal and ventral depictions) *vs*. the length of the head capsule.

Results

Description

Elongate beetle larva, more or less cylindrical, appears slightly dorso-ventrally flattened (Fig. 1A, B). Head with prominent moult suture, separating anterior part of head capsule (including structures of ocular segment; nasale; Fig. 1C, D). Post-ocular segment 1 with short and stout, cone-shaped antennae with only three apparent elements (Fig. 2A). Element 1 largest, truncated cone-shaped. Element 2 short and narrower, only 50% the length of element 1; disto-laterally with short protrusion (sensillum?). Element 3 slightly smaller than element 2, distally rounded (Fig. 2A). No externally visible structures of post-ocular segment 2 (intercalary segment). Post-ocular segment 3 with strongly anteriorly oriented (prognathous) mandibles (Fig. 2A), which appear distally bifurcate (tip and one tooth?). Post-ocular segments 4 and 5 with maxillae and labium, forming maxillo-labial complex, as apparent due to the maxillae extending further posterior than the labium (Fig. 2A). Maxilla elongate, proximal part (stipes) rectangular in functional ventral view; without apparent endites (galea, lacinia); distally with stout, short, cone-shaped palp roughly resembling the antenna, with four elements. Proximal three elements truncated cone-shaped, distal one cone-shaped. All elements about the same proximal-distal dimensions, but of distally narrowing diameter (Fig. 2A). Labium also rectangular in functional ventral view. Functional anteriorly with a pair of protrusions, unclear if representing palps or endites (Fig. 2A).

Trunk with twelve recognisable units, anterior eleven representing true segments (Fig. 1A–C). Trunk segment 1, prothorax, longer than head, longest trunk segment, slightly widening posteriorly. With four major sclerites (Fig. 1A, B), one dorsal (tergite), one ventral (sternite) and one on each ventro-lateral side (sclerotised membrane). Anterior (Fig. 2A) and posterior rim (Fig. 2C) with a furrowed ring-like region demarcated by numerous anterior-posterior running lines (about 100 around the segment). Ventrally with a pair of short locomotory appendages (legs) (Fig. 2B), leg length shorter than segment diameter (Fig. 1A, B). Only distal elements apparent, although exact subdivision unclear. Very distal part (claw?) sickle-shaped, further proximal elements tube-shaped with three to four pairs of spine-like setae along the median edge. Trunk segment 2, mesothorax, sub-similar to prothorax, but differing in certain aspects. Segment shorter, only about 60% the length. Furrowed rim only posterior (Fig. 2D). Trunk segment 3, metathorax (Fig. 2E), similar to mesothorax. Trunk segment 4, abdomen segment 1 (Fig. 2F), sub-similar to metathorax, but differing in certain aspects. Segment slightly longer and without ventral appendages. Trunk segments 5–11 sub-similar to trunk segment 4 (Fig. 2G–J), but tapering posteriorly (Fig. 2K). Trunk segments with few rather short setae. Trunk end (most likely representing compound of several segments) bulbous. Longer than a trunk segment, about 1.5× the length of last trunk segment. Slenderer than trunk segments, longer than wide, about 2.5 times. Posteriorly rounded, with few setae (Fig. 2K), some longer than setae on trunk segments (Fig. 2C–J). Antero-ventrally with protruding structure (anal opening, seemingly forming a pygopod; Fig. 2K).

Measurements: Plotting the ratio of width of antenna / length of head capsule vs. the ratio of length of antenna / length of head capsule reveals the exceptionality of the considered fossil. The antenna is much broader in the specimen examined, and therefore the specimen plots well above all extant representatives (Fig. 3).

Discussion

The specimen has an elongate, slightly flattened cylindrical body with short legs. On all trunk segments the posterior rims are furrowed (Fig. 2C–J), on the prothorax also the anterior rim (Fig. 2A). Such rims are well known in different larvae of Elateridae, the group of click beetles (Dušánek, 2013: fig. 10, p. 72; Furlan *et al*., 2021: fig. 2a, p. 4; Zippel *et al*., 2024). Another character known for larvae of this group is a maxillo-

