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New material of the cricket *Sinagrillus xinjiangensis* Wang *et al.*, 2019 (Grylloidea, Baissogryllidae) from the Lower Jurassic of Xinjiang, NW China

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Grylloidea is a large superfamily of orthopteran insects, comprising over 4,000 species in four extant families (Gryllidae, Mogoplistidae, Gryllotalpidae and Myrmecophilidae) and two extinct families (Baissogryllidae and Protogryllidae) to date (Resh & Cardé, 2009; Cigliano *et al.*, 2018; Wang *et al.*, 2019). Grylloids, commonly known as true crickets, are a group of adaptable insects occurring in all the temperate parts of the world except the highest mountain peaks. And interestingly, there are several apterous grylloid genera (*e.g.*, *Caconemobius*) living in mangrove swamps, where they use the stems to submerge themselves in saltwater and are able to “skate” on water surfaces (Resh & Cardé, 2009; Kim & Kim, 2010).

The extinct family Baissogryllidae comprises 21 genera in five subfamilies (Baissogryllinae, Bontzaganiinae, Cearagryllinae, Olindagryllinae and Sharategiinae) from the Cretaceous of Brazil, Mongolia, Russia and the United Kingdom, and the Jurassic of Mongolia and China (Sharov, 1968; Gorochoy, 1985; Martins-Neto, 1991; Gorochoy, 1992; Martins-Neto, 1995, 1999, 2002; Gorochoy *et al.*, 2006; Martins-Neto, 2009; Wang *et al.*, 2019). *Sinagrillus xinjiangensis* Wang *et al.*, 2019, the only baissogryllid known from China, was established based on a male forewing from the Lower Jurassic Sangonghe Formation of Xinjiang, northwestern China.

Herein we describe a new male forewing of *Sinagrillus xinjiangensis* from the same locality and horizon as the holotype of this species. A revised diagnosis of the genus *Sinagrillus* is given based on the observation of the new material and reexamination of the holotype, and the intraspecific variation is discussed.

Material and methods

The new material described herein was collected from the Upper Member of the Sangonghe Formation in the Haojiagou—Toutunhe section near Yongfeng Town, Urumqi City, Xinjiang, northwestern China (locality in Wang *et al.*, 2019: Fig. 1). Occurring in the Junggar, Turpan-Hami, Santanghu, Kupu, Hoxtolgay and Hefeng basins in northern Xinjiang, China, the Sangonghe Formation is represented by a set of fluvial, lacustrine, and delta sediments at a thickness of about 10–480 m (Deng *et al.*, 2010). It is biostratigraphically considered to be Early Jurassic in age (Deng *et al.*, 2010) but is upper part might enter the Middle Jurassic (Huang *et al.*, 2019). In this section, the Sangonghe Formation is in conformity with the overlying Middle Jurassic Xishanyao Formation and the underlying Lower Jurassic Badaowan Formation, and is divided into two members with a total thickness of 486.87 m (Deng *et al.*, 2010), yielding abundant fossils including plants, spores and pollen, megaspores, bivalves, gastropods, conchostracans, insects and ostracods (Zhu, 1994; Deng *et al.*, 2010; Wang *et al.*, 2019).

The specimen described here is deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGP171454). Photomicrographs were taken with a Zeiss Stereo Discovery V16 microscope system and Zen software, and drops of ethanol were briefly applied to the specimen to enhance the contrast and make wing venation more apparent. All images were digitally stacked photomicrographic composites of approximately 5–10 individual focal planes obtained using Helicon Focus software for a better illustration of the 3D structures of veins. The line drawings were produced by tracing the photographs using the image-editing software CorelDrawX7 and Adobe Photoshop CC.

