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New data on Jurassic Sinoalidae from northeastern China (Insecta, Hemiptera)

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Abstract.—The Sinoalidae, as one of the three Mesozoic froghopper families, was recently recognized from the latest Middle–earliest Late Jurassic Daohugou Biota of northeastern China. We herein report some new materials from the same horizon and locality, providing some new insights on morphological diversity and evolution of this family. *Shufania hani* new genus new species indicates that the relative branching position of veins M and CuA of the forewing is highly variable within the Sinoalidae and not appropriate for family-level diagnosis. The venations of three reported sinoalid hind wings are conservative, likely due to its simplified topology and reduced terminal branches. Color patterns of hind wings are likely variable for different sinoalid froghoppers. However, considering that color pattern is easily weakened or even erased by diagenetic processes for imprint fossils, the morphological character is not reliable for distinguishing different sinoalid taxa. Additionally, our new material suggests that the number of lateral spines of the hind tibia can vary intra-individually for sinoalids, just as in some recent froghoppers.

Introduction

The hemipteran superfamily Cercopoidea Leach, 1815, known as froghoppers or spittlebugs, comprises nearly 3000 described species. The high-level classification of living Cercopoidea is still controversial: five modern cercopoid families (Cercopidae Leach, 1815, Aphrophoridae Amyot and Serville, 1843, Clastopteridae Dohrn, 1859, Machaerotidae Stål, 1866, and Epipygidae Hamilton, 2001) have been described to date, but various taxonomists recognize three to five (Hamilton, 2001, 2012; Dietrich, 2002, 2005; Holzinger et al., 2003). Moreover, three extinct families from the Mesozoic have been attributed to this superfamily (Wang et al., 2012; Chen et al., 2015a).

The family Procercopidae Handlirsch, 1906, recorded from the Early Jurassic to Early Cretaceous in Germany, Russia, Central Asia, Southeast Asia, and China, is widely accepted as the stem group of cercopoids (Shcherbakov and Popov, 2002; Chen et al., 2015a). Representatives of the extinct froghopper families Sinoalidae Wang and Szwedo in Wang et al., 2012 and Cercopionidae Hamilton, 1990 were exclusively known from the Jurassic deposits in northeastern China and the Early Cretaceous of Brazil, respectively (Hamilton, 1990; Wang et al., 2012). By the mid-Cretaceous, primitive cercopoids became extinct and ancestors of modern groups appeared and became diversified (Shcherbakov and Popov, 2002; Chen et al., 2015a).

The family Sinoalidae was erected as part of the latest Middle–earliest Late Jurassic Daohugou Biota, Inner Mongolia of China. Sinoalidae, which is closely related to early Procercopidae and shares some plesiomorphic characters with ancient Hylicelloidea, represents one of the distinct diversifications of ancestral Cercopoidea. Up to now, five genera (*Luanpingia* Hong, 1983, ?*Hebeicercopis* Hong, 1983, *Huabeicercopis* Hong, 1983, *Sinoala* Wang and Szwedo in Wang et al., 2012, and *Jiania* Wang and Szwedo in Wang et al., 2012) from the Jurassic deposits of northeastern China have been attributed to this distinct froghopper family (Fig. 1; Wang et al., 2012).

We herein report some fossil sinoalids from the Daohugou Biota. A new genus and species with some significant morphological traits different from known con-familial taxa is established, and the family is revised further based on the new fossil specimens.

Materials and methods

The new Mesozoic sinoalids described herein were collected from the well-known Daohugou fossil-bearing strata of northeastern China (Fig. 1; Wang, 2009). Daohugou is now considered to be one of the most important insect Lagerstätten (Rasnitsyn et al., 2006) and has yielded abundant and diverse insects (e.g., Wang and Zhang, 2011; B. Wang et al., 2013; Chen et al., 2014; Yan et al., 2014). Generally, the fossil-bearing beds at Daohugou were placed within the Jiulongshan Formation of Bathonian–Callovian (late Middle Jurassic). However, recent isotopic dating results indicated that the Daohugou beds were deposited in the geological age of 164–158 Ma (Liu et al., 2006, 2012; L. Wang et al., 2013), which is Callovian–Oxfordian (latest Middle–earliest Late Jurassic) according to the

