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A new family of Triassic planthoppers (Hemiptera: Fulgoromorpha: Fulgoroidea) from the Shaanxi Province of China

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ABSTRACT

A new family of planthoppers, Szeiiniidae fam. nov., is described on the basis of a well-preserved forewing from the Upper Triassic Yanchang Formation of Huanglong County, Shaanxi Province, China. As the only specimen of the new family, *Szeiinia huanglongensis* gen. et sp. nov. differs from other families within Fulgoroidea by a unique combination of venation characters, and most significantly, the early branching of the MP vein, and low length/width ratio of the forewing. Our finding adds to the current understanding of morphological variability amongst planthoppers, and confirms high levels of diversity within Fulgoroidea at an early stage of the Mesozoic.

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THERE ARE presently two superfamilies of Fulgoromorpha known in the Triassic: Fulgoroidea (Latreille 1807) and Surijokocixioidea (Shcherbakov 2000). The later includes a single family, Surijokocixiidae, containing the Triassic taxa: *Boreocixius rotundatus* Becker-Migdisova, 1955 (T_1); *Boreocixius sibiricus* Becker-Migdisova, 1955 (T_1); *Boreocixius tongchuanensis* Zhang, Szwedo & Wang, 2021 (T_2) (Zhang *et al.* 2021); *Crosbixius carsburgi* Lambkin, 2021 (T_3); *Karesmina punicea* Lambkin, 2021 (T_3); and *Tricrosbia minuta* Evans, 1971 (T_3). Within the superfamily Fulgoroidea, there are two Triassic taxa: *Heseneuma hammelburgensis* Brauckmann et Schlüter, 1993 (T_2), which is of uncertain family-level affinities, and *Fulgoridiella raetica* Becker-Migdisova, 1962 (T_3–J_1), which is assigned to Fulgoridiidae (Handlirsch 1939, Szwedo *et al.* 2004, Bourgoin 2021, Lambkin 2021).

Although previously figured by Sze (1956, pl. LV), the specimen studied here had not been formally identified beyond its institutional registration number, NIGPAS PB.2500, and a general title of 'insect-wing'. The fossil was collected from an unknown bed and outcrop of the Yanchang Formation, in Huanglong County of Shaanxi Province, China (Fig. 1) (Sze 1956). Abundant plant fossils have been reported from the Yanchang Formation, the age of which is considered to be Late Triassic based on the identification of both the *Danaeopsis–Bernoullia* (Sze 1956) and *Thinnfeldia–Danaeopsis fecunda* (Zhou & Zhou 1983) palaeobotanical assemblages.

Fujiyama (1973) attributed NIGPAS PB.2500 to Hemiptera and produced a reproduction of the figure from (Sze 1956). Consequently, we re-examined NIGPAS PB.2500 to clarify its taxonomic status as an early member of Fulgoromorpha, and assess the implications for evolution of Triassic fulgoroids.

Materials and methods

Microscopic examination and photography was carried out using a Zeiss Stereo Discovery V16 stereomicroscope (produced at Rudolf-Eber-Strasse, Oberkochen, Germany) at NIGPAS. Chresonymy follows the open nomenclature suggested by Matthews (1973) and Bengtson (1988). Venation nomenclature follows Szwedo and Żyła (2009) and Bourgoin *et al.* (2015).

Institutional abbreviation

NIGPAS, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China.

Systematic palaeontology

Order HEMIPTERA Linnaeus, 1758
Suborder FULGOROMORPHA Evans, 1946
Superfamily FULGOROIDEA Latreille, 1807
Family SZEIINIIDAE fam. nov.
(Figs 2, 3)

Type genus. *Szeiinia* gen. nov.

