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New locustopsid fossils from the Middle Jurassic Yan'an Formation (Orthoptera: Caelifera)

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Abstract

Sinolocustopsis **gen. nov.** with two new species *Sinolocustopsis elongatus* **sp. nov.** and *Sinolocustopsis brevis* **sp. nov.** are described from the Yan'an Formation. These are the second and third Middle Jurassic Caelifera from China, the first described one being *Locustopsis rhytofemoralis* from the Haifanggou Formation (Callovian; = Jiulongshan Formation, Bathonian–Callovian boundary interval in original paper). It is a new evidence reveal the relationship between the insect assemblages from the Yan'an Formation and the Daohugou biota.

Key words: Insecta; Locustopsoidea; taxonomy; venation; Yanliao biota

Introduction

Mesozoic orthopteran fossils are quite common in China, but the vast majority belong to the ensiferan group Hagloidea. Very few Mesozoic Chinese Caelifera are currently described, belonging to the two families Locustopsidae and Elcanidae, mainly Cretaceous (Gu *et al.* 2016; Tian *et al.* 2019a,b). Only one Middle Jurassic Locustopsidae is recorded from China, while this family is quite diverse in Western Europe, especially in the Early Jurassic (Zessin 1983a,b, 1988, 1991).

Here we describe a new locustopsid genus and two species from the Middle Jurassic Yan'an Formation in China.

Geological setting

The Yan'an Formation is currently divided into the lower parts Baotashan Member and the upper parts Zaoyuan Member. The high-precision U-Pb zircon geochronological age (CA-ID-TIMS) obtained between 173.992 ± 0.053 Ma and 171.975 ± 0.047 Ma at the middle sections of the Yan'an Formation at the northeastern Ordos Basin (Zhang *et al.* 2021), which indicates that the fossil insect bearing layers at Yan'an City of the Yan'an Formation probably date from the early to middle parts of the Middle Jurassic. Therefore, the present fossil bearing layers is clearly older than the Daohugou biota from NE China (Lian *et al.* 2024). Since the major fauna and flora assemblages between the Yan'an and Haifanggou formations are clearly similar, the fossil assemblage of the Yan'an Formation and its correlate strata seems to correspond to the initial stage of the Yanliao biota (Xu *et al.* 2023). Then, the fossil assemblages of the Haifanggou Formation (e.g. Daohugou biota) and its correlate strata represent the flourishing stage of the Yanliao biota. The fossil assemblages of the Tiaojishan Formation and its correlate strata represent the decline stage of the Yanliao biota.

The fossil insects have been discovered from an unknown locality near the Peizhuang Village, which at least can be traced back to 1978. The first described insect fossil from the Yan'an Formation is an isophlebioid odonatan

collected from the Huangjiagou Village, Yuyang District, Yulin City, North Shaanxi Province (Zheng *et al.* 2017). In recent years we discovered abundant fossil insects at several localities near the Peizhuang Village (for locality map see Xu *et al.* 2023). These fossils were collected from green-grayish shale or mud stone at the middle sections of the Middle Jurassic Yan'an Formation. The entomofauna is diverse, including at least 13 orders (or superorder level taxon): Ephemeroptera, Odonata, Orthoptera, Blattodea, Dermaptera, Phasmatodea, Thripida, Hemiptera, Neuroptera, Coleoptera, Mecoptera, Diptera, and Hymenoptera. Until now, only a few tiny insect wings have been described from this locality (Xu *et al.* 2023; Huang 2023). The presently described locustopsid orthopterans were collected in the layer about half meter higher than those previously described tiny wings.

Material and methods

We examined a total of five specimens: one complete, two nearly complete, one with only the middle part preserved, and one represented by parts and counterparts. These specimens originated from the green-grayish mudstone of the Middle Jurassic Yan'an Formation at the locality near the Peizhuang Village, Yan'an City, Shaanxi Province, NW China (locality map see Xu *et al.* 2023).

The specimens were carefully prepared using a sharp knife. The fossils were photographed using a Zeiss AXIO Zoom V16 stereomicroscope. Type specimens were deposited at Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing.

We follow the nomenclature of wing venation by Béthoux and Nel (2002), emended by the work of Schubnel *et al.* (2020b) with respect to the postcubital vein.

Results

Order Orthoptera Olivier, 1789

Superfamily Locustopsoidea Handlirsch, 1906

Family Locustopsidae Handlirsch, 1906

Genus *Sinolocustopsis* gen. nov.

