

## Short communication

A new species of *Burmissus* (Hemiptera: Fulgoromorpha: Mimarachnidae) from mid-Cretaceous Burmese amberCihang Luo <sup>a, b</sup>, Tian Jiang <sup>c</sup>, Bo Wang <sup>b</sup>, Chuantao Xiao <sup>a, \*</sup><sup>a</sup> School of GeoSciences, Yangtze University, Wuhan, 430100, Hubei, China<sup>b</sup> State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology and Center for Excellence in Life and Palaeoenvironment, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing, 210008, China<sup>c</sup> China University of Geosciences (Beijing), Beijing, 100083, China

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## ABSTRACT

The eleventh species of Mimarachnidae and the second species of *Burmissus* is herein described from mid-Cretaceous Kachin amber. *Burmissus szwedoi* sp. nov. can be distinguished from the type species *Burmissus raunoi* Shcherbakov, 2017 by the number of carinae of the mesonotum, tegmen pattern and different broadest portion of the tegmen. Diagnostic features of the genus *Burmissus* are reviewed. The phylogeny of Mimarachnidae is discussed.

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## 1. Introduction

The order Hemiptera contains the biggest number of families among any insects, with more than three hundred extant and extinct known families inhabiting all terrestrial and some marine habitats (Szwedo, 2018). Fulgoromorpha (Planthoppers) is a sub-order of the Hemiptera and subdivided into three superfamilies: two extinct superfamilies – Permian Coleoscytoidea Martynov, 1935, Permian and Triassic Surjokocixioidea Shcherbakov, 2000 – and another superfamily Fulgoroidea Latreille, 1807, known in fossil records since the Jurassic (Szwedo, 2018). Up to now, various species of Fulgoromorpha have been described from mid-Cretaceous Burmese amber (Ross, 2019), including species from two extant planthoppers families: Achilidae Stål, 1866 and Cixiidae Spinola, 1839 (Cockerell, 1917; Szwedo, 2004; Brysz and Szwedo, 2018) and five extinct families: Dorytocidae Emeljanov et Shcherbakov, 2018 (Emeljanov and Shcherbakov, 2018), Jubisentidae Zhang, Ren et Yao, 2019 (Zhang et al., 2019), Mimarachnidae Shcherbakov, 2007b (Shcherbakov, 2007b), Perforissidae

Shcherbakov, 2007a (Shcherbakov, 2007a; Zhang et al., 2017), and Yetkhatidae Song, Szwedo et Bourgoin (2019) (Song et al., 2019).

The extinct Fulgoromorpha family Mimarachnidae was placed in the group of 'cixiidae-like' planthoppers (Bourgoin and Szwedo, 2008; Szwedo and Ansoerge, 2015), including 9 genera and 10 species at present (Bourgoin, 2019): *Mimarachne mikhailovi* Shcherbakov, 2007b and *Saltissus eskovi* Shcherbakov, 2007b from Early Cretaceous deposits (ca. 145–125 Ma) in Baissa, Transbaikalia, Russia (Shcherbakov, 2007b); *Nipponoridium matsuoii* Fujiyama, 1978 from early Cretaceous (ca. 140–120 Ma) Kaseki-kabe locality in Kuwajima, Japan (Szwedo, 2008); *Mimamontsecia cretacea* Szwedo et Ansoerge, 2015 and *Chalcoridulum montsecensis* Szwedo et Ansoerge, 2015 from Sierra del Montsec (Szwedo and Ansoerge, 2015), north-eastern Spain of early Barremian (ca. 130.0–125.5 Ma) age; *Burmissus raunoi* Shcherbakov, 2017, *Dachibangus trimaculatus* Jiang, Szwedo et Wang, 2018, *Jaculistilus oligotrichus* Zhang, Ren et Yao, 2018, *Dachibangus formosus* Fu, Szwedo, Azar et Huang, 2019 and *Mimaplax ekrypsan* Jiang, Szwedo et Wang, 2019 from mid-Cretaceous Burmese amber (Shcherbakov, 2017; Jiang et al., 2018; Zhang et al., 2018; Fu et al., 2019; Jiang et al., 2019). Some undescribed specimens are also known from localities like Turga (central Siberia) of early Cretaceous, Khurilt (Mongolia) of Barremian or Aptian, Khetana (East Siberia) of middle Albian, and

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Kzyl-Zhar Hill (Kazakhstan) of Turonian (Shcherbakov, 2007b, 2017; Jiang et al., 2018, 2019).