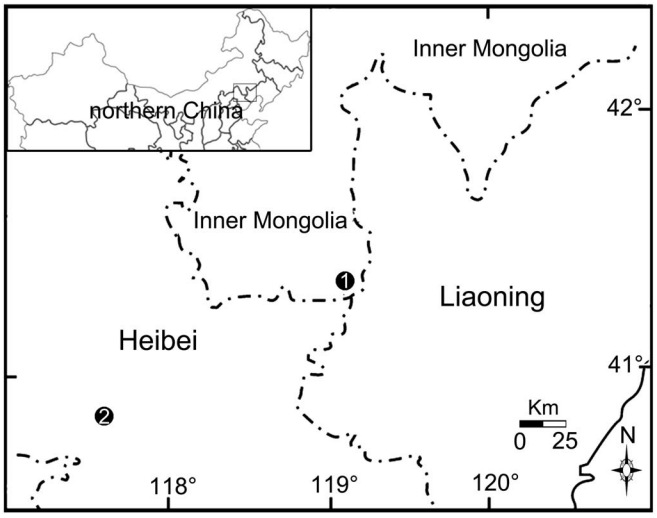

Figure 1. Locations of fossil specimens of the family Sinoalidae. 1, Daohugou, Ningcheng County, Inner Mongolia; 2, Zhouyingzi, Luangping County, Heibei.

updated International Chronostratigraphic Chart (Cohen et al., 2016).

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 the wing base and connected with CuP by a specialized crossvein *cua-cup* after its departure from M + R, which is remarkably different from the traditional interpretations. The venational terminologies used herein follow Nel et al. (2012).

The fossil sinoalids were examined dry or under alcohol, with details observed and photographed under a stereomicroscope (ZeissSteREO Discovery V8). Line drawings were prepared with CorelDraw 12.0 and Adobe Photoshop CS3.

Repository and institutional abbreviation.—All the material and figured specimens in this study are deposited in Shandong Tianyu Museum of Nature (STMN), Pingyi, Shandong Province, China.

Systematic paleontology

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

Diagnosis (emended).—Forewing with apices of costal area and clavus almost at the same level; costal area and/or clavus more sclerotized and punctate and remaining parts membranous; Pc + CP long and thicken, almost parallel to costal margin; M two-branched. Hind wing with M unbranched; crossvein *m-cua* basad of crossvein *r-m*. Three ocelli rather than two. Hind tibia with two rows of lateral spines (four at most in number for each row).

Remarks.—Our new fossil materials suggest that the relative branching position of M and CuA is variable in Sinoalidae and so not appropriate for family-level diagnosis. In addition, the fossils reported herein also provide some information on morphological diversity and evolution of hind wings and hind tibiae of the family (see Discussion).

Key to genera of the family Sinoalidae on characters of forewing (updated from Wang et al. [2012]):

1. Crossvein *m-cua* connecting to stem M, bifurcation of M distad of apices of costal area and clavus, CuA branching into CuA_1 and CuA_2 at junction with crossvein *m-cua*, slightly basad of bifurcation of M. . . . . *Shufania* n. gen.
   Crossvein *m-cua* absent or connecting to M_{3+4}, bifurcation of M basad of apices of costal area and clavus, CuA branching into CuA_1 and CuA_2 far away from junction with crossvein *m-cua*, distad of bifurcation of M 2

2. ScP + RA ~1.3 times as long as stem ScP + R, CuA forking distad of apices of costal area, stigmal cell as wide as radial cell, crossvein *m-cua* absent. . . . . *Luanpingia* Hong, 1983
   ScP + RA at least 1.5 times as long as stem ScP + R, CuA forking basad of apices of costal area, stigmal cell about half as wide as radial cell, crossvein *m-cua* present 3

3. Apex truncate, basal cell ~0.12 times as long as forewing length, ScP + RA ~10 times as long as stem ScP + R, crossvein *m-cua* connecting to branch CuA_1 . . . . . *Sinoala* Wang and Szwedo in Wang et al., 2012
   Apex rounded; basal cell long, ScP + RA at most 4.5 times as long as stem ScP + R, crossvein *m-cua* connecting to stem CuA 4

4. Stems ScP, R, M and CuA leaving basal cell at common point, branch ScP + RA ~4.4 times as long as ScP + R. . . . *Huabeicercopis* Hong, 1983
   Common stalk ScP + R + M existing, branch ScP + RA ~1.5 times as long as ScP + R . . . . . *Jiania* Wang and Szwedo in Wang et al., 2012

Genus *Shufania* new genus

Type species.—*Shufania hani* n. gen. n. sp., by present designation and monotypy.

Diagnosis.—As for the type species.

Etymology.—The generic name, *Shufania*, a feminine noun derived after Prof. Shufan Han, a well-known artist and the curator of the Museum of Linyi University.