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Type species. *Sinolocustopsis elongatus* sp. nov.

Diagnosis

Forewing characters only. Basal part of CuA between MP+CuA and CuP α very short, reduced to a veinlet looking like a crossvein perpendicular to M+CuA and distal part of CuA; part of MP(+CuA) between its separation from MA and the point of its narrowest distance with CuP α very long.

Etymology

The name is derived from *Sinica*, the Latin name for China, and the genus name *Locustopsis*. The gender is masculine.

***Sinolocustopsis elongatus* sp. nov.** (Fig. 1)

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Type material

Holotype: NIGP206064 (complete forewing, slightly deformed, with part and counterpart).

Etymology

Named after the narrow elongate wing, elongate part of RA distal of apex of ScP, and elongate stem of MP+CuA, main difference with the other Locustopsidae.

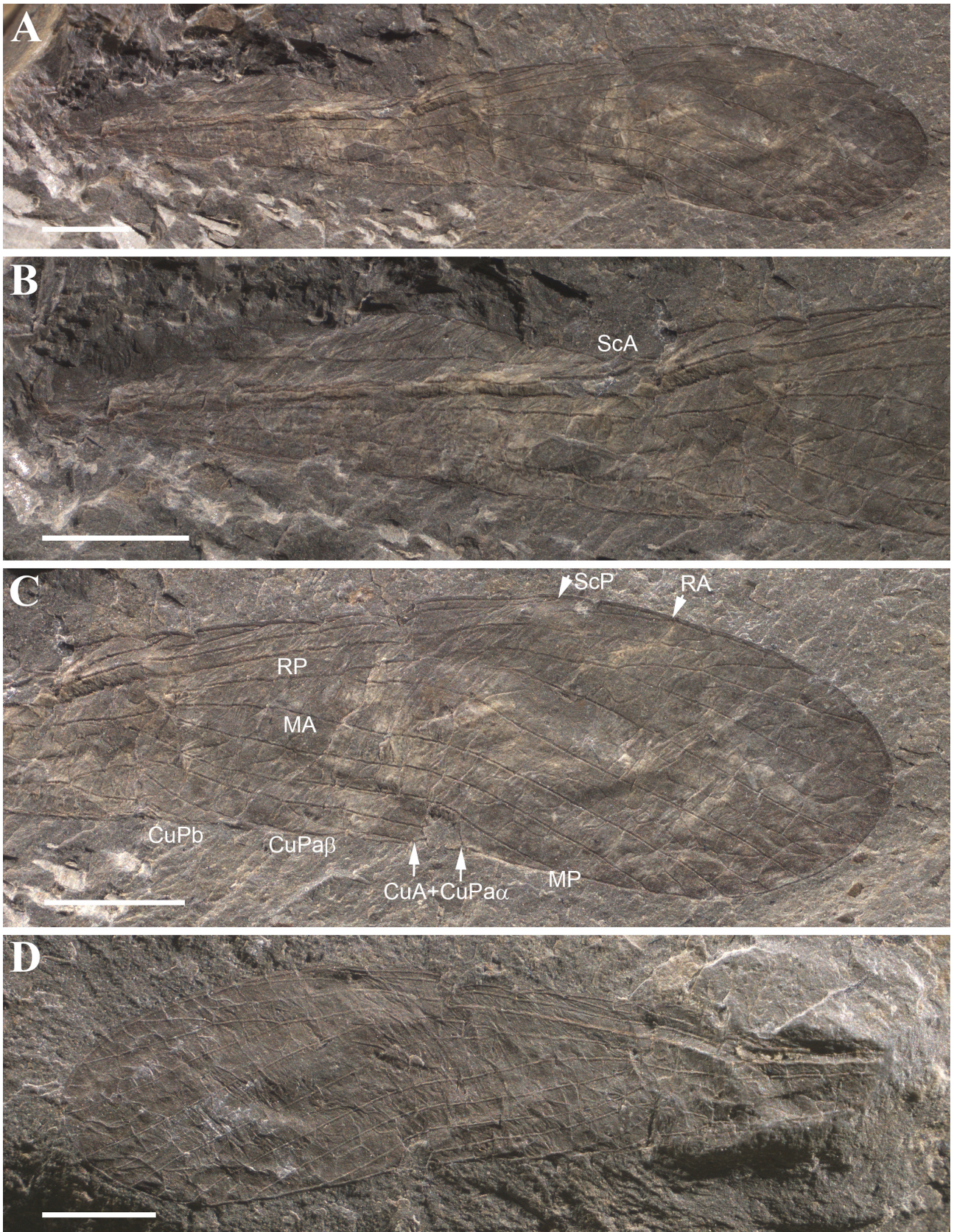


Figure 1. *Sinolocustopsis elongatus* sp. nov., Middle Jurassic Yan'an Formation, holotype NIGP206064a, b. **A**, Part. **B**, Enlargement of **A**, basal half part. **C**, Enlargement of **A**, apical half part. **D**, Counterpart. Scale bars = 2 mm.

