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Short communication

A new large-sized genus of Babinskaiidae (Neuroptera: Myrmeleontoidea: Nymphidoidae) from mid-Cretaceous Burmese amber

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ABSTRACT

A new genus and species *Gigantobabinskaia godunkoi* gen. et sp. nov. (Neuroptera: Babinskaiidae) is described from mid-Cretaceous Burmese amber. With wing lengths of about 21 mm, this is by far the largest of all known members of the family. Within Babinskaiidae, the new species shows closer affinities to the monotypic genus *Electrobabinskaia*. The functional significance of dilated tarsomeres in Babinskaiidae is discussed; their presence may point to an arboreal mode of life.

1. Introduction

The species-poor neuropteran family Babinskaiidae is placed within the epifamily Nymphidoidae of the superfamily Myrmeleontoidea (Makarkin et al., 2017). Babinskaiidae up to now comprise eleven described species in eight genera, which are only known from three localities, i.e., the Lower Cretaceous Brazilian Crato and Transbaikalian Zaza Formations, and mid-Cretaceous Burmese amber (Martins-Neto and Vulcano, 1989; Martins-Neto, 1992; Ponomarenko, 1992; Lu et al., 2017; Makarkin et al., 2017; Hu et al., 2018; Huang et al., 2019). All known species of Babinskaiidae are small-sized with a forewing length of 9–13 mm only. Here we add a new genus and species from Burmese amber, which is gigantic compared with these taxa. Its hind wing length is 21 mm, and its forewing length should be slightly more than 21 mm (both forewings are incompletely preserved). *Gigantobabiskaia godunkoi* gen. et sp. nov. features bilobed, crescent-shaped tarsomeres, which may point to an arboreal mode of life.

2. Material and methods

This study is based on a single specimen of Babinskaiidae embedded in a relatively large piece of Burmese amber (about 30 × 40 mm), with numerous small insects as syninclusions: Neuroptera: Berothidae (3 specimens), small Coleoptera (3 specimens), small Diptera: Nematocera (6 specimens), Lepidoptera (1 specimen), and undetermined insects (4 specimens, often fragmentary). Additionally, numerous secondary borings of piddocks (Bivalvia: Pholadidae), filled with sediment, are present at the outer margins of the amber piece (for details see also Smith and Ross, 2018).

Burmese amber originates from the Hukawng Valley in the state of Kachin in northern Myanmar. A map of this valley is given by Grimaldi et al. (2002, fig. 1). The age is currently considered to be earliest Cenomanian (Shi et al., 2012; Smith and Ross, 2018). The precise mine from which this piece originated cannot be determined. It was acquired from a local trader by Patrick Müller, Käshofen, Germany, who generously donated the amber piece to the State Museum of Natural History Stuttgart, Germany (SMNS).

The specimen was studied under a Leica M205C stereo microscope. Serial photographs were taken using a Leica Z16 APO Macroscope with attached Leica DMC5400 digital camera. Serial

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photographs were stacked with Helicon Focus Pro (HeliconSoft) to obtain enhanced depth of field, and optimised in sharpness, contrast and tonality with Adobe Photoshop CS5. Line drawings were prepared by VM using Adobe Photoshop CS3.

The venational terminology follows Makarkin et al. (2017). Terminology of wing spaces and details of venation (e.g., traces, veinlets) follows Oswald (1993).

All taxonomic acts established in the present work have been registered in ZooBank LSID (see below), together with the electronic publication urn:lsid:zoobank.org:pub:940B8623-423F-44F9-A812-4ABF866.

Abbreviations: AA1–AA3, first to third Anterior Analis; CuA, Anterior Cubitus; CuP, Posterior Cubitus; MA and MP, anterior and posterior branches of the Media; RA, Anterior Radius; RP, Posterior Radius; RP1, most proximal branch of RP; RP2, branch of RP distad RP1; ScP, Posterior Subcosta.

3. Systematic palaeontology

Order Neuroptera Linnaeus, 1758
Superfamily Myrmeleontoidea Latreille, 1802
Epifamily Nymphidoidae Rambur, 1842
Family Babinskaiidae Martins-Neto and Vulcano, 1989

Genus ***Gigantobabinskaia*** gen. nov.
(urn:lsid:zoobank.org:act:9A5107F2-7891-4CBE-A765-A2504E1ED974)
Type and only species. *Gigantobabinskaia godunkoi* sp. nov.

