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Short communication

The first Mesozoic froghopper in amber from northern Myanmar (Hemiptera, Cercopoidea, Sinoalidae)

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ABSTRACT

Representatives of the froghopper family Sinoalidae were exclusively known from Jurassic deposits in northeastern China. A new taxon, *Fangyuania xiai* Chen, Szwedo and Wang, gen. et sp. nov., is erected from mid-Cretaceous Burmese amber and assigned to this family. The remarkable new sinoalid distinctly differs from its con-familial Jurassic relatives in having a tegmen with cell between costal margin and Pc + CP broad, stem MP + CuA relatively long and connecting crossvein *cua-cup* just at its bifurcation, and having a hind wing with posterior margin strongly ripple-like and wing tip with narrow peripheric membrane wrinkled. This finding greatly expands the duration and geographic distribution of the family Sinoalidae. The new taxon, as the first Cercopoidea reported in Mesozoic amber, provides some insights on morphological diversification and evolutionary history of early Cercopoidea and Clypeata as well.

1. Introduction

The hemipteran superfamily Cercopoidea Leach, 1815, collectively named froghoppers, spittlebugs or cuckoo-spit insects, is a large and worldwide distributed insect group comprising over 2600 recent species and occurring in most terrestrial habitats (Cryan and Svenson, 2010; Hamilton, 2012; Wang et al., 2012; Chen et al., 2015a, b). The higher classification of Cercopoidea is subject of debate (Hamilton, 2001, 2012, 2013, 2014, 2015, 2016; Carvalho & Webb, 2005; Cryan and Svenson, 2010). Traditionally this superfamily includes extant families, i.e. Aphrophoridae Amyot et Serville, 1843, Cercopidae Leach, 1815, Clastopteridae Dohrn, 1859, Epipygidae Hamilton, 2001 and Machaerotidae Stål, 1866, and three extinct ones, i.e: Cercopionidae Hamilton, 1990, Procercopidae Handlirsch, 1906 and Sinoalidae Wang et Szwedo, 2012 (Wang et al., 2012).

There are controversies over the number, content and subdivisions of families within Cercopoidea (Hamilton, 2001, 2012, 2013, 2014, 2015, 2016; Dietrich, 2002, 2005; Cryan and Svenson, 2010; Cryan and Urba, 2012), inferred from various interpretations of morphological and molecular data, and these results do not resolve family-level relationships among modern cercopoids. So far, about one hundred fossil taxa are known to be placed in Cercopoidea (EDNA, 2015), but with a few exceptions they are in need of urgent revision, with number of fossils named in 19th and in beginning of 20th centuries (Metcalf and Wade, 1966) and never analyzed since then.

Cercopoidea, similarly as other Clypeata, are descendants of extinct Hylicelloidea. The family Procercopidae, reported from the Early Jurassic to Early Cretaceous in Eurasia, gradually transforms morphologically into modern cercopoid forms (Shcherbakov and Popov, 2002), with a quite rich fossil record from the Palaeogene and Neogene (Metcalf and Wade, 1966; Carpenter, 1992). The little known family Cercopionidae comes from the Lower Cretaceous Crato Formation, Brazil (Hamilton, 1990). The placement of *Mesojassula* Evans, 1956 (represented by a hindwing from the Carnian of Mt. Crosby, Queensland, Australia) in Cercopoidea *incertae sedis*

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(Becker-Migdisova, 1962) or Cercopionidae (Hamilton, 1992) is unresolved yet, but this fossil more probably represents Hylicellidae or earliest Membracoidea. The family Sinoalidae was established based on fossils from the uppermost latest Middle Jurassic of Daohugou, Ningcheng County, Inner Mongolia of northeastern China (Wang et al., 2012).

The Sinoalidae distinctly differs from the widely distributed Procercopidae mainly in the following characteristics: tegmen with costal area and clavus more sclerotized and punctate (*vs*. whole tegmen punctate in the latter), hind wing without submarginal vein and appendix (*vs*. ambient vein and narrow appendix in the latter), and hind tibia with two rows of lateral spines (*vs*. one small single lateral spine in the latter) (Wang et al., 2012). Up to now, six genera (*Luanpingia* Hong, 1983, ?*Hebeicercopis* Hong, 1983, *Huabeicercopis* Hong, 1983, *Sinoala* Wang and Szwedo, 2012, *Jiania* Wang and Szwedo, 2012, and *Shufania* Chen et al., 2017) exclusively recorded from Jurassic deposits of northeastern China have been attributed to this distinct froghopper family (Wang et al., 2012; Chen et al., 2017).

The Cercopoidea has been widely recorded in Mesozoic deposits of Germany, Russia, Central Asia, China and Brazil (Hamilton, 1990; Chen et al., 2015a, b). However, all reported Mesozoic cercopoids are imprint fossils and most of them are incomplete, even just with sole tegmen or hind wing preserved. Amber affords exceptional three-dimensional preservation of insects, often providing more details than imprint fossils (Chen et al., 2016a). We here report a complete male adult froghopper, referable to Sinoalidae, in mid-Cretaceous Burmese amber.