Shufania hani new species
Figure 2

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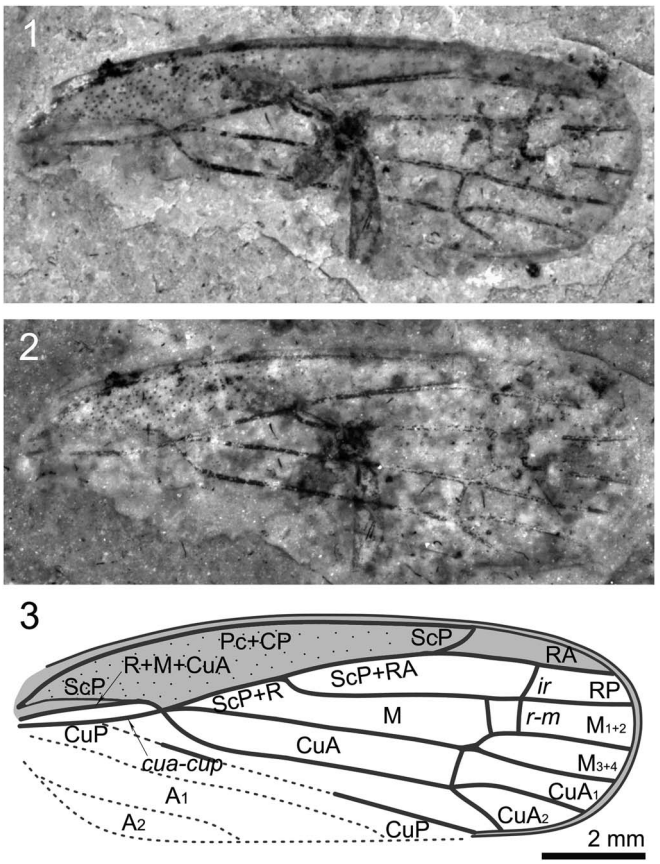

Figure 2. *Shufania hani* n. gen. n. sp.: (**1**) holotype STMN48-1807; (**2**) holotype under alcohol; (**3**) illustration of holotype. Scale bar for all images.

Holotype.—STMN48-1807, sex unknown, a sole forewing with clavus missing.

Diagnosis.—Forewing small, basal cell long, about one-fourth as long as forewing length; ScP + R + M + CuA bifurcating into ScP + R + M and CuA at junction with crossvein *cua-cup* stem ScP + R + M extremely short; ScP + RA ~1.5 times as long as stem ScP + R; base of RP strongly curved; M very long and nearly straight, branched into M_{1+2} and M_{3+4} at about basal 0.75 wing length; crossvein *m-cua* connecting to stem M basad of bifurcation of M; CuA branching into CuA_1 and CuA_2 at junction with crossvein *m-cua*, slightly basad of bifurcation of M.

Occurrence.—This specimen was collected from Daohugou Village (41°18′N, 119°13′E), Shantou Township, Ningcheng County of Inner Mongolia, China. The fossil bed is Callovian–Oxfordian (latest Middle–earliest Late Jurassic) in age.

Description.—Specimen STMN48-1807 (Fig. 2): Forewings length ~11.6 mm long, width as preserved ~4.2 mm. Costal margin slightly arched. Apical margin rounded. Costal area punctate, long and narrow, with length/width ratio ~6.0. Apices of costal area and clavus almost at the same level, at ~0.75 of wing length. Basal cell long, about one-quarter as long as forewing length. Apical cells six. Pc + CP long and thicken, almost parallel to costal margin. ScP weak and short, running to and fusing with R + M + CuA at ~0.2 of wing length, separating from the latter and then ending at apex of costal area. ScP + R + M + CuA bifurcating into ScP + R + M and CuA at junction with crossvein *cua-cup*, near basal quarter of wing length; stem ScP + R + M extremely short. ScP + RA ~1.5 times as long as stem ScP + R; R bifurcating into RA and RP in basal 0.45 wing length; RA and RP unbranched, connected to each other by crossvein *ir*; RA slightly arched, RP strongly curved at base and then nearly straight. Crossvein *r-m* two; basal one slightly oblique; apical one nearly vertical and connecting to RP at junction of RP and crossvein *ir*. Stem M very long and nearly straight, branched into M_{1+2} and M_{3+4} at about basal 0.75 wing length, just distad of the apices of costal area and clavus; M_{1+2} and M_{3+4} unbranched. Crossvein *im* invisible; crossvein *m-cua* connecting to stem M instead of branch M_{1+2}. Stem CuA strongly curved at base, and then nearly straight, branching into CuA_1 and CuA_2 at junction with crossvein *m-cua*, slightly basad of bifurcation of M. CuP largely destroyed, as preserved straight. A_1 and A_2 completely missing.

Etymology.—The species is named after Prof. Shufan Han.

