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RESEARCH ARTICLE

Earliest teredid beetle from mid-Cretaceous amber of northern Myanmar (Coleoptera: Coccinelloidea: Teredidae): new genus and species

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ABSTRACT. The earliest fossil member of Teredidae, *Delteredolaemus hei* Li & Cai **gen. et sp. nov.**, is reported from mid-Cretaceous Burmese amber. *Delteredolaemus* is assigned to the extant tribe Teredini, and shares a generally similar morphology with the extant genus *Teredolaemus* Sharp, 1885, although it can be distinguished from all other members in the tribe by the shape of the pronotum and mesoventral process, as well as the anteromedially tumid metaventrite.

KEY WORDS. Mesozoic, fossil, taxonomy, Burmese amber, Teredini.

INTRODUCTION

Teredidae is a small family in Coccinelloidea, with 10 genera and about 160 extant species described (Ślipiński et al. 2010, Robertson et al. 2015). Members of this taxon have been traditionally included in Bothrideridae (e.g., Pal and Lawrence 1986, Ślipiński and Pakaluk 1991, Philips and Ivie 2002, Ślipiński et al. 2010). A recent phylogenetic study by Robertson et al. (2015) based on eight gene markers revealed that Teredinae, Anommatinae and Xylariophilinae (former subfamilies of Bothrideridae s.l.) together formed an independent lineage not closely related to Bothriderinae. Thus, a familial status of Teredidae was recognized to accommodate these three subfamilies. Robertson et al. (2015) also discovered a sister relationship between Teredidae and Euxestidae + Cerylonidae, which has been generally confirmed by further studies (if not considering the polyphyly of Cerylonidae sensu Robertson et al. 2015) (Zhang et al. 2018, McKenna et al. 2019, Cai et al. 2022).

The fossil record of Teredidae is extremely sparse. The only fossil ever reported was a member of *Teredolaemus* Sharp, 1885 from the Eocene Baltic amber (Alekseev et al. 2022). In the present study, we describe a new genus and species of Teredidae based on a well-preserved specimen from mid-Cretaceous amber of Myanmar, which represents the earliest record for this family.

MATERIAL AND METHODS

The Burmese amber specimen studied herein (Figs 1–17) originated from amber mines near Noije Bum (26°20′ N, 96°36′ E), Hukawng Valley, Kachin State, northern Myanmar. The holotype of *Delteredolaemus hei* gen. et sp. nov. is deposited in the Nanjing Institute of Geology and Palaeontology (NIGP), Chinese Academy of Sciences, Nanjing, China. The amber piece was trimmed with a small table saw, ground with emery paper of different grit sizes, and finally polished with polishing powder.

Photographs under incident light were taken with a Zeiss Discovery V20 stereomicroscope. Confocal images were obtained with a Zeiss LSM710 confocal laser scanning microscope, using the 488 nm Argon laser excitation line (Fu et al. 2021). Images under incident light were stacked in Helicon Focus 7.0.2 and Adobe Photoshop CC. Confocal images were stacked with color coding for depth in ZEN 3.4 (Blue Edition), or semi-manually stacked in Helicon Focus 7.0.2 and Adobe Photoshop CC. Microtomographic data were obtained with a Zeiss Xradia 520 Versa 3D X-ray microscope at the micro-CT laboratory of NIGP and analyzed in VGStudio MAX 3.0. Scanning parameters were as follows: isotropic voxel size, 2.2514 µm; power, 3 W; acceleration voltage, 40 kV; exposure time, 2 s; projections, 2701.

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Images were further processed in Adobe Photoshop CC to adjust brightness and contrast.

The morphological terminology follows Lawrence and Ślipiński (2013).

TAXONOMY

Coleoptera Linnaeus, 1758

Coccinelloidea Latreille, 1807

Teredidae Seidlitz, 1888

Teredinae Seidlitz, 1888

Teredini Seidlitz, 1888

Delteredolaemus Li & Cai gen. nov.

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Type species. *Delteredolaemus hei* sp. nov., by present designation and monotypy.

