ZOOLOGIA 39: e21030
ISSN 1984-4689 (online)
scielo.br/zool

RESEARCH ARTICLE

# *Anomocephalobus*, a new genus of minute marsh-loving beetles from mid-Cretaceous Burmese amber (Coleoptera: Limnichidae)

**Yan-Da Li[1], Ya-Li Yu[2], Manfred A. Jäch[3], Di-Ying Huang[1], Chen-Yang Cai[1,4]**

[1] *State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, and Centre for Excellence in Life and Paleoenvironment, Chinese Academy of Sciences. Nanjing 210008, China.*
[2] *Guangdong Key Laboratory of Animal Conservation and Resource Utilization, Guangdong Public Laboratory of Wild Animal Conservation and Utilization, Institute of Zoology, Guangdong Academy of Sciences. Guangzhou 510260, China.*
[3] *Naturhistorisches Museum Wien. Burgring 7, 1010 Vienna, Austria.*
[4] *School of Earth Sciences, University of Bristol. Life Sciences Building, Tyndall Avenue, Bristol BS8 1TQ, United Kingdom.*
*Corresponding author: Chen-Yang Cai (cycai@nigpas.ac.cn)*

*http://zoobank.org/499DC091-D527-44CE-84C7-717CB91EDC33*

ABSTRACT. Limnichidae are currently a moderately diverse beetle family with a sparse fossil record. Here we describe a new limnichid genus and species, *Anomocephalobus liuhaoi* Li, Jäch & Cai **gen. et sp. nov.**, from the mid-Cretaceous amber from northern Myanmar. *Anomocephalobus* **gen. nov.** is tentatively assigned to the extant subfamily Cephalobyrrhinae, based on its transverse metacoxae, 5-segmented protarsi, and absence of grooves on the ventral surface for reception of legs, though its oval body shape is somewhat deviating from extant Cephalobyrrhinae. The generic placement of the recently described *Erichia cretacea* Yu, Ślipiński, Ren & Pang, 2018 is also discussed.

KEY WORDS. Mesozoic, fossil, taxonomy, Myanmar, Cephalobyrrhinae.

## INTRODUCTION

Limnichidae, or the minute marsh-loving beetles, are a group of small beetles in the recently defined superfamily Dryopoidea (Cai et al. 2022), or in the broadly defined paraphyletic Byrrhoidea (McKenna et al. 2019). By the year of 2016, a total of 387 extant limnichid species in 37 genera had been described (Hernando and Ribera 2016). Additional new species were added in the past few years (e.g., Hernando and Ribera 2017, 2020, Yoshitomi 2019a, 2019b, Matsumoto 2020, 2021a, 2021b, Liu and Jia 2021), implying that the diversity of Limnichidae is still not fully documented.

Morphological studies have consistently suggested a close relationship among Lutrochidae, Dryopidae, Heteroceridae, and Limnichidae (Crowson 1978, Lawrence 1988, Costa et al. 1999). Recent molecular results, however, revealed that Lutrochidae + Dryopidae and Heteroceridae + Limnichidae are only distantly related (Kundrata et al. 2017, Zhang et al. 2018, McKenna et al. 2019). Additionally, Limnichidae have been regarded to be paraphyletic due to Heteroceridae nested within them. At present, four subfamilies are recognized in Limnichidae, namely Hyphalinae, Thaumastodinae, Cephalobyrrhinae, and Limnichinae. The interrelationships among them have not been well studied and remain largely unclear. A preliminary study by Kundrata et al. (2017), nevertheless, suggested that the largest subfamily, Limnichinae, may not be monophyletic.

The fossil record of Limnichidae is quite sparse. Only three pre-Quaternary fossils have been reported to date, all of which were found in amber deposits. *Platypelochares electricus* Hernando, Szawaryn & Ribera, 2018 from Baltic amber was assigned to an extant genus of Limnichinae (Hernando et al. 2018), whereas *Palaeoersachus bicarinatus* Pütz, Hernando & Ribera, 2004 from the same deposit was placed as incertae sedis (Pütz et al. 2004). *Erichia cretacea* Yu, Ślipiński, Ren & Pang, 2018 from Burmese amber was placed in Cephalobyrrhinae (Yu et al. 2018). In this study, we report a new fossil genus and species of Limnichidae from Burmese amber, which adds valuable information on the paleodiversity of the family.

## MATERIAL AND METHODS

The Burmese amber specimens studied herein originated from amber mines near Noije Bum (26°20′ N, 96°36′ E), Hukawng Valley, Kachin State, northern Myanmar. The holotype of *Anomocephalobus liuhaoi* gen. et sp. nov. (Figs 1–13) 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. The holotype of *E. cretacea* (CNU-COL-BR2014808, deposited in the Capital Normal University, Beijing, China), was re-examined (Figs 15–22).