Herein we describe a new species of Mimarachnidae, *Burmissus szwedoi* sp. nov., from mid-Cretaceous Burmese amber.

## 2. Material and methods

The studied specimen comes from the Cretaceous amber deposits in Hukawng Valley of Myanmar. The mining area is located at Noije Bum, close to Tanai township (26°21'33.41" N, 96°43'11.88" E; palaeolatitude  $5.0 \pm 4.7^\circ$  S) (Kania et al., 2015; Thu and Zaw, 2017; Westerweel et al., 2019; see locality in Fig. 1 of Chen et al., 2019), which is the main source of amber in the country until 2017. Radiometric U–Pb zircon dating from the volcanoclastic matrix attached the amber provided a refined age of  $98.79 \pm 0.62$  Ma (earliest Cenomanian) (Shi et al., 2012), but slightly older age was proposed (late Albian by Zheng et al., 2018; Albian-Cenomanian

boundary by Rasnitsyn et al., 2016). The Burmese amber preserve the most diverse Cretaceous biota, including plants, arthropods, bivalves, ammonites, reptiles, and even birds and dinosaurs (Grimaldi et al., 2002; Xing et al., 2016; Guo et al., 2017; Smith and Ross, 2018; Yu et al., 2019). They are the ideal materials for studying the Cretaceous Terrestrial Revolution, which is marked by the radiation of angiosperms, social insects, and early mammals (Jiang et al., 2018).

Observations were performed using a Zeiss Stemi 508 microscope. The photographs were taken with a Zeiss Stereo Discovery V16 microscope system, in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, and measurements were taken using Zen software. Photomicrographic composites of more than 30 individual focal planes were digitally stacked as obtained using the software HeliconFocus 6.7.1 for a better illustration of 3D structures. Because of the amber thickness, some of the pictures were taken when ambers' surface covered by a sugary liquid