Diagnosis. Tegmen well developed, unique venation pattern including an early dividing MP and low forewing length/

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width ratio (<2) compared to other known taxa in the Fulgoroidea. Costal margin thickened, Pc + CP slightly shifted mediad, forming narrow costal area with transverse veinlets emerging, extending more than half tegmen length (costal margin thickened, no costal area developed in Qiyangiricaniidae). Basal cell nearly trapezoidal, with basal section closing it ('arculus') weakened, and basal veinlet *cua-cup* thickened; basal section of ScP slightly shifted from stem R + MP + CuA, later fused with R (similar as in Qiyangiricaniidae); stem ScP + RA divided at basal half of tegmen; prenodal branches of RA developed (absent in Qiyangiricaniidae); branch RP early separated, more basad than ScP + RA fork, forked on membrane (RP forked at level of nodal line in Qiyangiricaniidae); stem MP dividing basad of half of tegmen length but apicad of ScP + R fork (stem MP forked apicad of nodal line, on membrane in Qiyangiricaniidae), branches of stem MP forking on membrane; stem CuA dividing basad of half of tegmen length, apicad of stem MP forking, forking again basad of nodal line, and on membrane; vein CuP distinct; veins Pcu and A_1 simple, connected with veinlets (as in Qiyangiricaniidae); clavus closed; appendix well developed, with distinct perpendicular wrinkles.

Szeiinia gen. nov.
(Figs 2, 3)

Type species. *Szeiinia huanglongensis* sp. nov.

Diagnosis. Costal area reaching half of tegmen length, with scarce veinlets; costal cell wide, intersected by prenodal branchings; stem ScP + R forking earlier than the stems of MP and CuA, vein (ScP)+RA_1 forked slightly apicad of stem CuA forking, reaching Pc + CP, RA branches forked basad and apicad of nodal line; vein RP dividing on membrane, beyond nodal line at about apical 1/4 of tegmen length, branches of vein RA more than those of vein RP. Stem MP curved at basal cell base, diverging mediad from stem ScP + R for a distance; first forking basad of stem CuA fork and apicad of stem ScP + R fork. Stem CuA forking at about basal 1/3 of tegmen length, branch CuA_1 forking at about half of tegmen length, about same level as RA_{2b2} fork and basad of CuA_2 fork, branches of CuA forked on membrane; claval vein CuP distinct, veinlets between CuP and Pcu present; clavus closed, apex of clavus reaching 3/4 of tegmen length; claval veins Pcu and A_1 fused late, at about 2/3 of clavus length, with irregular connecting veinlets; long S-shaped veinlets *im* and *icua,* resembling longitudinal veins branching (false longitudinal veins) present.

Etymology. In memory of Mr H.C. Sze, discoverer of the holotype and one of the pioneers of palaeobotanical research in the People's Republic of China. Gender masculine.

Szeiinia huanglongensis sp. nov.
(Figs 2, 3)

1956 Sze, p. 76, 106, pl. LV, figs 6, 6a [notes, illustrated]
1973 Fujiyama, p. 336, 371, fig 18 [notes, illustrated]

Diagnosis. Tegmen hyperpterous, about twice as long as wide, basal portion of costal margin rounded, costal area about 1/3 of costal cell width, reaching half of tegmen length; costal cell with a few prenodal branches of stem ScP + RA; tornus arcuate; cell C1 about twice as long as cell C3; branch RA multiforked, branch RP with two terminals; branch MP with three terminals, branch CuA multiforked; radial area and cubital area subequal, distinctly more spread than medial area; general coloration dark, longitudinal veins lighter, two bands, first oblique from apex of costal area to half of tornus, second submarginally on membrane, arcuate, subparallel to apical margin.

Etymology. Derived from Huanglong County, where the type specimen was found.

Holotype. NIGPAS PB.2500, tegmen with complete clavus.

Type locality, unit and age. Undetermined locality within Huanglong County, Shaanxi Province, China; Yanchang Formation, undetermined Late Triassic horizon.

