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Short communication

A new species of *Cretodorus* (Hemiptera: Fulgoromorpha: Fulgoroidea: Mimarachnidae) from Upper Cretaceous amber of northern Myanmar

Xiao Zhang [a, *], Yunzhi Yao [b], Dong Ren [b], Hong Pang [a]

[a] State Key Laboratory of Biocontrol, School of Life Sciences/School of Ecology, Sun Yat-sen University, Guangzhou 510275, PR China
[b] College of Life Sciences and Academy for Multidisciplinary Studies, Capital Normal University, Xisanhuanbeilu 105, Haidian District, Beijing 100048, PR China

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ABSTRACT

A new species of Mimarachnidae, *Cretodorus rostellatus* sp. nov., with well-preserved male genitalia is described from the Upper Cretaceous (lowermost Cenomanian) Burmese amber. Diagnostic features of the genus *Cretodorus* are reviewed. The paedomorphic nature of this family are discussed, including sensory pits, median carinae, tarsal segment.

1. Introduction

Mimarachnidae, a small extinct family in Fulgoroidea, which were regarded as member of the 'cixiidae-like' planthoppers (an informal group comprises some extinct and extant families similar to Cixiidae, such as Delphacidae, Kinnaridae, etc.), and characterized by mesonotum with double median carinae, tegmina with simplified longitudinal venation and irregular meshwork veinlets, basal cell weak or absent (Brysz and Szwedo, 2019). Besides that, this family also have shown amazing morphological peculiarities, such as spider mimic or camouflaged configuration (Shcherbakov, 2007; Jiang et al., 2019), extremely long rostrum and head (Shcherbakov, 2017; Zhang et al., 2018), and giant size (Jiang et al., 2018).

Hitherto, this family have only been reported in the Cretaceous Eurasia, containing 12 genera and 17 species. *Mimarachne mikhailovi* Shcherbakov, 2007 and *Saltissus eskovi* Shcherbakov, 2007 from the Lower Cretaceous (145–125 Ma) Baissa in Russia; *Nipponoridium matsuoi* (Fujiyama, 1978) from the Lower Cretaceous (140–120 Ma) Kuwajima in Japan (Szwedo, 2008); *Mimamontsecia cretacea* Szwedo and Ansorge, 2015 and *Chalicoridulum montsecensis* Szwedo and Ansorge, 2015 from the Lower Cretaceous (130.0–125.5 Ma) north-eastern Spain. The remaining majority species are from Upper Cretaceous (98.79 ± 0.62 Ma) Burmese amber: *Burmissus latimaculatus* Fu and Huang, 2020, *Burmissus raunoi* Shcherbakov, 2017, *Burmissus szwedoi* Luo et al., 2020, *Dachibangus formosus* Fu et al., 2019, *Dachibangus trimaculatus* Jiang et al., 2018, *Jaculistilus oligotrichus* Zhang et al., 2018, *Mimaplax ekrypsan* Jiang et al., 2019, *Ayaimatum minutum* Fu and Huang, 2021, *Ayaimatum trilobatum* Jiang and Szwedo, 2020, *Cretodorus angustus* Fu and Huang, 2020, *Cretodorus granulatus* Fu and Huang, 2020 and *Mimaeurypterus burmiticus* Fu and Huang, 2021. Besides that, some undescribed specimens assigned to this family were reported from the Lower Cretaceous Mongolia, central and east Siberia, Upper Cretaceous Kazakhstan (Shcherbakov, 2007; Luo et al., 2020).

Herein we describe a new species of Mimarachnidae, *Cretodorus rostellatus* sp. nov., based on one specimen collected from the Upper Cretaceous northern Myanmar, providing more morphological characters evidence: the clear and complete male genitalia, retained sensory pits, pronotum and mesonotum with double median carinae, fore and mid tarsi two-segmented.

* Corresponding author.
E-mail address: zhangxiaofossil@163.com (X. Zhang).

