comptes rendus palevol

2023 • 22 • 23

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art. 22 (23) — Published on 11 July 2023
www.cr-palevol.fr

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Académie des sciences, Institut de France, 23 quai de Conti, 75006 Paris.

ISSN (imprimé / *print*) : 1631-0683/ ISSN (électronique / *electronic*) : 1777-571X

A new campterophlebiid damsel-dragonfly (Odonata: Isophlebioidea) from the Middle Jurassic Yanan Formation of Yulin City, Shaanxi Province, NW China

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Submitted on 8 April 2022 | Accepted on 20 September 2022 | Published on 11 July 2023

urn:lsid:zoobank.org:pub:73122322-1744-463F-A812-D4C5BE79A858

Tian F., Zheng D., Nel A., Ye Y., Mei T. & Zhang H. 2023. — A new campterophlebiid damsel-dragonfly (Odonata: Isophlebioidea) from the Middle Jurassic Yanan Formation of Yulin City, Shaanxi Province, NW China. *Comptes Rendus Palevol* 22 (23): 491-496. https://doi.org/10.5852/cr-palevol2023v22a23

ABSTRACT
The family Campterophlebiidae Handlirsch, 1920 is the dominant Jurassic clade of Odonata Fabricius, 1793, especially hosting a high diversification in northern China. The Chinese campterophlebiid damsel-dragonflies were mainly recovered from the Middle Jurassic of Inner Mongolia, northern China. In the present study, a new campterophlebiid, *Parasinitsia qingyunensis* n. gen., n. sp., is described from the early Middle Jurassic Yanan Formation of the Ordos Basin, NW China.

KEY WORDS
Campterophlebiidae,
Yanan Formation,
Middle Jurassic,
Ordos Basin,
China,
new genus,
new species.

Parasinitsia n. gen. resembles the genus *Sinitsia* Pritykina, 2006 recorded from the Upper Jurassic of eastern Transbaikalia, but differs from the latter in having two or three rows of cells between RA and RP1 distal of the pterostigma, IR2 and RP3/4 with at least four rows of cells near the wing margin, and CuAa with about 15 rows of cells between it and the posterior wing margin in the broadest area. The new damsel-dragonfly comes from a new early Middle Jurassic insect site from the Ordos Basin, providing new clues to understand the terrestrial ecosystems during this epoch.

RÉSUMÉ
Un nouveau campterophlebiid demoiselle-libellule (Odonata: Isophlebioidea) de la formation Yanan du Jurassique moyen de la ville de Yulin, province de Shaanxi, au Nord-Ouest de la Chine.
La famille Campterophlebiidae Handlirsch, 1920 est le clade jurassique dominant des Odonata Fabricius, 1793, avec notamment une forte diversité dans le Nord de la Chine. Les Campterophlebiidae de Chine proviennent principalement du Jurassique moyen de la Mongolie intérieure. Dans la présente étude, un nouveau Campterophlebiidae, *Parasinitsia qingyunensis* n. gen., n. sp., est décrit de la formation de Yanan du Jurassique moyen inférieur du bassin de l'Ordos, dans le nord-ouest de la Chine. *Parasinitsia* n. gen. ressemble au genre *Sinitsia* Pritykina, 2006 du Jurassique supérieur de l'est de la Transbaïkalie, mais diffère de ce dernier en ayant deux ou trois rangées de cellules entre RA et RP1 en aval du pterostigma, IR2 et RP3/4 avec au moins quatre rangées de cellules près du bord de l'aile, et CuAa avec environ 15 rangées de cellules entre elle et la marge postérieure de l'aile dans la zone la plus large. Le nouveau taxon provient d'un nouveau site d'insectes du début du Jurassique moyen du bassin de l'Ordos, fournissant de nouveaux indices pour comprendre les écosystèmes terrestres à cette époque.

MOTS CLÉS
Campterophlebiidae,
Formation Yanan,
Jurassique moyen,
bassin de l'Ordos,
Chine,
genre nouveau,
espèce nouvelle.