Diagnosis. Body elongate, cylindrical, with scattered hairs (Figs 1–6). Antenna 11-segmented, with 2-segmented club (Figs 7, 17). Pronotal disc without paired cavities or impressions at base; posterior pronotal edge posteriorly produced at the middle, forming rather distinct angle (Fig. 12). Elytra with clear puncture rows, without prominent costae (Fig. 3). Mesoventral process slightly broadened at middle, apically narrowly rounded (Fig. 9). Metaventrite anteromedially tumid (Fig. 9). Tibial spines present only at outer apical angle of tibiae (Figs 8–10). Tarsi simple; tarsal formula 4-4-4 (Figs 8–10). Empodium present. Abdominal ventrite 1 with intercoxal process narrow and apically acuminate (Fig. 10).

Etymology. The generic name is formed based on the Greek "delta", referring to the triangle-shaped projection of its posterior pronotal edge, and the generic name *Teredolaemus*, referring to its general similarity with the latter. The name is masculine in gender.

Delteredolaemus hei Li & Cai sp. nov.

Figs 1–17

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Material. Holotype, NIGP200000.

Locality and horizon. Amber mine located near Noije Bum Village, Tanai Township, Myitkyina District, Kachin State, Myanmar; unnamed horizon, mid-Cretaceous (Upper Albian to Lower Cenomanian; Shi et al. 2012, Mao et al. 2018).

Diagnosis. As for the genus.

Description. Body elongate, cylindrical, about 1.75 mm long, 0.45 mm wide, widest in anterior part of abdomen; surface with scattered setae.

Head (Fig. 7) prognathous, widest across the eyes. Compound eyes (Fig. 7) finely facetted, without interfacetal setae. Antennal insertions (Fig. 16) exposed from above. Antennae (Figs 7, 17) likely 11-segmented; antennomere 1 robust; antennomeres 1–4 progressively narrower; antennomeres 10 and 11 forming a relatively compact club; antennomeres 1–9 with scattered long setae only; antennomere 11 with dense sensorial setae. Mandibles (Fig. 7) (at least) bidentate. Maxillary palps (Fig. 7) 4-segmented, with apical palpomere subconical. Labial palps (Fig. 7) with apical palpomere likely cylindrical.

Pronotal disc about 1.4 times as long as wide; surface without special modifications (carinae, cavities, grooves, or paired impressions); posterior pronotal edge posteriorly produced at middle, forming rather distinct angle (Fig. 12); lateral pronotal carinae complete (Fig. 15). Notosternal suture complete (Fig. 15). Prosternal process either absent or completely concealed by projecting procoxae (Fig. 8). Procoxae (Fig. 8) projecting and contiguous (status of coxal cavities unknown).

Scutellar shield (Fig. 12) small and rounded. Elytra (Fig. 3) elongate; surface with clear puncture rows, without costae; scutellar striole absent; epipleura narrow. Mesoventrite (Fig. 9) without median carina; mesoventral process well-developed, slightly broadened at middle, apically narrowly rounded. Mesocoxal cavities narrowly separated (Fig. 9). Metaventrite anteromedially tumid (Figs 6, 9); median discrimen absent. Metacoxae (Fig. 10) transversely oval, narrowly separated.

Legs well-developed, slender. Trochanters large and well visible, with strongly oblique trochanterofemoral joint (Figs 8–10). Tibiae with spines present at outer apical angle only (Figs 8–10); tibial spurs 2-2-2, well-developed (Figs 8–10). Tarsi all 4-segmented; tarsomeres simple, unlobed (Figs 8–10). Pretarsal claws simple; empodium present, bisetose.

Abdomen with five ventrites (Figs 10, 11). Ratio of ventrite lengths along middle: 3.8:1.3:1.1:1.0:1.5. Ventrite 1 with intercoxal process narrow and apically acuminate (Fig. 10).