Photographs under incident light were mainly taken with a Zeiss Discovery V20 stereomicroscope. Widefield fluorescence images were captured with a Zeiss Axio Imager 2 light microscope combined with a fluorescence imaging system. 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 and wide field fluorescence were stacked in Helicon Focus 7.0.2 or Zerene Stacker 1.04. Confocal images were stacked with Helicon Focus 7.0.2 and Adobe Photoshop CC. Images were further processed in Adobe Photoshop CC to enhance contrast.

## TAXONOMY

Coleoptera Linnaeus, 1758
Dryopoidea Billberg, 1820 (1817)
Limnichidae Erichson, 1846
Cephalobyrrhinae Champion, 1925
*Anomocephalobus* Li, Jäch & Cai gen. nov.

http://zoobank.org/1B8A15B3-3BEA-47FB-99B1-E62E01622348

Type species. *Anomocephalobus liuhaoi* sp. nov., by present designation and monotypy.

Etymology. The generic name is derived from the Greek “*anomos*”, meaning unusual, and part of the generic name “*Cephalobyrrhus*”, the type genus of Cephalobyrrhinae, referring to the fossil’s somewhat unsual habitus within extant Cephalobyrrhinae. The name is masculine in gender.

Diagnosis. Body relatively wide, oval. Ventral surface without grooves for reception of legs. Head largely covered by

Figures 1–2. General habitus of *Anomocephalobus liuhaoi* gen. et sp. nov., holotype, NIGP177044, under incident light: (1) dorsal view; (2) ventral view. Scale bars: 1 mm.

pronotum; anterior pronotal edges reaching compound eyes. Antennal insertion capsule closed. Antennomeres 1–3 slender and elongate; antennomeres 4–11 serrate. Posterior pronotal angles rounded; posterior pronotal margin and basal elytral margin crenulate. Prosternal process broad, distinctly wider than one third of maximum width of prosternum. Metacoxae transverse and without large metacoxal plates. All legs with five tarsomeres.

## *Anomocephalobus liuhaoi* Li, Jäch & Cai, sp. nov.

Figs 1–13

http://zoobank.org/45F69AF5-4EE7-4E94-9ACE-B04A82CA2D22

Type material. Holotype, NIGP177044, female.

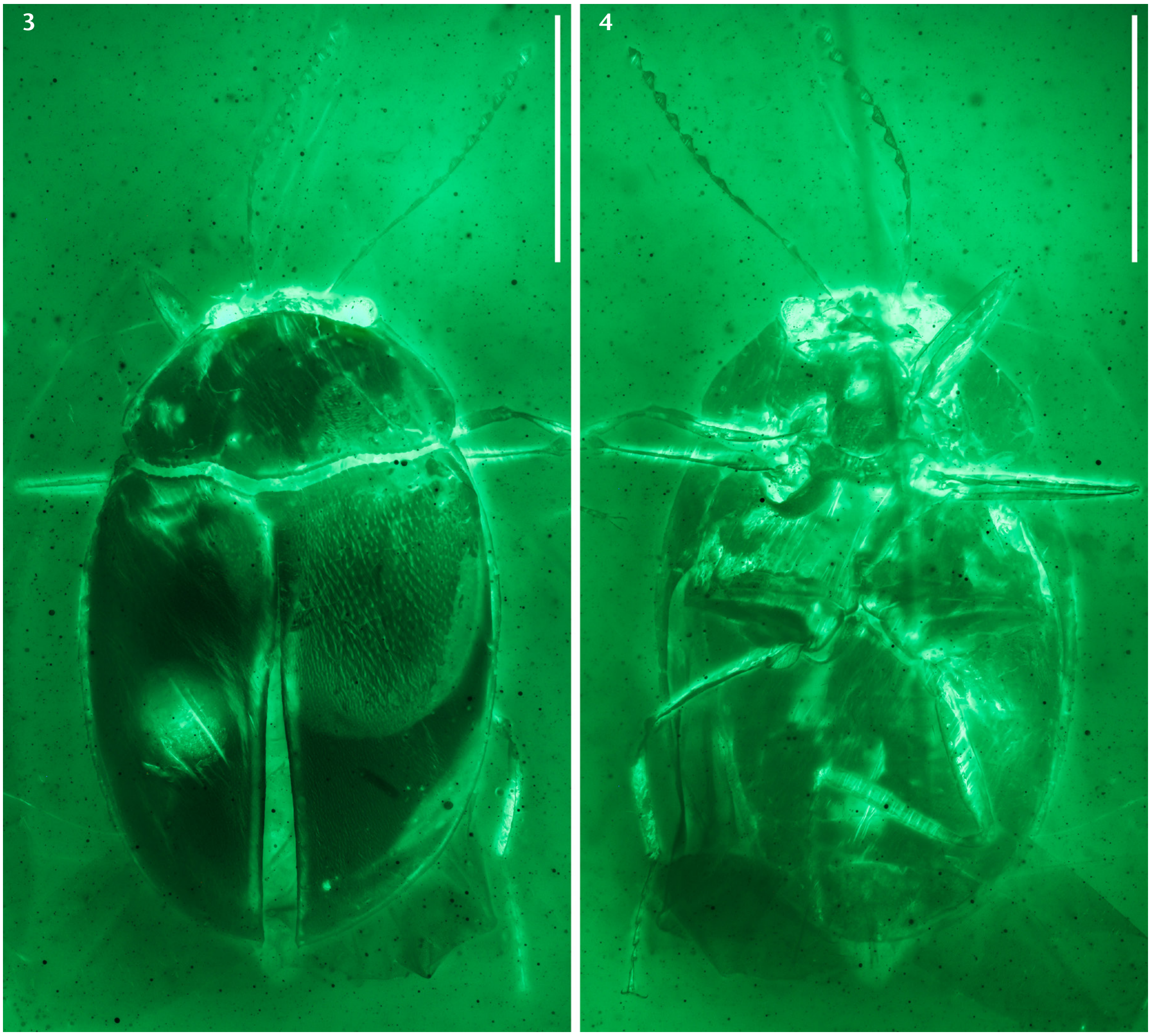
Locality and horizon. Amber mine located near Noije Bum Village, Tanai Township, Myitkyina District, Kachin State, Myanmar; unnamed horizon, mid-Cretaceous, Upper Albian to Lower Cenomanian.

