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A new stem-coenagrionoid genus of damselflies (Odonata: Zygoptera) from mid-Cretaceous Burmese amber

CLAUDIA MÖSTEL[1], MARTIN SCHORR[2] & GÜNTER BECHLY[3,4]

[1]*Universität Hohenheim, Schloss Hohenheim 1, 70599 Stuttgart, Germany. E-mail: Claudia-Sareyka@web.de*
[2]*International Dragonfly Fund e. V., Schulstraße 7b, 54314 Zerf, Germany. E-mail: info@dragonflyfund.org*
[3]*Staatliches Museum für Naturkunde Stuttgart, Rosenstein 1, 70191 Stuttgart, Germany. E-mail: guenter.bechly@smns-bw.de*
[4]*Corresponding author: bechly@mac.com*

Abstract

A new genus and species of damselfly, *Burmagrion marjanmatoki,* **gen. et sp. nov.**, is described from Early Cretaceous Burmese amber. It is attributed to the basal stem group of Coenagrionoidea. The inclusion of five wings from the same species suggests that the amber piece contains the remains of a mating pair of damselflies.

Key words: damselfly, Coenagrionoidea, fossil insect, Cenomanian

Introduction

Even though numerous Odonata have been described from Cretaceous sedimentary deposits, including representatives from at least 16 families from the Lower Cretaceous Santana Formation in Brazil (Bechly 1996a, 1998b, 2007, 2010) and numerous taxa from Lower Cretaceous deposits in England (Jarzembowski *et al.* 1998) and France (Nel *et al.* 2008), and even though odonate fossils are well represented in Tertiary amber (Bechly 1993, 1996b, 1998a, 2000; Bechly & Wichard 2008), descriptions of damselflies in Cretaceous amber were very rare until the recent boom of paleoentomological studies on Burmese amber. The first description of a damselfly in Cretaceous Burmese amber, *Palaeodisparoneura burmanica,* was published in 2010 (Poinar *et al.* 2010). Meanwhile, several further damselfly taxa have been described from this locality (Huang *et al.* 2015, 2017, Zheng *et al.* 2016a, 2016b, 2016c, 2016d), representing the families Hemiphlebiidae, Perilestidae, Dysagrionidae, Platystictidae, and Platycnemididae—Disparoneurinae, and Mesomegaloprepidae. Further new descriptions are in preparation (Bechly in prep., and André Nel pers. comm. 2016). The present study describes a new genus and species of damselfly from Burmese amber, which is only the third known fossil record from the stem group of the very diverse superfamily Coenagrionoidea.

Material and methods

The fossil is preserved in a small piece of Burmese amber. The specimen was obtained from a German trader and originated from an amber mine in the Hukawng Valley (Kachin State) in Myanmar (Burma), but the precise mine is unknown.

Burmese amber was first assigned to the Early Cretaceous through paleontological evidence (Cruickshank & Ko, 2003). Shi *et al.* (2012) later provided a very precise absolute age at 98.79 ± 0.62 Ma by radiometric U–Pb zircon dating of the volcanoclastic matrix.

The presence of characteristic wood fibers as well as nuclear magnetic resonance (NMR) spectra both suggest an araucarian tree source (possibly genus *Agathis*) for the fossil resin from this locality (Poinar *et al.* 2007), but Dutta *et al.* (2011) rejected this attribution and rather suggested Pinaceae.

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Observations and drawings were made using a Leica M80 (1.6 Plan Achromat lens) stereoscopic microscope with camera lucida system. Photographs were taken with a Leica DFC490 digital camera on a Leica Z16-Apo macroscope. Images were processed for focus stacking with Leica Application Suite 3.8.0. Drawings and Photos were subsequently edited and polished using Photoshop CS6® imaging software.

The terminology of odonate wing venation is based on Riek & Kukalová-Peck (1984), as modified by Nel *et al.* (1993) and Bechly (1996a). The used phylogenetic framework of the order Odonata is mainly based on Bechly (1996a, 2003), and the classification is based on the most recent revision of odonate systematics by Dijkstra *et al.* (2013).

Abbreviations
C = Costa
ScP = Subcosta posterior
RA = Radius anterior
RP = Radius posterior
IR = Interradius
MA = Media anterior
MP = Media posterior
CuA = Cubitus anterior
arc = arculus
ax1 and ax2 = primary antenodal brackets
dc = discoidal cell
ddv = distal discoidal vein MAb
n = nodus
pt = pterostigma
ptbr = pterostigmal brace vein
sdc = subdiscoidal cell

Veins that create a fold that is convex to the dorsal side of the wing are designated as convex or positive with "+", while veins that create a fold that is convex to the ventral side of the wing are designated as concave or negative with "-".

Systematic Paleontology

Class Insecta Linné, 1758

Order Odonata Fabricius, 1793

Suborder Zygoptera Selys, 1854

Superfamily Coenagrionoidea Kirby, 1890

Familia incertae sedis

Burmagrion n. gen.

Type specis. *Burmagrion marijanmatoki* n. sp.

Diagnosis. Same as type species since monotypic.

Etymology. Named after the old name Burma for Myanmar and the damselfly genus name *Agrion*.

***Burmagrion marijanmatoki* n. sp.**
Figures 1–10

Holotype. Specimen no. SMNS Bu-158, deposited in the amber collection of the paleontological department at the State Museum of Natural History in Stuttgart (Germany).