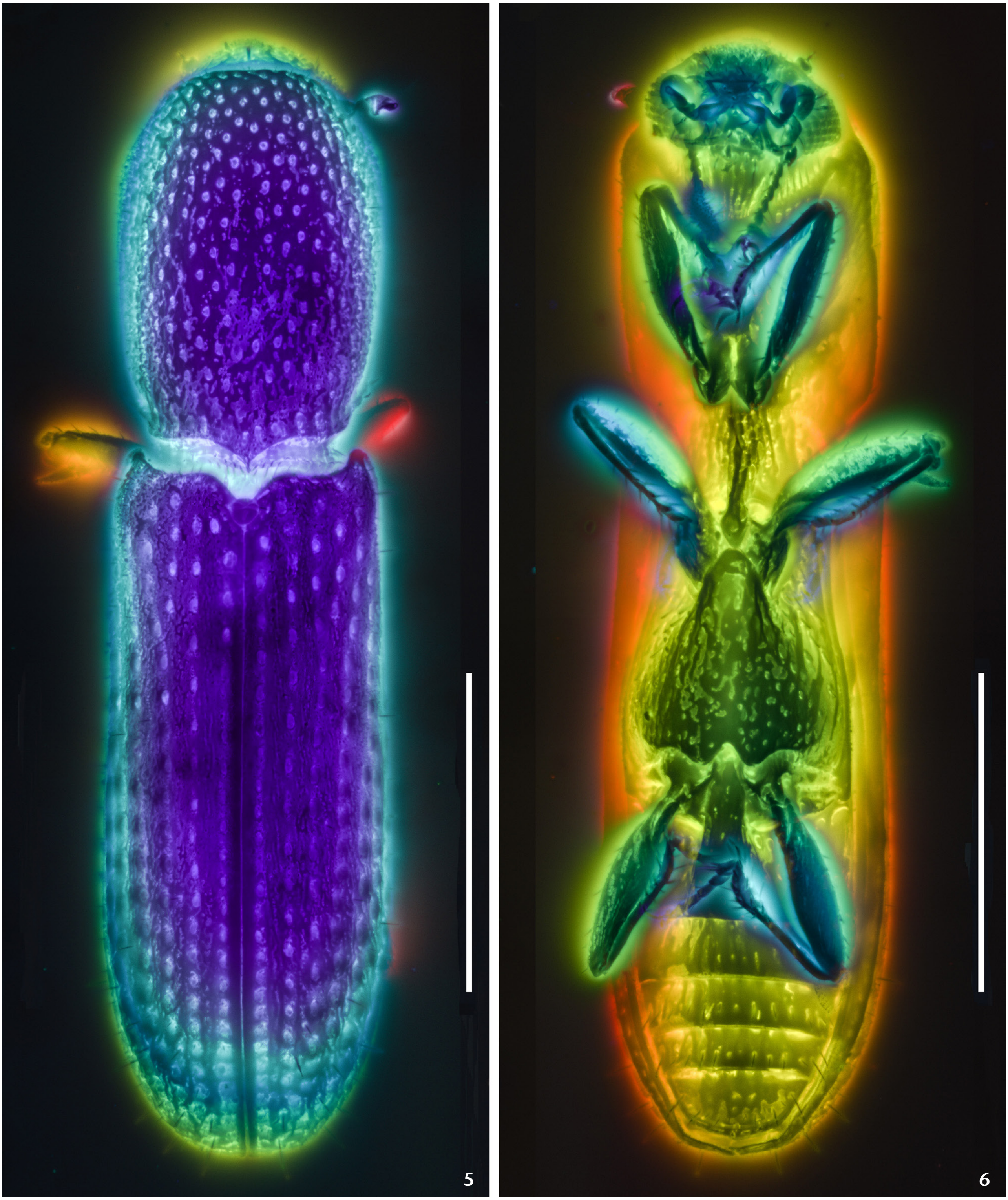
Etymology. The species is named after Mr. Hai-Kun He (Guangdong, China), who kindly donated many fossils for our research.