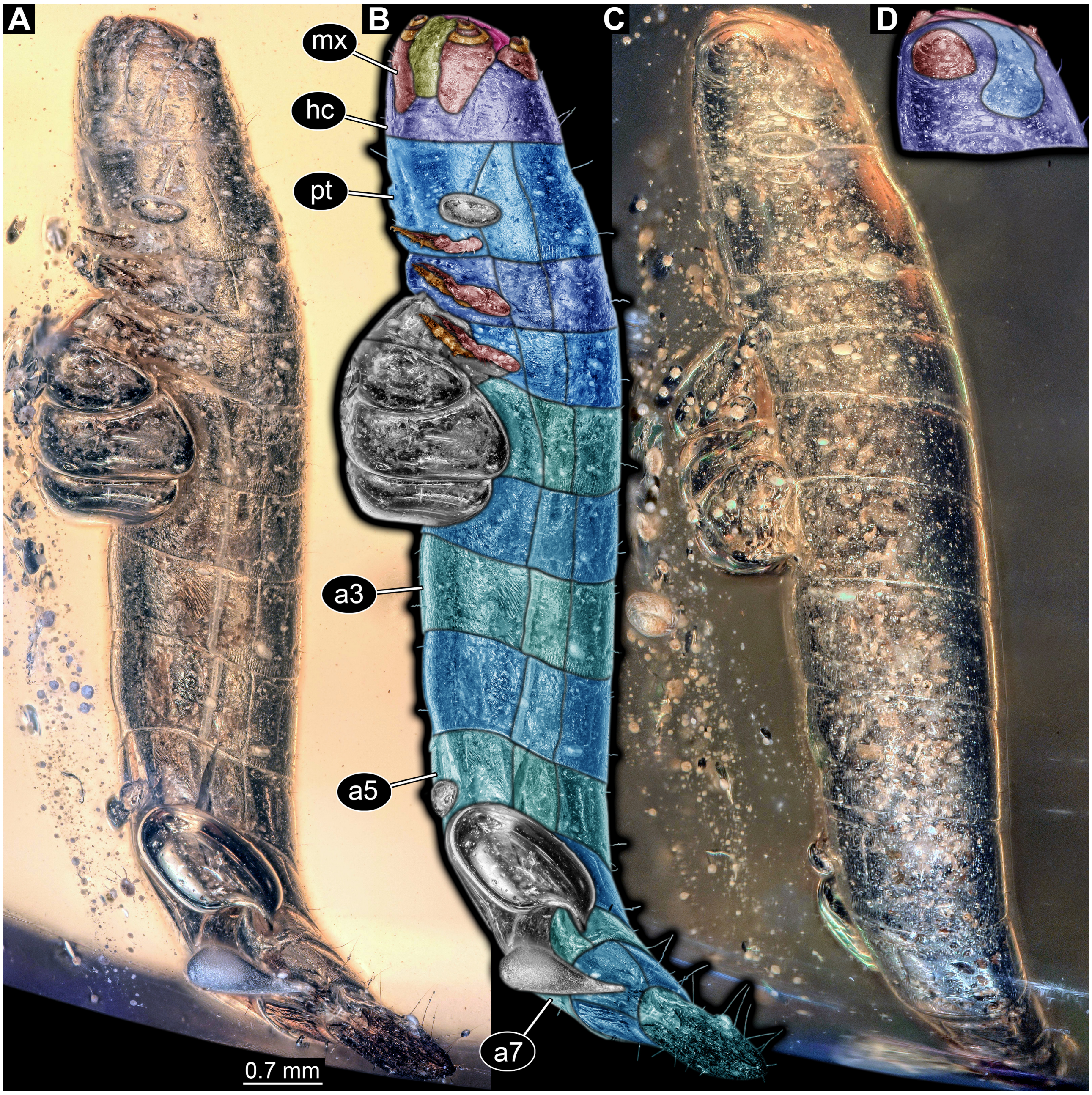

FIGURE 1. New wireworm-like larva, SNHMB.G 8518. **A**, Overview in ventro-lateral view, image horizontally flipped. **B**, Colour-marked version of **A**. **C**, Overview in dorso-lateral view. **D**, Colour-marked details of **C**, note the nasale in light blue. Abbreviations: a3–7 = abdomen segments 3–7; hc = head capsule; mx = maxilla; pt = prothorax.

labial complex (Casari, 2002: fig. 2, p. 95; Costa *et al.*, 2010), which is also apparent in the fossil (Fig. 2A). Also, many click beetle larvae have a small sensorial structure on the penultimate element of the antennae like that in the examined fossil (Fig. 2A; Casari & Biffi, 2012: fig. 3, p. 68; Rosa & Costa, 2013: fig. 1G, p. 303). The moulting suture (forming the nasale) is not well apparent (Fig. 1C), but indicated in the fossil, which is also well known in modern click beetle larvae (Van Zwaluwenburg, 1939; Casari & Costa, 1998: fig. 3, p. 705; Seal, 2011: fig. 3, p. 2). Click beetle larvae often have a prominent ventrally oriented anal opening (pygopod; Kadej *et al.*, 2015: figs 5, 6, p. 1057). A pygopod-like anal opening is apparent in the fossil (Fig. 2K).