Diagnosis. As for the genus.

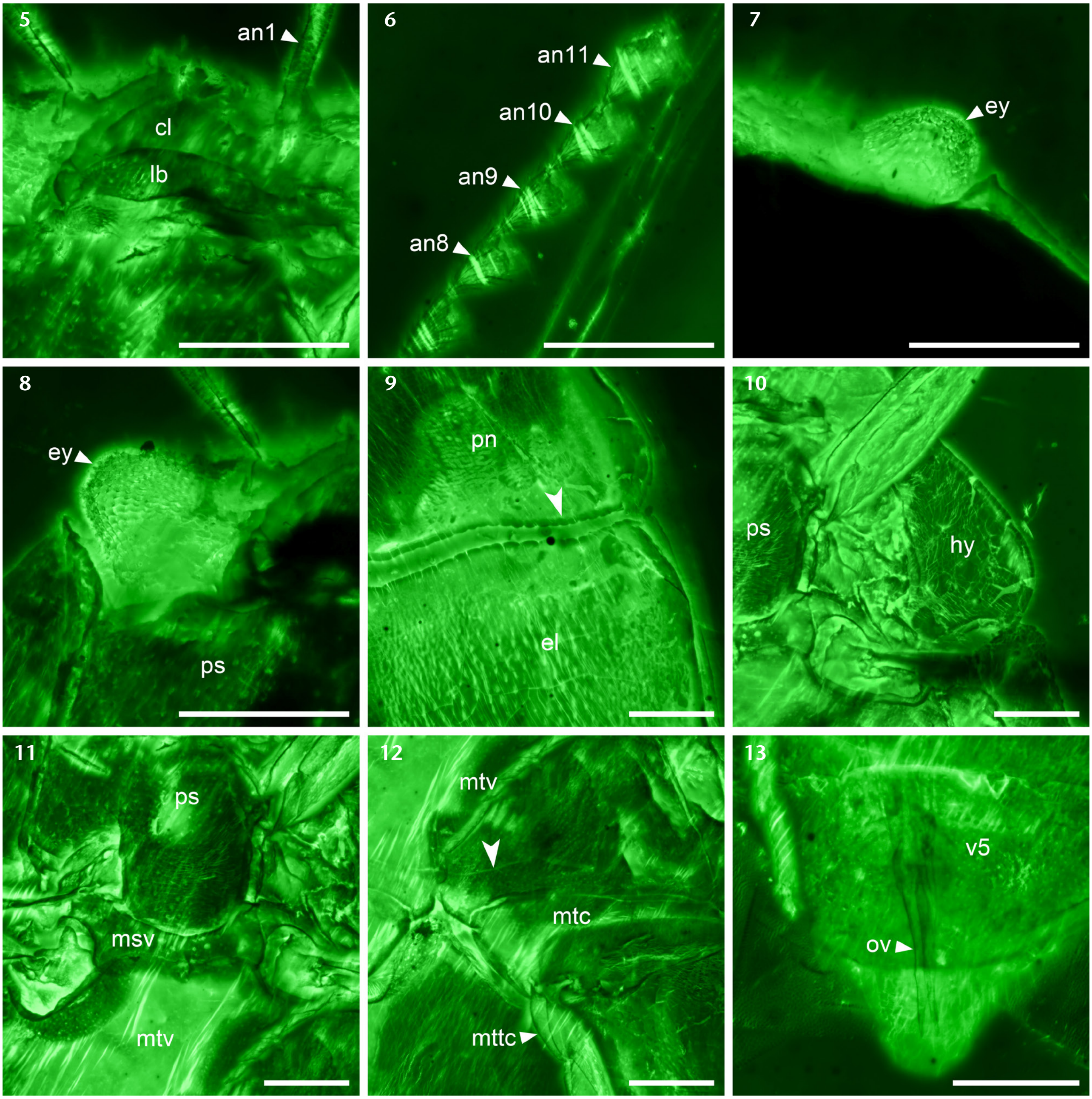
Description. Adult female. Body relatively wide, oval, 2.6 mm long, 1.7 mm wide.

