First Chinese Cymatophlebiidae from the Middle Jurassic of Inner Mongolia (Odonata: Anisoptera: Aeshnoptera)

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Abstract

Sinacymatophlebia mongolica n. gen., n. sp., the oldest and first Chinese record of the Mesozoic aeshnopteran dragonfly family Cymatophlebiidae, is described from the Middle Jurassic Jiulongshan Formation of Inner Mongolia.

Keywords: Odonata, Aeshnoptera, Cymatophlebiidae, n. gen., n. sp., Daohugou fauna, Jiulongshan Formation, China.

Zusammenfassung

Sinacymatophlebia mongolica n. gen., n. sp. wird aus dem Mittel-Jura (Jiulongshan-Formation) in der Inneren Mongolei beschrieben. Es ist dies der bisher stratigraphisch älteste Nachweis der mesozoischen Aeshnoptera-Familie Cymatophlebiidae und gleichzeitig deren erster Nachweis in China.

1. Introduction

The clade Aeshnoptera ('aeshnid' dragonflies sensu lato) was very diverse during the Late Jurassic and the Early Cretaceous, with numerous families now extinct (Bechly et al. 2001). Among these fossils, the Late Jurassic family Cymatophlebiidae is one of the best represented and diverse, but until now it was known only from European outcrops, except for a species described long ago from Mongolia but of uncertain position (Cockerell 1924). This situation is rather surprising when compared to that of the contemporaneous aeshnopteran family Liupanshaniidae which was distributed in Europe, South America, Siberia and China (Bechly et al. 2001; Lin et al. 2002).

The present discovery of two fossil specimens attributable to the Cymatophlebiidae in the Middle Jurassic of China extends the distribution of this family in space and time. Both are housed in the collection of Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China.

The volcanic deposits of the Middle Jurassic Jiulongshan Formation near the Daohugou Village, Wuhua Township, Ningcheng County, Inner Mongolia, North-east China have yielded very rich exceptional fossils such as plants, invertebrates (e. g. insects, conchostracans, anostracans, spiders, harvestman), and vertebrates (e. g. salamanders, pterosaurs, mammaliaforms) (Huang et al. 2006). The inanimate rather small conchostracan carapaces preserved in normal bedding planes are the typical character of these rocks. The most common insects from Daohugou are nymphs of mayflies and aquatic bugs. This palaeoentomofauna is very diverse. Hitherto, more than 20 insect orders have been distinguished from our collections (more than 40,000 specimens).

In the description below we follow the wing venation nomenclature of Riek & Kukalová-Peck (1984), amended by Kukalová-Peck (1991), Nel et al. (1993) and Bechly (1996). The higher classification of fossil and extant Odonatoptera, as well as familial and generic characters followed in the present work, are based on the phylogenetic system proposed by Bechly (1996) and Bechly et al. (2001) for the Mesozoic Aeshnoptera.

Abbreviations

AA	anal vein
AP	anal posterior
Ax0, Ax1, Ax2	primary antenodal cross-veins
CuAa	distal branch of cubitus anterior
CuAb	proximal branch of cubitus anterior
IRi	intercalary radial veins
MAa	distal 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
tp	trigonal planate

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2. Systematic palaeontology

Order Odonata Fabricius, 1793
Clade Aeshnoptera Bechly, 1996
Family Cymatophlebiidae Handlirsch, 1906

Genus *Sinacymatophlebia* n. gen.

Typus generis: *Sinacymatophlebia mongolica* n. sp.
Derivatio nominis: Named after Sinica, Latin name for China, and *Cymatophlebia*.

Diagnosis. – RP1 and RP2 basally parallel up to pterostigma but with two rows of cells between them; IR1 short; RP2 with a strong curve; IR2 weakly curved; RP3/4 and MA with a strong double curve; two oblique cross-veins 'O'; no Mspl; no trigonal planate vein; a clear Rspl but with two rows of cells between it and IR2; pterostigma short, covering two cells; pterostigmal brace oblique and aligned with basal side of pterostigma; hypertriangle free or crossed by one vein; hindwing discoidal triangle divided into two to four cells, more elongate than that of forewing; subdiscoidal triangle two-celled; no accessory cubito-anal cross-veins in submedian space between CuP-crossing and PsA; PsA simple and weakly curved; anal loop small, four-celled, posteriorly closed; no specialised secondary male genital structures of the third abdominal segment.

Sinacymatophlebia mongolica n. sp.
Figs. 1–6

Holotype: Print and counterprint of a nearly complete male hindwing with only postero-distal margin missing, and part of a fore wing and trunk with the four basal abdominal segments (NIGP 148312) (Figs. 1–3).
Paratype: A thorax with three abdominal segments and two hindwings and a forewing base attached (NIGP 148313) (Figs. 4–6).
Derivatio nominis: Named after Mongolia.
Stratum typicum: Middle Jurassic, Jiulongshan Formation (ca. 165 Ma).
Locus typicus: Near the Daohugou Village, Wuhua Township, Ningcheng County, Chifeng City, Inner Mongolia, north-east China.

Diagnosis. – As for the genus.