Derivation of name. From the Greek *gigas* [genitive *gigantos*], gigantic, huge; and *Babinskaia*, a genus-group name, referring to largest babinskaiid known so far. Gender feminine.
Diagnosis. Largest babinskaiids with forewing ≥21 mm long [9–13 mm long in other species]; basitarsus only slightly longer than second tarsomere, with very broad lateral wing-like dilatations (as broad as those of second tarsomere) [basitarsus markedly longer than second tarsomere, with narrow lateral wing-like dilatations (markedly narrower than dilatations of second tarsomere) in other genera]; proximal-most forked subcostal veinlet located proximad RP1 origin in forewing, slightly distad RP1 origin in hind wing [in other genera this veinlet is located well distad RP1 origin in both wings]; in hind wing, second gradate series of crossveins well developed, with six crossveins between branches of RP [second gradate series absent in other genera]; RP with 15 branches [3–8 in other genera].

Gigantobabinskaia godunkoi sp. nov.
(urn:lsid:zoobank.org:act:49E24B41-F7CF-4567-B602-E75B464542A0/8)
Figs. 1–4

Derivation of name. The species is dedicated to Roman J. Godunko, Ukrainian ephemeropterist, in appreciation of his contributions to fossil mayflies in amber.
Type material. Holotype SMNS BU-339, ex coll. P. Müller, deposited in the amber collection of Stuttgart State Museum of Natural History, Stuttgart, Germany. The specimen is incompletely preserved: head, forelegs, and right mid leg are missing, left mid leg only partly preserved; wings incompletely preserved with distal parts missing; posterior half of abdomen ventrally damaged at length, sternites and genitalia not preserved).
Type locality and horizon. Burmese amber (Northern Myanmar: Kachin State: Myitkyina District: Tanai Township: Hukawng Valley). Upper Cretaceous: Lowest Cenomanian.

Description. Head missing. Thorax poorly preserved, details not discernible. Legs not preserved except hind legs and proximal part of left mid leg. Metafemur relatively stout, metatibia more slender, both long and covered with very dense, rather short setae; metatarsus covered with scarce, rather short, fine setae on both surfaces (density of setae decreases towards fifth metatarsomere): first to fourth tarsomeres with very broad lateral wing-like dilatations (metabasitarsus longest, second to fourth metatarsomeres crescent-shaped); fifth metatarsus smallest metatarsomere, cordiform; metapretarsus very small; claws thin, elongate, slightly curved at half-length, widely spaced and perpendicular to axis of tarsus. Abdomen ca. 12.5 mm long: first and second segments short, transverse; third to eighth tergite elongate (fourth to sixth longest); ninth tergite transverse, relatively long; ectoproct (tenth tergite) relatively large, elongated. Posterior half of abdomen ventrally damaged at length, sternites sixth to ninth missing or broken. Posterior abdominal tergites covered with dense, fine, rather long setae.

Forewing ca. 13.8 mm long as preserved (estimated complete length ca. 22 mm); ca. 6.3 mm wide as preserved (estimated complete width ca. 6.8 mm). Costal space narrowed basally, continuously dilated distad. Proximal subcostal veinlets simple, widely spaced; more distal veinlets (distad origin of RP) more inclined and closely spaced, mostly shallowly once forked. Subcostal space relatively narrow; crossveins not detected. RP originates far from wing base; RP1 originates rather far from origin of RP; basal portions of three other branches preserved, with two crossveins between these. Between R/RP and M eight preserved crossveins: five presectoral, of these distal-most crossvein connected by two additional crossveins with R/RP; two crossveins between two origins of RP and RP1; and one between RP1 and M. Basal crossvein 1r-m not detected, probably absent. M not forked and branched in proximal half. Several widely-spaced crossveins between M and Cu/CuA (nine detected); 1m-cu rather long, slightly oblique. Cu dividing into CuA, CuP near wing base. CuA pectinate, with 11 preserved long branches; three proximal-most branches simple, distal parts of others not preserved. Three long crossveins between four proximal-most branches form short gradate series. CuP pectinate, with four rather short, simple branches; no crossveins between these branches. Six crossveins between CuA, CuP; distal-most crossvein shortest connecting CuA1 and anterior trace of CuA. Anal veins (AA1 to AA3) short, simple, arched. Two crossveins between these anal veins.