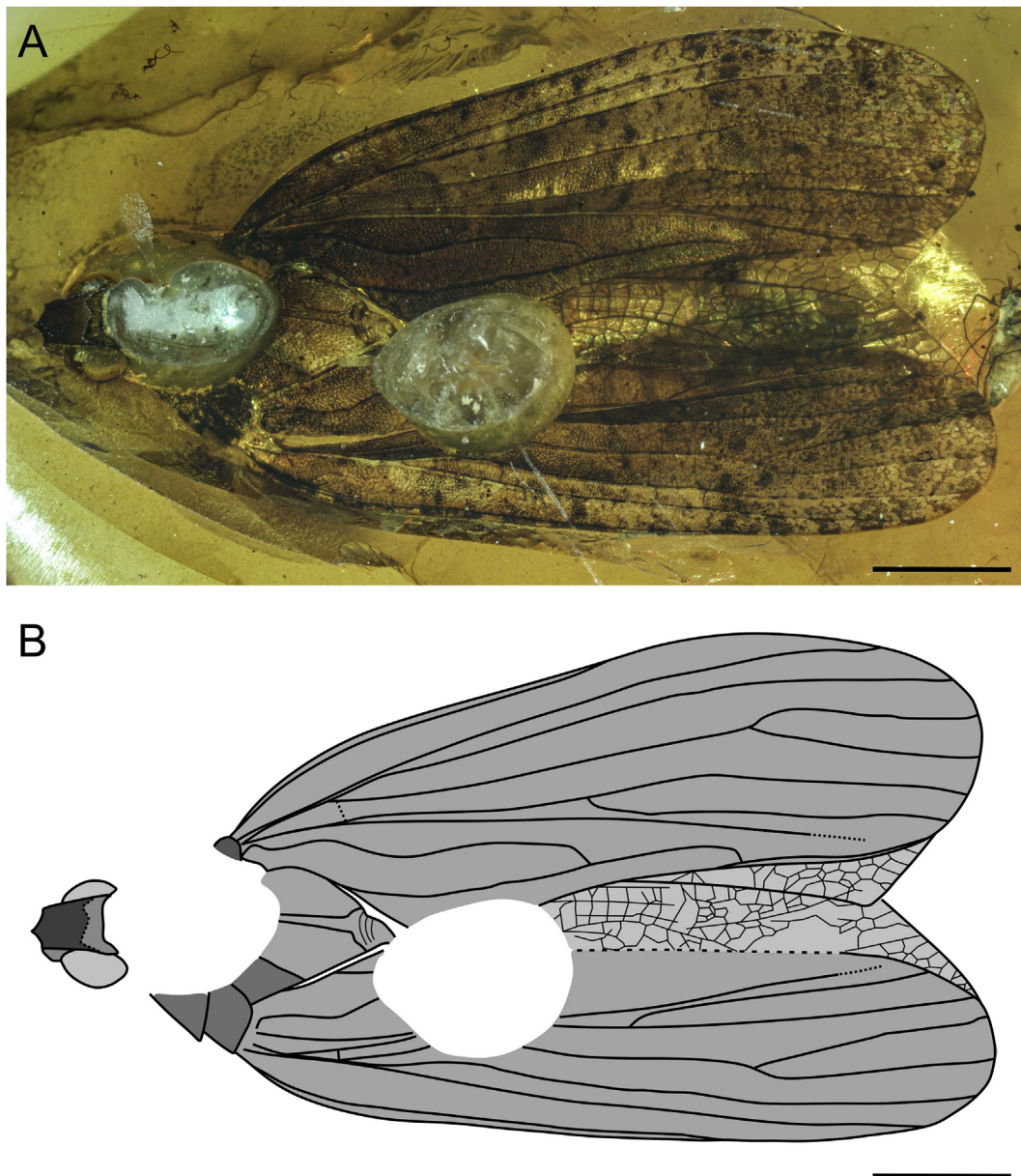


Fig. 1. Holotype of *Burmissus szwedoi* sp. nov. A, Photograph of habitus in dorsal view. B, Line drawing of habitus in dorsal view. Scale bars = 2 mm.

to improve their light transmission and remove optical distortions. Photographs and drawings were adjusted and composed into plates using CorelDraw X7 graphic software.

The venational nomenclature follows the proposals presented by Bourgoïn et al. (2015). Vein abbreviation: CA, costal margin; Pc + CP, precosta + costa posterior; ScP + R, subcosta posterior + radius; RA, radius anterior branch; RP, radius posterior branch; MP, media posterior; CuA, cubitus anterior; CuP, cubitus posterior; Pcu, postcubitus; A<sub>1</sub>, first anal vein; A<sub>2</sub>, second anal vein.

### 3. Systematic palaeontology

Class Insecta Linnaeus, 1758

Order Hemiptera Linnaeus, 1758

Suborder Fulgoroidea Evans, 1946

Superfamily Fulgoroidea Latreille, 1807

Family Mimarachnidae Shcherbakov, 2007b

Genus *Burmissus* Shcherbakov, 2017

Type species *Burmissus raunoi* Shcherbakov, 2017

Diagnostic characters (revised based on Shcherbakov, 2017). Body slightly dorsoventrally depressed, with tegmina shallowly tectiform in repose; rostrum extremely long, slender, reaching beyond tips of tegmina; anterior margin of compound eyes distinctly exceeding half of the head length on middle; pronotum and mesonotum with doubled median carina; pronotum transverse with horizontal paranota, sharp posterior angles, and shallowly W-shaped posterior margin; costal margin arched near base; Pc + CP subparallel to costal margin and submerged to margin at more than half of the tegmen; MP forked at about 3/10 length of the tegmen before margin and forked once; stem CuA forked apical of claval veins junction; claval veins Pcu and A<sub>1</sub> fused before half of the tegmen length, their common portion reaching wing-coupling fore fold; wing-coupling fore fold (WCFF) present; legs slender; hind tibia and first two tarsomeres with 4–5, 5, and 4–5 asetigerous apical teeth, correspondingly.

*Burmissus szwedoi* sp. nov.

(Figures. 1–4)

*Etymology.* The specific name refers to Dr. Jacek Szwedo, in honor of his contribution to the study of fossil Fulgoroidea. The species is registered under LSID urn:lsid:zoobank.org:pub:1C1B0A08-2FC1-4DA5-B64F-7FDC3C527C9E.

*Material.* Holotype. Burmese amber, oval lump, 26 × 22 × 4 mm, Specimen No. NIGP 172207, deposited in Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing. Holotype inclusion incomplete: rostrum and legs missing; ventral view of head capsule invisible; pronotum almost completely blocked; head, mesonotum, left tegmen and right tegmen partly blocked; hind wings and abdomen partly preserved.

*Locality and horizon.* Burmese amber, from deposits near the Tanai Village in the Hukawng Valley of northern Myanmar; upper Albian to lower Cenomanian (mid-Cretaceous).