Remarks.—The genus undoubtedly belongs to the family Sinoalidae on the following characteristics: costal area punctate; apical cells six; Pc + CP long and thicken, almost parallel to costal margin; ScP weak and short; RA and RP unbranched; M with two terminal branches. *Shufania* n. gen., however, distinctly differs from all known sinoalids in having forewing with crossvein *m-cua* connecting to stem M, bifurcation of M distad of apices of costal area and clavus, CuA branching into CuA_1 and CuA_2 at junction with crossvein *m-cua*, slightly basad of bifurcation of M. In addition, the new taxon differs from *Jiania* Wang and Szwedo, 2012 in possessing a smaller forewing; from *Sinoala* Wang and Szwedo, 2012, *Luanpingia* Hong, 1983, and *Huabeicercopis* Hong, 1983 in possessing a forewing with a very short stalk M + R.

Genus *Jiania* Wang and Szwedo in Wang Szwedo, and Zhang, 2012

Jiania gracila Wang and Szwedo in Wang Szwedo, and Zhang, 2012

Figure 3

2012 *Jiania gracila* Wang and Szwedo in Wang et al., p. 1237, figs. 3E, 4D, 4E, 7C, 9.

2013 *Jiania gracila*; Li et al., p. 7, fig. 5.

Diagnosis.—Forewing ~3.1–3.6 times as long as wide; C3 ~1.5 times as long as adjoining apical cell; ScP + R + M + CuA bifurcating into ScP + R + M and CuA at junction with crossvein *cua-cup*, near basal one-fifth wing length; stalk ScP + R + M present, extremely short. Hind wing with distal part darkly stained; R bifurcating into RA and RP at base of ending point of A_2; CuA and CuA_1 at 145° angle; CuA and CuA_2 in alignment.

Materials.—STMN48-1808, female, adult in dorsoventral aspect with wings preserved at the top of the body, head missing; STMN48-1809, female, adult in dorsoventral aspect with wings preserved at the top of the body, nearly complete.

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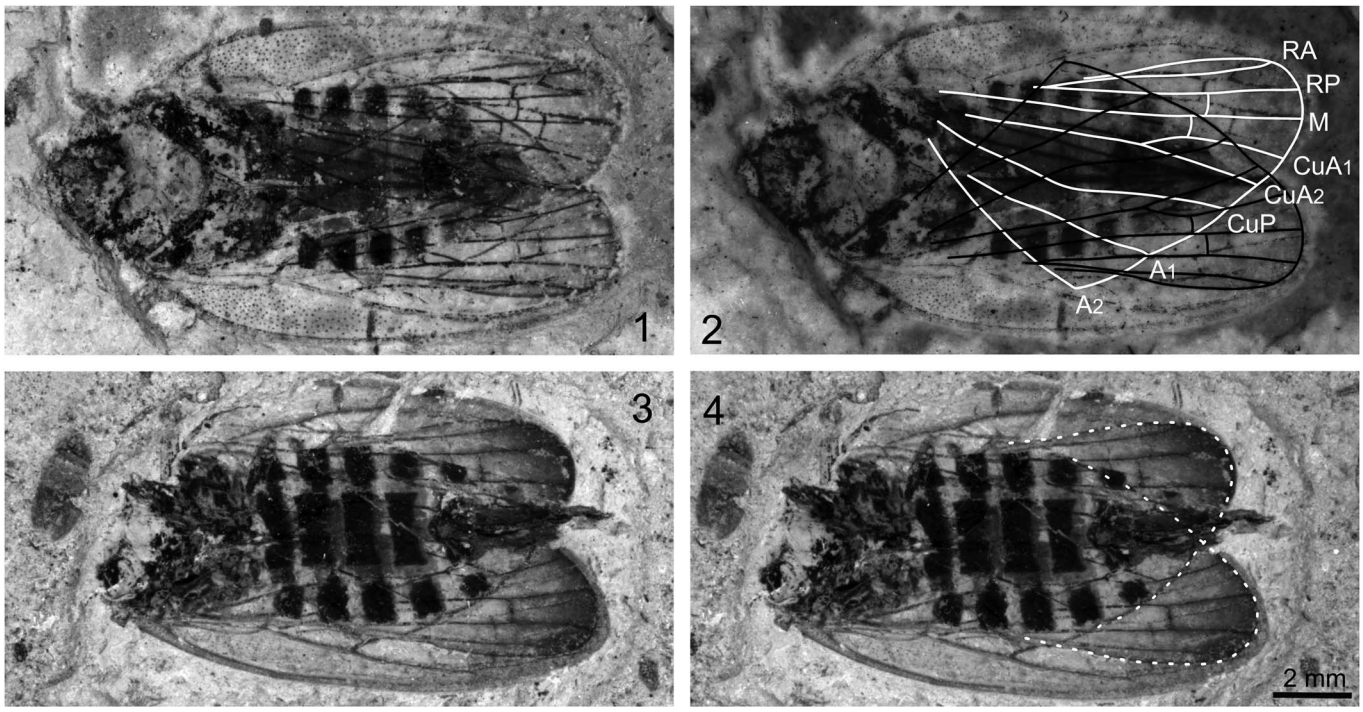