Hind wing elongated, narrowed proximally and dilated medially, 21.0 mm long, 5.0 mm wide. Costal space narrowed basally, continuously dilated distad. Subcostal veinlets simple and widely spaced proximally becoming increasingly inclined and closely spaced to pterostigmal region; subcostal veinlets forked distad origin of RP1. Subcostal space moderately narrow. ScP fused distally with RA; ScP+RA entering margin beyond wing apex, with closely spaced veinlets which are shallowly forked. RA space narrowed towards apex, with six widely-spaced crossveins before fusion of ScP and RA, and one detected crossvein after. RP originates far from wing base, with 15 branches. RP1 simple (possibly once forked in left wing); other branches mainly once forked. In radial/medio-radial spaces, crossveins form three gradate series: inner series consists of three long crossveins; second (intermediate) series included seven crossveins; third (outer) series consists of 10 short crossveins (three most distal ones barely traceable). Between R/RP and MA few crossveins: at least three presectoral crossveins; three long crossveins between origins of RP and RP1; three detected crossveins between RP1 and MA. MA pectinately branched distally, with eight branches; most of these simply. MP conspicuously bent at origin of MP1; strongly pectinate, with 14 branches; MP1 stouter than other branches, originated at level of origin of RP; proximal

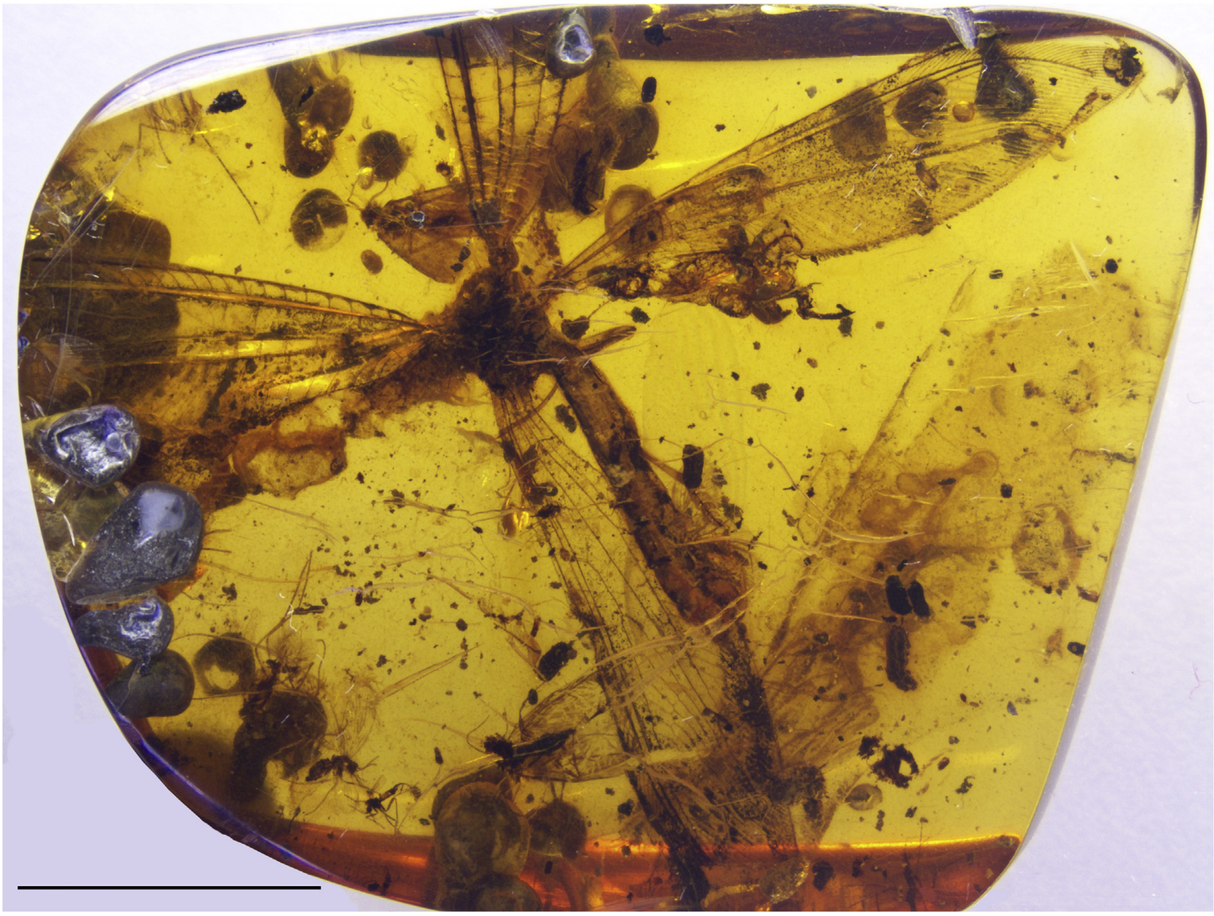

Fig. 1. *Gigantobabinskaia godunkoi* sp. nov., holotype SMNS BU-339. Specimen as preserved. Scale bar represents 10 mm.

branches simple, distally forked. Crossveins between MA and MP and between MP and CuA widely spaced. CuA nearly parallel to hind wing margin, pectinately branched, with six simple, widely-spaced branches; branches become longer towards apex. CuP short, basally fused with AA1; free distal parts of CuP and AA1 short, simple. AA2, AA3 not detected.

Remarks. The upper and lower wing membranes are strongly separated in some areas of both wings, which is seemingly resulting in doubled veins (see Fig. 3).