INTRODUCTION

The family Campterophlebiidae Handlirsch, 1920 is the most diversified damsel-dragonfly clade discovered from the Mesozoic of China, the majority of taxa being recorded from the Middle Jurassic of Inner Mongolia, and few in the Lower Jurassic of Xinjiang and the Middle Jurassic of Shaanxi (Fleck & Nel 2002; Nel *et al.* 2008, 2009; Zheng *et al.* 2016, 2017, 2018, 2019; Huang *et al.* 2018). Herein, we describe a new campterophlebiid damsel-dragonfly from the early Middle Jurassic Yanan Formation in Qingyun Village of eastern Yulin City, Shaanxi Province, northwestern China. The Yanan Formation in Huangjiagou Village of Yulin has already yielded a campterophlebiid damsel-dragonfly (Zheng *et al.* 2017). The present study describes a new genus and species of Campterophlebiidae, and reveals a new Middle Jurassic entomofauna from northern Ordos Basin.

MATERIAL AND METHODS

The newly described damsel-dragonfly described was collected from the early Middle Jurassic Yanan Formation in Qingyun Town, Yulin City, Shaanxi Province, NW China (Fig. 1). The Yanan Formation unconformably underlies the Pliocene Baode Formation and conformably overlies the Lower Jurassic Fuxian Formation in Yulin. It is considered to be early Middle Jurassic in age (*c.* 174-172 Ma; Zhang *et al.* 2021). Preserved together with the new damsel-dragonfly, there are abundant fossils including fishes, bivalves, gastropods, plants, and representatives of some other insect orders (Ephemeroptera Hyatt & Arms, 1891, Phasmatodea Jacobson & Bianchi, 1902, Coleoptera Linnaeus, 1758, Mecoptera Hyatt & Arms, 1891, Neuroptera Linnaeus, 1758, Orthoptera Latreille, 1793 and Hemiptera Linnaeus, 1758).

The specimen was examined dry using a Nikon SMZ1000 stereomicroscope. Observation was augmented by temporary wetting with laboratory alcohol which improved the contrast between the fossil and the matrix, eliminating the surface irregularity of the latter. Photographs were taken using a Canon 5D digital camera and the line drawings were prepared from photographs using image-editing software (CorelDraw X7 and Adobe Photoshop CS6). The specimen is housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS). All taxonomic acts established in the present work have been registered in ZooBank.

The higher classification of fossil and extant Odonatoptera is based on the phylogenetic system of Bechly (1996). The nomenclature of the dragonfly wing venation used in this paper is based on the interpretations of Riek (1976) and Riek & Kukalová-Peck (1984), as modified by Nel *et al.* (1993) and Bechly (1996).

Abbreviations

AA	anal anterior;
AP	anal posterior;
Arc	arculus;
Ax	primary antenodal crossvein;
C	costa;
Cr	nodal crossvein;
CuAa	distal branch of cubitus anterior;
CuAb	proximal branch of cubitus anterior;

CuP cubitus posterior;
DC discoidal cell;
IR intercalary radial vein;
MAa anterior branch of median anterior;
MAb posterior branch of median anterior;
MP median posterior;
N nodus;
'O' oblique vein;
Pt pterostigma;
RA radius anterior;
RP radius posterior;
Sn subnodal crossvein;
ScP subcosta posterior.

SYSTEMATIC PALAEONTOLOGY

Order ODONATA Fabricius, 1793
Suborder EPIPROCTOPHORA Bechly, 1996
Subordinal clade ISOPHLEBIOPTERA Bechly, 1996
Subclade ISOPHLEBIIDA Bechly, 1996
Superfamily ISOPHLEBIOIDEA Handlirsch, 1906
Family CAMPTEROPHLEBIIDAE Handlirsch, 1920

Genus *Parasinitsia* n. gen.

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DIAGNOSIS. — One row of cells in basal areas between MAa and MP, and between MP and CuAa; width of basal areas between MAa and MP, and between MP and CuAa nearly identical; CuAa approaching MP, with at least three rows of cells between it and posterior wing margin distally; area between MAa and MP widened before N, with at least three rows of cells in broadest area; MP with many posterior intercalary veins, with 15 rows of cells between it and posterior wing margin in broadest area; 'O' seven cells distal of Sn; a strong and long oblique vein between IR1 and RP2, oriented towards the wing base, lying slightly close to level of Pt base than to IR1 base; Pt long and elongate, covering six cells and not braced; two or three rows of cells between RA and RP distal of Pt.

TYPE SPECIES. — *Parasinitsia qingyunensis* n. sp.

ETYMOLOGY. — Prefix "para" after the similarities with the genus *Sinitsia* Pritykina, 2006.