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2. Materials and methods

This study is based on a specimen from Myanmar amber, the material comes from the amber deposits Kachin (Hukawng Valley) in northern Myanmar. Grimaldi et al. (2002: Fig. 1) gave the Hukawng Valley map. The age of Burmese amber was estimated to be 98.79 ± 0.62 Ma (earliest Cenomanian) (Shi et al., 2012). The specimen studied in this paper is housed in the Key Laboratory of Insect Evolution and Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Yunzhi Yao, Curator).

The specimen was examined and photographs were taken using Nikon SMZ 25 microscope with a Nikon DS-Ri 2 digital camera system. The line drawings were prepared with Adobe Illustrator CS6 and Adobe Photoshop CC graphics software. The wing venational nomenclature is based on Bourgoin et al. (2015). Measurements are given in millimeters (mm).

3. Systematic palaeontology

Order Hemiptera Linnaeus, 1758
Suborder Fulgoromorpha Evans, 1946
Superfamily Fulgoroidea Latreille, 1807
Family Mimarachnidae Shcherbakov, 2007

Key to genera of Mimarachnidae of Burmese amber

1. MP with no fewer than four terminals……..…2
   MP with fewer than four terminals…..……..……3.
2. CuA_2 curved mediad at level of tornus, tornus distinct, tegmen with three black spots……
   ……*Dachibangus* Jiang, Szwedo and Wang, 2018
   CuA_2 nearly straight, posterior margin straight, tegmen with two black spots……*Jaculistilus* Zhang, Ren and Yao, 2018.
3. Tegmen coriaceous, mesonotum with median carinae not reaching anterior margin……
   …..……..……*Mimaeurypterus* Fu and Huang, 2021
   Tegmen membranous, mesonotum with median carinae reaching anterior margin 4.
4. pronotum protruded anteriorly, MP unbranched……
   ……*Cretodorus* Fu and Huang, 2020
   pronotum not protruded anteriorly, MP branched……..…..…5.
5. Tegmen costal margin sinuate, costal cell broad, pronotum and mesonotum with strongly elevated, cristate median carinae……*Mimaplax* Jiang, Szwedo and Wang, 2019
   Tegmen costal margin almost straight, costal cell narrow, pronotum and mesonotum median carinae not cristate……6.
6. Head with trigons not visible from above, rostrum extending to metacoxa, CuA forked slightly basad of claval veins Pcu and A1 junction……*Ayaimatum* Jiang and Szwedo, 2020
   Head with trigons visible from above, rostrum extending far beyond metacoxa, CuA forked apicad of claval veins Pcu and A1 junction……..…..……..……*Burmissus* Shcherbakov, 2017.

Key to species of* Cretodorus *from Burmese amber

1. Pronotum and mesonotum without granules, postcostal cell and radial cell as wide as cell C1, hind wing ScP + R forked, metatibio-metatarsal formula 6: 6: 6……
   …..……..……*C. angustus* Fu and Huang, 2020
   Pronotum and mesonotum with granules, postcostal cell and radial cell wider than cell C1, hind wing ScP + R single, metatibio-metatarsal formula 5: 5: 5……..……..……2.
2. Rostrum reaching slightly beyond hind coxae, the lenghth of Pcu more than twice of Pcu + A1 common stalk, pygofer lobes extending not beyond anal tube……
   ……*C. rostellatus* Zhang, Yao and Pang, sp. nov.
   Rostrum reaching beyond tips of tegmina, the lenghth of Pcu twice as long as Pcu + A1 common stalk, pygofer lobes extending beyond anal tube……..……
   ……..……..……*C. granulatus* Fu and Huang, 2020.

Genus *Cretodorus* Fu and Huang, 2020
Type species: *Cretodorus granulatus* Fu and Huang, 2020; by original designation.

Diagnostic characters (revised based on Fu and Huang, 2020). Head moderately elongate, acutely angled in middle; rostrum long, apex at least exceeding metacoxae; pronotum protruded anteriorly, lateral carinae nearly parallel to each other; pronotum and mesonotum sometimes with many rounded granules; tegmina longitudinal veins straight, nearly parallel to each other, branch ScP + RA, RP and MP single, tornus indistinctive.

Cretodorus rostellatus Zhang, Yao and Pang, sp. nov. (Figs. 1–4).
http://zoobank.org/E60D8523-88EE-4F0C-AADF-F2893554C78A.