4. Discussion

Wing venation, shape of metatarsus and thin, curved tarsal claw of *Gigantobabinskaia* gen. nov. are most similar to those of the monotypic genus *Electrobabinskaia* Lu et al., 2017 from Burmese amber, but these genera are easily distinguished from each other (see diagnosis). Unfortunately, the ventral posterior half of the abdomen in the new species is strongly damaged and distal sternites are broken or missing; as a result, it is very hard to determine its sex. The shape of terminal abdominal tergites of *Gigantobabinskaia* is generally similar to those of both males and females of *Electrobabinskaia* (see Lu et al., 2017, fig. 4C, D; Hu et al., 2018, fig. 5E, F). *Gigantobabinskaia* is more distantly related to other genera of Babinskaiidae.

The similar curvature of the slender elongated claws in both *Gigantobabinskaia* and *Electrobabinskaia* is especially significant. Claws of other Babinskaiidae when preserved (i.e., *Babinskaia formosa* Martins-Neto and Vulcano, 1989; *Burmobabinskaia tenuis* Lu et al., 2017; *Parababinskaia makarkini* Hu et al., 2018) are stouter and shorter than in these genera and generally similar to claws of most other Neuroptera.

The dilatation of all five metatarsomeres is most developed in *Gigantobabinskaia* compared to other Babinskaiidae and to Neuroptera in general. These tarsomeres are only slightly less dilated than those in *Electrobabinskaia burmana* Lu et al. (2017), differing mainly by the nearly undilated basitarsus (see Hu et al., 2018, fig. 5C). Tarsi are moderately dilated in *Parababinskaia makarkini* (see Hu et al., 2018, fig. 2C). In *Babinskaia formosa* (the only impression species with preserved tarsal structure), three tarsomereres of protarsus (second to fourth) are bilobed and moderately dilated, but tarsomeres of meso- and metatarsus do not appear to be dilated (Martins-Neto and Vulcano, 1989, fig. 5). The tarsal dilatation is least developed in *Burmobabinskaia tenuis* and probably *Pseudobabinskaia martinsnetoi* (Lu et al., 2017).