Parasinitsia qingyunensis n. gen., n. sp.
(Figs 2; 3)

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DIAGNOSIS. — The same as for the monotypic genus.

MATERIAL. — Holotype, NIGP163538a, b, part and counterpart of a well-preserved forewing, with posterior wing base and middle-distal wing half preserved (Fig. 2); deposited in NIGPAS.

TYPE LOCALITY AND STRATUM. — Qingyun Town, Yulin City, Shaanxi Province, NW China; Yanan Formation, early Middle Jurassic (*c.* 174-172 Ma, Aalenian; Zhang *et al.* 2021).

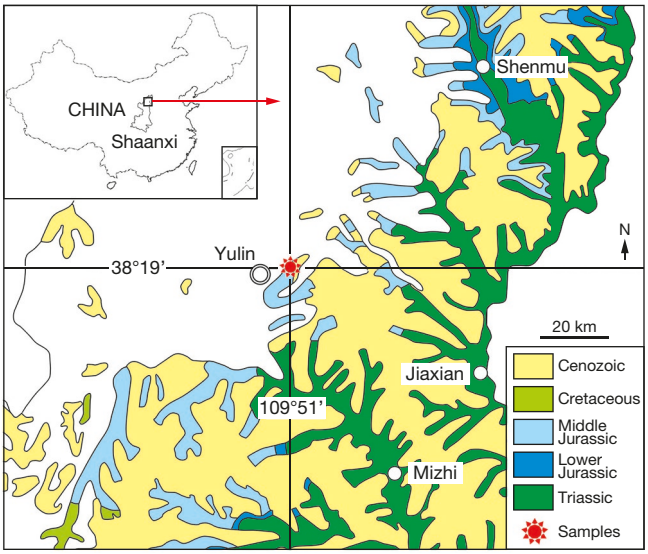

FIG. 1. — Geographical sketch map showing insect locality in eastern Yulin City, north Shaanxi Province, northwestern China.

ETYMOLOGY. — The specific name is after Qingyun Town, main locality in the area where the specimen was found.

DESCRIPTION

Specimen NIGP163538a, b (Figs 2; 3), middle-distal wing part of wing 41.7 mm long, width at level of N 14.4 mm; distance from wing base to Arc 6.6 mm, and from N to Pt 18.8 mm. Median area free of crossveins. CuP strong, separating submedian and subdiscoidal areas at 0.7 mm basal of Arc. DC open. Subdiscoidal area broad and transverse, free of crossveins. CuA separated from MP 9.3 mm from wing base, aligned with MAb basally. Area between CuAa and MP with one row of cells basally, and as wide as postdiscoidal area, 1.9 mm wide, distinctly narrowing distally and very broad in most distal part; CuAa with 1-3 rows of cell between it and posterior wing margin in basal area. MP sigmoidally curved. MAa slightly curved, more or less parallel with MP distal of level of N; postdiscoidal area with one row of large cells basally, expanded distally with two or three cells before N, narrower distally with one row of cells below N, and two rows distally. No secondary antenodal crossveins present between C and ScP near N; three secondary antenodal crossveins present between ScP and RA distal of A×2. Fourteen postnodal crossveins present between C and RA, not aligned with nineteen postsubnodal crossveins between RA and RP1 basal of Pt. Seven antesubnodal crossveins present in distal part of area. Seven postnodal crossveins present distal of Pt. Bqr space between RP, RP2, IR2 and oblique vein 'O' very long and narrow, with one row of cells and 15 crossveins preserved. Single oblique vein 'O' present, seven cells and 5.8 mm distal of RP2 base. RP2 curved. Nodal structures well preserved; Sn oblique and well aligned with Cr and RP2. IR1 originating seven cells and 5.5 mm distal of RP2 base; IR1 weakly zigzagged basally, more or less parallel to RP1. Pt not braced, long and narrow, sclerotized, 7.7 mm long and 0.8 mm wide.