DISCUSSION

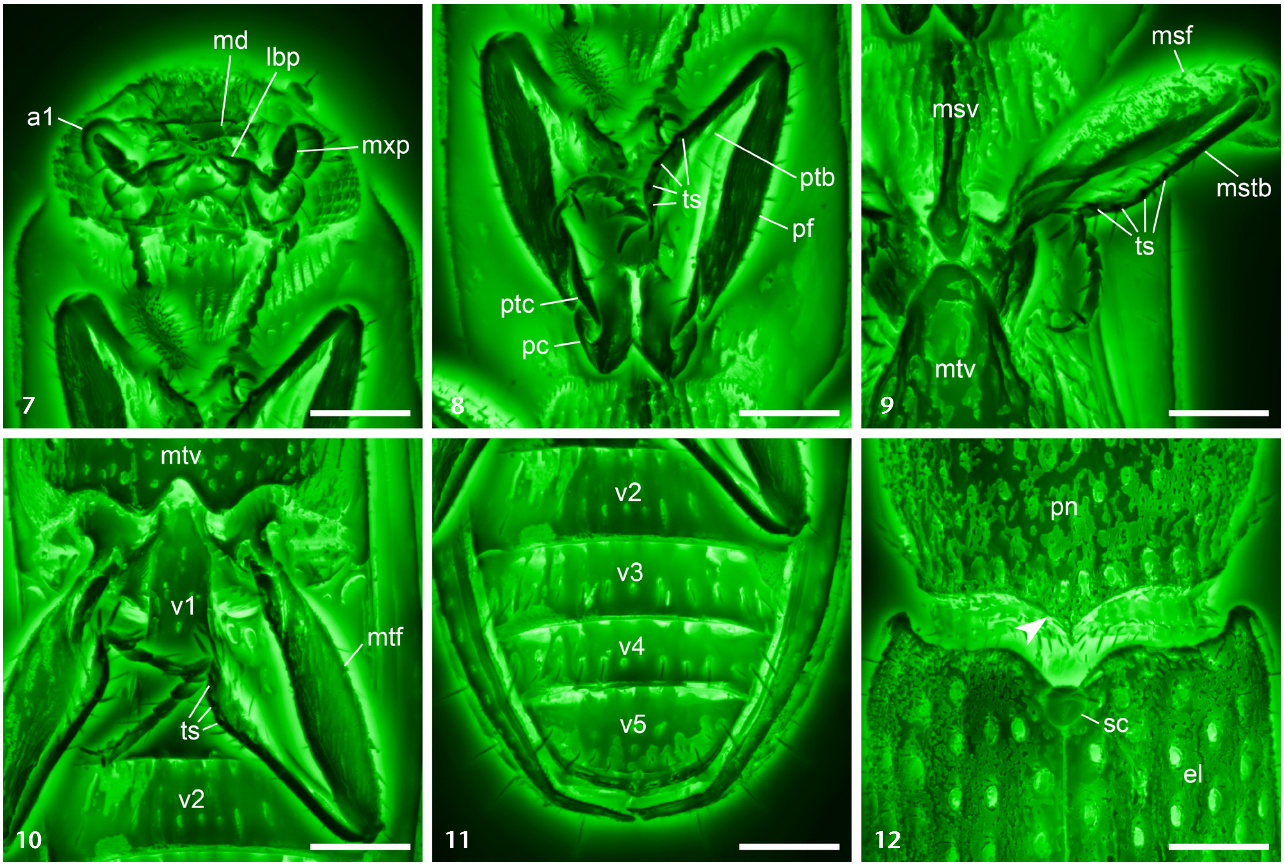
Teredidae has been recently split from Bothrideridae based on the molecular phylogeny (Robertson et al. 2015). The new fossil differs from the remaining Bothrideridae in having large and well visible trochanters (Figs 8–10) (trochanters small and located within excavations on femora in Bothrideridae – Ślipiński and Pal 1985, Pal and Lawrence 1986, Lord and McHugh 2013: fig. 54). Among the three subfamilies of Teredidae, Anommatinae clearly differs from *Delteredolaemus* in having 3-segmented tarsi (Coiffait 1984, Pal and Lawrence 1986) (tarsal formula 4-4-4 in *Delteredolaemus*), and Xylariophilinae differs from *Delteredolaemus* in the much broader and densely setose body and the absence of distinct empodium (Pal and Lawrence 1986) (body elongate, surface with only scattered hairs, and empodium present in *Delteredolaemus*). Within Teredinae, Sosylopsini has wide and apically truncate intercoxal process of abdominal ventrite 1 (Dajoz 1980, Ślipiński and Pal 1985), and Sysolini has prominent costae on elytra and 3-segmented antennal club (Ślipiński and Pal 1985), which are discordant with the morphology of *Delteredo-*

Figures 1–2. General habitus of *Delteredolaemus hei* gen. et sp. nov., holotype, NIGP200000, under incident light: (1) dorsal view; (2) ventral view. Scale bars: 500 µm.

Figures 3–4. General habitus of *Delteredolaemus hei* gen. et sp. nov., holotype, NIGP200000, under confocal microscopy: (3) dorsal view; (4) ventral view. Scale bars: 500 µm.