The functional significance of these dilated tarsomeres in Babinskaiidae is not obvious. In many beetle families, dilated tarsomeres are present only in the forelegs of males to assist the attachment to the female during copulation (Beutel and Leschen, 2016), a well-known example is the male foretarsi in Carabidae (Müller-Motzfeld, 2004). However, bilobed or widely expanded tarsomeres on all legs in both sexes of some arboreal ground beetles (Carabidae: Harpalini) are sometimes regarded as adaptation for walking on leaves (Ober, 2003). Likewise, this has been assumed for dilated tarsi present in many species of the Staphylinid genus *Stenus* Latreille, 1796 (Betz, 2002). However, in many insect groups with both dilated or non-dilated tarsi, tarsomeres of both sexes can be equipped with various adhesive devices, among them tenant hairs or hairy pads (Beutel and Gorb, 2001). In many

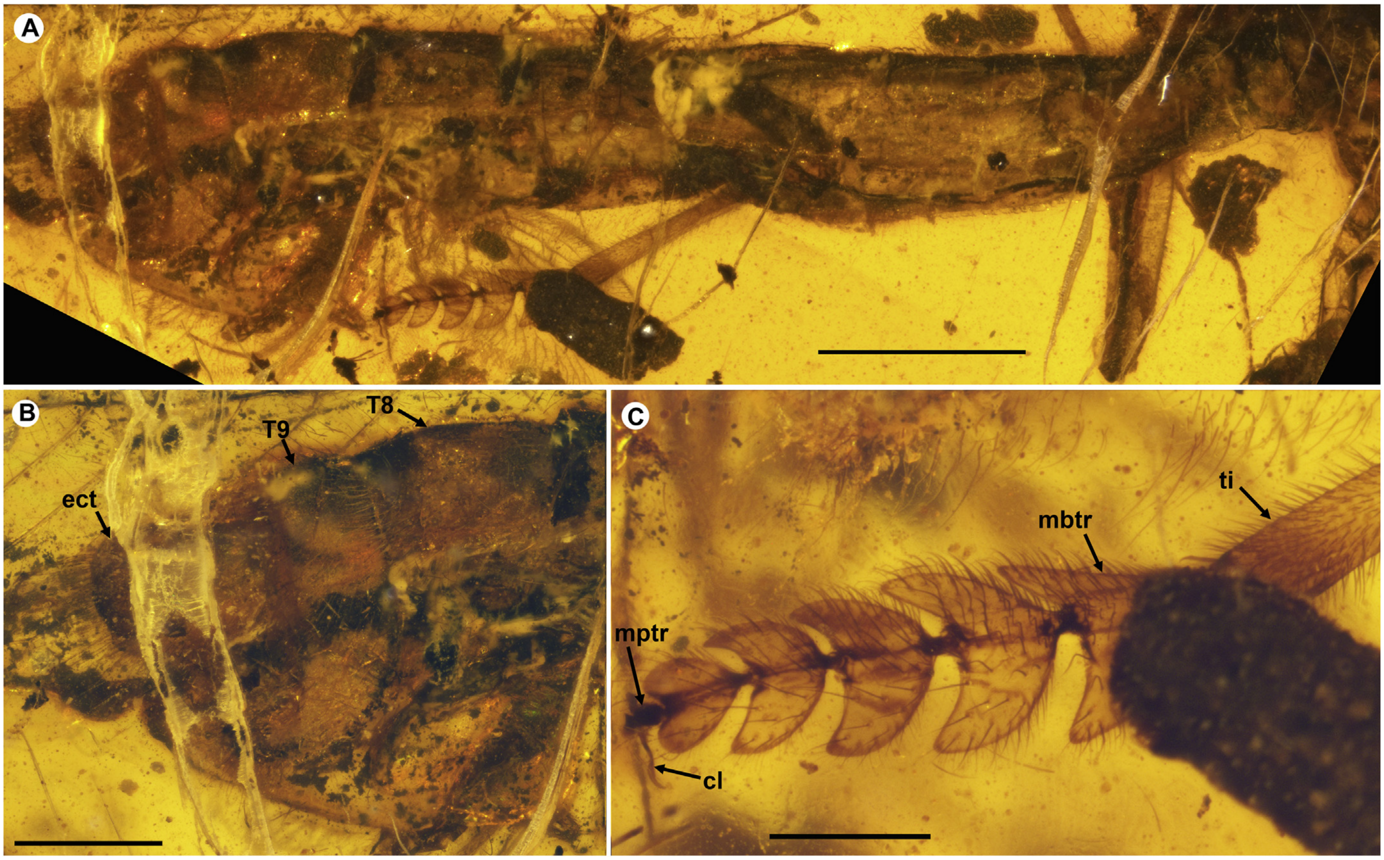

Fig. 2. *Gigantobabinskaia godunkoi* sp. nov., holotype SMNS BU-339. Abdomen and hind legs. A, abdomen, lateral view; B, apex of abdomen, lateral view; C, left metatarsus, dorsal view. cl, claw; ect, ectoptoct; mbtr, metabasitarsus; mptr, metapretarsus; ti, tibia; T8, T9, eight and nine tergites. Scale bars represent 2 mm (A), 1 mm (B), 0.5 mm (C).