Etymology. The specific name is from the Latin word 'rostellatus' meaning 'small rostrum', referring to its shorter rostrum.
Type material. Holotype, CNU-HOM-MA2020001, adult male, a well-preserved specimen, but part head and left tegmen absent.
Locality and horizon. From Hukawng Valley, Kachin State, northern Myanmar; lowermost Cenomanian (98.79 ± 0.62 Ma, Upper Cretaceous).
Diagnosis. Rostrum reaching slightly beyond hind coxae (not preserved in *C. angustus*; beyond tips of tegmina in *C. granulatus*); pronotum and mesonotum with granules (as in *C. granulatus*; without granules in *C. angustus*); postcostal cell and radial cell wider than cell C1 (as in *C. granulatus*; as wide as cell C1 in *C. angustus*); Pcu and A_1 fused basad of wing mid length and CuA fork (as in *C. granulatus*; apicad of wing mid length and CuA fork in *C. angustus*); the lenghth of Pcu more than twice of Pcu + A_1 common stalk (as in *C. angustus*; twice as long as Pcu + A_1 common stalk in *C. granulatus*); hind wing ScP + R single (as in *C. granulatus*; forked in *C. angustus*); metatibio-metatarsal formula 5: 5: 5 (as in *C. granulatus*; 6: 6: 6 in *C. angustus*); pygofer lobes extending not beyond anal tube (not preserved in *C. angustus*; beyond anal tube in *C. granulatus*).
Remarks. The new species can be assigned to *Cretodorus* Fu and Huang, 2020 primarily by the combination of characters: rostrum apex exceeding metacoxae, pronotum lateral carinae nearly parallel to each other, pronotum and mesonotum with granules, tegmina longitudinal veins nearly parallel to each other, ScP + RA, RP and MP unbranched.
Description. A well-preserved male specimen, but head and left wings partly preserved, total length of the insect about 8.09 mm.
Head. Head incomplete, preserved head including compound eyes about 1.02 mm wide, length of preserved head nearly as long as pronotum in mid line, vertex projecting beyond eyes, vertex punctate, without median carina, lateral margins slightly converging anteriorly. Frons narrow, lateral margin carinate, median carina present and faint, marginal carinae of the frons extending to clypeus, postclypeus median carina absent, widest point of clypeus at clypeal suture, rostrum long, reaching slightly beyond hind coxae (Fig. 1D). Compound eyes large and bulging. Antennae scapus subcylindrical; pedicel subconical, longer than wide; flagellum bristle-like, base bulbous.
Thorax (Figs. 2A, 4C). Pronotum punctate, length slightly shorter than mesonotum in mid line, with many irregularly arranged granules, pronotum central disc elevated, anterior margin almost straight, posterior margin shallowly incised in median portion,