*Diagnosis.* Head relatively long; vertex subpentagonal, anterior margin triangular with sharp angle in dorsal view, trigons not visible from above; pronotum with taper-like posterior angles; mesonotum with densely punctures even between two median carina; median carina diverging posteriad before mesoscutellum; mesoscutellum subtriangular with transverse wrinkles; tegula relatively large, subquadrate, covered with punctures; tegmen mottled, without distinctive dark bands or dark streaks; stem Pc + CP submerged to margin at about 2/3 length of the tegmen; stem ScP + RA separated with RP + MP at very base of the tegmen; common stem ScP + R slightly shorter than twice as long as basal

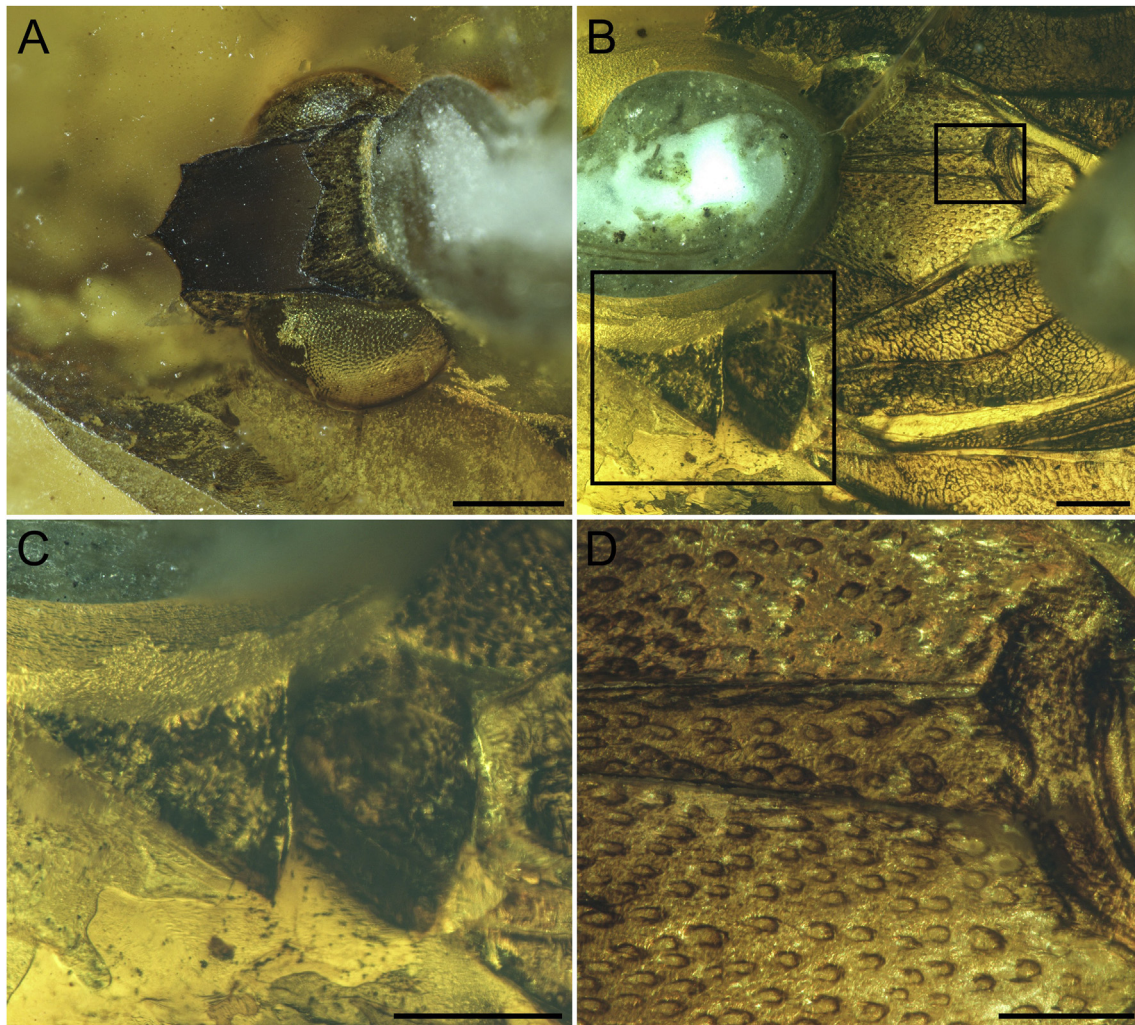
cell; terminal portion of CuP weaken before margin; stem Pcu strongly curved, especially at base; hind wing transparent with dark veins and a meshwork of veinlets, R fork apparently distal to CuA fork.