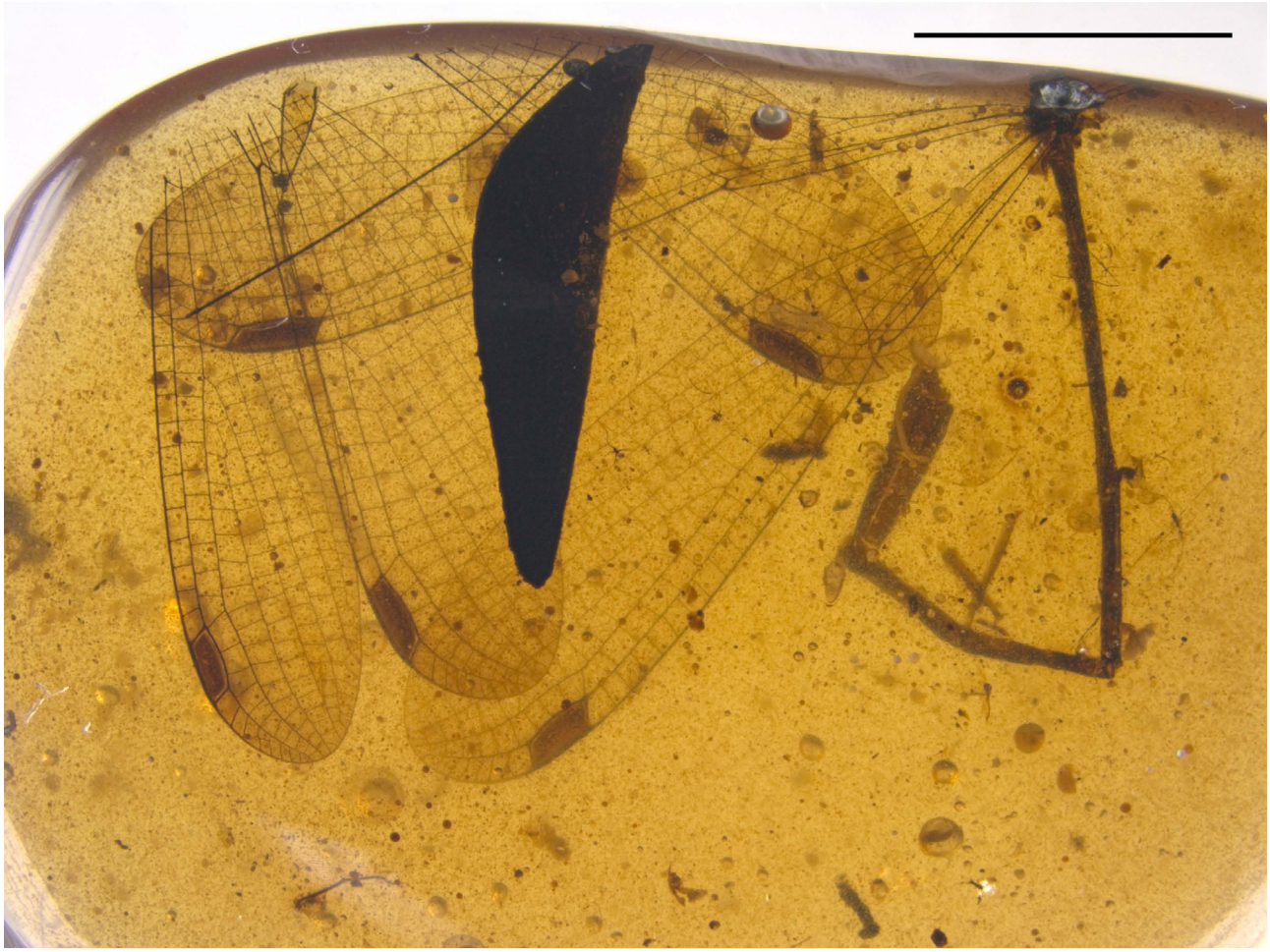

FIGURE 1. Photograph of complete Burmese amber piece SMNS Bu-158 with holotype of *Burmagrion marijanmatoki* **gen. et sp. nov.** Scale bar = 5 mm.

Diagnosis. This species can be discriminated from all known Recent and fossil odonates by the following combination of characters in the wing venation: wings strongly petiolated; ax1 and ax2 very widely separated; arculus slightly distal of ax2; ca. 15 postnodal cross-veins, of which only the most basal 3 are aligned and connected to incipient pseudo-transverse veins; pterostigmata 2.5–3.5 cells long and distinctly braced; no lestine oblique vein; no intercalary veins except IR1 and IR2; discoidal cell basally closed, elongate, free, and distally acute; subdiscoidal cell elongate and free; CuP-crossing at origin of AA+CuA; about 6 cells between subnodus and origin of RP2, and 3 cells between origins of RP2 and IR1; only one row of cells between CuA and hind margin.

Description. A small piece of clear Burmite amber (27x19x6 mm) with numerous inclusions of tiny water droplets or air bubbles, containing a female damselfly with body fragment (Figure 1) and two complete wings (Figures 2–5), as well as large fragments of three further wings (Figures 6–9), which clearly belong to another specimen of the same species. The main syninclusion is part of an unidentified angiosperm leaf of asymmetrical lanceolate shape and very dark color (Figure 6).

Body. Head, prothorax, and legs missing. Only part of pterothorax preserved, with a single attached pair of wings. Abdomen 15.4 mm long without male secondary genital apparatus, but with ovipositor pouch. Terminal appendages very short and inconspicious.

