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A new species of *Luanpingia* (Hemiptera: Cercopoidea: Sinoalidae) from the Middle–Upper Jurassic Daohugou Bed

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The hemipteran superfamily Cercopoidea Leach, 1815, usually named spittlebugs (for nymphs) or froghoppers (for adults), is the second largest superfamily in Cicadomorpha, comprising over 2600 extant species widely distributed around the world (Dietrich, 2002; Bartlett *et al.*, 2018). Cercopoidea includes five extant and three extinct families reported from the Mesozoic (Cryan & Svenson, 2010; Szwedo, 2018).

The Mesozoic froghopper family Sinoalidae Wang & Szwedo, 2012, one of the early representatives of Cercopoidea, is considered as the sister lineage of Procercopidae, sharing some symplesiomorphies with Hylacelloidea (Wang *et al.*, 2012). This extinct family differs from other cercopoid families mainly in having metatibiae each bearing two rows of lateral piliferous spines, only part of tegmen more sclerotized and punctate, and hind wing lacking a peripheric membrane (Wang *et al.*, 2012). Sinoalidae is only recorded in the Middle Jurassic to the earliest Late Jurassic Daohugou biota (*i.e.*, early assemblage of Yanliao biota) of China and mid-Cretaceous Kachin of Myanmar (Chen *et al.*, 2019a; Fu & Huang, 2019a, b). The number of described species in sinoalids has risen rapidly over the past three years (Fu & Huang, 2019a). Up to now, sixteen genera and twenty species have been attributed to this family (Chen *et al.*, 2019a; Fu & Huang, 2019a, b). Sinoalidae was originally established by Wang & Szwedo (2012) based on 27 specimens from the Daohugou biota, Inner Mongolia, northeastern China. In Wang *et al.* (2012), two genera and three species have been established and three monotypic genera were assigned to Sinoalidae Hong, 1983. Subsequently, four additional genera and seven species were described from the Daohugou biota were assigned to this family. *Chengdecercopis* Hong, 1983 was transferred from Procercopidae to Sinoalidae (Fu & Huang, 2019a). *Parasinoala* Fu & Huang, 2019c was considered a junior synonym of *Juroala* Chen & Wang, 2019b (Fu & Huang, 2019a). Therefore, nine genera with thirteen species

have been described from the Middle–Upper Jurassic Jiulongshan (= Longmen) and Haifanggou Formations of northeastern China. They include *Huabeicercopis yangi* Hong, 1983, *Hebeicercopis triangulata* Hong, 1983, *Luanpingia longa* Hong, 1983, and *Chengdecercopis xiaofanzhangziensis* Hong, 1983 from the Jiulongshan Formation of Hebei Province, and *Sinoala parallelivena* Wang & Szwedo, 2012, *Jiania crebra* Wang & Szwedo, 2012, *J. gracila* Wang & Szwedo, 2012, *Shufania hani* Chen *et al.*, 2017, *Luanpingia daohugouensis* Fu, Cai & Huang, 2018, *Stictocercopis wuhuaensis* Fu & Huang, 2018, *Juroala daohugouensis* Chen & Wang, 2019b, *J. daidaleos* Fu & Huang, 2019c, and *J. minuta* Fu & Huang, 2019c from the Daohugou Bed, Inner Mongolia.

Herein we report a new species of Sinoalidae, *Luanpingia youchongi* sp. nov., from the Daohugou Bed. This discovery enriches the known palaeodiversity of *Luanpingia* to three species, and provides more information about the morphological diversification of Sinoalidae in the Middle to Late Jurassic.