Description. Coloration – tegmen dark, longitudinal veins on corium and membrane lighter, claval veins and veinlets lighter; membrane with two lighter bands, first – oblique from apex of costal area to half of tornus, second submarginally on membrane, arcuate, subparallel to apical margin. Tegmen 8.75 mm long, 4.75 mm wide, length/width ratio 1.84. Costal margin thickened, distinctly arcuate at base, then slightly arcuate, anteroapical angle widely arcuate, posteroapical angle arcuate (partly damaged), apex widely rounded, tornus arcuate (?), membrane slightly wider than corium; clavus long, closed, reaching 3/4 of tegmen length. Costal vein CA thickened, costal veins Pc + CP weaker, slightly shifted, closing costal area, about 1/3 of costal cell width, with a few veinlets, with apex reaching half of tegmen length. Basal cell wide, about twice as long as wide, closed with weakened basal section of CuA, basal *cua-cup* distinct. Basal section of ScP slightly shifted from stem R + MP + CuA; stem (ScP)+R leaving basal call basad of stem MP, forked at basal 1/4 of tegmen length; branch ScP + RA with two prenodal branchings, the second forked to reach Pc + CP and costal margin; branch (ScP+)RA about twice as long as common stem ScP + R, forked at basal 1/3 of tegmen length, branch RA_1 with four terminals, branch RA_2 with eight terminals, occupying anteroapical angle; branch RP subparallel to costal margin, forked at level of nodal line, reaching apical margin with two terminals; stem MP merely arcuate at base, first fork apicad of ScP + R forking, basad of CuA forking, branch MP_{1+2} single, branch MP_{3+4} forked on membrane. Stem CuA forked apicad of stem MP forking, then branch CuA_1 forked slightly basad of nodal line, branch CuA_2 forked more basad, slightly apicad of claval veins junction; branches of CuA_1 and CuA_2 forked on membrane reaching posteroapical angle with seven (?) terminals. Nodal line not distinct, not regular, formed by veinlets of *ira*, *ra-rp*, *rp-mp*$_{1+2}$, *imp*, *mp*$_{3+4}$-*cua*$_1$. Two distinct prenodal S-shaped veinlets (false longitudinal branches) present *imp* and *icua*; prenodal *mp-cua* veinlet at level of

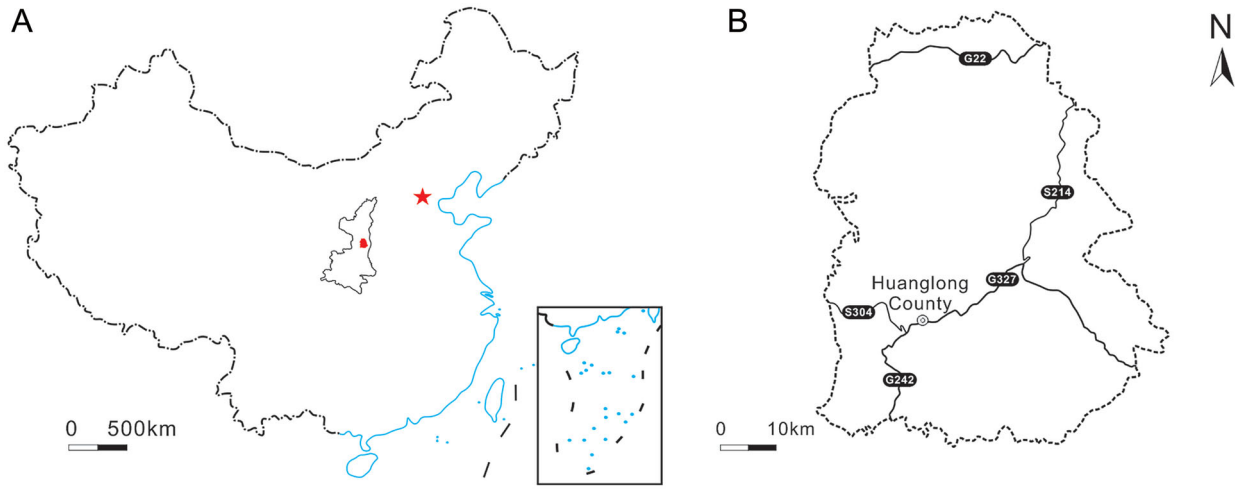

Fig. 1. **A**, Locality map showing Huanglong County in Shaanxi Province, northwestern China; **B**, geographic map of Huanglong County indicating the type locality for *Szeiinia huanglongensis*.