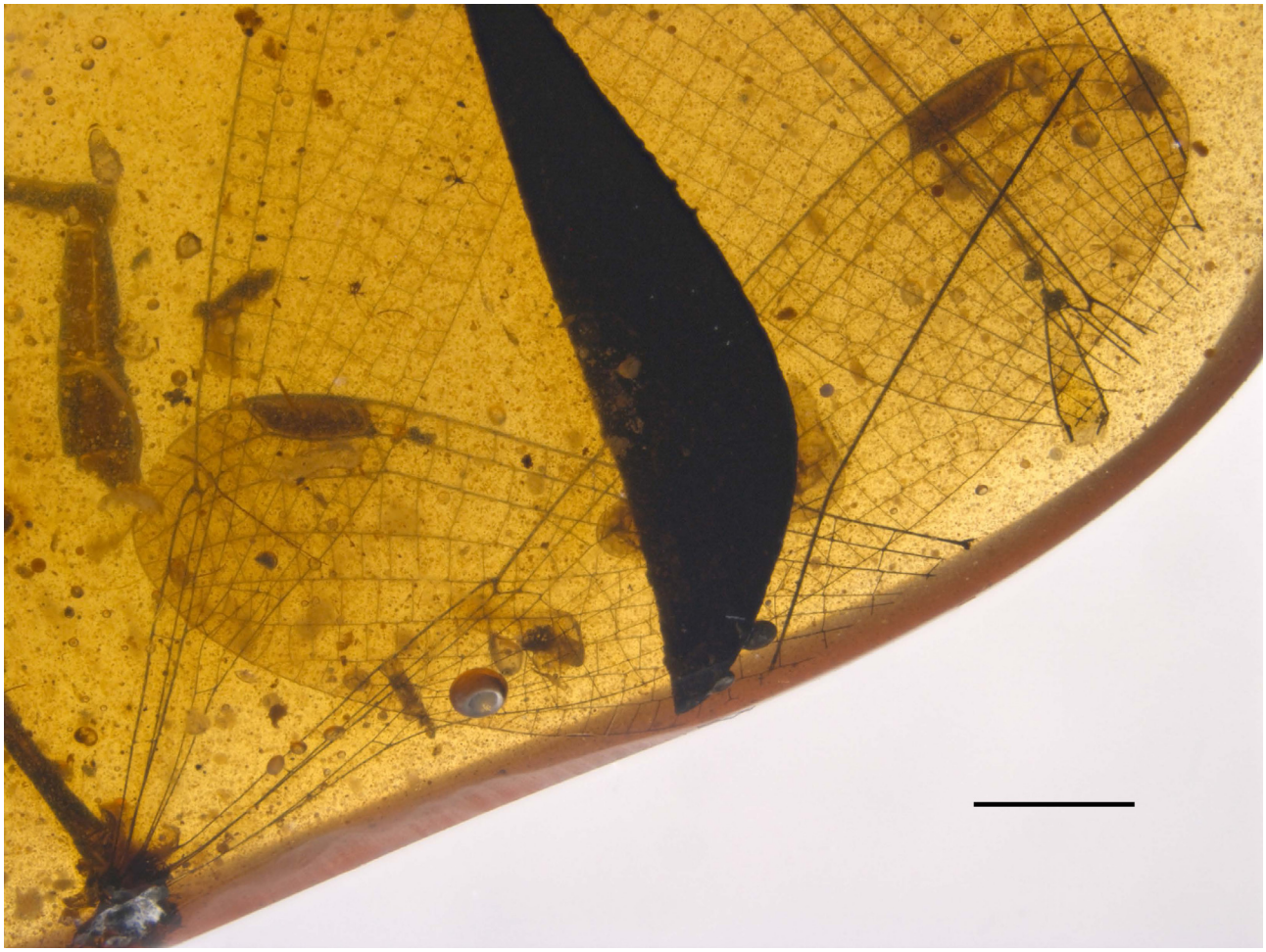

FIGURE 2. Photograph of forewing of *Burmagrion marijanmatoki* **gen. et sp. nov.**, holotype SMNS Bu-158. Scale bar = 2 mm.

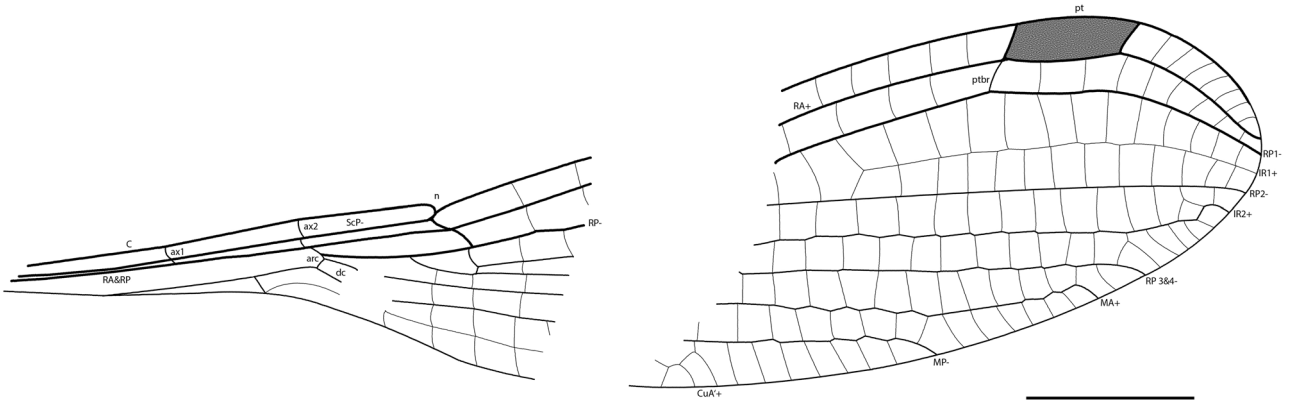

FIGURE 3. Drawing of forewing of *Burmagrion marijanmatoki* **gen. et sp. nov.**, holotype SMNS Bu-158. Scale bar = 2 mm.