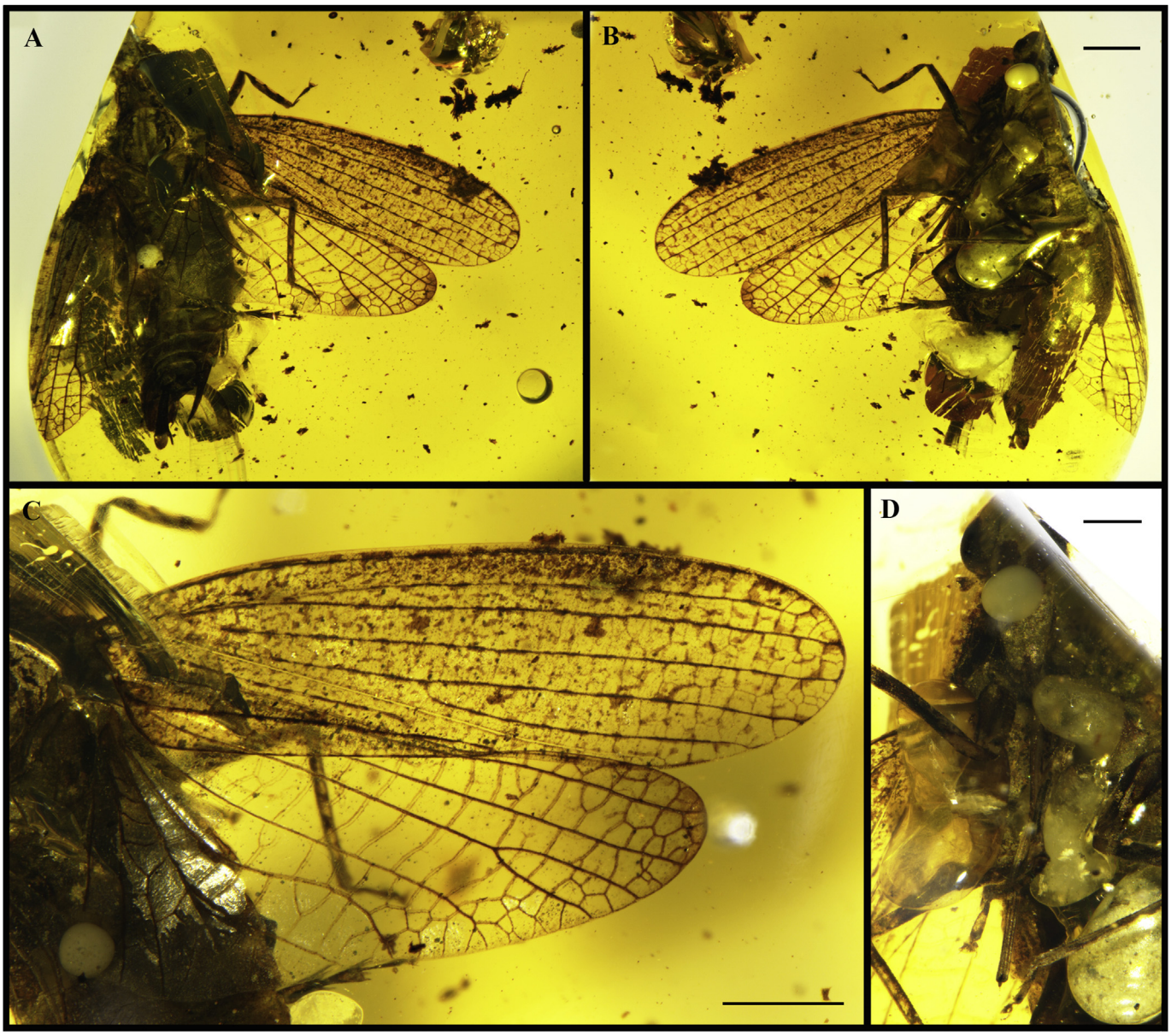

Fig. 1. Holotype (CNU-HOM-MA2020001) of *Cretodorus rostellatus* sp. nov. A, Photograph habitus in dorsal view. B, Photograph habitus in ventral view. C, Wings in dorsal view. D, Head and rostrum in ventral view. Scale bars for A-C = 1 mm; D = 0.5 mm. The scale bar of B is also valid for A.

double median carinae present throughout, slightly converging mediad, lateral carinae straight and parallel. Mesonotum punctate, slightly wider than long in mid line, with two sets of small granules arranged in triangle between the median and lateral carinae, median carinae paired and parallel, reaching anterior margin, lateral carinae distinct and sinuate, converging with anterior margin and posterior margin, scutellum transversely wrinkled. Tegula large and punctate, subtriangular, distinctly carinate.

Wings. Wings membranous. Tegmen (Figs. 1C, 4A) mottled, 6.18 mm long, 1.84 mm wide, about 3.4 times as long as wide, with irregular meshwork veinlets, forming polygonal cells, especially obvious in the distal section, costal margin mildly arched at base, then straight, apical margin round, posterior margin almost straight, arculus invisible, costal area long and narrow, with several dark bands, narrowing toward wing apex, Pc + CP submerged to margin at 0.87 of wing length, common stem ScP + R + M nearly as long as common stem ScP + R, ScP + RA not forked, posterior portion curved upward to apical margin, RP almost straight, single, subparallel to costal margin and branch ScP + RA, MP straight and simple, CuA forked before half of tegmen length, with two terminals, CuA_1 almost straight, CuA_2 strongly curved at base, CuP present throughout tegmen, clavus open, claval apex reaching tegmen apical third, Pcu and A_1 fused proximad of wing mid length. Narrow marginal membrane present.