Figure 3. *Jiania gracila* Wang and Szwedo in Wang et al., 2012: (**1**) specimen STMN48-1809; (**2**) specimen STMN48-1809 under alcohol, with line drawings of hind wings; (**3**) specimen STMN48-1808; (**4**) specimen STMN48-1808 with outline of hind wings. Scale bar for all images.

Occurrence.—The two specimens were collected from Daohugou Village (41°18′N, 119°13′E), at the same locality where the holotype was collected.

Description.—Specimen STMN48-1809 (Fig. 3.1, 3.2): body 15.2 mm long including forewings in repose. Head with compound eyes length as preserved 1.5 mm, obviously narrower than pronotum. Pronotum ~1.6 mm long and 3.5 mm wide, anterior margin straight, posterior margin poorly preserved. Mesonotum ~3.1 mm long in midline and ~4.0 mm wide at base. Abdomen with ovipositor ~8.3 mm long and ~4.7 mm wide, with seven segments visible. Ovipositor slightly extending beyond forewing tips.

Forewings slender, ~13.0 mm long, 4.2 mm wide, with length/width ratio ~3.1. Costal margin slightly arched. Posterior margin almost straight. Apical margin rounded. Costal area punctate, long and narrow, with length/width ratio ~6.0. Clavus strongly arched, long, with length/width ratio ~5.2. Apices of costal area and clavus almost at the same level, at ~0.7 of wing length. Apical cells six. Pc + CP long and thicken, almost parallel to costal margin. ScP weak and short, running to and fusing with ScP + R + M + CuA, separating from the latter and then ending at apex of costal area. ScP + R + M + CuA bifurcating into ScP + R + M and CuA at junction with crossvein *cua-cup*, near basal one-fifth wing length; stem ScP + R + M extremely short. R bifurcating into RA and RP in basal 0.4 wing length; RA and RP unbranched, connected to each other by crossvein *ir*; RA slightly arched, RP sinuous and curved at junction with crossvein *ir* and *r-m*. Stem M nearly straight, branched into M_{1+2} and M_{3+4} slightly distad of middle of wing (at about basal 0.55 wing length); M_{1+2} and M_{3+4} unbranched, connected to each other by crossvein *im*. Cell C3 ~1.5 times as long as adjoining apical cell. Stem CuA strongly curved at base, and then nearly straight, branching into CuA_1 and CuA_2 at basal 0.68 wing length. CuP strongly curved at junction with crossvein *cua-cup*, and then nearly straight. A_1 and A_2 poorly preserved.

Hind wing slightly shorter than forewing, with distal portion darkly stained, without peripheric membrane. Stem R bifurcating RA and RP at base of ending point of A_2. Vein M unbranched, nearly straight, connected to RP by short crossvein *r-m*. Stem CuA straight, branching into CuA_1 and CuA_2 nearly at the same level of ending point of A_1; CuA and CuA_1 at 145° angle; CuA and CuA_2 in alignment; CuA_1 connected to M by short crossvein *m-cua*, at base of crossvein *r-m*. CuP strongly curved at the same level of ending point of A_2.

Specimen STMN48-1808 (Fig. 3.3, 3.4): body with ovipositor as preserved 15.2 mm long. Head destroyed. Legs poorly preserved, obscure. Abdomen with ovipositor ~9.8 mm long and ~4.8 mm wide, with seven segments visible. Ovipositor extending just beyond forewing tips.