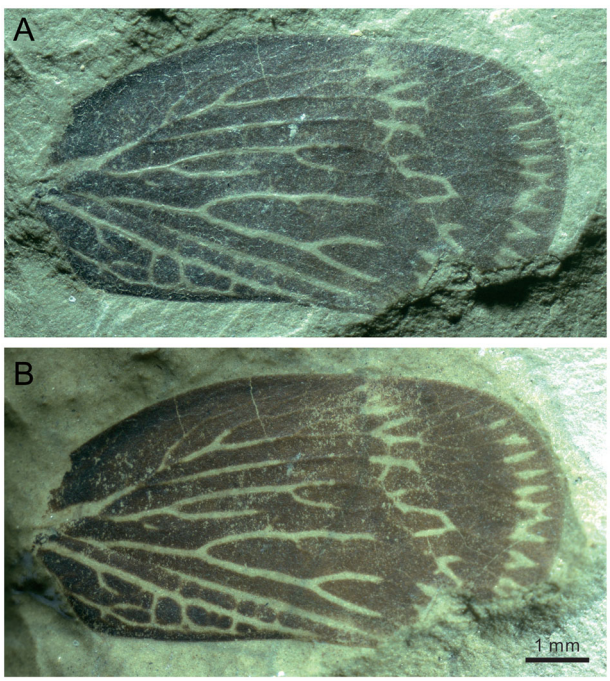

Fig. 2. *Szeiinia huanglongensis*. **A**, Imaged without alcohol covering the tegmen; **B**, imaged with alcohol covering the tegmen.

claval veins junction present; not regular post nodal and preapical veinlets present. Clavus with a few transverse veinlets in posterocubital cell and irregular veinlets in cubitoposterior cell. Cell C1 elongate, closed with nodal *ir* veinlet, cell C5 shorter than C1, about 3/4 of its length, delimited apically by S-shaped veinlet, cell C5 distinctly wider than cells C1 and C3, subpentagonal, about 1/2 of C1 length.

Discussion

Szeiinia huanglongensis represents an early member of Fulgoroidea. The taxon differs from the Permian–Triassic Surijokocixiidae in its branching ScP + RA, which are unlike the simple and more oblique branching RA and apically branched RP in surijokocixiids. The MP is also more apical, and the CuA is simpler in surijokocixiids.

Szeiinia huanglongensis can be distinguished from other known Triassic–Jurassic fulgoroids, including *Fulgoridiella raetica* (Fulgoridiidae), from the Hettangian–Sinemurian Dzhil Formation of Kirgizstan (Becker-Migdisova 1962), because it lacks branching RP on the membrane, and has different branching of the MP and CuA terminals; forking along the MP stem is also unlike the typical fulgoroid condition.

Triassic fulgoromorphs (Szwedo *et al.* 2004), such as *Heseneuma hammelburgensis* from the Anisian Röt Formation of Bavaria in Germany (Brauckmann & Schlüter 1983), have more elongate and punctate tegmina with MP that fork apicad of the nodal line. Four terminals also occur on the MP and the CuA is forked in the apicad half of the tegmen.

Szeiinia huanglongensis is reminiscent of *Qiyangircania cesta* Lin, 1986 (Qiyangiricaniidae) from the Toarcian Fengjiachong Member of the Guanyintan Formation in Hunan Province, China (Lin 1986, Szwedo *et al.* 2011) in lacking a regular nodal line (widespread among modern fulgoroids). However, it also lacks fusion of the veins in the costal complex, and the RP does not possess the apicad multi-forking characteristic of *Q. cesta* (Szwedo *et al.* 2011), or the meshwork of veinlets filling cells on the membrane. Finally, indistinct irregular lines of postnodal and subapical veinlets make the wing of *S. huanglongensis* hyperpterous (sensu Bourgoin *et al.* 2015).