cases, this is even regarded as important character used for phylogeny (Gnaspini et al., 2017). These specialised tenant hairs may even allow some groups to move on vertical surfaces (see e.g., Voigt et al., 2017). Well known is also the secretion of lipids by tarsal gland cells, which facilitate adhesion on smooth surfaces (e.g., Betz, 2003).

However, tarsi of *Gigantobabinskaia* and other Babinskaiidae are ventrally only scarcely covered with fine setae and do not show any dense clusters of tenant hairs. Moreover, so far no adhesive devices or tarsal secretion are reported in extant Myrmelontoidea (Beutel and Gorb, 2001). Most likely these hairs present on the tarsi of *Gigantobabinskaia* do have a tactile function. We certainly do not

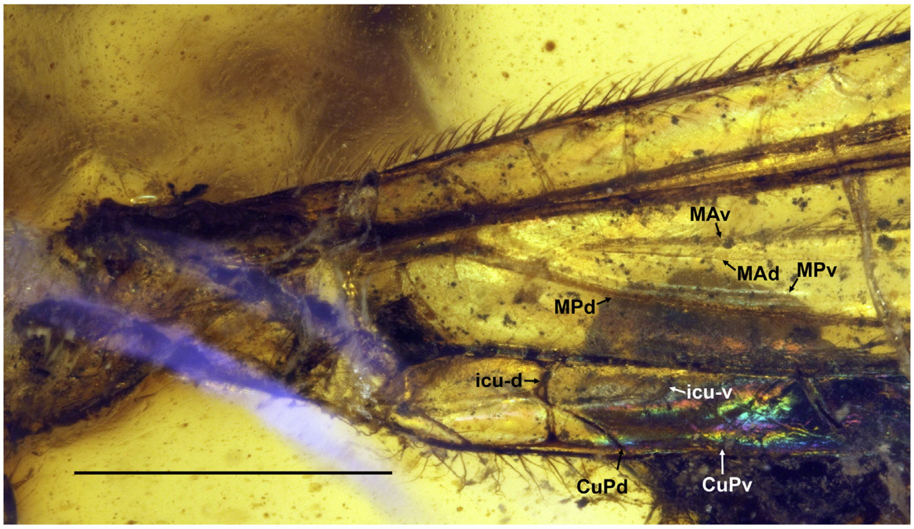

Fig. 3. *Gigantobabinskaia godunkoi* sp. nov., holotype SMNS BU-339. Basal portion of the right hind wing showing the separation and strong shift of dorsal and ventral membranes. icu-d, icu-v, crossvein between CuA and CuP on dorsal and ventral membrane, respectively; MAd, MAv, Media Anterior on dorsal and ventral membrane, respectively; MPd, MPv, Media Posterior on dorsal and ventral membrane, respectively; CuPd, CuPv, Cubitus Posterior on dorsal and ventral membrane, respectively. Scale bar represents 1 mm.