Diagnosis

As for the genus. Part of RA distal to apex of ScP very long, emitting a very long sigmoidal anterior veinlet; basal part of CuP α distinctly curved and short, covering less than one cell basal to its fusion with CuA.

Description

Holotype forewing 18.3 mm long, 3.7 mm wide, 2.0 mm wide at basal fourth, narrow in basal half; area between C and ScA rather broad and long, 0.6 mm wide, 5.0 mm long, with a net of cells and long sigmoidal veinlets emerging from ScA; area between ScA and ScP narrower; ScP elongate, 14.2 mm long, with three long sigmoidal anterior veinlets; area between ScP and R/RA as narrow as that between ScA and ScP; part of RA distal to apex of ScP 3.0 mm long, with three distal anterior sigmoidal veinlets, first one ending into ScP, second very long and third short; base of RP at 7.3 mm from wing base, stem of RP elongate, 3.8 mm long, RP with four simple posterior branches, covering wing apex; M+CuA appressed to R at wing base, gradually diverging from it, straight, with separation of MA from MP+CuA 7.3 mm from wing base; stem of MA short, 2.0 mm long, MA with two simple branches, well separated from RP; stem of MP+CuA elongate, 1.7 mm long; basal part of CuA short, perpendicular to MP and CuA+CuP α ; CuA+CuP α with a distal fork; stem of CuP very long, 7.1 mm long; CuP α sigmoidal and closely parallel to posterior margin of wing in its distal part; basal free part of CuP α curved and short; PCu very long, parallel to stem of CuP; one anal vein visible, short; two rows of cells in distal part of area between M+CuA and CuP.

Locality and horizon. Peizhuang village, Yan'an City; Middle Jurassic Yan'an Formation.

Remark

Among the Mesozoic caeliferan families, this forewing strongly differs from the Elcanoidea in the RP well separated from M, but it strongly resembles Locustopsoida, a superfamily that comprises the Triassic Locustavidae Sharov, 1968, the Mesozoic Locustopsidae, the Cretaceous Araripelocustidae Martins-Neto, 1995 and Bouretidae Martins-Neto, 2001, and the Permian Eolocustopsidae. This last family is currently attributed to Riek (1976) (see <http://orthoptera.archive.speciesfile.org>), but this author only described the genus *Eolocustopsis* in the Locustopsidae, on the basis of an incomplete forewing in which the distal parts of veins MA, MP, CuA and vein CuP α are not preserved. The exact affinities of this Permian fossil are uncertain. The family Araripelocustidae Martins-Neto, 1995 is based on *Araripelocusta* Martins-Neto, 1995 (Martins-Neto 1995, 2003), on poorly preserved fossils, probably belonging to the Locustopsidae, as it shares all the main characters of this family. The family Bouretidae is based on a very poor fossil, whose affinities are quite uncertain.

Nel & Jouault (2022) indicated that there is no clear synapomorphy in the forewing structures to define the Locustavidae, Locustopsidae, and Locustopsoida as genuine clades.

The new fossil differs from the Triassic Locustavidae in the distance between the MA/MP and MA1/MA2 splits short (vs. relatively long); CuA+CuP α simple or with a rudimentary distal fork (vs. long posterior branches); and CuP branched well distal to wing base (vs. near base) (Béthoux & Ross 2005; Xu *et al.* 2020). On the contrary these characters of the new fossil are shared by the Locustopsidae. After Gorochov (1995), the differences in the forewings between the Locustavidae and the Locustopsidae would concern the multi-branched CuA+CuP α in the former vs. two-three-branched in the latter (at most), and the presence of more branches of the anal veins 1A and 2A vs. only one or two in the latter. The new fossil has these characters of the Locustopsidae.