Head hypognathous (Fig. 5), largely covered by pronotum, with anterior pronotal edges reaching compound eyes (Fig. 7). Frontoclypeal suture seemingly present (Fig. 5). Eyes separated by more than twice the width of single eye, without interfacetal setae (Figs 7, 8). Antennal insertion capsule closed. Antennae 11-segmented; antennomeres 1–3 slender and elongate; antennomeres 4–11 serrate (Fig. 6), with gradually increasing asymmetry from antennomeres 4 to 7.

Pronotum with sharp lateral edges; posterior pronotal angles rounded (Fig. 9); posterior pronotal margin bisinuate,



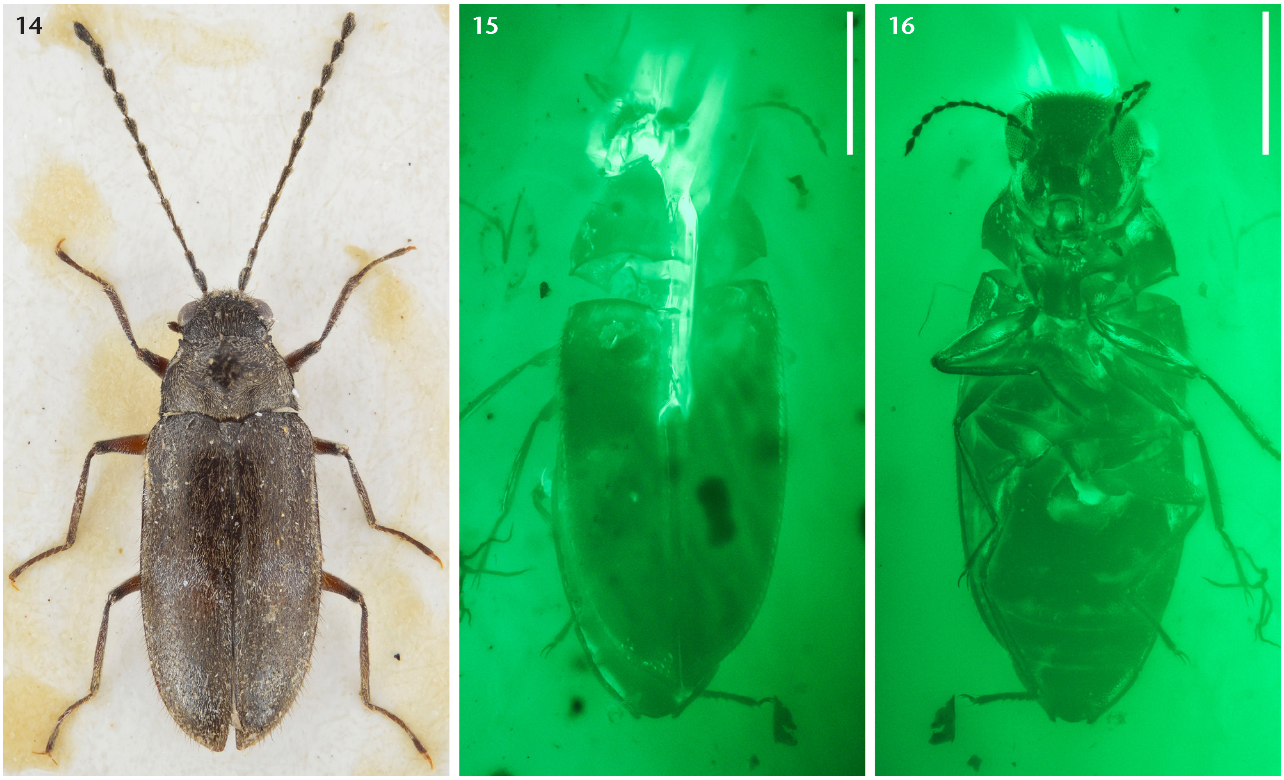
Figures 3–4. General habitus of *Anomocephalobus liuhaoi* gen. et sp. nov., holotype, NIGP177044, under widefield fluorescence: (3) dorsal view; (4) ventral view. Scale bars: 1 mm.