*Description.* Body with wings 14.1 mm long, 7.4 mm wide. Head including compound eyes 1.54 mm wide (1.12 mm in length in mid, and 0.75 mm in width without compound eyes); vertex sub-pentagonal, anterior margin triangular with a sharp angle in dorsal view, lateral margins carinate, slightly diverging posteriad. Disc of vertex without median carina, anterior portion of vertex posterior widened. Compound eyes bulging, anterior margin distinctly exceeding half of the head length on middle, 0.93 mm long and 0.51 mm wide.

Pronotum only preserved the left posterior part, with taper-like posterior angles and densely punctate. Mesonotum lost anterior part, probably transversely diamond-shaped, with two median carinae, slightly diverging posteriad before mesoscutellum; two lateral carinae, with right one covered by tegmen, left one diverging posteriad, reaching posterior margin of the mesonotum; mesonotum covered with densely punctures even between two median carinae; punctures usually U-shape. Mesoscutellum flat, sub-triangular with transverse wrinkles. Tegula relatively large (0.57 mm long, 0.90 mm wide), subquadrate, covered with punctures.

Tegmen coriaceous, translucent, mottled, without distinctive dark bands or dark streaks, some irregular patches of darker areas preserved, about 3.3 times as long as wide (11.0 mm long, 3.3 mm wide at level of tornus). Tegmen broadest at about 3/5 length, filled with meshwork of veinlets, forming irregular polygonal cells and these polygonal cells become bigger in the distal section of the tegmen, but still smaller than polygonal cells of the hind wing. Costal margin slightly curved at base, then almost straight. Anteroapical angle widely rounded, apex rounded; posteroapical angle rounded; tornus slightly arcuate; claval margin slightly curved. Stem Pc + CP fused from base, then subparallel to costal margin and submerged to margin at about 2/3 length of the tegmen. Stem ScP + RA separated from RP + MP at very base of the tegmen, then fused; stem ScP + R + MP straight, about 2/3 length of common stem ScP + R. Stem ScP + R forked at basal 1/5 of the tegmen length, branch ScP + RA single, slightly arcuate, subparallel to costal margin, reaching margin at anterorapical angle; branch RP single, nearly parallel to ScP + RA, reaching margin more apically than branch ScP + RA; cell C1 long and narrow; *cua-cup* indistinctive. Stem MP slightly curved, then straight and forked at 7/10 of the tegmen length, reaching margin with 2 terminals. Common stem CuA + CuP straight at basal cell, then CuA separated from CuP at junction of *cua-cup* and CuA + CuP; stem CuA slightly curved from base, forked near apical of claval veins junction, branch CuA<sub>1</sub> basally subparallel to distal section of stem MP, then slightly arcuate, reaching margin at level of posteroapical angle, branch CuA<sub>2</sub> curve at base and close to CuP, then curve back and slightly diverging from CuP, sinuate and subparallel to CuA<sub>1</sub>, reaching margin at level of posteroapical angle. Clavus open, stem CuP slightly arcuate, weakened before reaching margin; claval vein Pcu strongly curved and sinuate, especially at base; claval veins Pcu and A<sub>1</sub> fused at about 2/5 of the tegmen length, their common portion strongly arcuate distally, reaching wing-coupling fore fold at about 0.6 of the tegmen length. Wing-coupling fore fold (WCFF) present, with densely transverse veins between WCFF and margin. Basal cell triangular, 1.35 mm long. Costal area very narrow, 6.2 mm long and no more than 0.1 mm wide. Cell C1 8.6 mm long, 0.4 mm wide; cell C3 3.3 mm long, 0.54 mm wide; cell C5 5.5 mm long, 0.51 mm wide.

Hind wing membranous, transparent, slightly shorter than tegmen, with dark veins and a meshwork of veinlets, forming



**Fig. 2.** Detailed photographs of *Burmissus szwedoi* sp. nov. A, Head. B, Pronotum and mesonotum. C, Enlargements of B, showing details of pronotum and tegula. D, Enlargements of B, showing details of punctures. Scale bars for A, B, C = 0.5 mm; D = 0.2 mm.

irregular, polygonal cells. Costal margin straight, then strongly curved apicad of stem R fork to anteroapical angle, posterior margin arcuate. Stem ScP + R straight, subparallel and close to costal margin, forked at the level of the wing-coupling fore fold, branch ScP + RA simple, reaching margin slightly basad of the apex, branch RP simple, reaching margin at the apex. Stem MP single, straight, parallel to stem RP, reaching margin slightly basad of the apex. Stem CuA slightly curved, forked apparently basad of stem ScP + R forking, stem CuA<sub>1</sub> slightly curved and stem CuA<sub>2</sub> straight. Cell C1 3.48 mm long, cell C5 4.13 mm long.