In the Locustopsidae, the basal part of CuA between MP+CuA and CuP α is very short, reduced to a veinlet looking like a crossvein or even not distinguishable from the crossveins around it, as in some extant Caelifera. Also the part of MP(+CuA) between its separation from MA and the point of its narrowest distance with CuP α is quite short in the already described Locustopsidae vs. very long in the new fossil (Brauer *et al.* 1889; Bode 1953; Sharov 1968; Zessin 1983a, 1991; Whalley 1985: fig. 21; Hong & Wang 1990; Martins-Neto 1998, 2003; Gorochov *et al.* 2006; Smith *et al.* 2011; Gorochov & Coram 2023).

Notice that *Orichalcum* Whalley, 1985 has a particular course of the MA vein, making a strong angle and curve, vs. more straight in the other Locustopsidae. Its attribution to this family is questionable.

In the new fossil, the free CuA is only slightly stronger than the crossveins around it as in the Locustopsidae, but the MP+CuA is very long, unlike in nearly all other taxa in this family. *Plesioschwinzia* Zessin, 1988 shows a very particular situation in which MA has three branches (vs. one or two in other Locustopsidae) and MP does not separate from CuA. Also the new fossil differs from this genus in the distinctly shorter basal part of CuP α (Zessin 1988).

Pseudoacrida costata Lin, 1982, type species of *Pseudoacrida* Lin 1982, and *Pseudoacrida sennlaubi* Nel & Jouault, 2022 have a CuA that separates from M very basally, and thus a forewing venation strongly different from those of the other Locustopsidae and from the new fossil (Lin 1982: pl. 30, fig. 7; Nel & Jouault 2022).