Forewings slender, ~13.3 mm long, 4.1 mm wide, with length/width ratio ~3.2. Basal portion of forewings deformed, basal portion of left forewing partly missing. Costal margin slightly arched. Posterior margin almost straight. Apical margin rounded. Costal area long and narrow; costal area of right forewing punctate at basal part, but not visible for left one. Clavus strongly deformed. Apices of costal area and clavus almost at the same level. Apical cells six. Pc + CP long and thicken, almost parallel to costal margin. ScP weak and short,

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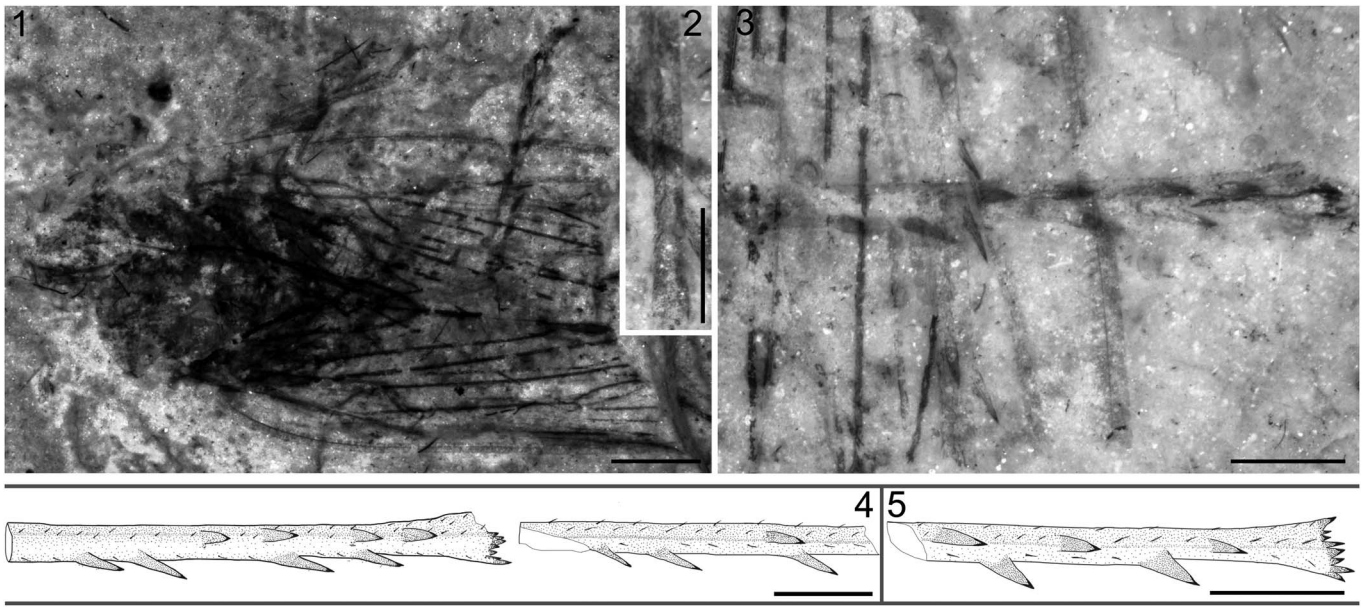

Figure 4. *Jiania* sp. STMN48-1810 and reconstructions of hind tibiae of *Jiania* Wang and Szwedo in Wang et al., 2012: (**1**) *Jiania* sp. STMN48-1810, under alcohol; (**2**) enlarged fore tibiae of *Jiania* sp. STMN48-1810, under alcohol; (**3**) enlarged hind tibiae of *Jiania* sp. STMN48-1810, under alcohol; (**4**) reconstructions of hind tibiae of *Jiania* sp. STMN48-1810; (**5**) reconstruction of hind tibia of *Jiania crebra* Wang and Szwedo in Wang et al., 2012, specimen NIGP154599. Scale = 2 mm (**1**) or 1 mm (**2**–**5**).

running to and fusing with ScP + R + M + CuA, separating from the latter and then ending at apex of costal area. ScP + R + M + CuA bifurcating into ScP + R + M and CuA at junction with crossvein *cua-cup*; stem ScP + R + M extremely short. RA and RP unbranched, connected to each other by crossvein *ir*; RA slightly arched. Stem M two-branched; M_{1+2} and M_{3+4} connected to each other by crossvein *im*. Cell C3 ~1.5 times as long as adjoining apical cell. Stem CuA branching into CuA_1 and CuA_2 just basad of apices of costal area and clavus. CuP, A_1, and A_2 obscure.

Hind wing slightly shorter than forewing, with distal portion obviously darkly stained, without peripheric membrane. RA and RP nearly straight. Vein M unbranched, nearly straight, connected to RP by short crossvein *r-m*. Stem CuA straight; CuA and CuA_1 at 145° angle; CuA and CuA_2 in alignment; CuA_1 connected to M by short crossvein *m-cua*, at base of crossvein *r-m*; CuA_1 slightly longer than CuA_2. Veins CuP, A_1, and A_2 obscure.