Material and methods

A complete forewing (NIGP171390) was collected from the lower-median section of the Daohugou Bed at Xiayingzi, stratigraphically slightly lower than the typical ‘conchostracan’ layers at Daohugou (for a map of the fossil layers that yielded material as well as locations near Daohugou, see Huang, 2015 and Jiang & Huang, 2017). The specimen was preserved in grayish tuffaceous shale from the Haifanggou Formation at Daohugou Village, Ningcheng County, Inner Mongolia, northeastern China. Photograph was taken using a digital camera attached to a Zeiss Discovery V16 microscope; stacked using Helicon Focus 6 software; the invert function in Photoshop CS6 software was used to invert colours of specimen images to show certain details more clearly. Line drawings were



B

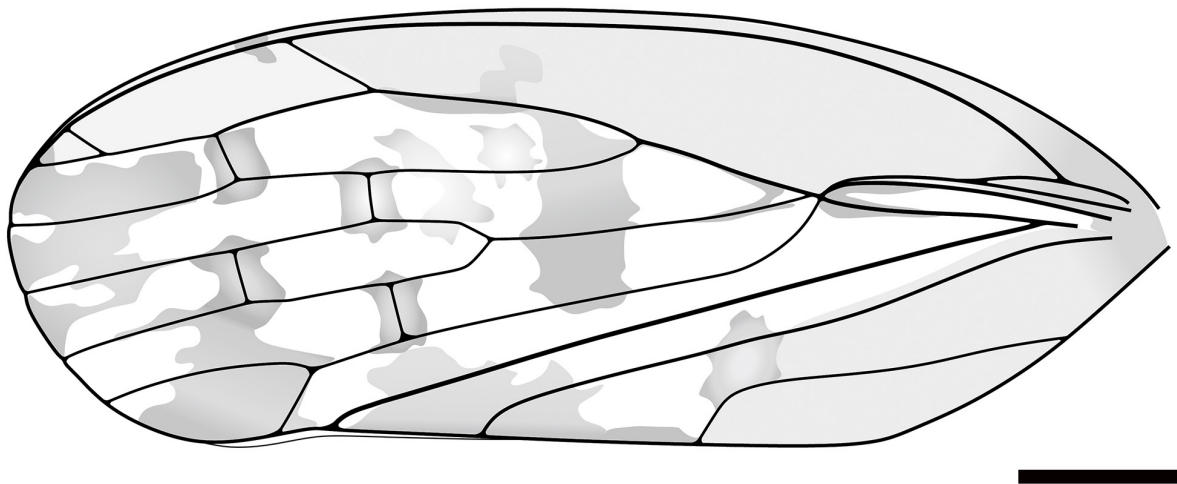


FIGURE 1. Holotype (NIGP171390) of *Luanpingia youchongi* sp. nov.. **A**, Photograph of forewing. **B**, Line drawing of forewing. (Scale bar = 2 mm).

drafted with Adobe Illustrator CC 2018 graphic software. The material studied here is deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China.

Wing venation terminology and cell nomenclature follows Nel *et al.* (2012) and Bourgoïn *et al.* (2015). All measurements are in millimeters.

Systematic palaeontology

Superfamily Cercopoidea Leach, 1815
Family Sinoalidae Wang & Szvedo, 2012
Genus *Luanpingia* Hong, 1983

Type species. *Luanpingia longa* Hong, 1983; by original designation.

Diagnostic features (revised after Wang & Szvedo, 2012 and Fu, Cai & Huang, 2018). Tegmen relatively wide, with length/width ratio less than 3.1; basal cell more than one-quarter of tegmen length; stigmal cell as wide as or slightly narrower than radial cell; stem ScP+RA no more than twice as long as ScP+R; cross-vein *ir* nearly as same level of *imp*.