In most modern click beetle larvae, the prothorax is shorter than the mesothorax (Becker & Dogger, 1991), unlike in the fossil here (Fig. 1A–C). A longer prothorax is known in larvae of Cebrioninae (Becker, 1991), now Cebrionini (as ingroup of Elaterinae), and certain other larvae of Elaterinae (Becker & Dogger, 1991; and also few other groups: Rosa *et al.*, 2015: fig. 12, p. 324; Rosa *et al.*, 2019: fig. 1A, p. 34). In Cebrionini, the ventral side

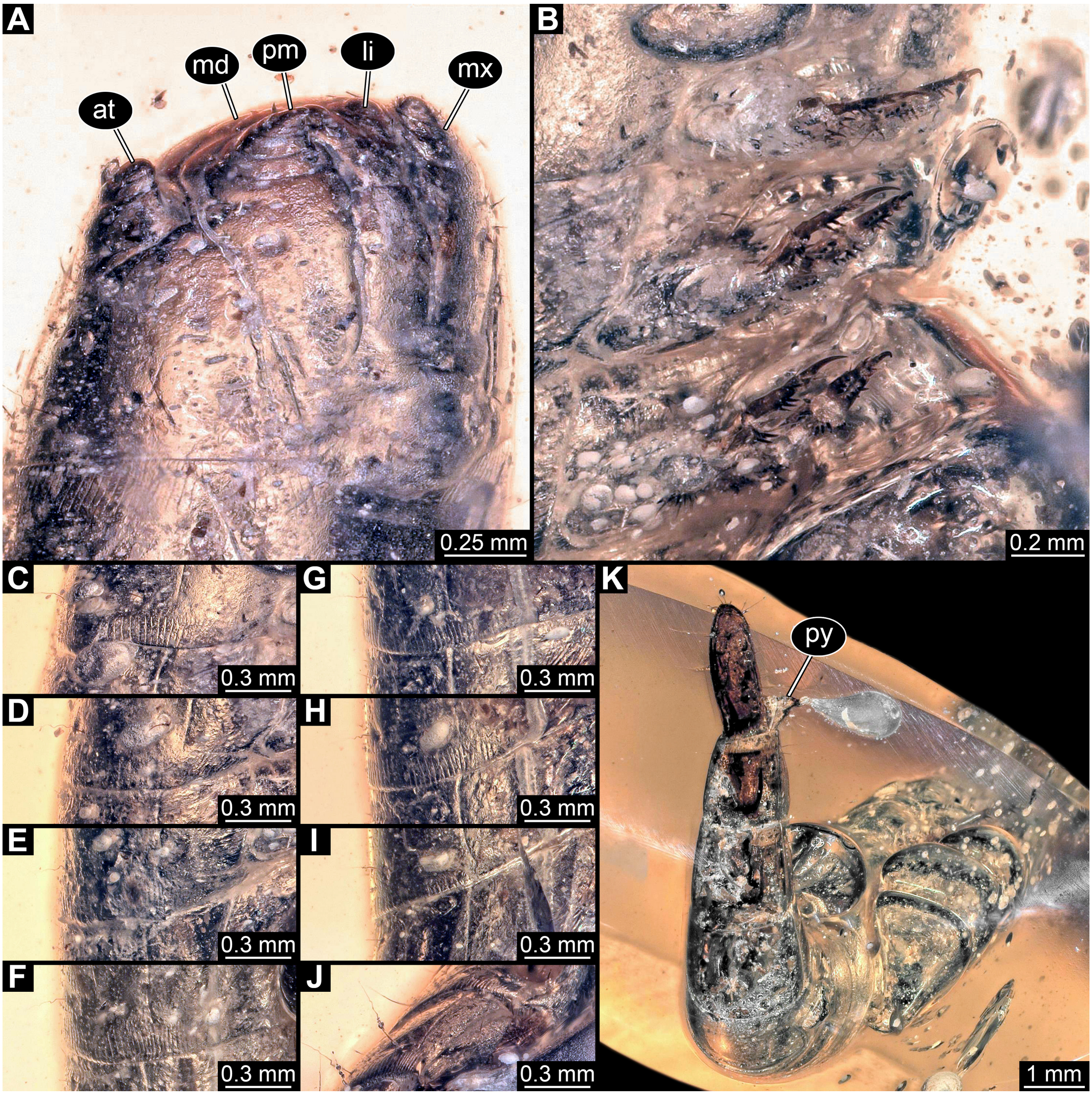

FIGURE 2. New wireworm-like larva, SNHMB.G 8518, continued. **A–J**, Close-ups in ventro-lateral view. **A**, Head with mouthparts; note the furrowed anterior rim of the prothorax. **B**, Locomotory appendages (legs). **C–J**, Posterior furrowed rims of trunk segments. **C**, Prothorax. **D**, Mesothorax. **E**, Metathorax. **F**, Abdomen segment 1. **G**, Abdomen segment 2. **H**, Abdomen segment 3. **I**, Abdomen segment 4. **J**, Abdomen segments 7 and 8. **K**, Oblique dorsal view on posterior abdomen segments and trunk end. Abbreviations: at = antenna; li = labium; md = mandible; mx = maxilla; pm = palp of maxilla; py = pygopod.

of the prothorax is drawn forward unlike in the fossil and in other larvae of Elaterinae. Larvae of Elaterini (ingroup of Elaterinae) have a gently rounded trunk end (Becker & Dogger, 1991: p. 414), similar to that in Cebrionini and the fossil under examination and also in larvae of Physorhinini (ingroup of Elaterinae; Buchholz, 1995: fig. 1, p. 291); those of Agriotini (ingroup of Elaterinae) have a slightly pointed trunk end (Becker & Dogger, 1991: p. 414), as do larvae of Dicrepidiini (ingroup of Elaterinae; Costa & Vanin, 2010: fig. 9, p. 7); larvae of Ampedini (ingroup of Elaterinae) have a more distinctly pointed trunk end (Becker & Dogger, 1991: p. 414). The trunk end of larvae of Melanotini (ingroup of Elaterinae) is flattened, in this aspect resembling more the trunk ends of other larvae of Elateridae, which are in addition bifurcate (Becker & Dogger, 1991; Calder *et al.*, 1993: fig. 29, p. 1362).

It seems unlikely that the similarities of larvae of Cebrionini and Elaterini evolved only once in the stem species of the group including both. The similarities with