Hind wing (Figs. 1C, 4B) membranous, 5.12 mm long, 2.76 mm wide, slightly shorter than tegmen, with irregular meshwork veinlets, forming polygonal cells, bigger than the cells of tegmen, costal margin sinuate, apical margin round, ScP + R not forked, slightly sinuate, close to costal margin, MP simple and straight, the bifurcation of CuA at distal half, reaching margin with two terminals,

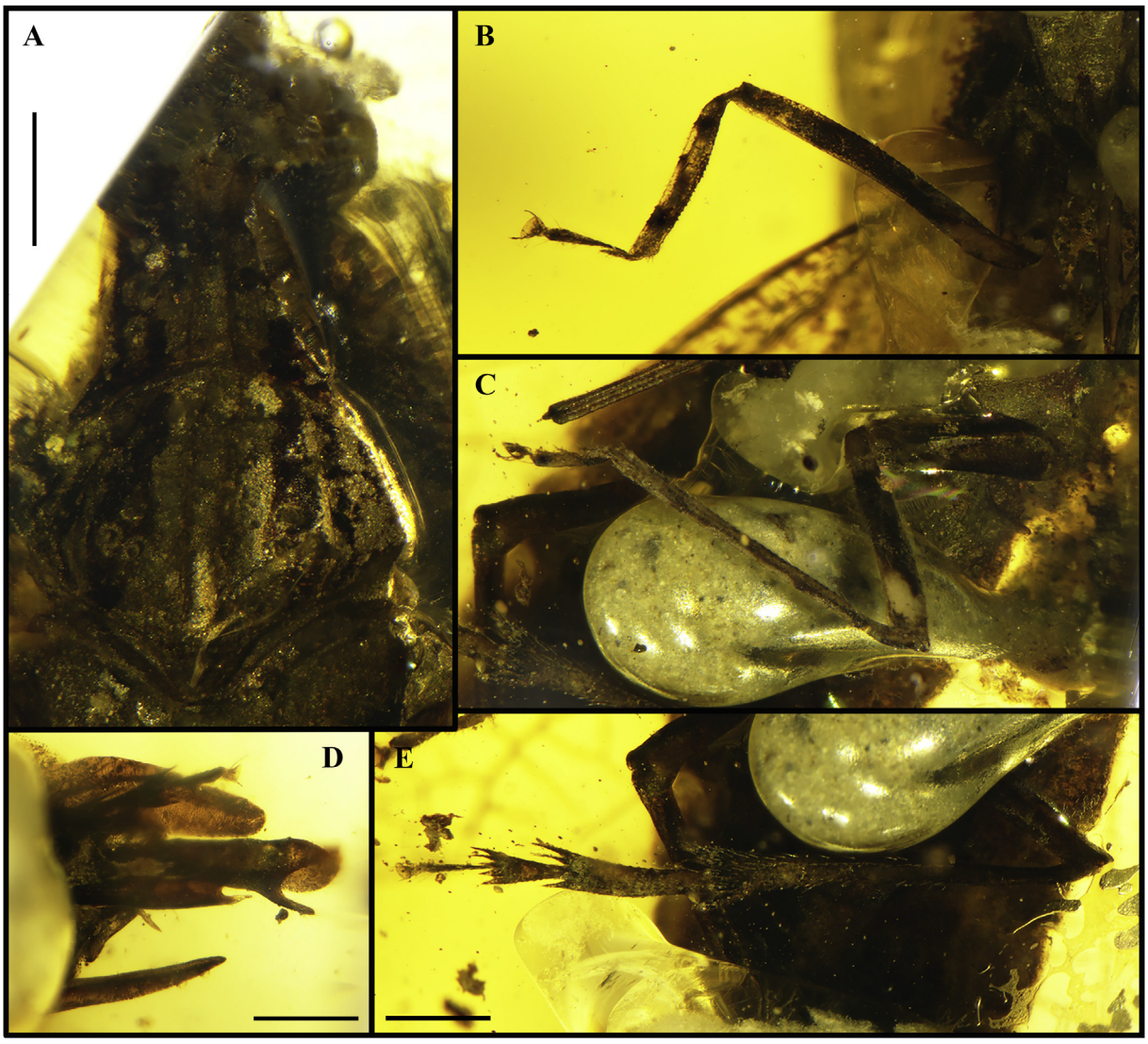

Fig. 2. Detailed photographs of *Cretodorus rostellatus* sp. nov. (CNU-HOM-MA2020001). A, Pronotum and mesonotum. B, Fore leg. C, Mid leg. D, Male terminalia in ventral view. E, Hind Leg. Scale bars = 0.5 mm. The scale bar of E is also valid for B and C.

CuP slightly sinuous, Pcu strongly curved to wing margin, vein A_1 forked, giving off two branches, vein A_2 forked, with two terminals, A_1 anastomosing with A_2.

Legs. Fore leg (Figs. 2B, 4D) 4.03 mm long, covered with short setae; coxa carinate and elongate; fore femur elongate and dilated, almost twice as long as fore tibia; fore tibia carinate, irregular dark color bands present, margins with rows of short setae; fore tarsi two-segmented, basitarsomere short and wedge-shaped, apical tarsomere distinctly longer than basitarsomere, length of fore tarsomeres: I 0.19 mm, II 0.40 mm, the plantar surfaces of basitarsomere and apical tarsomere with brush of setae; tarsal claws hooked, arolium developed. Mid leg (Figs. 2C, 4E) 4.16 mm long, covered with short setae; coxa elongate and carinate, mid coxa slightly shorter than mid femur; mid femur dilated and flattened, shorter than mid