Forewing (Figures 2 and 3). Hyaline without color pattern expect for dark pterostigma, which is 2.5 cells long and distinctly braced with oblique stigmal brace vein. Irregular microstructure of pterostigmata (not star-shaped) (Figure 11). Wings strongly petiolated (petiolus 3.2 mm long). Length from nodus to apex approx. 10 mm, total wing length 14.9 mm, maximum width 3.6 mm. Subnodus opposite IR2. Basal branching of RP (midfork) not recessed. Nodal and subnodal cross-veins oblique. Only the two primary antenodal cross-veins ax1 and ax2 that are widely separated for 1.7 mm. Arculus slightly distal of ax2 and complete: basal discoidal cross-vein forms posterior arculus, discoidal cell closed basally. No uparching of MP after discoidal cell. Postnodal and

postsubnodal cross-veins basally aligned, distally not aligned. CuA fuses with hind margin basal of discoidal cell. 7 to 9 cells between CuA and MP. Only a single row of cells between CuA and hind margin (cubito-anal field reduced). Only a single row of cells between all longitudinal veins, thus no intercalary veins (except IR1 and IR2). No lestine oblique vein. Pseudo-transverse veins weakly developed in the mid-third of wing, but absent distally.

Hindwing (Figures 4 and 5). Wing venation is very similar to that of the forewing with the following exceptions: Pterostigmata 3.5 cells long. Length from nodus to apex 10.5 mm, total wing length 14.8 mm, maximum width 3.4 mm. Petiolus 2.4 mm long. Discoidal cell elongated (0.8 mm long), undivided, basally closed, with oblique distal side MAb. Subdiscoidal cell long and undivided. 21 postnodal cross-veins and 23 postsubnodal cross-veins, of which only the most basal 3 are aligned. RP2 originates 6 cells distal of IR2, and IR1 3 cells distal of RP2.

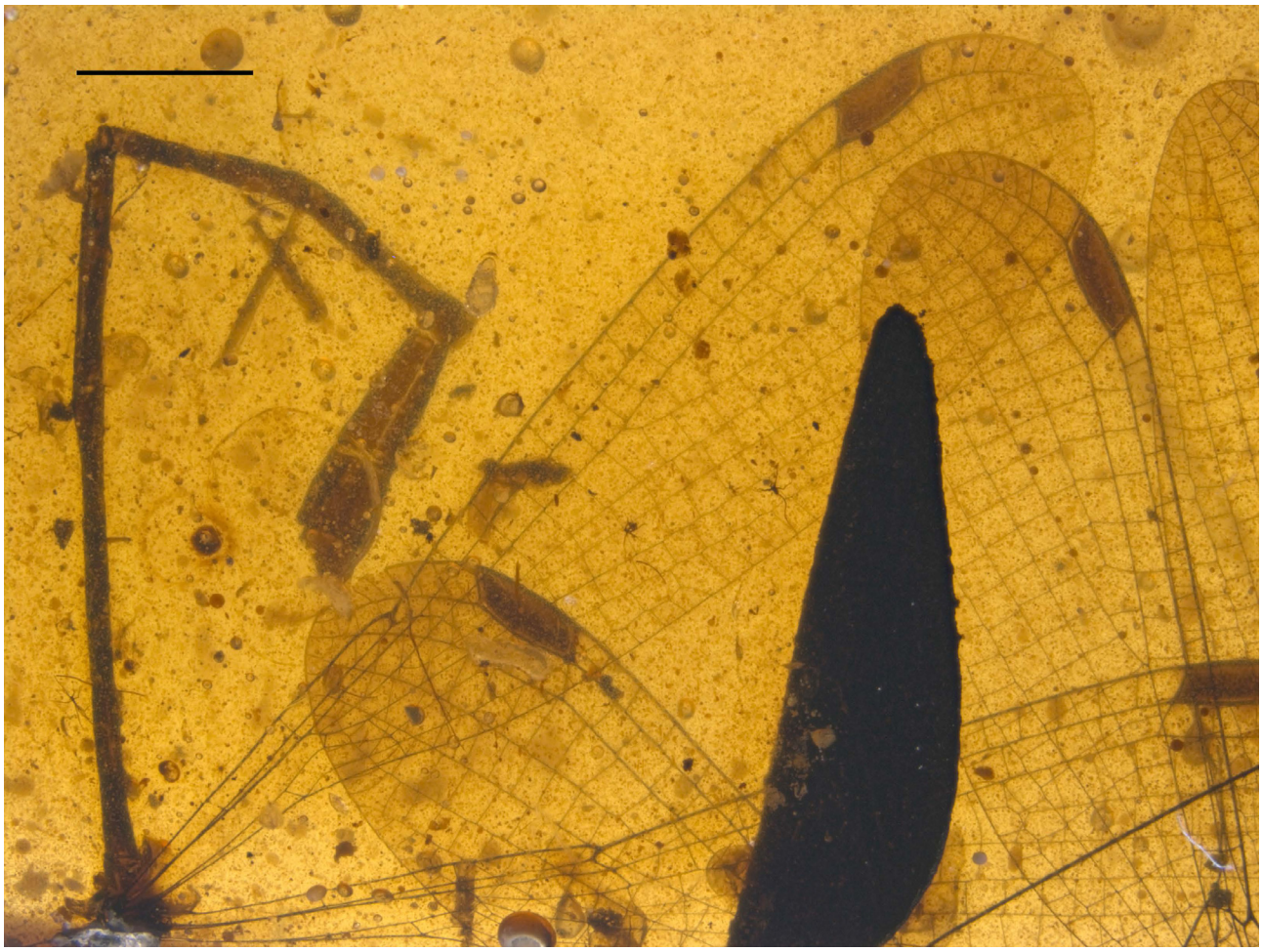

FIGURE 4. Photograph of hindwing of *Burmagrion marijanmatoki* **gen. et sp. nov.**, holotype SMNS Bu-158. Scale bar = 2 mm.