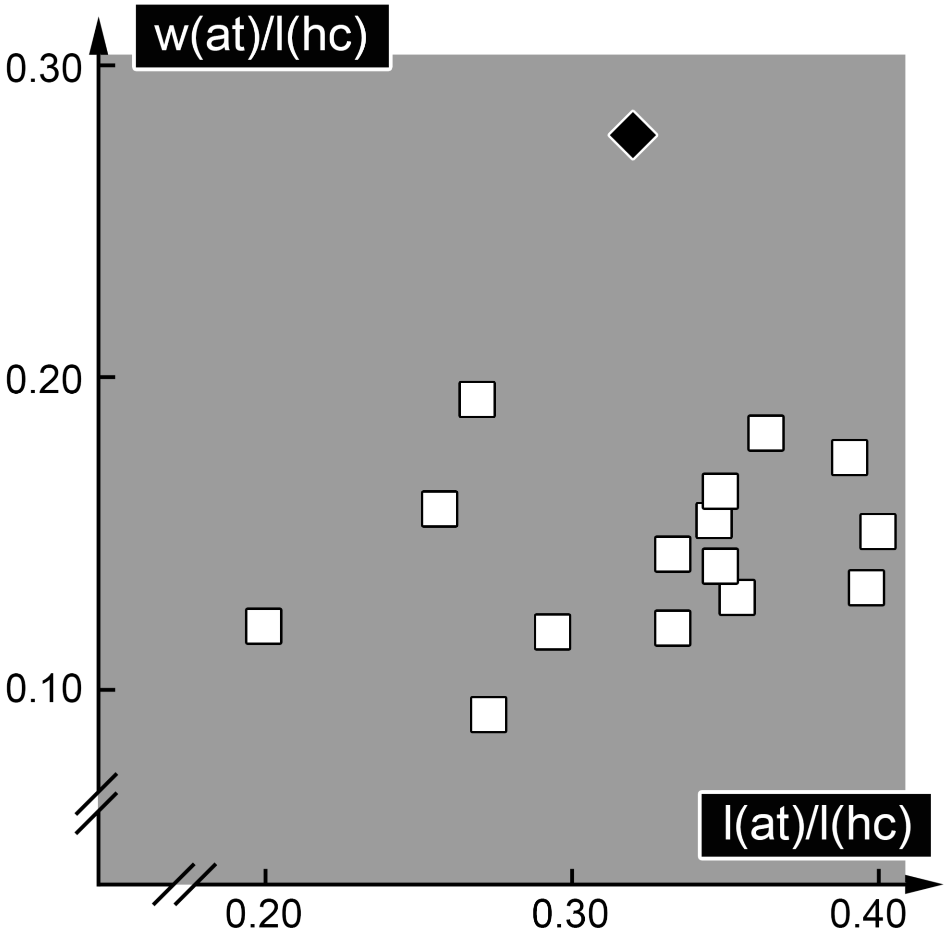

FIGURE 3. Scatter plot of ratios of width of antenna / length of head capsule vs. the ratio of length of antenna / length of head capsule. Note the extreme position of the fossil larva (black diamond) in comparison to extant wireworms (white squares). Abbreviations: l(at) = length of antenna; l(hc) = length of head capsule; w(at) = width of antenna.

the fossil here examined are therefore a bit challenging to interpret. The fossil shares characters with larvae of Cebrionini and other larvae of Elaterinae, most so with larvae of Elaterini and to a certain degree with Agriotini and Dicrepidiini, but also differs from them. Especially the very short antennae and palps are highly unusual. The considered larva could be related to Cebrionini, but can not be easily interpreted as an ingroup representative due to the lack of certain features (*e.g.*, drawn forward prothorax sternite), which would otherwise have to be interpreted as secondarily lost in the fossil. From the overall habitus, the fossil larvae shares more similarities with many larvae of Elaterinae, but no clear characterising feature for the group is apparent in the fossil, and the fossil would be an aberrant appearing representative. We can also not exclude that the considered larva is not related to any of the groups and that the similarity is another case of convergent evolution. Still, it seems most likely that the larva is a representative of Elateridae, hence a wireworm.

Only recently have the first larvae of click beetles been reported from Myanmar amber—in total three specimens (Zippel *et al*., 2024; Kundrata *et al*., 2025). The larva under consideration differs from these: from the one type in the trunk end morphology (bifurcate trunk end; Kundrata *et al*., 2025) and from both in the short antennae and palps (Zippel *et al*., 2024). Also some of their closer relatives (*i.e*., larvae of other ingroups of Elateroidea) have been found as larvae in Myanmar amber (Zhao *et al*., 2020; Haug *et al*., 2021b, 2023; Zippel *et al*., 2023). This is not surprising as also adults of these groups have already been reported (Qu *et al*., 2020; Li *et al*., 2021a, b, c, 2022a, b; Kundrata *et al*., 2021, 2023; Triskova *et al*., 2022; Zhao *et al*., 2022, 2023; Yang *et al*., 2024). However, fossil larvae often differ in certain aspects from closely related modern larvae, comparable to the case of the new fossil.