Figures 5–13. Details of *Anomocephalobus liuhaoi* gen. et sp. nov., holotype, NIGP177044, under confocal microscopy: (5) mouthparts, ventral view; (6) antenna, dorsal view; (7) compound eye, dorsal view; (8) compound eye, ventral view; (9) crenulate posterior pronotal margin (arrowhead), dorsal view; (10) pronotal hypomeron, ventral view; (11) mesothorax, ventral view; (12) metacoxa, ventral view; (13) ovipositor, ventral view. (an1–11) antennomeres 1–11, (cl) clypeus, (el) elytron, (ey) compound eye, (hy) hypomeron, (lb) labrum, (msv) mesoventrite, (mtc) metacoxa, (mttc) metatrochanter, (mtv) metaventrite, (ov) ovipositor, (pn) pronotum, (ps) prosternum, (v5) ventrite 5. Scale bars: 200 µm.

crenulate (Fig. 9). Prosternum in front of procoxae transverse; prosternal process parallel-sided, broad, distinctly wider than one third of maximum width of prosternum, apically rounded, fitting well into mesoventral cavity (Fig. 11). Hypomera without ridges and associated grooves for reception of fore legs (Fig. 10).

Scutellar shield triangular. Elytra widest near middle, gently arcuate in lateral margins; basal elytral margin crenulate (Fig. 9). Mesocoxal cavities circular, widely separated (Fig. 11).



Figures 14–16. Extant and extinct species of *Erichia*: (14) *Erichia longicornis* (= *Jaechobyrrhinus amanosius*), holotype of *Jaechobyrrhinus amanosius*, under incident light; (15–16) *Erichia cretacea*, holotype, CNU-COL-MA2018001, under widefield fluorescence. Scale bars: 500 µm.

Metaventrite with transverse suture; excavation for reception of mid legs absent (Fig. 12H). Metacoxae narrowly separated, transverse, without large metacoxal plates (Fig. 12).

Legs slender. Femora obliquely attached to trochanters; profemur excavated to receive protibia (Fig. 10). Tibiae as long as femora, without stout spines. Tarsal formula 5-5-5; tarsomeres 1–4 together longer than tarsomere 5. Pretarsal claws simple; empodium absent.

Abdomen with five ventrites. Excavation for reception of hind legs absent. Ratio of ventrite lengths along middle: 1.8:1.4:1.2:1.0:1.7. Ventrite 5 apically broadly rounded.

Etymology. The species is named after Hao Liu, who kindly shared with us helpful information about Burmese amber.

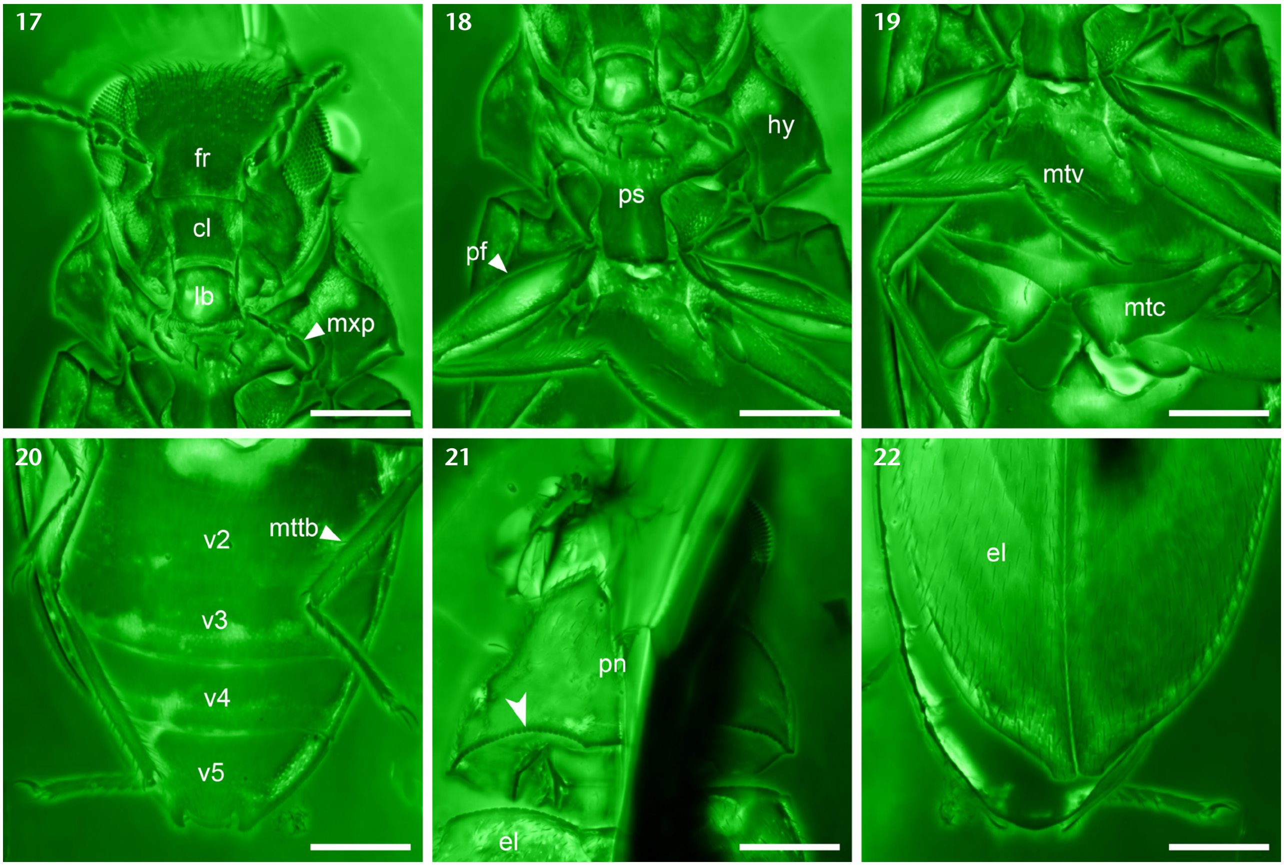
Remarks. The fossil was partially transparentized during the fossilization process (Figs 1, 2), making the ovipositor inside the body visible even under optical methods (Fig. 13), which is kind of unusual in Mesozoic fossils. The placement of the fossil in Dryopoidea (sensu Cai et al. 2022) seems to be well corroborated by this ovipositor, which, in fact, agrees remarkably well with that of *Cephallobyrrhus* (Yoshitomi 2019b).