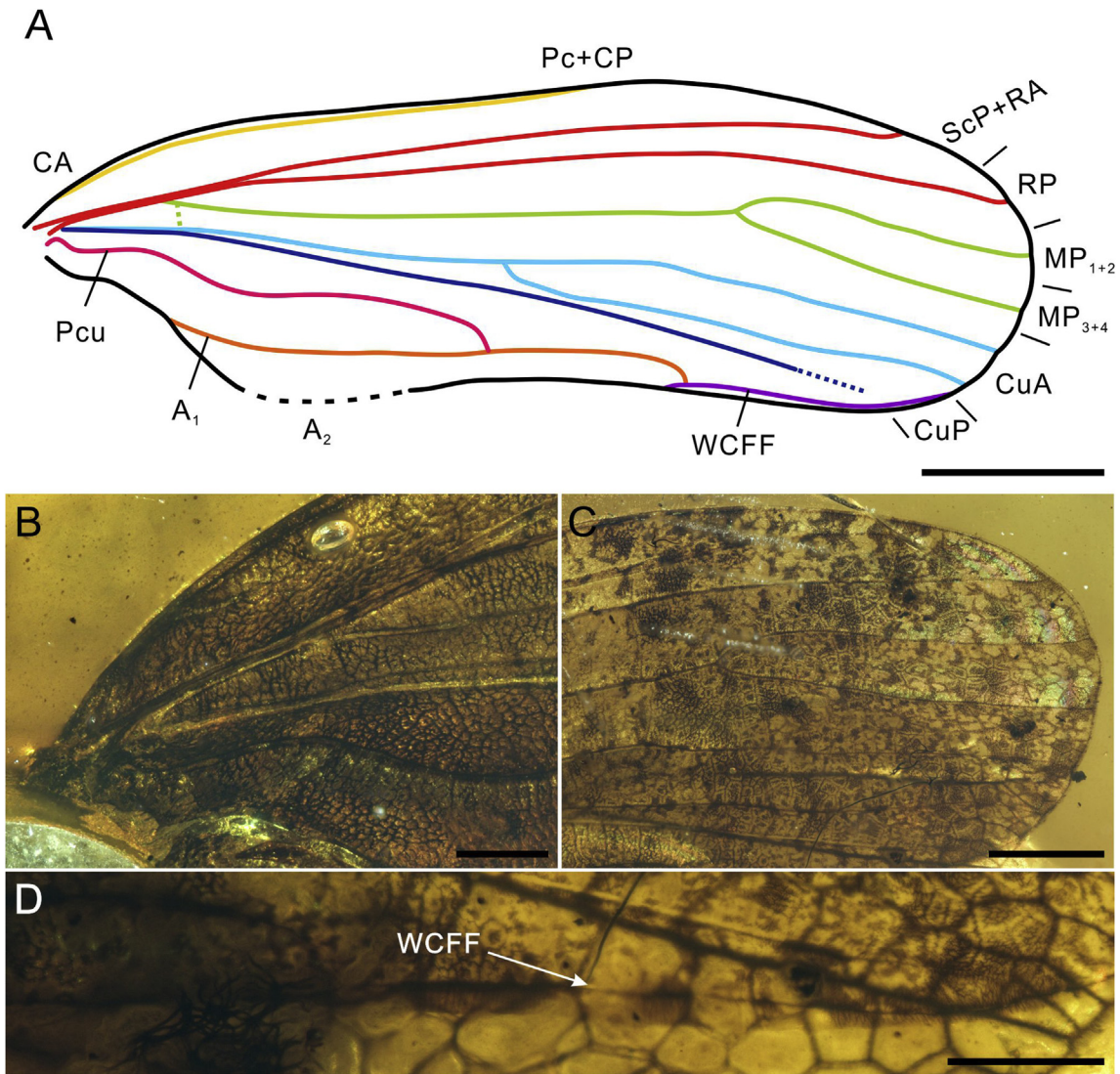
Abdomen elongate, flatten, not reaching tips of tegmina, weakly tapered to the apex. Female genitalia obscured with the inner structure almost invisible. Gonaplasts large and membranous. Anal tube slightly elongate, translucent in ventral view, with circular anal style in apex.