Importantly, *S. huanglongensis* displays a transverse veinlet between the claval fold vein of CuP and Pcu. This is diagnostic amongst modern fulgoroids, and distinguishes members of Dictyopharidae (Spinola 1839) from Fulgoridae (Latreille, 1807), as well as tribe distinctions within Cixiidae (Spinola 1839), and higher clades within Tropiduchidae (Stål 1866, Emeljanov 1979, 2002, Szwedo & Stroiński 2013, 2017). Veinlet meshworks are also present in examples of the Cretaceous family Mimarachnidae (Shcherbakov 2007), and modern fulgorids. Interestingly, both *S. huanglongensis* and *Q. cesta* exhibit 'false veins'—elongate S-shaped veinlets that connect the longitudinal veins. Similar 'false veins' occur in the fulgorid *Aulieezidium karatauense* Szwedo &

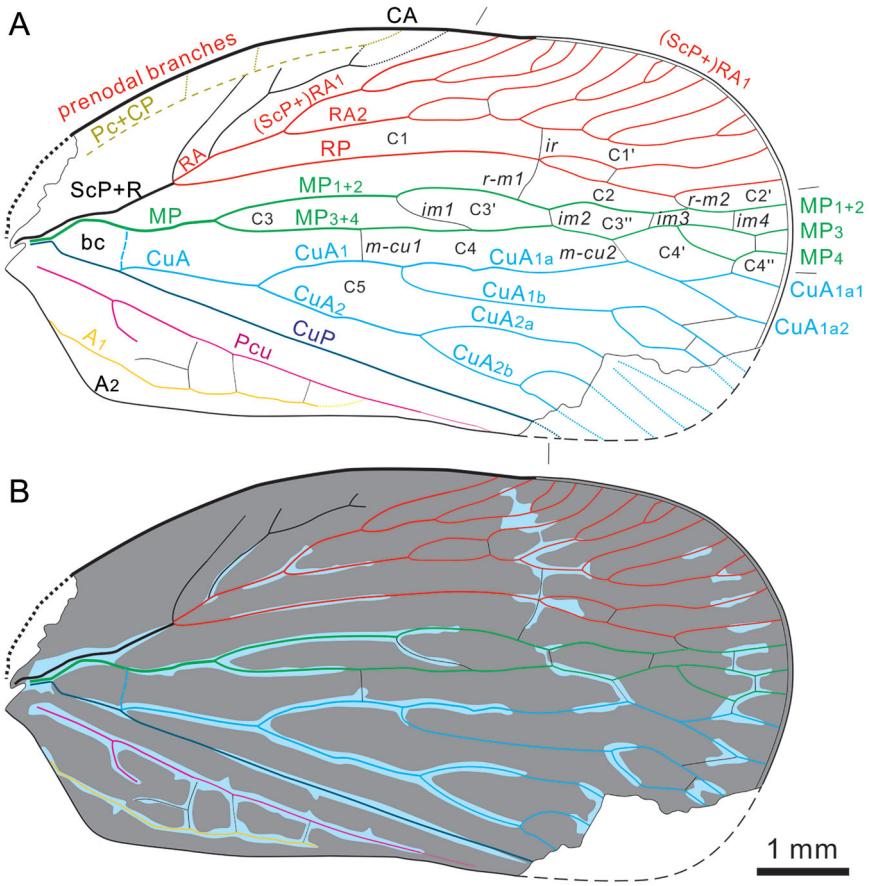

Fig. 3. *Szeiinia huanglongensis*. **A**, Line drawing showing wing venation; **B**, reconstruction showing the placement of light-coloured stigmal bands.

Żyła, 2009 from the Oxfordian–Kimmeridgian Karabastau Formation in the Karatau Range of Southern Kazakhstan, and could evidence variability in venation patterns amongst fulgoroids.

Szeiinia huanglongensis is the first hemipteran described from the Upper Triassic Yanchang Formation, and reveals the ecological presence of fulgoromorphs within this lacustrine-terrestrial depositional environment. Our finding adds new information on the morphological and taxonomic diversity of Triassic planthoppers from China, with two taxa now recognized: the surijokocixioid *Boreocixius tongchuanensis* from the Middle Triassic Tongchuan Formation (Zhang *et al.* 2021); and the Late Triassic *S. huanglongensis*, which represents the novel family Szeniiniidae. We subsequently suggest that fulgoromorphs might have dispersed from the southern Tongchuan region of the Ordos Basin towards the eastern Huanglong region during the later Triassic.

Disclosure statement

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