tibia; mid tibia simple and carinate, irregular dark color bands present; mid tarsi two-segmented, as in fore leg, length of mid tarsomeres: I 0.17 mm, II 0.39 mm, the plantar surfaces of basitarsomere and apical tarsomere with brush of setae; tarsal claws hooked, arolium developed. Hind leg (Figs. 2E, 4F) slender, covered with short setae; hind femur about 0.89 mm long, shorter than hind tibia, slightly flattened; hind tibia about 2.05 mm long, carinate, with rows of short setae along, widened apically, with a row of five apical teeth; hind tarsi three-segmented, basitarsomere longest, 0.91 mm long, with five apical teeth, basitarsomere slightly longer than mid and apical tarsomeres combined, midtarsomere 0.45 mm long, with five apical teeth, apical tarsomere 0.34 mm long, thin; tarsal claws and arolium small. The two lateroapical teeth of hind tibia and tarsi without subapical setae, median teeth with subapical setae.

Abdomen. Abdomen (Fig. 1A) flattened, continually narrowing distad, not reaching tegmina tips, broadest at the fourth segment. Male terminalia (Figs. 2D, 3A, B, C, D) with two symmetrical lobes, pygofer lobes broad and carinate; anal collar present; anal tube distinctly elongate, with setae apically, apex of anal tube concave; anal styles protruding and ligulate, covered with short setae; gonostyli bilaterally symmetrical, extended to each side of anal tube separately, bilobate in apical portion; lamina gonostyli sclerified, with a pair of hook-like process directed posterolaterally, aedeagus robust and elongate, not reaching anal style apex apically.