***Luanpingia youchongi* sp. nov.**
 (Figs 1, 2C)

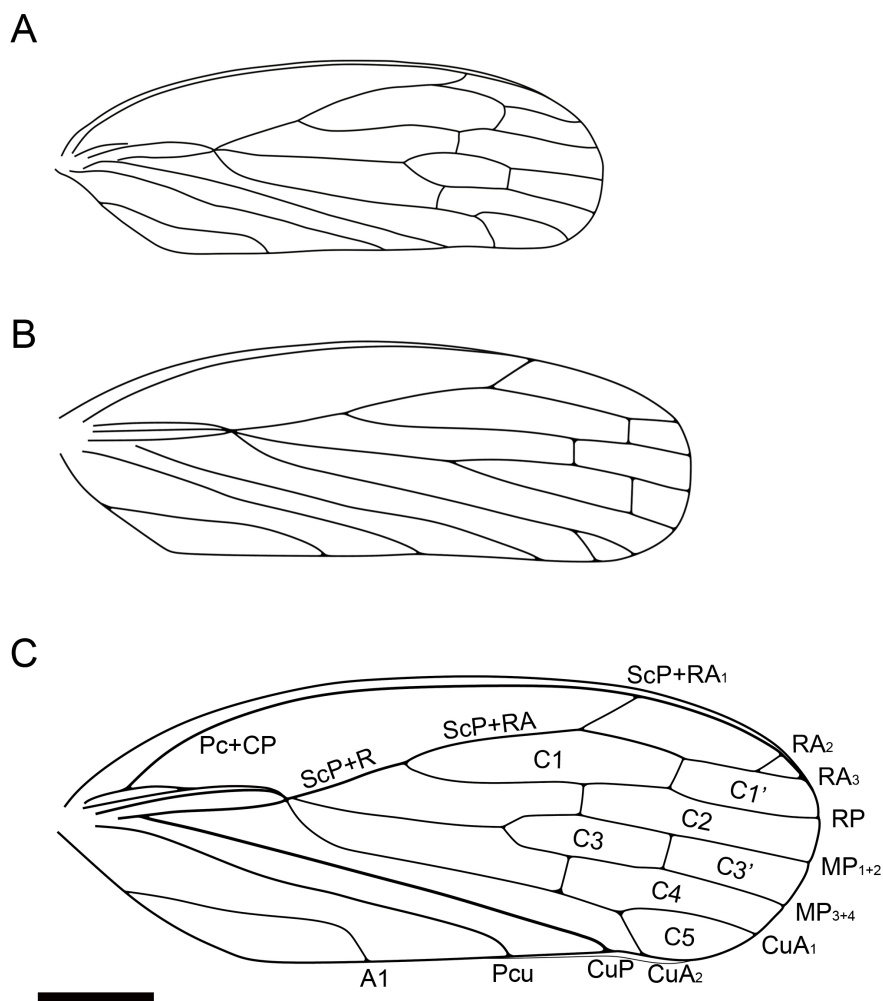


FIGURE 2. Line drawings of three species of *Luanpingia*. **A**, *Luanpingia daohugouensis* Fu, Cai & Huang, 2018. **B**, *Luanpingia longa* Hong, 1983. **C**, *Luanpingia youchongi* sp. nov. (Scale bar = 2 mm).

Holotype. NIGP171390, a complete forewing.

Etymology. The specific name is in honour of Professor You-Chong Hong, the Chinese pioneer of Palaeoentomology, who passed away on 4 July, 2019.

Type locality and horizon. Daohugou Village, Wuhua Township, Ningcheng County, Chifeng City, Inner Mongolia, China; Middle–Upper Jurassic; Haifanggou Formation.

Diagnosis. The new species differs from other known species of *Luanpingia* by the following combination of features: tegmen 14 mm long, with distinct colour pattern from base to end; Pc+CP extremely long, just reaching termination of RA₃; stem ScP+R+MP leaving basal cell slightly after CuA with an extremely short common portion; stigmal cell slightly wider than cell C1; RA with 3 terminals; cell C1 nearly twice as long as cell C1', cell C3 slightly longer than cell C3'; cell C5 broad; and CuA₁ much longer than CuA₂.

Description. Tegmen (Figs 1, 2C) length 13.5 mm, width 5.0 mm, length/width ratio about 2.7; surface with

irregular colour pattern from base to apex, with rectangular bands on middle section and near 4 cross veins much darker; costal area and clavus sclerotized and punctate; costal margin smoothly arched, apical margin rounded, posterior margin almost straight; Pc+CP extremely long, just reaching termination of RA₃; basal portion of ScP nearly reaching half of basal cell length; basal cell about 0.27 times as long as tegmen; costal cell broad, nearly twice as wide as cell C1; stigmal cell relatively large, about 1.2 times as wide as cell C1'; stem ScP+R+MP leaving basal cell slightly after CuA with an extremely short common portion; stem ScP+R branching into ScP+RA and RP at basal 0.45 of tegmen length; ScP+RA nearly 1.5 times as long as ScP+R; RA with 3 terminals; cross vein ir straight, connecting RA and RP, nearly as same level of cross vein imp; RP simple, connecting MP₁₊₂ by cross vein rp-mp, nearly as same level of cross vein mp-cua; cell C1 about 1.9 times as long as adjoining cell C1'; MP with two branches, branching into MP₁₊₂ and MP₃₊₄ distinctly basad of bifurcation of CuA at basal 0.59