2. Geological context

The amber specimen comes from the Hukawng Valley of Kachin Province in northern Myanmar (Burma) (locality in Kania et al., 2015: fig. 1). The age of Burmese amber had been obscure for a long time, even considered as young as Miocene (Grimaldi et al., 2005). In this century, some studies based on different biological inclusions widely considered Burmese amber to be Albian-Cenomanian (mid-Cretaceous) (e.g., Cruickshank and Ko, 2003; Grimaldi et al., 2005; Ross et al., 2010). Recent U–Pb zircon dating of the volcanoclastic matrix indicates the Burmese amber at an earliest Cenomanian age (98.79 ± 0.62 Ma) (Shi et al., 2012).

Burmese amber contains probably the most diverse Mesozoic palaeobiota (Shi et al., 2012), and its inclusions have been studied for about a century (Cruickshank and Ko, 2003; Kania et al., 2015; Zheng et al., 2016). Insects known from Burmese amber are abundant and highly diverse, providing some great insights into their ecology, ethology and evolutionary history (e.g., Delclòs et al., 2016; Wang et al., 2016). Some hemipterans have been reported in Burmese amber to date, with most being true bugs (the suborder Heteroptera) (e.g., Grimaldi and Engel, 2008; Poinar and Brown, 2016). The new froghopper is the first representative of the suborder Cicadomorpha.

3. Material and methods

The fossil froghopper (specimen no. BA16003), in yellow and transparent amber, is deposited in the Lingpoge Amber Museum in Shanghai, China. All taxonomic acts established in the present work have been registered in ZooBank (see below), together with the electronic publication LSID: urn:lsid:zoobank.org:pub:D6AD6905-DAC8-4A14-B016-AFAD78010D3D.

The specimen was examined, photographed and measured using the VHX 5000 digital microscope platform, with incident and transmitted light used simultaneously. The line drawings of tegmen and hind wing were prepared with two image-editing softwares (CorelDraw 12.0 and Adobe Photoshop CS3).

There is no consensus on Cicadomorpha venation pattern and vein homology; various authors (e.g., Emeljanov, 1987; Pulz and Carvalho, 1998; Hamilton, 2012) used various names and interpretations. Nel et al. (2012) proposed a new interpretation of wing venation pattern for all Paraneoptera, assuming that CuA gets fused with M + R stem at wing base and connected with CuP by a specialized crossvein *cua-cup*, which is remarkably different from the traditional interpretations. The venational terminologies used herein are slightly modified from Nel et al. (2012). The first longitudinal vein on the clavus is treated as open problem in Nel et al. (2012). We herein tentatively treat this longitudinal vein as Pcu rather than A_1. One more point is the complete fusion of MA with R in Paraneoptera, so only MP is present. Besides, the nomenclature of body structures proposed in Evans (1966) is mainly followed.

4. Systematic palaeontology

Order Hemiptera Linnaeus, 1758
Suborder Cicadomorpha Evans, 1946
Superfamily Cercopoidea Leach, 1815
Family Sinoalidae Wang and Szwedo, 2012

Genus Fangyuania Chen, Szwedo and Wang, gen. nov.
(urn:lsid:zoobank.org:act:BBCBDDD3-9B72-47BB-BA41-F89F8AF9A375)
Type species: *Fangyuania xiai* Chen, Szwedo and Wang, gen. et sp. nov; by present designation and monotypy.

Etymology. The generic name is dedicated to Mr. Fangyuan Xia, Director of the Lingpoge Amber Museum in Shanghai, for his contribution to the study of this amber specimen.
Diagnosis. Head about 1.5 times longer than pronotum in mid line. Anterior margin of head with angulate apex. Ocelli on head disc arranged in isosceles triangle with wide base. Tegmen with length/width ratio about 2.8; hypocostal carina distinct, reaching anteroapical angle; costal area and stigmal cell punctate; stem ScP + R about 0.6 of basal cell length; stem CuA forked basad of calval apex. Single lateral anteroventral spine and two lateral anterodorsal spines in row on metatibia.

Fangyuania xiai Chen, Szwedo and Wang, gen. et sp. nov.
(urn:lsid:zoobank.org:act:9AD387FA-9987-4BA3-9F59-2E495F249841)
Figs. 1–3

Etymology. The specific name is in honor of Mr. Fangyuan Xia.
Holotype. BA16003, male adult with wings attached to body, right wings at top of body and left tegmen and hind wing slightly outspread, deposited in the Lingpoge Amber Museum in Shanghai, China.
Locality and horizon. Hukawng Valley, Kachin Province, Myanmar; lowermost Cenomanian, Upper Cretaceous (Shi et al., 2012).
Diagnosis. As for genus as it is the only so far included species.
Description. Measurements (in mm). Body including tegmen in repose length 7.23; head with compound eyes length 1.24, width 1.60; antenna length 0.85; pronotum length 0.63, width 2.22; scutellum length 1.07, width 1.40; fore femur length 0.69, tibia length 0.65, tarsus length 0.35; middle femur length 0.81, tibia length 0.74, tarsus length 0.32; hind femur length 0.81, tibia length 1.52, tarsus length 0.52; apical process of aedeagus length 0.38; tegmen length 5.61, width 2.02.

Head. (Figs. 1, 3A–C). Head with compound eyes narrower than pronotum, anterior margin obtuse angled, with arcuate arms diverging at angle about 140°. Crown extended, depressed in the