Remarks.—The two new specimens are attributed to the genus *Jiania* Wang and Szwedo in Wang et al., 2012, based on the following diagnostic characters of the forewing: apical margin rounded, ScP + R + M + CuA bifurcating into ScP + R + M and CuA near basal one-fifth wing length, stalk M + R present, and bifurcation of M distad of ending point of A_1 and basad of bifurcation of CuA. The new specimens are assigned to *Jiania gracila* Wang and Szwedo in Wang et al., 2012 based on their long ovipositor extending slightly beyond forewing tips and forewing with cell C3 ~1.5 times as long as adjoining apical cell (versus ovipositor distinctly exceeding tip of forewing and forewing with cell C3 almost as long as adjoining apical cell in *Jiania crebra* Wang and Szwedo in Wang et al., 2012).

Although most morphological characters of the body structures and forewings are similar, the two specimens described herein are different from the holotype in the size, length/width ratio, and surface ornament of the costal area and clavus of the forewing. Recently, some studies based on abundant specimens demonstrated that the obvious variation in size of body and wings and length/width ratio of forewing occurs intraspecifically in fossil froghoppers (Wang and Zhang, 2009; Wang et al., 2012; Li et al., 2013; Chen et al., 2015a, b). Therefore, it is reasonable to consider the variation between the holotype and the two new specimens to be intraspecific. Forewing with clavus and basal costal area punctate is treated as important diagnostic character for *Jiania gracila* Wang and Szwedo in Wang et al., 2012 (Wang et al., 2012). In the new specimen STMN48-1809, both forewings possess costal areas that are entirely punctate, but clavus with puncta invisible. In STMN48-1808, puncta are only preserved on basal part of costal area of right wing. Tiny puncta are also poorly preserved or even completely missing for some sinoalid specimens reported in Wang et al. (2012). The location of puncta on the forewing might be variable for different sinoalids, but considering taphonomical and preserving factors, it is imprudent to identify taxa based on this single character.

Jiania sp.
Figure 4.1–4.4

Materials.—STMN48-1810, sex unknown, adult in dorsoventral aspect with wings preserved at the top of the body, middle and distal portion of wings destroyed.

Occurrence.—This specimen was collected from Daohugou Village (41°18′N, 119°13′E), Shantou Township, Ningcheng

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County of Inner Mongolia. The fossil bed is Callovian–Oxfordian (latest Middle–earliest Late Jurassic) in age.

Description.—Specimen STMN48-1810 (Fig. 4.1–4.4): head partly preserved. Compound eyes missing. Rostrum extending to hind coxae. Antennae length as preserved ~0.6 mm; flagellum filiform, with segments invisible. Pronotum partly destroyed, ~1.7 mm long. Mesonotum ~3.1 mm long in midline and ~3.5 mm wide at base. Fore femur strong, basal part invisible, ~0.6 mm wide; fore tibia ~2.5 mm long, setose, with distinct ridges; fore tarsus ~1.4 mm long; basitarsomere very short; apical tarsomere slightly longer than mid tarsomere; two claws visible. One middle leg preserved; middle femur slightly slenderer than fore femur; middle tibia shorter than fore tibia, setose, with distinct ridges; middle tarsus obscure; tarsal claws distinct. One hind leg nearly completely preserved, other one with tarsus and apical part of tibia missing; hind femur nearly as long as fore femur; hind tibia slender, ~3.7 mm long, with two rows of lateral spines (each row with four spines for the complete tibia, but only one and three for the tibia with apical part missing) and a row of apical teeth; basitarsomere as long as mid tarsomere, apical tarsomere and claws destroyed. Abdomen invisible.

Forewings with middle and distal part missing, length as preserved 8.9 mm; one forewing obviously deformed. Costal margin slightly arched. Posterior margin as preserved almost straight. Costal area and clavus arched, long and narrow. Pc + CP long, almost parallel to costal margin. ScP weak and short, running to and fusing with ScP + R + M + CuA. ScP + R + M + CuA, bifurcating into ScP + R + M and CuA nearly at junction with crossvein *cua-cup*; stem ScP + R + M extremely short. Stem M nearly straight as preserved; branching into M_{1+2} and M_{3+4} basad of bifurcation of CuA and distad of ending point of A_1. Stem CuA strongly curved at base, and then nearly straight as preserved. CuP strongly curved at junction with crossvein *cua-cup*, and then nearly straight. A_1 nearly straight and A_2 slightly sinuous. Hind wing obscure.