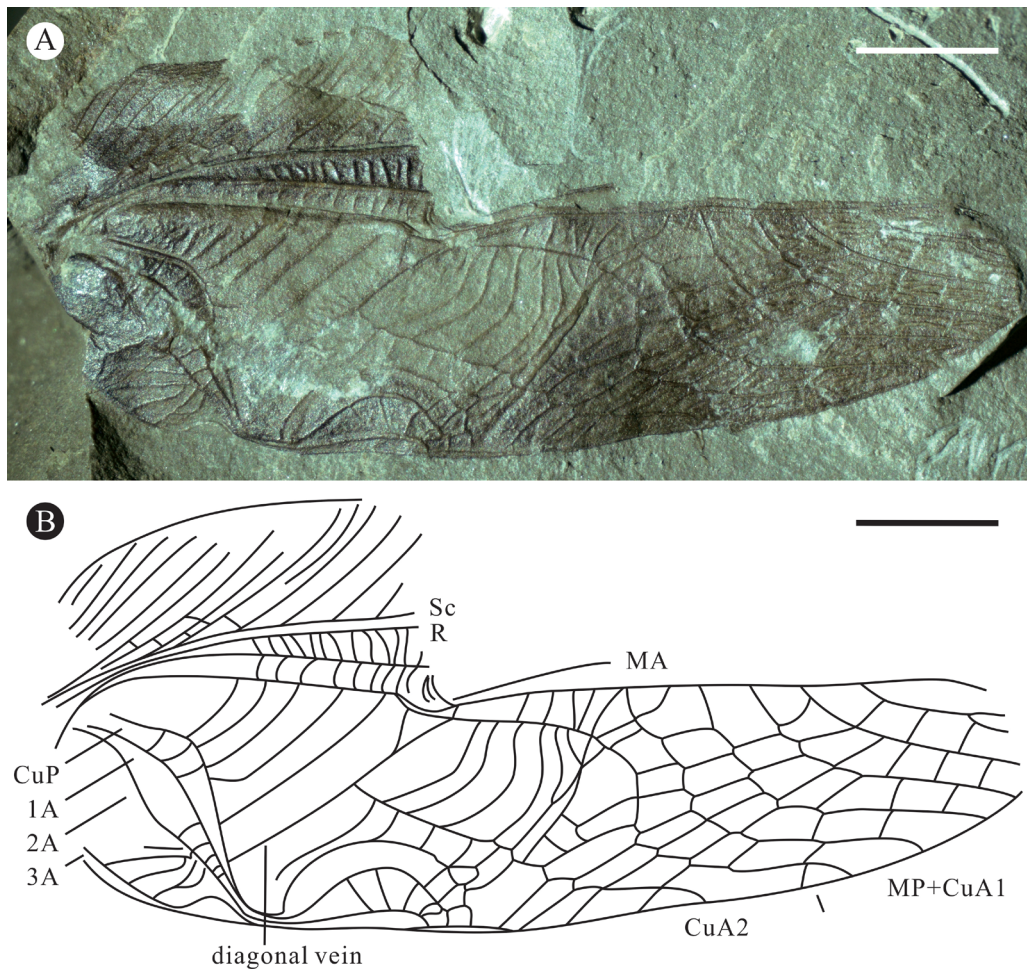


FIGURE 1. *Sinagrillus xinjiangensis* Wang *et al.*, 2019, NIGP171454, forewing. **A**, photograph. **B**, Reconstruction. Scale bars = 20 mm.

We follow the wing-venation nomenclature of Orthoptera proposed by Zeuner (1939), Sharov (1968, 1971), and amended by Gorochov (1986, 1995), which was also followed by Wang *et al.* (2019); the venational abbreviations used by Béthoux & Nel (2001, 2002) are given in parenthesis: C (ScA), costa; Sc (ScP), subcosta; RA, radius anterior; RS (RP), radial sector; M (M+CuA), media; MA (M), media anterior; MP (CuA), media posterior; Cu (CuP), cubitus; CuA (CuPa), cubitus anterior; CuP (CuPb), cubitus posterior; A, analis; 1A, first anal vein; 2A, second anal vein; 2A, third anal vein; and handle vein, a special cross-vein between CuA1 and CuA2.

Systematic palaeontology

Order Orthoptera Olivier, 1789

Superfamily Grylloidea Laicharting, 1781

Family Baissogryllidae Gorochov, 1985

Subfamily Baissogryllinae Gorochov, 1985

Genus *Sinagrillus* Wang *et al.*, 2019

Type species. *Sinagrillus xinjiangensis* Wang *et al.*, 2019.

Composition. Only known from the type species.

Diagnosis (revised after Wang *et al.*, 2019). Forewing only. Sc long and sigmoidal; R not fused with Sc and M basally; lancet-like area small; mirror small with three to five dividing veins; diagonal vein branched; cross-veins between diagonal vein and CuP parallel to diagonal vein; and cross-veins between branches of MP+CuA1 reticulated basally and regularly straight distally.