## DISCUSSION

Although Lutrochidae + Dryopidae and Heteroceridae + Limnichidae have been revealed to be only distantly related by molecular evidence (McKenna et al. 2019), these four families share a superficial morphological similarity (Crowson 1978). *Anomocephalobus* can be differentiated from members of the other three families based on the following characters. Lutrochidae and Dryopidae are characterized by the presence of interfacetal setae on the compound eyes, and in Lutrochidae the interfacetal setae are quite dense. As in other families of Byrrhoidea sensu lato, including Limnichidae, no interfacetal setae are detected on either dorsal or ventral surface of the fossil (Figs 7, 8). In addition, *Anomocephalobus* differs from Lutrochidae by the long antennae, extending beyond the posterior margin of pronotum, and from Dryopidae by the unexpanded antennomeres 1 and 2. *Anomocephalobus* can be easily separated from Heteroceridae due to the lack of a series of heterocerid apomorphies, including the absence of lateral pronotal carinae, the absence of a connection between prosternal process and mesoventral cavity, and the fossorial legs (Costa et al. 1999).

Currently, Limnichidae are divided into four subfamilies, i.e., Hyphalinae, Thaumastodinae, Cephalobyrrhinae, and Limnichinae, although this classification might not be natural (Kundrata et al. 2017, I. Ribera, personal communication). *Anomocephalobus* could be easily separated from Hyphalinae and Thaumastodinae based on the metacoxae and protarsi. The metacoxae of *Anomocephalobus* are simply transverse and without large metacoxal plates (Fig. 12), whereas in Hyphalinae the metacoxae are small and ovoid (Britton 1971, Liu et al. 2020: fig. 12), and in Thaumastodinae the metacoxae are oblique and with well-developed metacoxal plates (Spilman 1959, Skelley 2005: fig. 3). The protarsi of *Anomocephalobus* are 5-segmented, whereas those of Hyphalinae and Thaumastodinae are 4-segmented. Concerning the remaining two subfamilies, *Anomocephalobus* shares a more similar general appearance with Limnichinae. Limnichines generally have an oval and distinctly convex body, while the cephalobyrrhines are more elongate and less convex (Satô 1966). However, in Limnichinae there are shallow grooves on the ventral surface for the reception of legs, and the hypomeron has a transverse or oblique ridge. In both *Anomocephalobus* and Cephalobyrrhinae, there are no grooves on the ventral surface for leg reception, and hypomeral ridges are absent (Figs 10, 18). Besides, the capsule for the insertion of the antennae is closed in *Anomocephalobus*, which is also in accordance with a Cephalobyrrhinae placement (see Pütz et al. 2004). Thus, *Anomocephalobus* is here tentatively placed in Cephalobyrrhinae. Aside from its oval body, *Anomocephalobus* can be differentiated from other Cephalobyrrhinae by the head being largely concealed by the pronotum and the posterior pronotal angles being rounded. *Anomocephalobus* is additionally unusual in having long and slender basal antennal segments, which is unknown in any other Limnichidae.

The cephalobyrrhine genus *Erichia* Reitter, 1895 includes one extant species, *Erichia longicornis* Reitter, 1895 (Fig. 14). Yu et al. (2018) described a new species from Burmese amber, which they assigned to this genus: *E. cretacea* (Figs 15–22). The type species of *Erichia* differs from the species of *Cephalobyrrhus* Pic, 1923 mainly by the pointed anterior and posterior pronotal corners (Jäch & Pütz 2001, Yoshitomi 2019b). Though the posterior pronotal corners of *E. cretacea* are somewhat pointed, the anterior corners are not. Besides, the antennae of *E. longicornis* are longer than half of the body length (fig. 2 in Pütz 1991 seems to be inaccurate in this respect), whereas the antennae