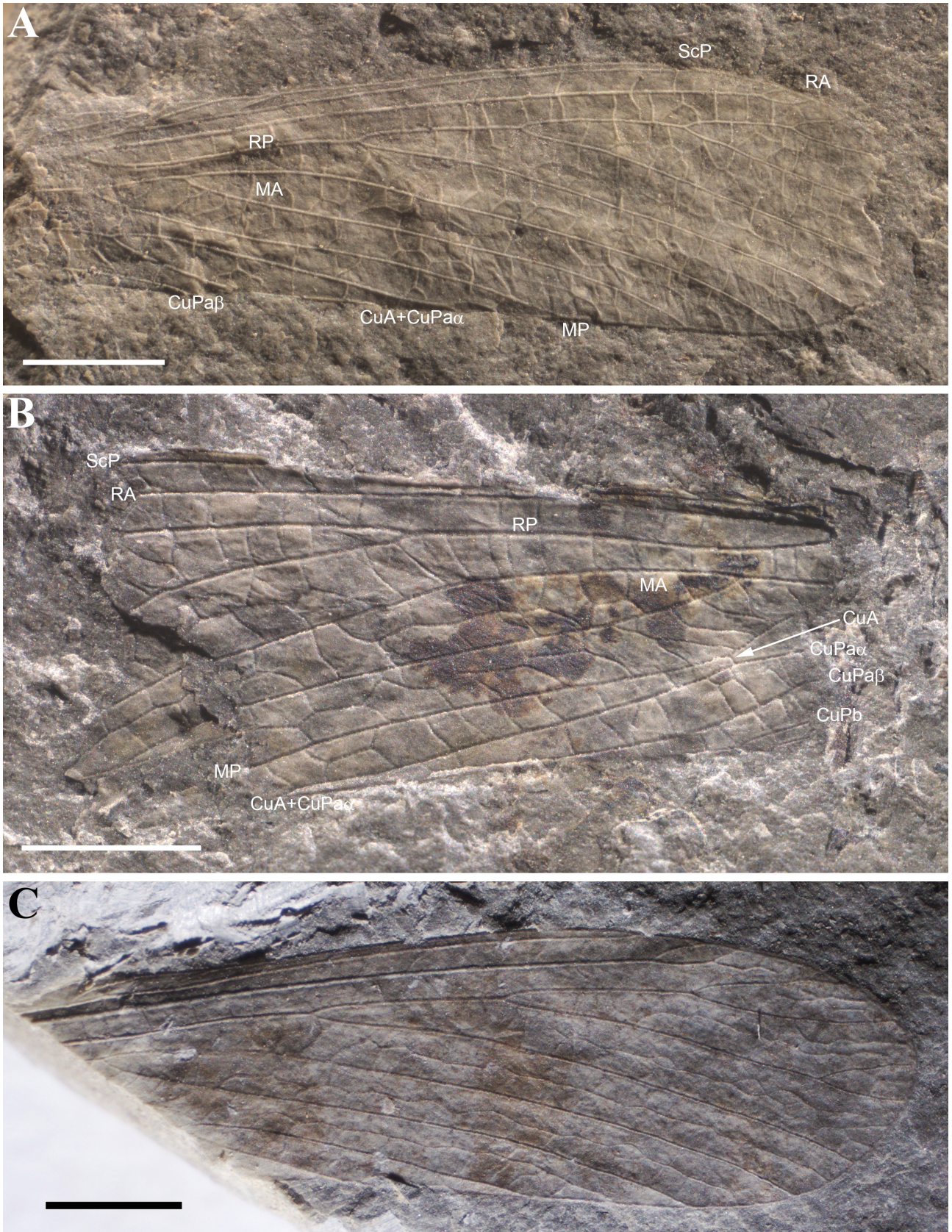


Figure 2. *Sinolocustopsis brevis* sp. nov., Middle Jurassic Yan'an Formation. **A**, Holotype NIGP206065. **B**, Paratype NIGP206135. **C**, Paratype NIGP206073. Scale bars = 2 mm.

***Sinolocustopsis brevis* sp. nov.** (Fig. 2)

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Type material

Holotype: NIGP206065 (nearly complete forewing, with basal section missing). Paratypes NIGP206135 (middle part of a forewing) and NIGP206073 (forewings with basal section missing).

Etymology

Named after the short part of RA distal of apex of ScP.

Diagnosis

Part of RA distal to apex of ScP very short, emitting only short and straight anterior veinlets; basal part of CuPa nearly straight, long, covering at least four cells basal to its fusion with CuA.

Description

Holotype forewing, preserved part 11.7 mm long, 3.7 mm wide, 2.3 mm wide at basal fourth, narrow in basal half; ScP elongate, with two long sigmoidal anterior veinlets just distal to apex of ScA, distal part of area between C and ScP very narrow; area between ScP and R/RA as narrow as that between ScA and ScP; part of RA distal to apex of ScP short, 1.8 mm long, with five anterior very short veinlets; stem of RP elongate, 3.9 mm long, RP with four simple posterior branches, covering wing apex; M+CuA straight; stem of MA short, 1.3 mm long, MA with two simple branches, well separated from RP; stem of MP+CuA elongate, 2.0 mm long; basal part of CuA short, perpendicular to MP and CuA+CuPaa; CuA+CuPaa forked; CuPaa sigmoidal and closely parallel to posterior margin of wing in its distal part; basal free part of CuPaa straight and long.

Preserved part of paratypes nearly identical to holotype, except in the CuA+CuPaa simple.

Locality and horizon. Peizhuang village, Yan'an City; Middle Jurassic Yan'an Formation.

Remark

These three wings share very similar venation in their preserved part, thus we consider that they belong to the same species. The holotype NIGP206065 and paratype NIGP206135 shares with *Sinolocustopsis elongatus* sp. nov. the same elongate stem of MP+CuA, characteristic of the genus *Sinolocustopsis* gen. nov. Otherwise, the venation fits quite well with those of the Locustopsidae. The differences with *Sinolocustopsis elongatus* sp. nov. are listed in the species diagnosis. The differences between the two proposed species are higher than those between the numerous species currently in the genus *Locustopsis* (see Zessin 1983a).

Conclusion

Sinolocustopsis elongatus sp. nov. and *Sinolocustopsis brevis* sp. nov. are the second and third Middle Jurassic Caelifera from China, the first described one being *Locustopsis rhytofemoralis* Gu, Yue, Shi, Tian & Ren, 2016 from the Daohugou biota (Gu *et al.* 2016) of the Callovian Haifanggou Formation (=Jiulongshan Formation, Bathonian–Callovian boundary interval, in original paper; Huang 2019). They demonstrate that Locustopsidae were well present in China during this period. This family is also known by two Cretaceous species *Pseudoacrida costata* Lin, 1982, and *Mesolocustopsis sinica* Hong, 1990. It is surprising that no records have been found from the Early Jurassic of China, despite its considerable diversity in Western Europe during the same period. This absence may be attributed to the limited availability of Early Jurassic deposits in western China or a lack of thorough collection and research efforts. The recent discovery of locustopsid records from the Middle Jurassic Yan'an Formation provides new evidence highlighting the similarities in insect assemblages between the Yan'an Formation in the Ordos Basin and the Haifanggou Formation in the Yanliao area (Xu *et al.* 2023; Huang 2023). This finding suggests that the origins of the renowned Yanliao Biota may trace back to the Yan'an Formation.

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