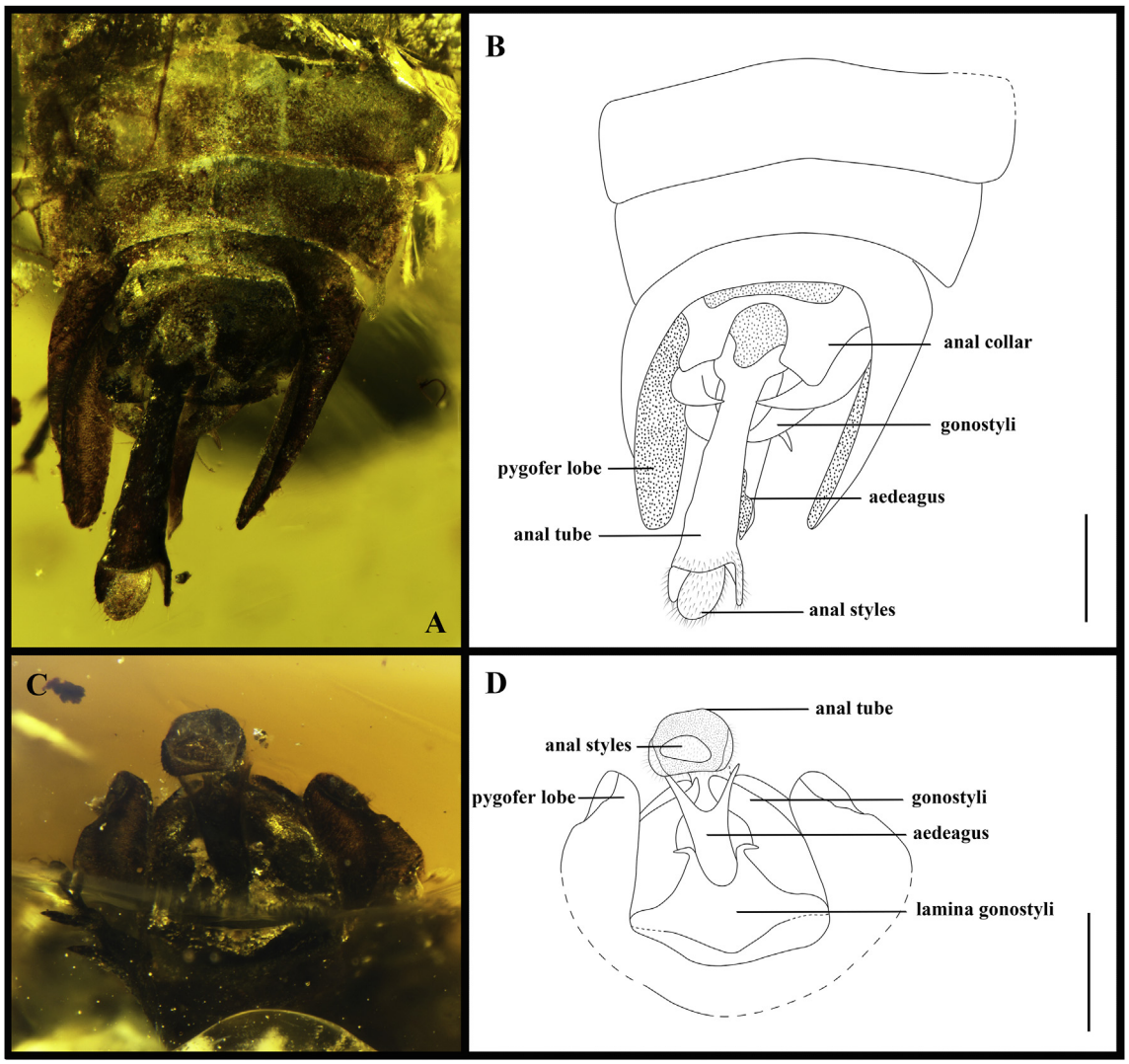

Fig. 3. Male terminalia of *Cretodorus rostellatus* sp. nov. (CNU-HOM-MA2020001). A, Photograph in dorsal view. B, Line drawing in dorsal view. C, Photograph in posteroventral view. D, Line drawing in posteroventral view. Scale bars = 0.5 mm. The scale bar of B is also valid for A; D is valid for C.

4. Discussion

For the Cretaceous Mimarachinidae, the male genital characters are striking, such as the well developed pygofer lobes, the strangely shaped and extended gonostyli, anal collar present, and the developed lamina gonostyli. In comparison, other known representatives of Fulgoroidea have no such developed pygofer lobes and gonostyli, anal collar usually absent, and lamina gonostyli is generally present in Tettigometridae. The potential phylogenetic or functional value of these structures remain unclear.