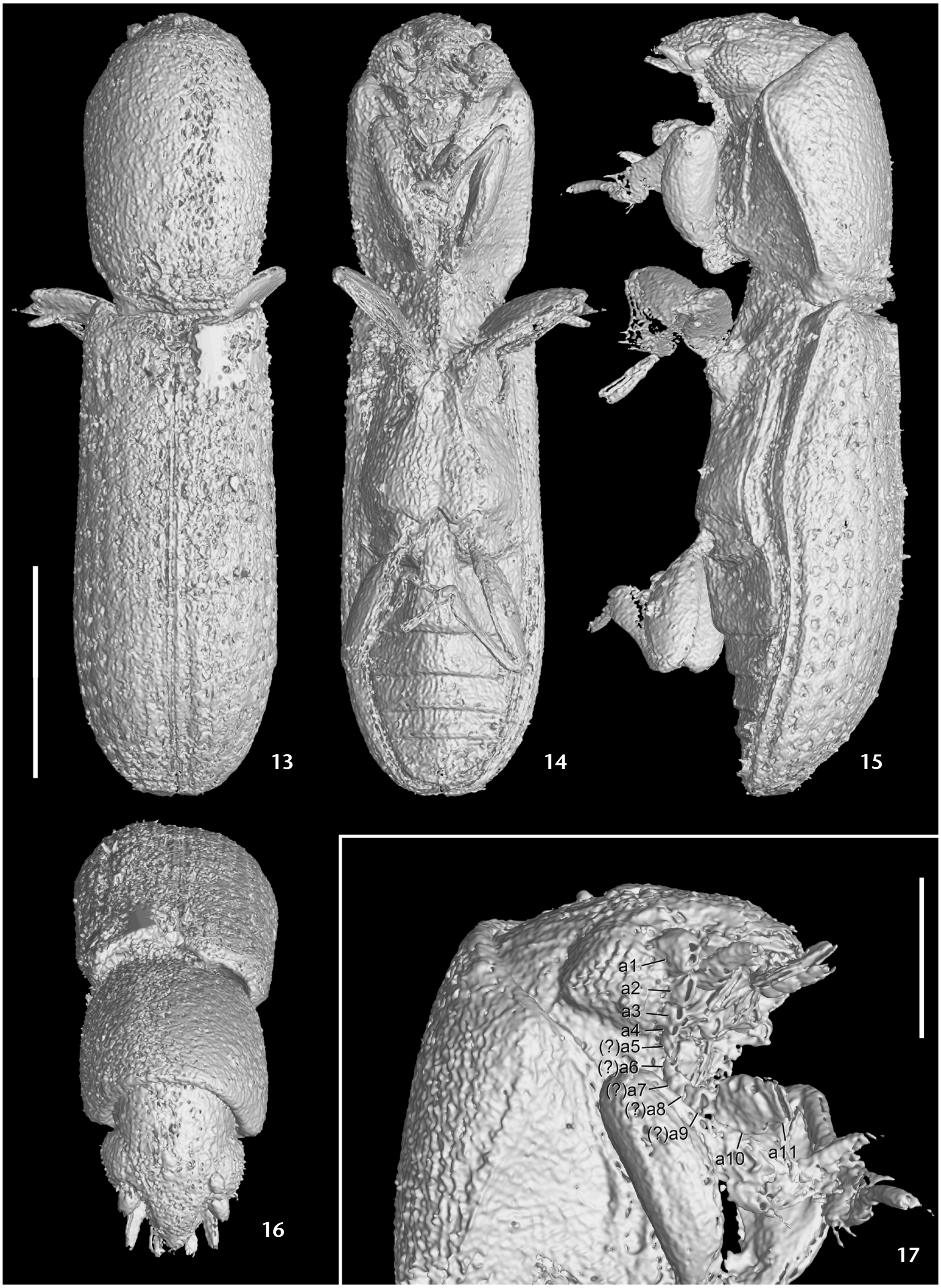
Figures 5–6. General habitus of *Delteredolaemus hei* gen. et sp. nov., holotype, NIGP200000, under confocal microscopy, with depth color coding: (5) dorsal view; (6) ventral view. Scale bars: 500 μm.