Figures 17–22. Details of *Erichia cretacea*, holotype, CNU-COL-MA2018001, under confocal microscopy: (17) head, ventral view; (18) pro- and mesothorax, ventral view; (19) metathorax, ventral view, showing the presence of median discrimen and katepisternal suture; (20) abdomen, ventral view; (21) prothorax, dorsal view, showing the crenulate posterior pronotal margin (arrowhead); (22) elytral apex, dorsal view. (cl) clypeus, (el) elytron, (fr) frons, (hy) hypomeron, (lb) labrum, (mtc) metacoxa, (mttb) metatibia, (mtv) metaventrite, (mxp) maxillary palp, (pf) profemur, (pn) pronotum, (ps) prosternum, (v2–5) ventrites 2–5. Scale bars: 200 µm.

of *E. cretacea* and (at least many) *Cephalobyrrhus* are distinctly shorter, not reaching half body length. However, since the internal relationships within Limnichidae are currently not well understood, we prefer not to propose any formal act regarding the generic placement of *E. cretacea* at this moment.

## ACKNOWLEDGEMENTS

We are grateful to Rong Huang (Institute of Soil Science, CAS, China) for technical help in confocal imaging, Hong Pang (Sun Yat-sen University, China) and Dong Ren (Capital Normal University, China) for help in arranging a loan of the holotype of *Erichia cretacea*, and Hiroyuki Yoshitomi (Ehime University, Japan) and Keita Matsumoto (Natural History Museum, London, UK) for help with the literature. Harald Schillhammer (Natural History Museum, Vienna, Austria) is thanked for the habitus photograph of *Erichia longicornis*. Thanks are also due to Carles Hernando (Badalona, Spain) and Ignacio Ribera (†) for sharing their knowledge about the subfamily classification of Limnichidae. Two anonymous reviewers provided helpful comments on an earlier version of this paper. Financial support was provided by the Second Tibetan Plateau Scientific Expedition and Research Project (2019QZKK0706), the Strategic Priority Research Program of the Chinese Academy of Sciences (XDB26000000), and the National Natural Science Foundation of China (41688103).

## LITERATURE CITED

Britton EB (1971) A new intertidal beetle (Coleoptera: Limnichidae) from the Great Barrier Reef. Journal of Entomology, Series B, Taxonomy 40: 83–91. https://doi.org/10.1111/j.1365-3113.1971.tb00108.x

Cai C, Tihelka E, Giacomelli M, Lawrence JF, Ślipiński A, Kundrata R, Yamamoto S, Thayer MK, Newton AF, Leschen RAB, Gimmel ML, Lü L, Engel MS, Bouchard P, Huang D, Pisani D, Donoghue PCJ (2022) Integrated phylogenomics and fossil data illuminate the evolution of beetles. Royal Society Open Science 9: 211771. https://doi.org/10.1098/rsos.211771

Costa C, Vanin SA, Ide S (1999) Systematics and bionomics of Cneoglossidae with a cladistic analysis of Byrrhoidea sensu Lawrence & Newton (1995) (Coleoptera, Elateriformia). Arquivos de Zoologia, São Paulo 35: 231–300.

Crowson RA (1978) Problems of phylogenetic relationships in Dryopoidea (Coleoptera). Entomologica Germanica 4: 250–257.

Fu Y-Z, Li Y-D, Su Y-T, Cai C-Y, Huang D-Y (2021) Application of confocal laser scanning microscopy to the study of amber bioinclusions. Palaeoentomology 4: 266–278. https://doi.org/10.11646/palaeoentomology.4.3.14

Hernando C, Ribera I (2016) Limnichidae Erichson, 1846. In: Beutel RG, Leschen RAB (Eds) Handbook of Zoology, Arthropoda: Insecta, Coleoptera, beetles. Walter de Gruyter, Berlin, vol. 1, 2nd ed., 605–612. https://doi.org/10.1515/9783110373929-022

Hernando C, Ribera I (2017) Three new species of the genus *Caccothryptus* Sharp, 1902 from Asia (Coleoptera: Limnichidae). Zootaxa 4243: 366–370. https://doi.org/10.11646/zootaxa.4243.2.5

Hernando C, Ribera I (2020) A new species of *Hyphalus* Britton, 1971 from the Mascarene Islands (Indian Ocean). Koleopterologische Rundschau 90: 243–252.

Hernando C, Szawaryn K, Ribera I (2018) A new species of *Platypelochares* from Baltic amber (Coleoptera: Limnichidae). Acta Entomologica Musei Nationalis Pragae 58: 17–20. https://doi.org/10.2478/aemnp-2018-0003

Jäch MA, Pütz A (2001) *Erichia* is a cephallobyrrhine limnichid! (Coleoptera Limnichidae). Bollettino della Società entomologica italiana 133: 195–197.