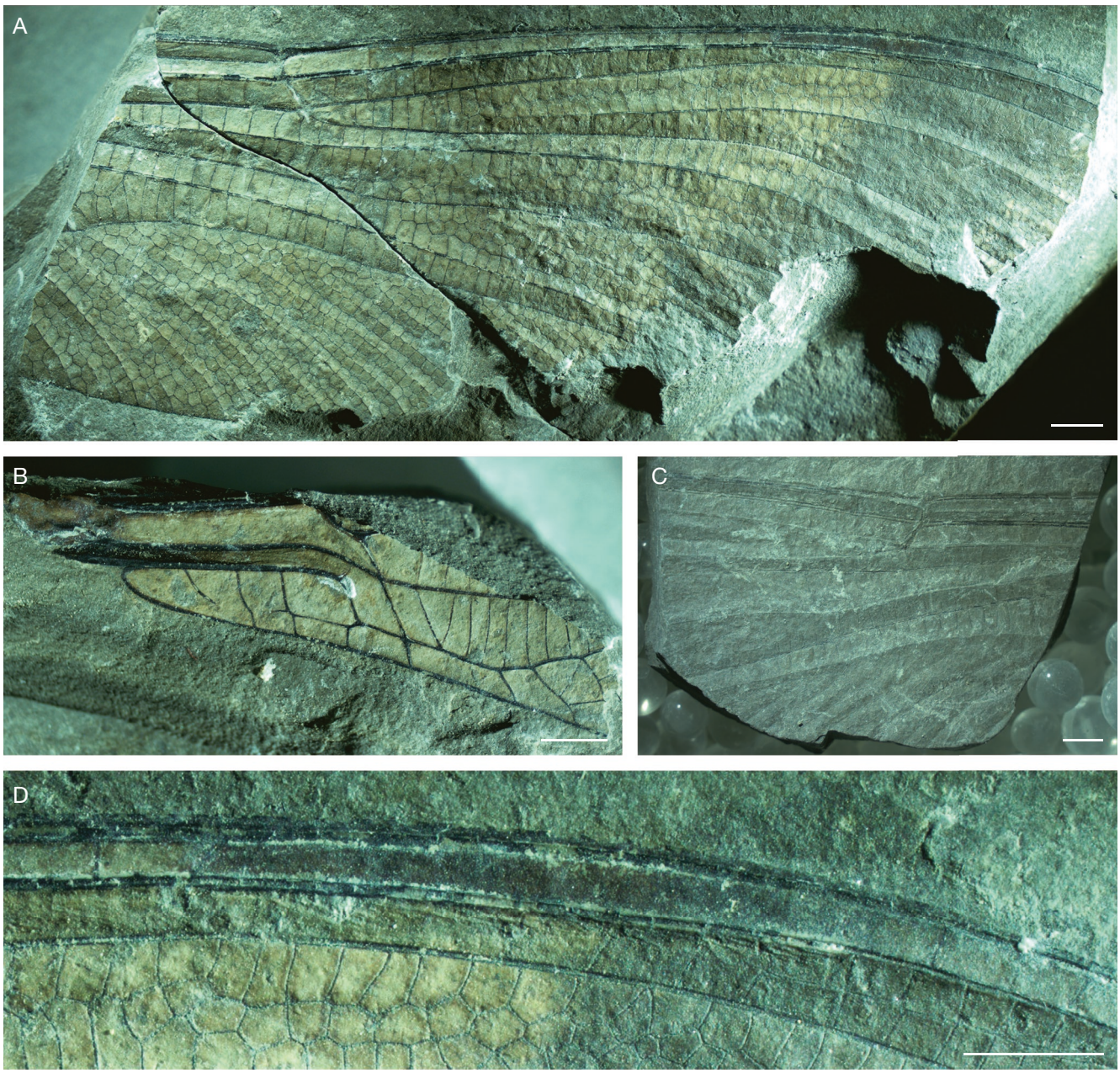

FIG. 2. — *Parasinitsia qingyunensis* n. gen., n. sp., holotype, photographs of part and counterpart (NIGP163538a, b): **A**, middle-distal part; **B**, basal part; **C**, middle part (counterpart of A); **D**, pterostigmal part. Scale bars: 2 mm.