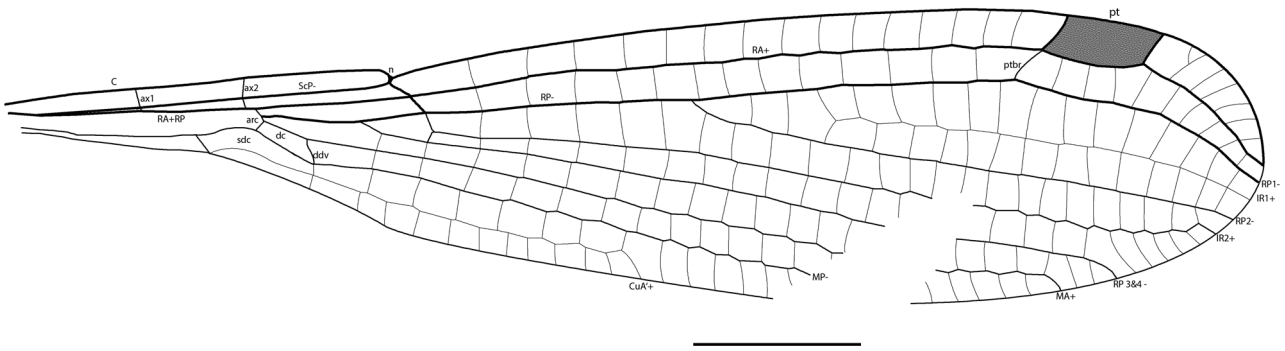

FIGURE 5. Drawing of hindwing of *Burmagrion marijanmatoki* **gen. et sp. nov.**, holotype SMNS Bu-158. Scale bar = 2 mm.

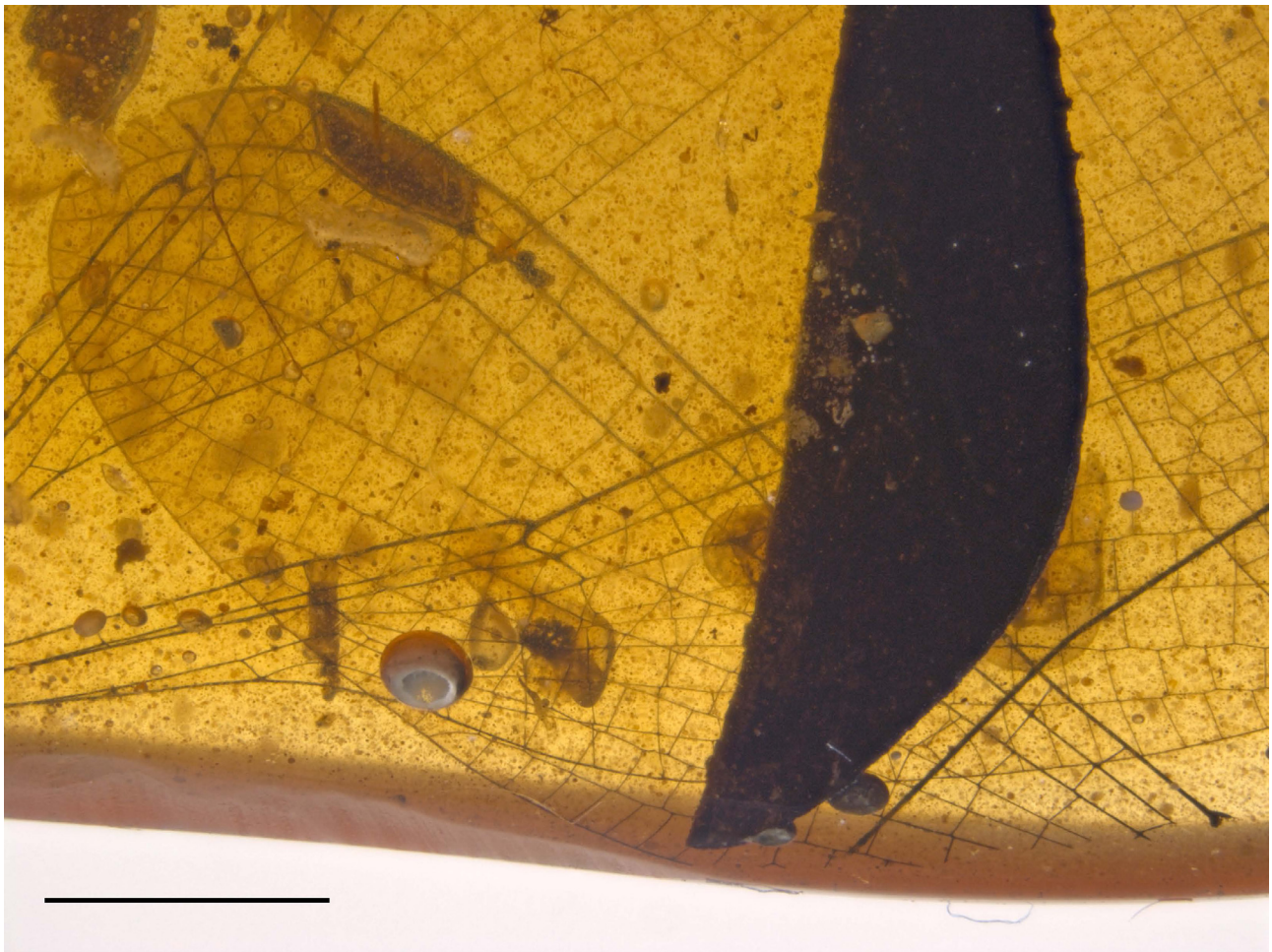

FIGURE 6. Photograph of isolated wing of putative male specimen of *Burmagrion marijanmatoki* **gen. et sp. nov.**, SMNS Bu-158. Scale bar = 2 mm.