Fulgoroidea are incomplete metamorphosis insects whose nymphs are similar to adults, but many features of the nymphs at different developmental stages are obviously different from the adults. For example, sensory pits are specific organs of the nymphs, but usually disappear in the adults (Emeljanov, 2001; Zhang et al., 2017); median carination of pronotum and mesonotum is generally separated by the ecdysial line at nymphal stages, while only a single median carina present in most adults (Yang and Yeh, 1994; Emeljanov, 1996, 2001; Szwedo and Ansorge, 2015; Shcherbakov, 2017); the leg tarsi are two-segmented in early nymphal instars, but become three-segmented in late nymphal intars or the adults (Zhou et al., 1985).

Adults of planthopper species during the late Mesozoic still have some ancestral traits similar to the nymphs. For example, adults of Mimarachinidae have small and dense sensory pits cover the head and thorax, and even the tegula; pronotum and mesonotum with two median carinae. These features were treated as neotenic characters, retained in the adults of Mimarachnidae (Szwedo and Ansorge, 2015; Shcherbakov, 2017; Jiang et al., 2018). In the new species *Cretodorus rostellatus* sp. nov., the fore and mid tarsi are two-segmented, but hind tarsi has three segments. This tarsal formula was also reported from *Jaculistilus oligotrichus* (re-examined), *Mimaplax ekrypsan* and *Ayaimatum minutum*. Therefore, in Mimarachinidae, the two-segmented fore and mid tarsi may represent another nymphal feature retained by the adults. The different number of fore, mid and hind tarsi also indicates that the evolutionary rates of tarsal segmentation varied in Mimarachinidae.

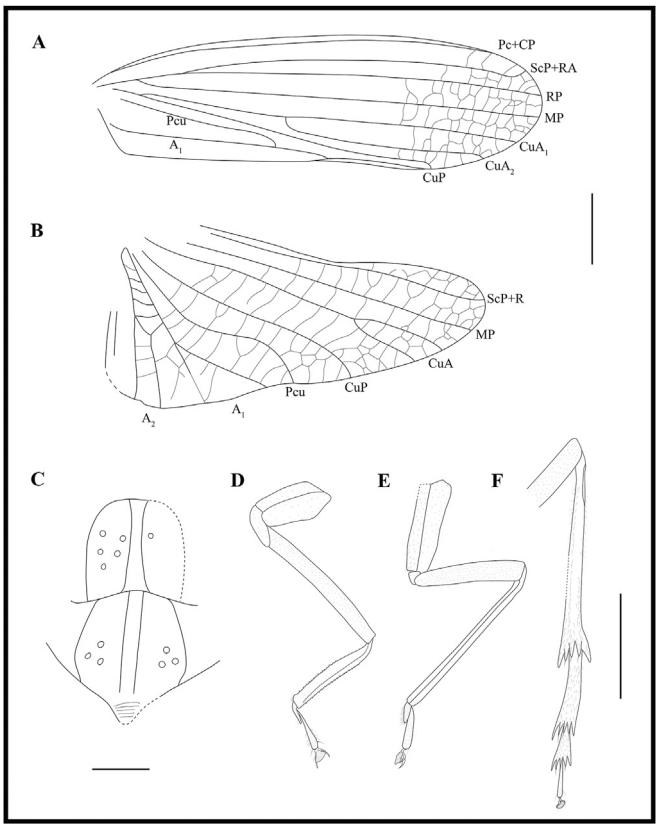

Fig. 4. Line drawings of *Cretodorus rostellatus* sp. nov. A, Forewing. B, Hind wing. C, Pronotum and mesonotum. D, Fore leg. E, Mid leg. F, Hind leg. Scale bar for A-B = 1 mm; C = 0.5 mm; D-F = 1 mm. The scale bar of B is also valid for A; F is valid for D and E.

5. Conclusions

The third species of *Cretodorus* in Mimarachinidae, *Cretodorus rostellatus* sp. nov., from Upper Cretaceous (lowermost Cenomanian) amber of northern Myanmar is documented. The new specimen, the first one with clearly preserved male genitalia, provides important information on the morphology of the Mesozoic planthoppers. The two-segmented fore and mid tarsi in Mimarachinidae could result from neoteny, and the tarsal segmentation should have undergone different evolutionary rates.

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