Legs not preserved.

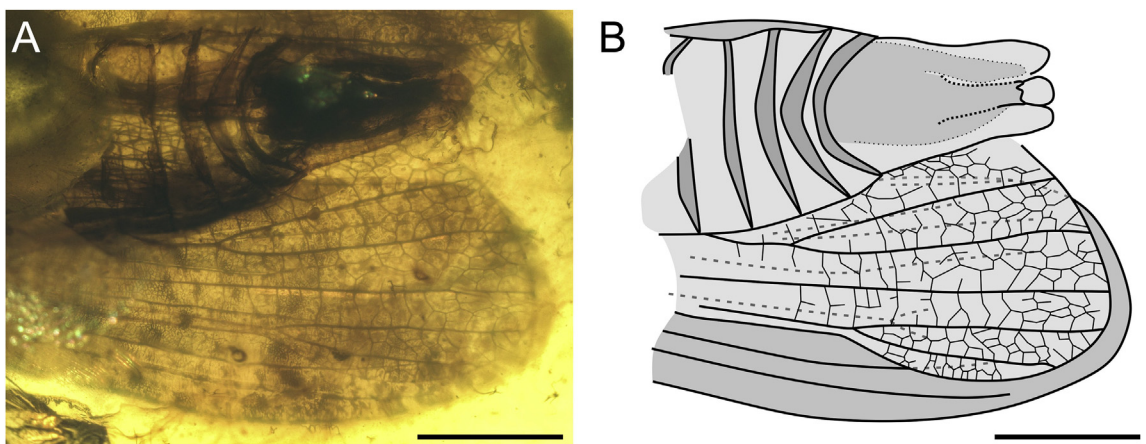
#### 4. Discussion

The extinct family Mimarachnidae was established by Shcherbakov (2007b) with distinct characters such as the sensory pits retained in the adults, mesonotum with double median

carinae, simplified venation with poorly longitudinal vein branches and irregular meshwork of cross veins, weakened or absent basal cell (Shcherbakov, 2007b; Zhang et al., 2018; Fu et al., 2019), which can be easily identified in *Burmissus szwedoi* sp. nov. The new species can be assigned to *Burmissus* Shcherbakov, 2017 regarding the following features presented: costal margin arched near base; costal area of the tegmen very narrow (costal area relatively broad in *Dachibangus* and *Jaculistilus*); stem Pc + CP subparallel to costal margin and submerged to margin at more than half of the tegmen (veins of costal complex fused from base in *Mimaplax*); common stem ScP + R nearly twice as long as common stem ScP + R + MP (common stem ScP + R nearly slightly longer than common stem ScP + R + MP in *Dachibangus* and *Jaculistilus*); stem ScP + R forked narrow, at basal no more than 1/4 of the tegmen length (stem ScP + R forked very close to the basal cell in *Dachibangus* and *Jaculistilus*); stem MP forked at about 3/10 length of the tegmen before margin, reaching margin with 2 terminals (stem MP with 6 terminals in *Dachibangus* and 4 terminals in *Jaculistilus*); stem CuA separated from CuP near junction of *cua-cup* and stem CuA + CuP; stem CuA forked near apical of claval veins junction (stem CuA forked apparently basad of claval veins junction in *Mimaplax*, *Dachibangus*, *Jaculistilus*), branch CuA<sub>2</sub>



**Fig. 3.** Detailed line drawing and photographs of right tegmen of *Burmissus szwedoi* sp. nov. A, Line drawing of venation pattern. B, Photograph showing detail of basal part. C, Photograph showing detail of distal part. D, Photograph showing detail of WcFF (white arrow). Scale bars for A = 2 mm, B, D = 0.5 mm, C = 1 mm. Abbreviation: WcFF, wing-coupling fore fold.



**Fig. 4.** Detailed photographs of *Burmissus szwedoi* sp. nov. A, Photograph of abdomen and right wings in ventral view. B, Line drawing of abdomen and right wings in ventral view. Scale bars = 2 mm.

curve at base and close to CuP; stem Pcu apparently curved; claval veins Pcu and A<sub>1</sub> fused before half of the tegmen length and submerged towing-coupling fore fold; wing-coupling fore fold (WCFF) present between terminals of branch CuA<sub>2</sub> and stem Pcu + A<sub>1</sub>. Hind wing with stem ScP + R subparallel and close to costal margin; branch ScP + R forked once; stem MP single, straight; stem CuA forked once (stem CuA with 3 terminals in *Nipponoridium*).