***Sinagrillus xinjiangensis* Wang *et al.*, 2019**

Diagnosis. As for the genus.

Material. NIGP171454, deposited in Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China an incomplete male right forewing. Basal part comparatively well-preserved, anterior remigium lost for over distal half; apex slightly damaged.

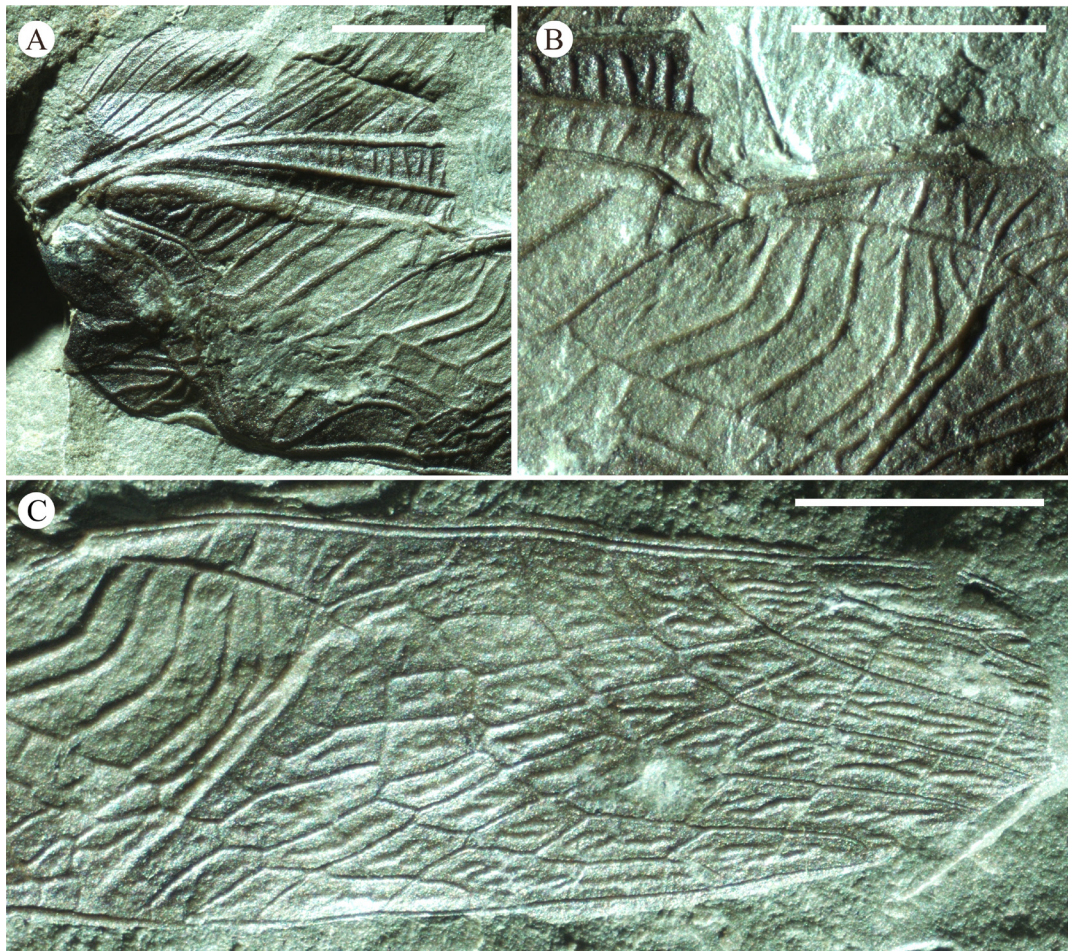


FIGURE 2. *Sinagryllus xinjiangensis* Wang *et al.*, 2019, NIGP171454, forewing, photographs. **A**, Details of basal part. **B**, Details of mirror. **C**, Details of MP + CuA1 and CuA2. Scale bars = 20 mm.

Locality and horizon. Haojiagou-Toutunhe section, Haojiagou valley, Yongfeng Town, Urumqi County, Urumqi City, Xinjiang, northwestern China; Sangonghe Formation, Lower Jurassic.