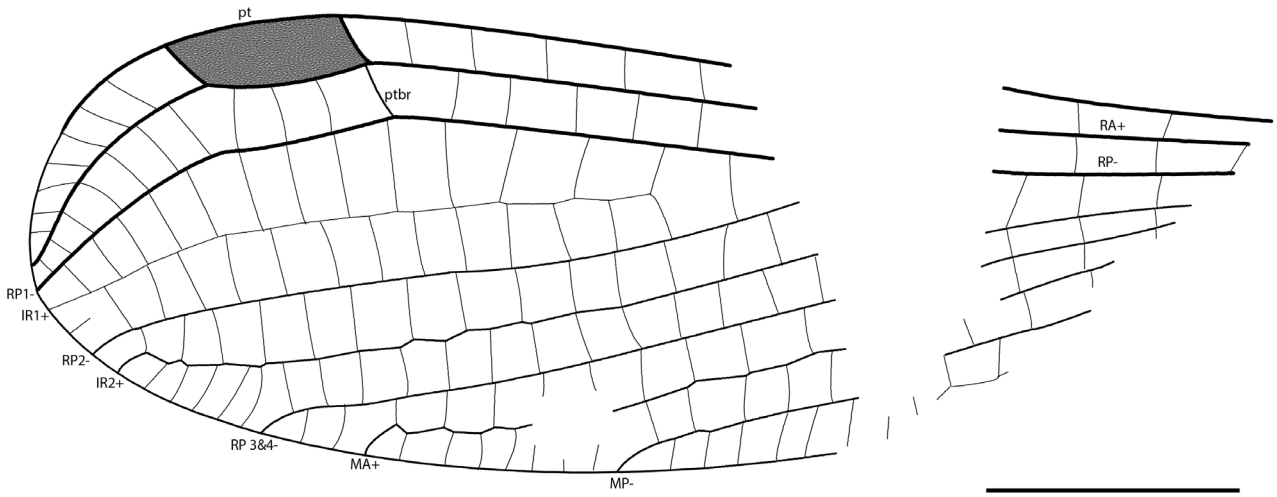

FIGURE 7. Darwing of isolated wing of putative male specimen of *Burmagrion marijanmatoki* **gen. et sp. nov.**, SMNS Bu-158. Scale bar = 2 mm.

Type locality and horizon. Burmese amber / Burmite (Hukawng Valley, Kachin State, Myanmar). Mid-Cretaceous: earliest Cenomanian.

Etymology. A noun in the genitive case, named after Mr. Marijan Matok (born 28th March 1972 in Ulm-Söflingen, Germany), in appreciation of his material support through the International Dragonfly Fund.

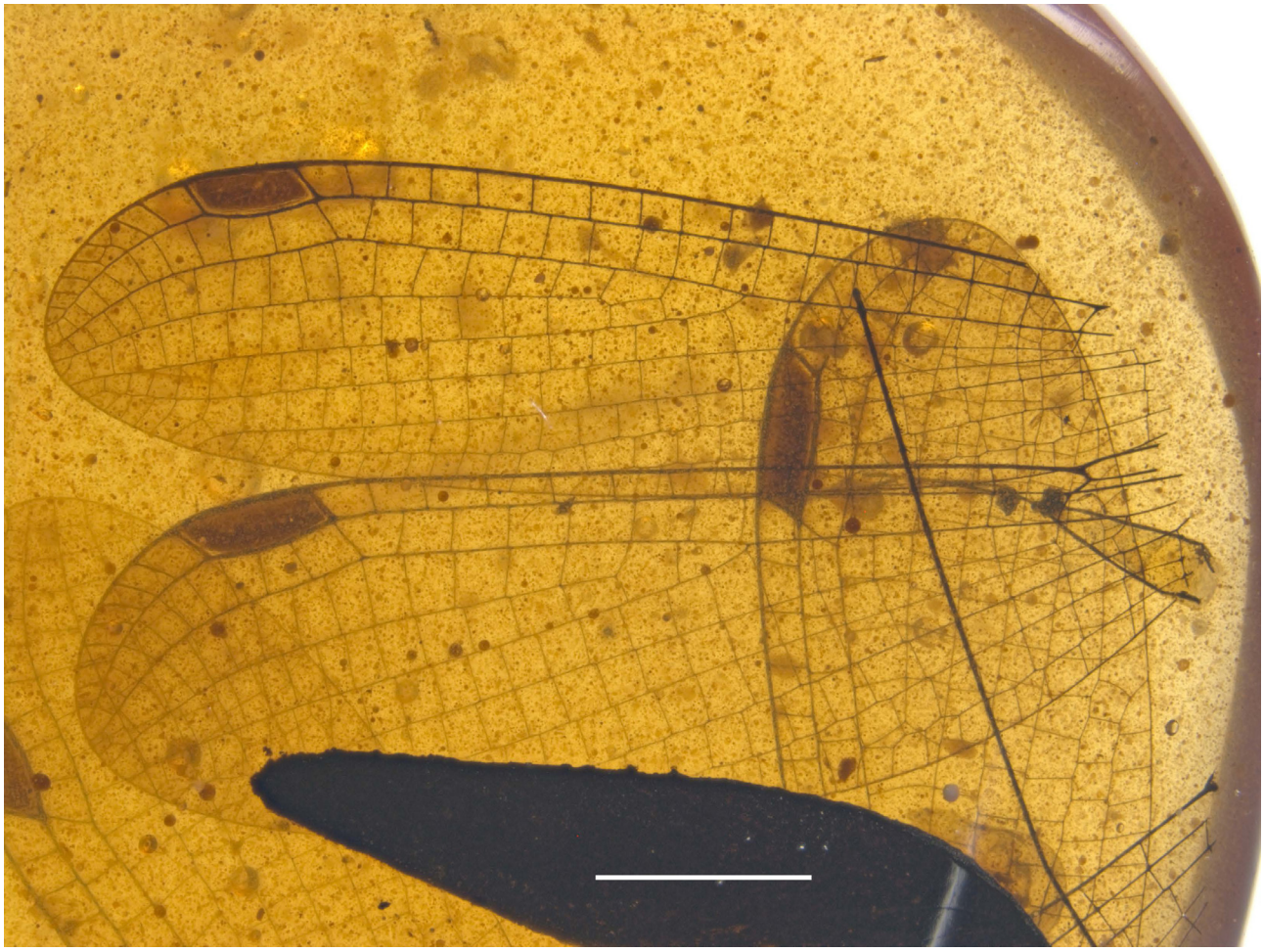

FIGURE 8. Photograph of isolated pair of wings of putative male specimen of *Burmagrion marijanmatoki* **gen. et sp. nov.**, SMNS Bu-158. Scale bar = 2 mm.