Remarks.—This specimen undoubtedly belongs to the family Sinoalidae based on its body structures and unique forewing with Pc + CP long, almost parallel to costal margin, ScP weak and short, and R, M and CuA divided from stem ScP + R + M + CuA very closely. We placed the new specimen in the genus *Jiania* Wang and Szwedo in Wang et al., 2012 based on the following venational characters of forewings: short stalk ScP + R + M existing (vs. short stalk M + CuA existing in *Sinoala* Wang and Szwedo, 2012 and R, M, CuA separated from stem ScP + R + M + CuA at the same point in *Luanpingia* Hong, 1983 and *Huabeicercopis* Hong, 1983) and M branching into M_{1+2} and M_{3+4} basad of bifurcation of CuA and distad of ending point of A_1 (versus M branching into M_{1+2} and M_{3+4} basad of ending point of A_1 in *Sinoala* Wang and Szwedo, 2012 and M branching into M_{1+2} and M_{3+4} just distad of bifurcation of CuA in *Shufania* n. gen.). However, due to incomplete preservation and somewhat deformation of the specimen, it is impossible to get more specific characters to compare it with the other two congeneric species in detail. Therefore, we herein maintain the specimen in open nomenclature in the genus *Jiania* Wang and Szwedo, 2012.

Discussion

The Sinoalidae, with six known genera, is known so far only from the Middle to earliest Late Jurassic of northeastern China (Wang et al., 2012; this study). The new genus reported in the present study is distinct from all other genera in forewing venations, leading to the necessity to revise the family Sinoalidae. Bifurcation of vein M basad of bifurcation of CuA on forewing is considered as one of the important diagnostic characters for the Sinoalidae, differing from the con-superfamilial Procercopidae. However, *Shufania* n. gen. possesses a forewing with bifurcation of vein M apparently distad of bifurcation of CuA. Chen et al. (2015b) erected a new species, *Anthoscytina elegans*, based on ten well-preserved procercopid fossils collected from the Daohugou Biota. These specimens show high intraspecific variation on relative branching position of M and CuA. Therefore, this venational character, unstable even at species level for the Cercopoidea, is not appropriate for family-level diagnosis.

Up to now, only two sinoalid species with information on hind wings have been reported (Hong, 1983; Wang et al., 2012). Wang et al. (2012) established *Sinoala parallelivena* based on several fossils from the latest Middle-earliest Late Jurassic of Inner Mongolia, China, including information of body structures, forewings, and hind wings. Hong (1983) erected *Hebeicercopis triangulata* based on an almost completely isolated hind wing and *Huabeicercopis yangi* mainly based on forewings from the Middle Jurassic of Heibei, China. Wang et al. (2012) considered that these two taxa might be synonymous because of the corresponding size and the same original horizon and locality. We herein report two new imprint fossils of *Jiania gracila* with some interesting information about sinoalid hind wings. Although the forewings of the genera *Huabeicercopis*, *Sinoala*, and *Jiania* are significantly different (see Wang et al., 2012), the venations of the three sinoalid hind wings are obviously less variable, which is expected because the venations of sinoalid hind wings are very simplified in topology and obviously reduced in branches of longitudinal veins.

Hind wings with distal portion obviously darkly stained are well preserved for STMN48-1808, and visible for STMN48-1809 and most of the reported *Jiania* fossils (Fig. 3; Wang et al., 2012). However, this color pattern is completely absent for the seven well-preserved *Sinoala* fossils in Wang et al. (2012), so hind wings of this genus are likely colorless and transparent. Color patterns of hind wings are likely variable for different sinoalid froghoppers. However, wing color pattern is easily weakened or even erased by diagenetic processes for imprint fossils, so the morphological character is not reliable to distinguish sinoalids, as is the case for other fossil cicadomorphs (e.g., Chen et al., 2016).

Modern taxa of the Cercopoidea possess hind tibia with one row of immobile spines (1–6, commonly 2) (Wang et al., 2012). Some studies based on abundant whole-body fossils suggest

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that the Procercopidae (Shcherbakov and Popov, 2002) likely just has one single spine (Shcherbakov, 1988; Wang and Zhang, 2009; Li et al., 2013; D. Chen et al., 2015; Chen et al., 2015a). The Sinoalidae differs from the Procercopidae and modern Cercopoidea in having hind tibia with two rows of spines laterally (Fig. 4.4, 4.5; at most four for each row, as shown in the new specimen STMN48-1810). The left and right hind tibiae preserved in STMN48-1810 suggest that lateral spines might be different in number and/or position (Fig. 4.4). Lateral spines (4–6 in number) on the hind tibia of the living aphrophorid *Sinophora* Melichar, 1902 (Anufriev, 1972; Liang, 1990) are sometimes variable in number for the same species or even the same individuals (Chou et al., 1986; Wang et al., 2012). STMN48-1810 indicates that the number of spines of the hind tibia might be also different intra-individually within the Sinoalidae, or at least their relative position is variable.

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