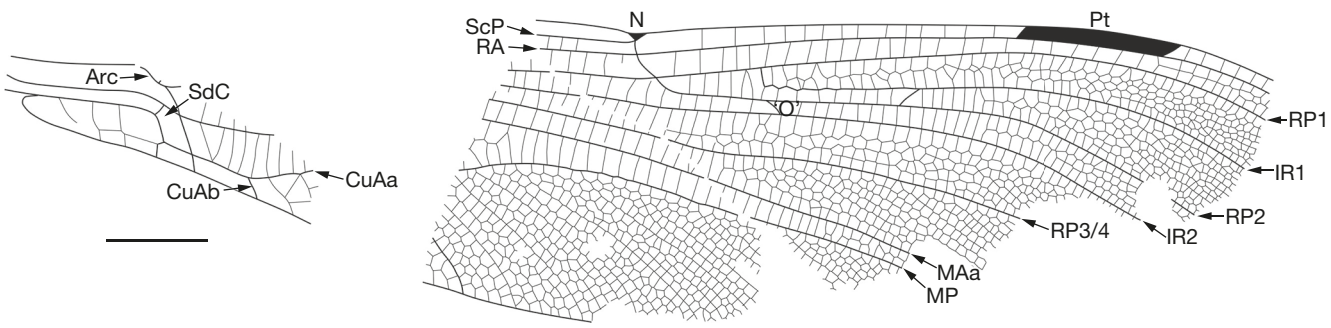

FIG. 3. — *Parasinitsia qingyunensis* n. gen., n. sp., holotype (NIGP163538), line drawing showing forewing venation. Scale bar: 5 mm.

Area between MAa and RP3/4 widened distally, with many cells along below Pt. Area between RP3/4 and IR2 with one row of cells basal of N level, expanded distally with six rows of cells below N. Area between IR2 and RP2 with one row of cells slightly before Pt, expanded distally with 2-4 rows of cell below Pt. Area between RP2 and IR1 with one rows of cells slightly basal of Pt base, widened distally with many rows of cells. Area between IR1 and RP1 with two rows of cells before Pt, widened distally with many rows of cells. Area between RA and RP1 before Pt end, widened distally with two or three rows of cells.

DISCUSSION

Parasinitsia qingyunensis n. gen., n. sp. shares the typical characters of Campterophlebiidae: a medium size, no secondary antenodal crossveins between C and ScP, and basally opened discoidal cell in the forewing (Nel *et al.* 2009; Li *et al.* 2012a). *Parasinitsia qingyunensis* n. gen., n. sp. has similar widths of the basal parts of the postdiscoidal area between MAa and MP, and that between MP and CuA, and only one row of cells between these veins in their basal parts, only shared by the following campterophlebiid damsel-dragonflies: *Ctenogampsophlebia* Petrulevičius, Huang & Nel, 2011, *Honghea* Zheng, Shi, Wang, Chang, Dou, Wang & Zhang, 2017, *Karatawia* Martynov, 1925, *Melanohypsa* Pritykina, 1968, *Parazygokaratawia* Huang, Cai & Nel, 2018, *Sinitsia*, and *Zygokaratawia* Nel, Huang & Lin, 2008.

Ctenogampsophlebia and *Honghea* have smaller wing sizes, MAa ending on MP, and fewer rows of cells between the main veins below the pterostigma, showing differences with *Parasinitsia qingyunensis* n. gen., n. sp. (Petrulevičius *et al.* 2011; Zheng *et al.* 2017). *Karatawia* has MAa zigzagged distally, one row of cells between RA and RP1 distal of the pterostigma, MP with fewer rows of cells between it and the posterior wing margin, differing from *P. qingyunensis* n. gen., n. sp. (Nel *et al.* 1993; Li *et al.* 2012b). *Melanohypsa* Pritykina, 1968, although only preserved with wing base, is similar with *P. qingyunensis* n. gen., n. sp. in sharing with an acute distal angle of the discoidal cell and two rows of cells in the anal area; it, however, differs from *P. qingyunensis* n. gen., n. sp. in having CuAa remaining parallel with MP instead of making a strong anterior curvature towards it (Pritykina 1968; Nel *et al.* 1993). *Parazygokaratawia* and *Zygokaratawia* have smaller sizes (30.8 and 35.5 mm, respectively), MAa zigzagged and weakened distally, a short pterostigma covering two or three cells, and less rows of cells between the main veins below the pterostigma, excluding any affinities with *P. qingyunensis* n. gen., n. sp. (Nel *et al.* 2008; Huang *et al.* 2018). *Sinitsia* quite resembles *P. qingyunensis* n. gen., n. sp. in having CuAa moving towards MP distally, no constriction between RP2 and IR2, many rows of cell between the main veins in the distal half of wing, plus a strong and long oblique vein between IR1 and RP2, oriented towards the wing base, and lying slightly close to the level of the pterostigmal base than to IR1 base, and a long pterostigma (Pritykina 2006; Nel *et al.* 2009). *Parasinitsia qingyunensis* n. gen., n. sp. differs from *Sinitsia* in having the oblique vein 'O' seven cells distal of Sn, two or three rows of cells between RA and RP1 distal of the pterostigma, at least three rows of cells in the broad part of postdiscoidal area basad the nodus, up to eight rows of cells in the area between IR2 and RP3/4 below the pterostigma, vs only four in *Sinitsia*, and *c.* 15 rows of cells between MP and posterior wing margin in the broadest area, vs 13 in *Sinitsia* (Pritykina 2006; Nel *et al.* 2009). Some Campterophlebiidae genera are based on incomplete wings in which the basal part of the postdiscoidal area is not preserved, e.g. *Sarytashia* Pritykina, 1970. This genus differs from the new fossil in the areas between IR2 and RP2 and between RP2 and IR1 much narrower (Nel *et al.* 1993).