of tegmen length; MP_{1+2} and MP_{3+4} subequal in length, connected by cross vein imp; cell C3 as wide as adjoining cell C2 and C3', about 1.2 times as long as C3'; CuA curved anteriorly, branching into CuA_1 and CuA_2 at basal 0.74 of tegmen length; CuA_1 mildly convex at base, about 2.7 times as long as CuA_2 , CuA_2 straight; cell C5 broad, slightly wider than cell C4; CuP nearly straight, ending close to termination of CuA_2 ; PCu slightly sinuous, sub-parallel to CuP , ending slight after midpoint of wing; A_1 nearly straight anteriorly, and then down-curved at basal 0.37 of tegmen length.

Discussion

The Daohugou biota has yielded abundant cicadomorphan insects, including Hylcelloidea (Hylcellidae), Palaeontinoidea (Palaeontinidae), Cicadoidea (Tettigarctidae), and Cercopoidea (Procercopidae and Sinoalidae), with the most abundant group belonging to cercopoids (Li *et al.*, 2010; Fu *et al.*, 2018). To date, six genera with nine species of sinoalids and three genera with seven species of procercopids reported from the Daohugou biota (Fu *et al.*, 2018; Fu & Huang, 2019a).

Luanpingia, transferred from Tettigarctidae to Sinoalidae by Wang *et al.*, (2012), previously included four species. *L. liugouensis* Hong, 1983 and *L. senjituensis* Hong, 1984 were transferred to the family Procercopidae (Wang *et al.*, 2012). Therefore, two species attributed to *Luanpingia* to date (*i.e.*, *L. longa* Hong, 1983 and *L. daohugouensis* Fu, Cai & Huang, 2018) from the Jiulongshan Formation at Zhouyingzi Village, Luanping County, Hebei Province and the Haifanggou Formation at Daohugou respectively. The new species, *Luanpingia youchongi* sp. nov. described here is known from a forewing only, and it can be definitely assigned to *Luanpingia* based on the on the following apomorphic features: tegmen relatively wide, with length/width ratio about 2.7 (less than 3.1); stigmal cell as wide as radial cell; stem $ScP+RA$ nearly 1.5 times as long as $ScP+R$ (no more than twice); and cross-vein ir nearly as same level of imp. The new species is similar to the coeval *L. daohugouensis*, including tegmen dotted with rectangular color bands on the median section, similar length ratio in cell C1 and C1', C3 and C3', and cell C5 relatively large. The new species also shares several features with the type species *L. longa* in having a broad stigmal cell and the CuP ending more close to termination of the CuA_2 . However, it differs from other two species within *Luanpingia* in the following characters: 1) tegmen length about 13.5 mm (9.5 mm long in *L. daohugouensis* and 11 mm long in *L. longa*); 2) tegmen dotted with irregular colour pattern from base to end (color bands only stained on the lower median section in *L. daohugouensis*,

and probably with color bands in Plate 12–4 (Hong, 1983) but details remain unknown in *L. longa*); 3) stem $ScP+R+MP$ leaving basal cell with an extremely short common portion ($ScP+R$, MP and CuA leaving basal cell at common point in *L. daohugouensis* and *L. longa*); 4) stigmal cell slightly wider than cell C1 (cell C1 much wider than stigmal cell in *L. daohugouensis*); 5) vein RA 3-branched (RA 2-branched in *L. daohugouensis* and *L. longa*); 6) cell C1 nearly twice as long as cell C1', cell C3 slightly longer than cell C3' (cell C1 more than 4 times as long as cell C1', cell C3 more than 3 times as long as cell C3' in *L. longa*); and 7) Cell C5 broad, CuA_1 much longer than CuA_2 (cell C5 extremely small, CuA_1 nearly as long as CuA_2 in *L. longa*).

Acknowledgements

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