Figures 7–12. Details of *Delteredolaemus hei* gen. et sp. nov., holotype, NIGP200000, under confocal microscopy: (7) head, anteroventral view; (8) prothorax, ventral view; (9) mesothorax, ventral view; (10) abdominal base, ventral view; (11) abdominal apex, ventral view; (12) pronotal and elytral bases, dorsal view, with arrowhead showing the medially produced posterior pronotal edge. (a1) antennomere 1, (el) elytron, (lbp) labial palp, (md) mandible, (msf) mesofemur, (mstb) mesotibia, (msv) mesoventrite, (mtf) metafemur, (mtv) metaventrite, (mxp) maxillary palp, (pc) procoxa, (pf) profemur, (pn) pronotum, (ptb) protibia, (ptc) protrochanter, (sc) scutellum, (ts) tibial spine, (v1–5) ventrites 1–5. Scale bars: 100 µm.

laemus. The antennal, elytral and abdominal morphologies of *Delteredolaemus* are well consistent with those of Teredini. Thus, *Delteredolaemus* could be assigned to the tribe Teredini, which as currently recognized, however, is possibly a paraphyletic group (Robertson et al. 2015).

Currently, there are five genera in Teredini, i.e., *Rustleria* Stephan, 1989, *Teredus* Dejean, 1835, *Oxylaemus* Erichson, 1845, *Teredomorphus* Heinze, 1943, and *Teredolaemus* Sharp, 1885. *Rustleria* can be easily separated from *Delteredolaemus* based on its fine and scattered elytral punctures (Stephan 1989, Philips and Ivie 2002). In *Delteredolaemus* and the other four genera, the elytral punctures are much coarser and arranged in regularly longitudinal rows (Fig. 3). *Delteredolaemus* differs from *Teredus* and *Oxylaemus* in the pattern of tibial spines. Spines are distributed along the entire outer edge of tibiae in *Oxylaemus*, and are absent in *Teredus* (Lawrence 1985), whereas in *Delteredolaemus* the spines are confined to the outer apical angle of tibiae (Figs 8–10). *Oxylaemus* additionally differs from *Delteredolaemus* in prosternum anteriorly prominent (Heinze 1943: fig. 3) and often having paired cavities or impressions at pronotal base (Recalde Irurzun and San Martín Moreno 2007: fig. 1). *Delteredolaemus* shares a similar arrangement of tibial spines with *Teredomorphus* and *Teredolaemus*, and appears to be more similar to *Teredolaemus* in the anteriorly non-prominent prosternum (Heinze 1943, Pope 1961, Lawrence 1985). Nevertheless, *Delteredolaemus* differs from *Teredolaemus* in the morphology of pronotum and ventral pterothorax. In extant Teredini, including *Teredolaemus*, the posterior pronotal edge is at most weakly and smoothly curved, while in *Delteredolaemus* the posterior pronotal edge is posteriorly produced at the middle, forming a rather distinct angle (Fig. 12). Additionally, in extant Teredini, the mesoventral process is usually gradually narrowed posteriorly and subtruncate apically,



Figures 13–17. X-ray microtomographic reconstruction of *Delteredolaemus hei* gen. et sp. nov., holotype, NIGP200000: (13) dorsal view; (14) ventral view; (15) lateral view; (16) anterodorsal view; (17) head, ventrolateral view. (a1–11) antennomeres 1–11. Scale bars: 500 µm in (13–16), 200 µm in (17).

and the metaventrite is relatively flat (e.g., Zhou et al. 2017: figs 2–7, Liu et al. 2021: fig. 3D). In contrast, in *Delteredolaemus*, the mesoventral process is slightly broadened in the middle and narrowly rounded apically, and the metaventrite is somewhat tumid anteromedially (Figs 6, 9).

As the earliest fossil record of Teredidae from mid-Cretaceous amber (~99 Ma), *Delteredolaemus* is critical for understanding the diversification of the family in molecular dating analysis. The divergence between *Teredolaemus* (Teredinae) and *Xylariophilus* Pal & Lawrence, 1986 (Xylariophilinae) has been dated to approximately 31–81 Ma (McKenna et al. 2019) or 37–91 Ma (Cai et al. 2022). If *Delteredolaemus* is indeed most closely related to *Teredolaemus* (or at least closer to *Teredolaemus* than *Xylariophilus*), it would lead to an earlier estimation for the divergence times of the internal lineages of Teredidae.

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Author Contributions

Y-DL and C-YC conceived the study. Y-DL acquired and processed the photomicrographs. Y-DL drafted the manuscript, to which C-YC contributed. All authors commented on the manuscript and gave final approval for publication.

Competing Interests

The authors have declared that no competing interests exist.

Data Availability

The original confocal data and micro-CT are available in Zenodo repository (https://doi.org/10.5281/zenodo.7072965).

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