Within Campterophlebiidae, *Parasinitsia qingyunensis* n. gen., n. sp. has many rows of cells between the main veins in the distal part (especially for the present of two or three rows of cells between RA and RP1 distal of the pterostigma), area between MAa and MP broadened in the middle part and distally constricted, many secondary intercalary veins originating from MP, 'O' seven cells distal of RP2 base, a strong and long oblique vein between IR1 and RP2 oriented toward the wing base, lying slightly close to the level of Pt base than to IR1 base and Pt covering many cells, all characters shared by *Parafleckium* Li, Nel, Ren & Pang, 2012 (Li *et al.* 2012a, c). *Parafleckium* however, obviously differs from *Parasinitsia qingyunensis* n. gen., n. sp. in having a broad area between MP and CuAa, which is three times the size of the postdiscoidal area, MP with fifteen rows of cells between it and the posterior wing margin in the broadest part, and CuAa with only one row of cells between it and the posterior wing margin. *Junfengi yulinensis* Zheng & Zhang, 2017 is based on a male hind wing discovered from the Yanan Formation of Yulin (Zheng *et al.* 2017). Any affinities between *Junfengi* Zheng & Zhang, 2017 and *P. qingyunensis* n. gen., n. sp. can be excluded, since the former has MAa nearly parallel with MP, MP with fewer rows of cells between it and the posterior margin, the oblique vein 'O' three cells distal of Sn, fewer postnodal crossveins before the pterostigma, and IR2 with only one row of cells between it and RP3/4 before the level of IR1.

In conclusion, *Parasinitsia qingyunensis* n. gen., n. sp. resembles the campterophlebiid dragonfly *Sinitsia* and *Parafleckium*, but still strongly differs from these genera. We therefore justify a new genus for this unique damsel-dragonfly.

CONCLUSIONS

A new Campterophlebiidae, *Parasinitsia qingyunensis* n. gen., n. sp., is described from the Middle Jurassic Yanan Formation in northern Ordos Basin, northwestern China. *Parasinitsia* n. gen. exhibits most similarities with *Sinitsia*, but distinguished from all other campterophlebiid damsel-dragonflies in having MP with fifteen rows of cells between it and the posterior wing margin, two or three rows of cells between RA and RP1 distal of the pterostigma. *Sinitsia* is only recorded from the Upper Jurassic in Translaikalia. The present discovery suggests

the existence of complex relationships between the Middle and Upper Jurassic faunas of Campterophebiidae during the Jurassic, which are still unresolved. The new discovery not only adds to the diversity of Campterophlebiidae, but also provides new information useful to understand the evolution of this family during early Middle Jurassic, a period earlier than the Daohugou Biota that yields abundant Campterophlebiidae.

Acknowledgements
We offer our sincere gratitude to Mr Huang Junwei for his help during the fieldtrip investigation, the two anonymous reviewers, the associated editor, Annalisa Ferretti, and the editor-in-chief, Michel Laurin, for the very useful comments on the earlier version of the manuscript. This research was supported by the Chinese Academy of Sciences (E221020002), and National Natural Science Foundation of China (42125201, 41688103).

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Submitted on 8 April 2022;
accepted on 20 September 2022;
published on 11 July 2023.