Description. NIGP171454. Male right forewing, preserved length 14.1 mm; width 5.9 mm. Sc lost distally, presumably long and reaching anterior margin over mid-length of forewing, with only 14 distinct and strongly oblique branches preserved; lancet-like area between R and proximal part of MA small; M forking into MA and MP at about 1 mm from wing base; area between MP, CuP and diagonal vein wide, with oblique veins simple and slightly curved; diagonal vein forked anteriorly; MP + CuA1 slightly arched basally, with first branch sigmoidal; CuA2 slightly curved basally and subparallel to MP + CuA1 distally; area between CuA2, lateral part of diagonal vein, and proximal part of branch of MP + CuA1 (mirror) wide; true mirror present in male forewing stridulatory apparatus; mirror with five dividing veins (cross-veins), sigmoidal and more or less parallel to true oblique veins; first to fourth dividing veins simple and fifth one forked medially; cross-veins between branches

of MP + CuA1 reticulated basally and regularly straight distally; area between CuP, diagonal vein and MP+CuA1 comparatively wide, with several cross-veins parallel to true oblique veins; CuP and 1A fused at about one-fifth of forewing length from base and then forked; 2A greatly close to 1A where CuP and 1A are fused, and then gradually distant from 1A; 3A present and distinctly arched just before its ending on wing posterior margin at level of fusion of CuP and 1A.

Discussion

The fossil family Baissogryllidae was erected by Gorochov (1985) on the basis of the following characteristics: a true mirror in the male forewing stridulatory apparatus; proximal branch of MP + CuA1 S-shaped; a distinct widening of the area between CuA2, lateral part of diagonal vein and proximal part of the above-mentioned branch of MP + CuA1; and dividing veins (cross-veins) of the mirror obliquely longitudinal, more or less parallel

to true oblique veins (Gorochov *et al.*, 2006). As one of the most diverse subfamilies within Baissogryllidae, the Jurassic-Cretaceous subfamily Baissogryllinae comprises seven genera: *Baissogryllus* Sharov, 1968, *Eubaissogryllus* Gorochov, 1985, *Storozhenkoana* Gorochov, 1992, *Ponomarenkoana* Gorochov, 1992, *Castillogryllus* Martins-Neto, 1995, *Speculogryllus* Gorochov, Jarzembowski & Coram, 2006 and *Sinagryllus* Wang *et al.*, 2019 (Sharov, 1968; Gorochov, 1985, 1992; Gorochov *et al.*, 2006; Wang *et al.*, 2019).

As the earliest representative of Baissogryllidae, *Sinagryllus xinjiangensis* Wang *et al.*, 2019 was established based on a well-preserved male right forewing. The new male forewing described above is distinguished from the holotype of *Sinagryllus xinjiangensis* in having a mirror with five dividing veins (three in the holotype), diagonal vein with only anterior end branched (both ends branched in the holotype), and a quadrangular cell closed by diagonal vein, CuA2 and first cross-vein between them (triangular in the holotype). The differences, however, only exist in or are closely related to cross-veins and therefore they are considered as interspecific variations here. Considering that they are subequal in size, basically consistent in venation and from the same locality and horizon, the two forewings are considered here to belong to the same species. And accordingly, the diagnosis of the genus *Sinagryllus* is revised as above.

In many male crickets, a small portion of the inner surface of left forewing is modified into a plectrum and the outer surface of right forewing bears a file. Male crickets produce pure-tone mating calls by rubbing their forewings together and the veins around the mirror are response to sound radiation (Walker, 1962; Montealegre *et al.*, 2011). The intraspecific variation happening around the mirror in *Sinagryllus xinjiangensis* demonstrates that baissogryllids had differentiation in the male forewing stridulatory apparatus, probably, in order to dominate in mating and adapt to intraspecific competition in the Early Jurassic ecological system of northwestern China.

Conclusion

A newly collected male cricket forewing from the Lower Jurassic Sangonghe Formation of Xinjiang, northwestern China is basically consistent venationally with the holotype (a male forewing) of *Sinagryllus xinjiangensis* Wang *et al.*, 2019 from the same locality and horizon, and therefore it is assigned to this species. Some differences observable in or closely related to cross-veins are treated as intraspecific variations. The intraspecific variation detected around the mirror in the species indicates that baissogryllid crickets became complicated in the male

forewing stridulatory apparatus, probably, in order to dominate in mating and adapt to the strong intraspecific competition in the Early Jurassic terrestrial ecosystems of northwestern China.

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