However, *B. szwedoi* sp. nov. is different from *B. raunoi* Shcherbakov, 2017 in possessing the following characters: trigons not visible from above; length of head capsule about 1.5 times as long as width (the width of head capsule is about twice as long as length in mid in *B. raunoi*); mesonotum with two carinae and two lateral carinate (two carinae, lateral carinae and intermediate carinae, 6 carinae in all in *B. raunoi*); median carinae slightly diverging posteriad before mesoscutellum (subparallel to each other in *B. raunoi*); mesonotum covered with densely punctures even between two median carinae (punctures between two median carinae absent in *B. raunoi*); punctures usually U-shape (O-shape in *B. raunoi*); mesoscutellum flat (raised in *B. raunoi*); tegmen without distinctive dark bands or dark streaks, with some irregular patches of darker areas preserved (tegmen with four oblique dark bands and eight dark streaks near costal margin in *B. raunoi*); tegmen broadest at about 3/5 length (broadest before midlength in *B. raunoi*); stem Pc + CP submerged to margin at about 2/3 length of the tegmen (1/2 in *B. raunoi*); stem ScP + R + MP straight, about 2/3 length of common stem ScP + R (1/4 in *B. raunoi*); stem Pcu strongly curved, especially at base (Pcu slightly S-shaped in *B. raunoi*); hind wing stem CuA forked apparently basad of stem ScP + R fork (hind wing with subequal R and CuA forks in *B. raunoi*); with abundant crossveins (few crossveins in distal part in *B. raunoi*).

As the eleventh species discovered in Mimarachnidae, the extinct family has shown amazing taxonomic diversity and morphological disparity, including species with different and peculiar morphological characters such as spider mimic pattern (*Mimarachne mikhailovi* Shcherbakov, 2007b), a rostrum that exceeds the length of the body (*B. raunoi* Shcherbakov, 2017), giant size (*Dachibangus trimaculatus* Jiang, Szewo et Wang, 2018), elongated head (*Jaculistilus oligotrichus* Zhang, Ren et Yao, 2018) and camouflaged configuration (*Mimaplax ekrypsan* Jiang, Szewo et Wang, 2019) (Shcherbakov, 2007b, 2017; Jiang et al., 2018; Zhang et al., 2018; Jiang et al., 2019), and these characters present various ecological strategies. Shcherbakov (2007b) suggested that Mimarachnidae share homoplastic similarities with another Cretaceous planthopper family Perforissidae, like narrowing of costal area, reduction of forking of stems on membrane, open clavus, presence of nymphal sensory pits (punctures) in adults, destabilization and underdevelopment of the hind leg armature, presence of double median carina on pronotum and mesonotum, reflecting that they are parallel descent of Jurassic Fulgoridiidae (or related forms), and can be one of the most primitive, 'pre-cixioid' section of planthoppers. However, Bourgoin and Szewo (2008), Szewo (2009) and Szewo and Ansoerge (2015) assigned Mimarachnidae into the 'cixiidae-like' planthoppers group, which contain extinct families Fulgoridiidae Handlirsch, 1939, Lalacidae Hamilton, 1990, Neazoniidae Szewo, 2007 and extant families Cixiidae Spinola, 1839, Delphacidae Leach, 1815, Kinnaridae Muir, 1925, Meenopliidae Fieber, 1872, Achilidae Stål, 1866, Achilixiidae Muir, 1923 and Derbidae Spinola, 1839. These families share many symplesiomorphic characters together, like retention of nymphal characters, variability and modification of venational patterns as well as destabilization of hind leg armature. However, the relationships between those 'cixiidae-like' groups are still not clear, and the

family Mimarachnidea and other basal lineages of Fulgoroidea still need to be further studied.

## 5. Conclusions

*Burmissus szwedoi* sp. nov. from mid-Cretaceous Burmese amber is the eleventh species of Mimarachnidea. It can be distinguished from the type species *Burmissus raunoi* Shcherbakov, 2017 by the number of carinae of the mesonotum, tegmen pattern and different broadest portion of the tegmen. The new species enhances the taxonomic diversity and morphological disparity of Mimarachnidea, but the phylogenetic position of Mimarachnidae still needs further research.

## CRedit authorship contribution statement

**Cihang Luo:** Writing - original draft. **Tian Jiang:** Writing - original draft. **Bo Wang:** Writing - original draft. **Chuantao Xiao:** Methodology.

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