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Forever Love: The Hitherto Earliest Record of Copulating Insects from the Middle Jurassic of China

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Abstract

Background: Mating behaviors have been widely studied for extant insects. However, cases of mating individuals are particularly rare in the fossil record of insects, and most of them involved preservation in amber while only in rare cases found in compression fossils. This considerably limits our knowledge of mating position and genitalia orientation during the Mesozoic, and hinders our understanding of the evolution of mating behaviors in this major component of modern ecosystems.

Principal Finding: Here we report a pair of copulating froghoppers, *Anthoscytina perpetua* sp. nov., referable to the Procercopidae, from the Middle Jurassic of northeastern China. They exhibit belly-to-belly mating position as preserved, with male's aedeagus inserting into the female's bursa copulatrix. Abdominal segments 8 to 9 of male are disarticulated suggesting these segments were twisted and flexed during mating. Due to potential taphonomic effect, we cannot rule out that they might have taken side-by-side position, as in extant froghoppers. Genitalia of male and female, based on paratypes, show symmetric structures.

Conclusions/Significance: Our findings, consistent with those of extant froghoppers, indicate froghoppers' genitalic symmetry and mating position have remained static for over 165 million years.

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Introduction

Mating behaviors for extant insects have been studied and documented, for example, for froghoppers[1], scorpionflies[2] and planthoppers[3]. However, fossil records of unequivocal insect mating are fairly sparse. Boucot and Poinar[4] listed 33 instances of fossilized mating insects, such as fireflies, mosquitoes, planthoppers, leafhoppers, water striders, bees and ants, 27 of which are preserved in amber, others on compression fossils. The hitherto oldest example of copulation in fossil insects is a pair of chironomids (Diptera) discovered in Early Cretaceous amber from Lebanon [4,5].

Herein, we report a pair of well-preserved copulating froghoppers, *Anthoscytina perpetua* sp. nov., referable to the Procercopidae, from Jiulongshan Formation at the Daohugou Village in northeastern China. Procercopidae is an extinct family in the superfamily of froghoppers, Cercopoidea Leach, 1815. Froghoppers get their name because the adults hop around on plants and shrubs like tiny frogs. The nymphs of froghoppers are called spittlebugs because they cover themselves with foaming spittle, composed of tiny air bubbles trapped in secretions from their Malpighian tubules, which provides protection from predation, parasitism and desiccation[6]. This discovery of the earliest record of copulating insects hitherto sheds light on the evolution of mating behavior in this group of insects.

Daohugou Village (N41°18′38″, E119°13′20″) is located in Shantou Township, Ningcheng County, Inner Mongolia Autonomous Region, northeastern China. The Jiulongshan Formation is considered to be of late Middle Jurassic age (Bathonian–Callovian boundary interval, 164–165 Ma), based on Ar-Ar and SHRIMP U-Pb dating results [7–10]. Currently, about 19 insect orders have been reported from this locality[11].

Materials and Methods

Materials

We examined more than 1200 specimens from the locality of Daohugou, Inner Mongolia, China. All fossil materials studied are housed in the fossil insect collection of the Key Laboratory of Insect Evolution and Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Dong Ren, Curator). The extant *Cosmoscarta heros* (Fabricius) specimens are from the Insect Collection of Sun Yat-sen University, Guangzhou, China.