Kundrata R, Jäch MA, Bocak L (2017) Molecular phylogeny of the Byrrhoidea-Buprestoidea complex (Coleoptera, Elateriformia). Zoologica Scripta 46: 150–164. https://doi.org/10.1111/zsc.12196

Lawrence JF (1988) Rhinorhipidae, a new beetle family from Australia, with comments on the phylogeny of the Elateriformia. Invertebrate Systematics 2: 1–53. https://doi.org/10.1071/IT9880001

Liu Z-H, Jia F-L (2021) Descriptions of two new species of *Mexico* Spilman, 1972 from the Oriental region (Coleoptera: Limnichidae). Journal of Natural History 55: 909–920. https://doi.org/10.1080/00222933.2021.1931516

Liu Z-H, Xie Q, Jia F-L (2020) *Hyphalus shiyuensis* sp. nov. from Xisha Islands, China (Coleoptera, Limnichidae, Hyphalinae). ZooKeys 941: 91–99. https://doi.org/10.3897/zookeys.941.48873

Matsumoto K (2020) Description of new species of *Resachus* Delève, 1968 (Coleoptera: Limnichidae). Zootaxa 4852: 578–581. https://doi.org/10.11646/zootaxa.4852.5.6

Matsumoto K (2021a) A new species of *Byrrhinus* Motschulsky (Coleoptera: Limnichidae) from Côte d'Ivoire. The Coleopterists Bulletin 75: 56–58. https://doi.org/10.1649/0010-065X-75.1.56

Matsumoto K (2021b) Six new species of the genus *Caccothryptus* from the Himalayas (Coleoptera: Limnichidae). European Journal of Taxonomy 739: 168–184. https://doi.org/10.5852/ejt.2021.739.1275

McKenna DD, Shin S, Ahrens D, Balke M, Beza-Beza C, Clarke DJ, Donath A, Escalona HE, Friedrich F, Letsch H, Liu S, Maddison D, Mayer C, Misof B, Murin PJ, Niehuis O, Peters RS, Podsiadlowski L, Pohl H, Scully ED, Yan EV, Zhou X, Ślipiński A, Beutel RG (2019) The evolution and genomic basis of beetle diversity. Proceedings of the National Academy of Sciences 116: 24729–24737. https://doi.org/10.1073/pnas.1909655116

Pütz A (1991) *Jaechobyrrhinus* – eine neue Gattung der Familie Limnichidae aus der Türkei (Col., Limnichidae). Entomologische Nachrichten und Berichte 35: 132–134.

Pütz A, Hernando C, Ribera I (2004) A new genus of Limnichidae (Coleoptera) from Baltic amber. Insect Systematics & Evolution 35: 329–334. https://doi.org/10.1163/187631204788920257

Satô M (1966) The limnichid beetles of Japan. Transactions of the Shikoku Entomological Society 9: 55–62.

Skelley PE (2005) A new species of ‘jumping shore beetle’ in the genus *Mexico* Spilman from the Bahamas (Coleoptera: Limnichidae: Thaumastodinae). Insecta Mundi 19: 119–122.

Spilman TJ (1959) A study of the Thaumastodinae, with one new genus and two new species (Limnichidae). The Coleopterists’ Bulletin 13: 111–122.

Yoshitomi H (2019a) Review of the Asian Thaumastodinae (Coleoptera, Byrrhoidea, Limnichidae), with a phylogeny of the genera. European Journal of Taxonomy 583: 1–45. https://doi.org/10.5852/ejt.2019.583

Yoshitomi H (2019b) Revision of the genus *Cephalobyrrhus* of Japan and Taiwan (Coleoptera, Limnichidae). ZooKeys 817: 61–72. https://doi.org/10.3897/zookeys.817.31530

Yu Y, Ślipiński A, Ren D, Pang H (2018) The first fossil Limnichidae from the Upper Cretaceous Burmese amber (Coleoptera: Byrrhoidea). Annales Zoologici 68: 843–848. https://doi.org/10.3161/00034541ANZ2018.68.4.008

Zhang S-Q, Che L-H, Li Y, Liang D, Pang H, Ślipiński A, Zhang P (2018) Evolutionary history of Coleoptera revealed by extensive sampling of genes and species. Nature Communications 9: 205. https://doi.org/10.1038/s41467-017-02644-4

Submitted: October 10, 2021
Accepted: February 22, 2022
Editorial responsibility: Gabriel L.F. Mejdalani

**Author Contributions**

Y-DL and C-YC conceived the study. Y-DL acquired and processed the photomicrographs. Y-DL and C-YC drafted the manuscript, to which Y-LY and MAJ 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 are available in Zenodo repository (https://doi.org/10.5281/zenodo.5809388).

**How to cite this article**

Li Y-D, Yu Y-L, Jäch MA, Huang D-Y, Cai C-Y (2022) *Anomocephalobus*, a new genus of minute marsh-loving beetles from mid-Cretaceous Burmese amber (Coleoptera: Limnichidae). Zoologia (Curitiba) 39: e21030. https://doi.org/10.1590/S1984-4689.v39.e21030

**Published by**

Sociedade Brasileira de Zoologia at Scientific Electronic Library Online (https://www.scielo.br/zool)