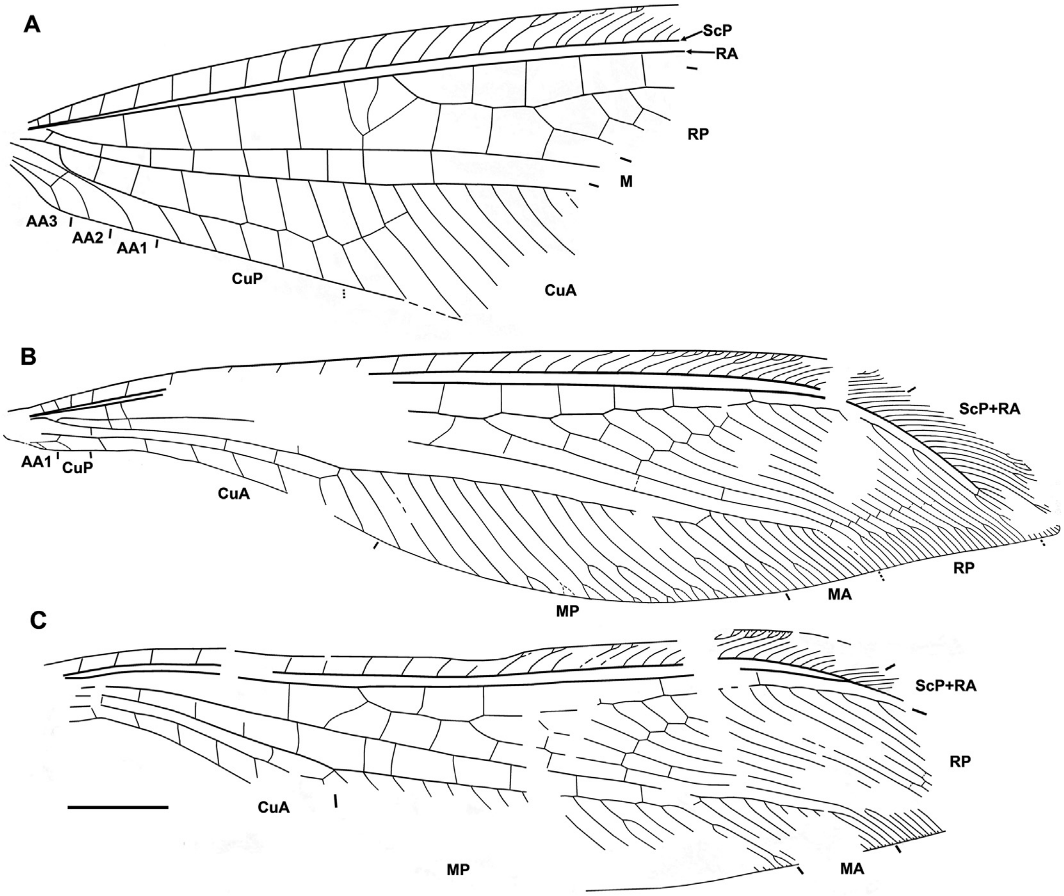

Fig. 4. Wing venation of *Gigantobabinskaia godunkoi* sp. nov., holotype SMNS BU-339. A, left forewing; B, right hind wing; C, left hind wing (A and C converted to standard view, with apex to the right). Scale bar represents 2 mm (all to scale).

assume that the dilated tarsomeres facilitated attachment during copula, as they are most probably strongly dilated in all legs (fore- and mid-tarsi in *Gigantobabinskaia* not preserved, but we assume similar dilatation as in *Electrobabinskaia*). However, the dilatation of tarsomeres as such may have had a selective advantage in an arboreal environment faciliating movement on leaves.

The wings of *Gigantobabinskaia godunkoi* are the largest and their venation is the densest within Babinskaiidae, but they possess all character states, which are characteristic of the family (see Makarkin et al., 2017). In particular, the diagnosis of Babinskaiidae includes the reduction of two anal veins in the hind wing (i.e., AA2 and AA3), which is considered as autapomorphy of the family. However, a short AA2 was recently discovered in *Parababinskaia makarkini* and *Electrobabinskaia burmana* (see Hu et al., 2018, figs. 3E, 5B). In *Gigantobabinskaia godunkoi*, AA2 or AA3 cannot be observed due to preservation. In general, the anal space of the babinskaiid hind wing is so small (restricted to very basal area of the wing) that it is hard to detect these veins even if these are present. Thus, the very small anal space and the reduction of AA3 may be considered as autapomorphic characters of Babinskaiidae.

5. Conclusions

The discovery of *Gigantobabinskaia godunkoi* gen. et sp. nov. from mid-Cretaceous Burmese amber, so far the largest member of Babinskaiidae, considerably increases our knowledge on this uncommon family. All tarsomeres of hind legs (at least) in this species are much dilated compared to those of other Babinskaiidae and Neuroptera in general, which may point to an arboreal mode of life. Nevertheless, the venation of the new genus does not principally differ from that of other genera of the family, especially *Electrobabinskaia*.

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