Holometabolan larvae in Myanmar amber seem to represent some record holders with very unusual structures in comparison with those known in the modern fauna. Especially among lacewings we can find extreme structural properties not seen before or since (Haug *et al*., 2021a), often strong elongations of mouthparts, legs, or processes. Among beetle larvae, such cases are so far lacking, with differences between fossil and extant forms often representing retained possible plesiomorphies in the fossils or unusual combinations of characters, but not measurable superlatives. The newly recorded larva may be an extreme, with the very stout antennae and palps not known in modern click beetles. Still, this is not really comparable to the cases in lacewings. Possibly there are no cases of extinct superlatives in beetle larvae, as all of these morphologies survived into the modern fauna.

Regardless whether the larva under current examination is closely related to Cebrionini or other ingroups of Elaterinae, the similar morphology may indicate similar life habits of the larvae. Larvae of Cebrionini are not well known concerning their ecology, but they have been reported to occur in soil (Becker, 1991: p. 418), as have larvae of Physorhinini (Buchholz, 1995: p. 290). Other larvae are associated with decaying wood (Husler & Husler, 1940). Larvae of Dicrepidiini live in termite nests, hence are also associated with rotting wood (Costa & Vanin, 2010). There are examples of amber predominantly preserving soil fauna (*e.g*., Perrichot, 2004; Adl *et al*., 2011), but a life style associated to wood presumably enhances the chances to be preserved in amber. While wireworm-like larvae living in soils may be pests of plants (Lehmhus & Niepold, 2015; Stolpe Nordin, 2017; Furlan *et al*., 2021), those living in wood are usually predators of wood-boring larvae. If the considered larva had such a life style, the very short antennae and palps may have been advantageous, as the little-protruding structures could hardly be attacked by prey during defence.

Acknowledgements

The study was funded by the German Research Foundation (DFG HA 6300/6-1) and by the Volkswagen Foundation with a Lichtenberg professorship to JTH. We thank all people dedicating their free time to providing free and open source software. This is LEON publication #41.

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