Discussion

Phylogenetic relationship. The fact that both pairs of wings are of identical shape and venation, distinctly stalked with long petiolus, and with closed discoidal cell, clearly show that *Burmagrion* n. gen. belongs to the crown group of Zygoptera.

The wings show a complete arculus, so this species is not part of the stem group of the superfamily Lestoidea. Since there is no arching of MP after the discoidal cell, it is also not part of the crown group of Lestoidea, which is further supported by the missing star-shaped micro sculpturing of the pterostigmata.

The basal branching of RP is not recessed, and the pterostimata are braced with an oblique stigmal brace vein, so the species does not belong to the crown group of Calopterygoidea.

The combination of the wing venational characters (wing stalked, no secondary antenodal cross-veins, no lestine oblique vein, at least incipient pseudo-transverse veins, no supplementary intercalary veins, discoidal cell acute, pterostigma with wrinkled micro-sculpturing) suggests that the new taxon belongs to Coenagrionoidea (sensu Dijkstra *et al.* 2013). The absence of intercalary veins, narrow cubito-anal area, and presence of only a single row of cells between all longitudinal veins also exclude a few argiolestine genera (e.g., *Argiolestes*) that are otherwise similar in wing venation.

The fact that only the most basal postnodal and postsubnodal cross-veins are aligned, as well as the elongate pterostigmata that span 2.5–3.5 cells, suggests that this new taxon does not belong to the crown group of Coenagionoidea.

A similar basal stem-coenagrionoid *Balticoagrion paulyi* was described by Bechly (2012) from Eocene Baltic

amber. However, it differs from *Burmagrion* n. gen. in the more strongly non-aligned postnodal cross-veins, and in the more derived short pterostigma. The only other known fossil stem group representative is *Cretarchistigma greenwoodi* described by Jarzembowski *et al.* (1998) from the Weald Clay. It differs from *Burmagrion* n. gen. in the position of the arculus slightly basal of ax2, all postnodals non-aligned, no pseudo-transverse veins, fewer cross-veins and cells, and shorter pterostigmata. Because of these significant differences, it seems very unlikely that these three stem-coenagrionoids belong to a common extinct family.

The characteristics of the wings shown by this fossil are unlike any known damselfly family, so that it could be placed in a new family. However, we here refrain from the naming of a new family, because there are only few and weak characters available, and also to avoid the unnecessary creation of a further redundant taxon.

Sex determination. The preserved body of the holotype has no secondary male genital apparatus on abdominal segments 2+3 and an ovipositor pouch on segment 8, which clearly shows that it is a female specimen. Based on the likely assumption of a trapped mating pair, the other 3 isolated wings most probably belong to a male specimen.

Taphonomy. The circumstances of a female damselfly with three additional wings from a second conspecific specimen suggests either a pair of damselflies trapped by a flow of resin during mating on a tree trunk, or (less likely) another female specimen trapped during group oviposition in the bark of the tree.

Conclusions

This fossil damselfly represents a new genus and species from the mid-Cretaceous amber from the Hukawng Valley in northern Myanmar. It adds to our knowledge of the diverse entomofauna of Burmese amber and to our knowledge of the stem group of Coenagrionoidea.

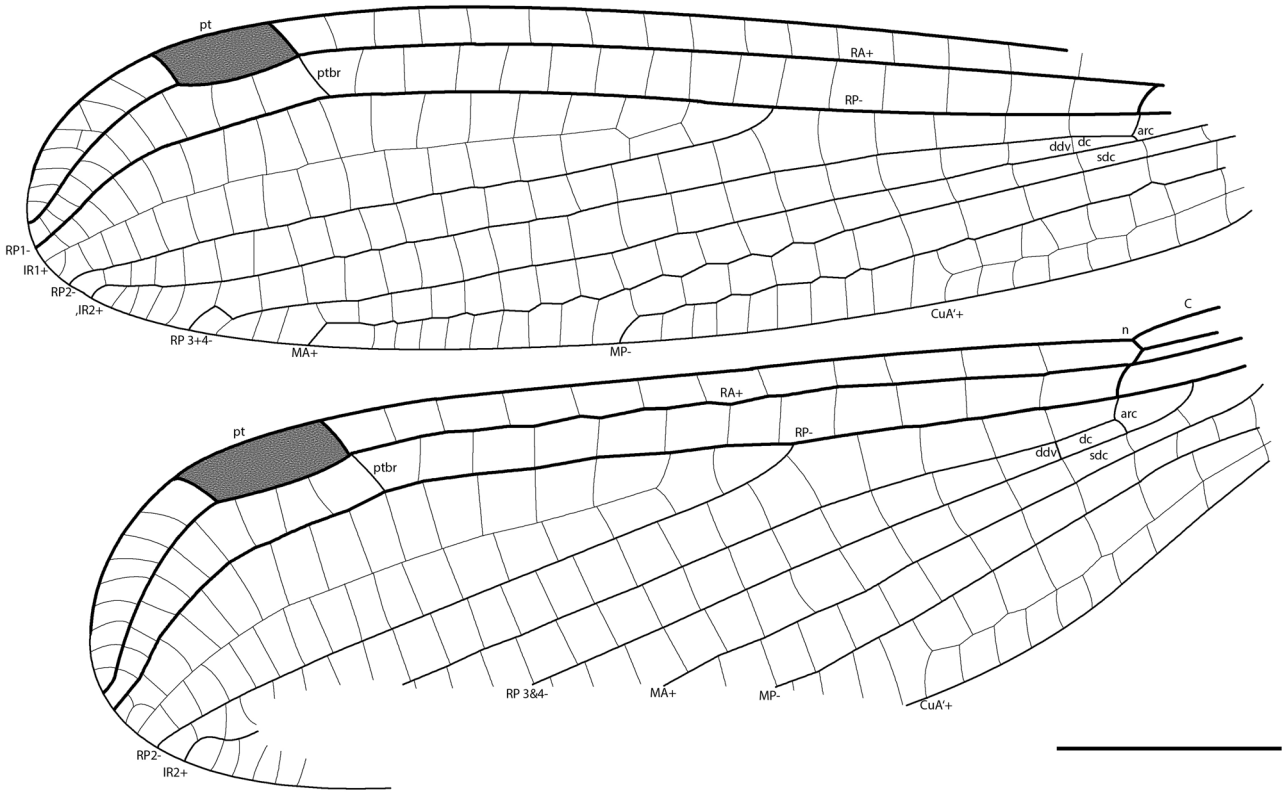

FIGURE 9. Drawing of isolated pair of wings of putative male specimen of *Burmagrion marijanmatoki* **gen. et sp. nov.**, SMNS Bu-158. Scale bar = 2 mm.

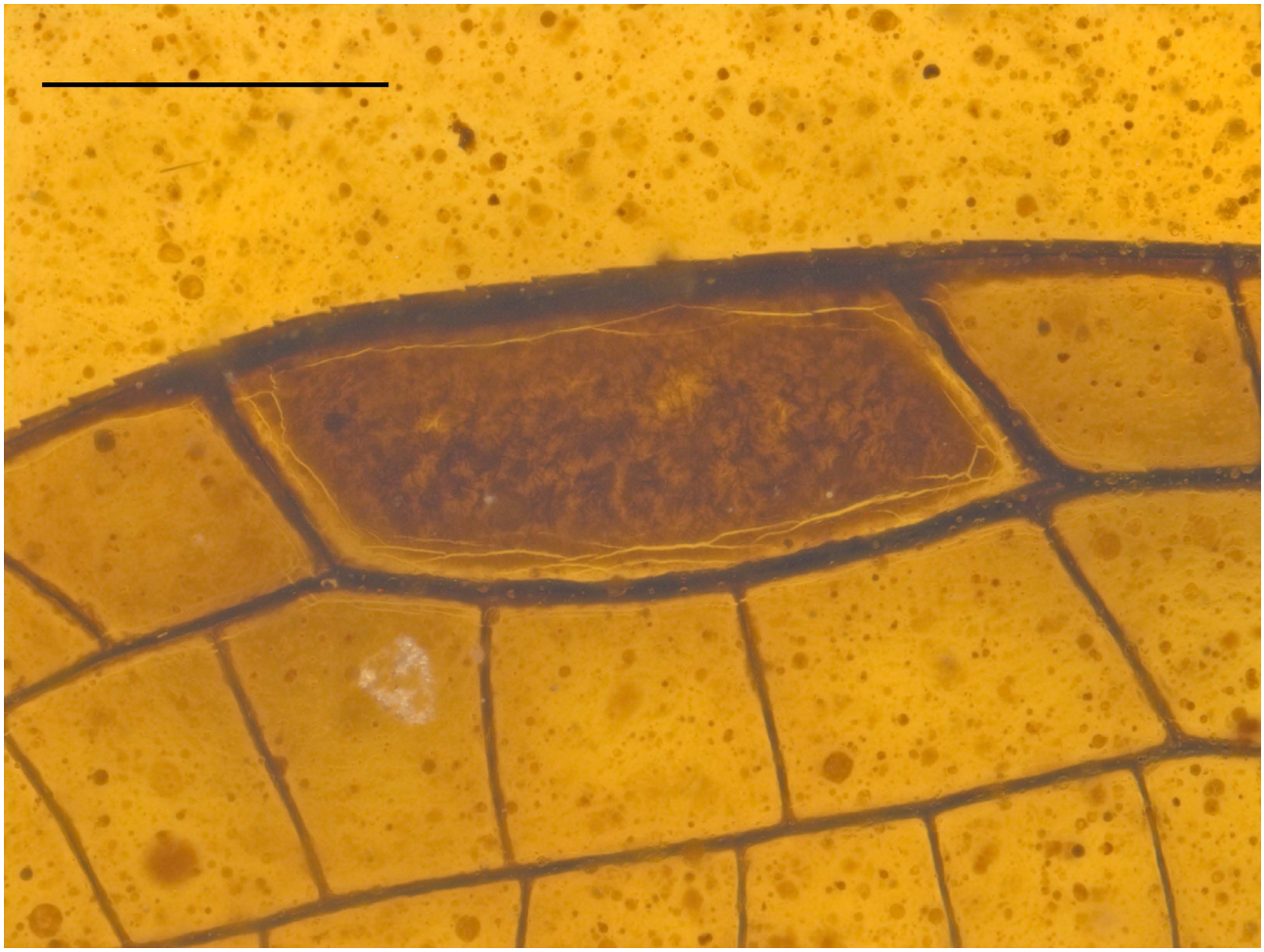

FIGURE 10. Micro photograph of forewing pterostigma of *Burmagrion marijanmatoki* **gen. et sp. nov.**, holotype SMNS Bu-158. Scale bar = 0.5 mm.

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