Description. – Wings hyaline; hind wing 43.4 mm long (NIGP 148312), 13.8 mm wide (NIGP 148312), 15.6 mm wide (NIGP 148313); distance from base to arculus 4.8 mm (NIGP 148312), 5.3 mm (NIGP 148313); from arculus to nodus 13.6 mm (NIGP 148312), 14.1 mm (NIGP 148313); from arculus to base of RP3/4 9.1 mm (NIGP 148312), 8.9 mm (NIGP 148313); no secondary antenodal cross-vein basal of Ax1, four antenodal cross-veins of first row and two of second row between Ax1 and Ax2 (NIGP 148312), six of first row and seven of second row distal of Ax2 (NIGP 148312); distance from wing base to Ax1 4.1 mm (NIGP 148312), between Ax1 and Ax2 5.0 mm (NIGP 148312); Ax2 just basal of apex of discoidal triangle; RP and MA strongly separated in arculus; hypertriangle 5.0 mm long (NIGP 148312), 5.5 mm (NIGP 148313), free; discoidal triangle 0.9 mm distal of arculus (NIGP 148312), 1.1 mm (NIGP 148313), divided into two smaller cells in NIGP 148312 but four in NIGP 148313, elongate and rather narrow, with basal side 2.2 mm long, anterior side 4.5 mm long, and MAb 4.3 mm long (NIGP 148312); no angle in MAb and no convex trigonal planate; postdiscoidal area with three rows of cells; no Mspl; no pseudo-ScP distal of nodus; basal part of area between RA and RP with three to five cross-veins basal of RP3/4, and three distal of base of RP3/4 and basal of subnodus; area between RP and MA with six cross-veins basal of RP3/4; two oblique veins 'O', first two cells distal of base of RP2 and second three cells distally; RP2 strongly curved just basal of pterostigma; IR2 with a weak but distinct curve; two rows of cells between RP2 and IR2; area between RP1 and RP2 basal of pterostigma narrow but with two rows of

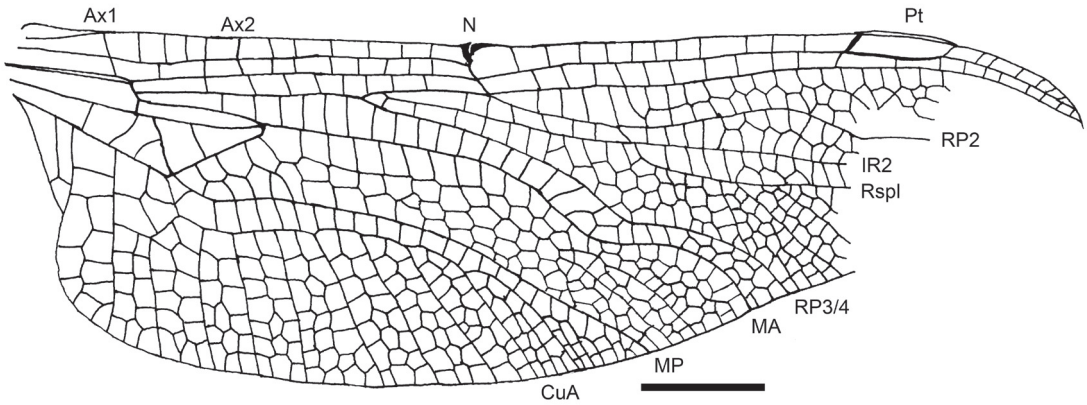

Fig. 1. *Sinacymatophlebia mongolica* n. gen., n. sp., holotype NIGP 148312, reconstruction of hindwing venation. – Scale bar = 5 mm.

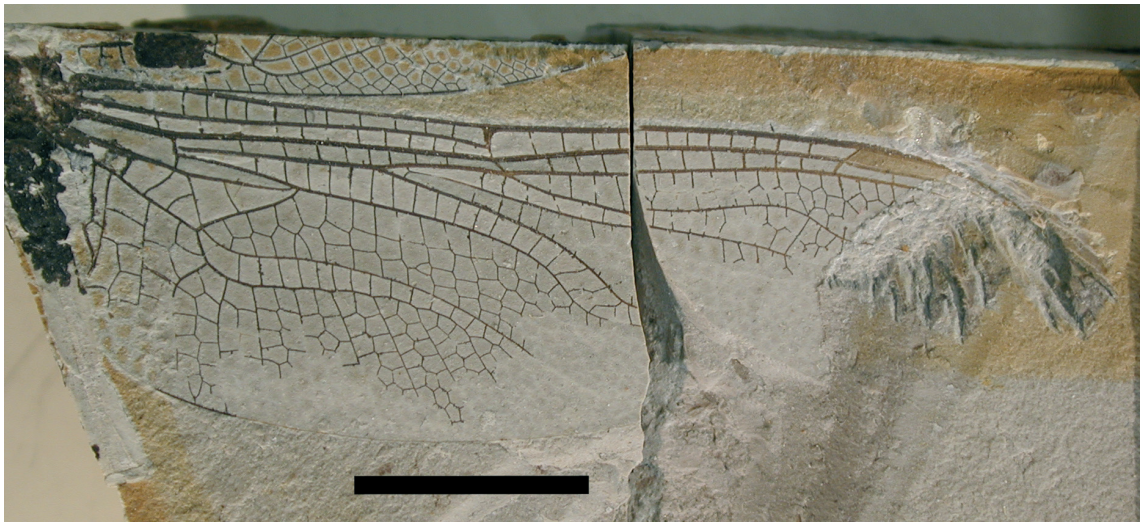

Fig. 2. *Sinacymatophlebia mongolica* n. gen., n. sp., holotype NIGP 148312, photograph of print. – Scale bar = 10 mm.

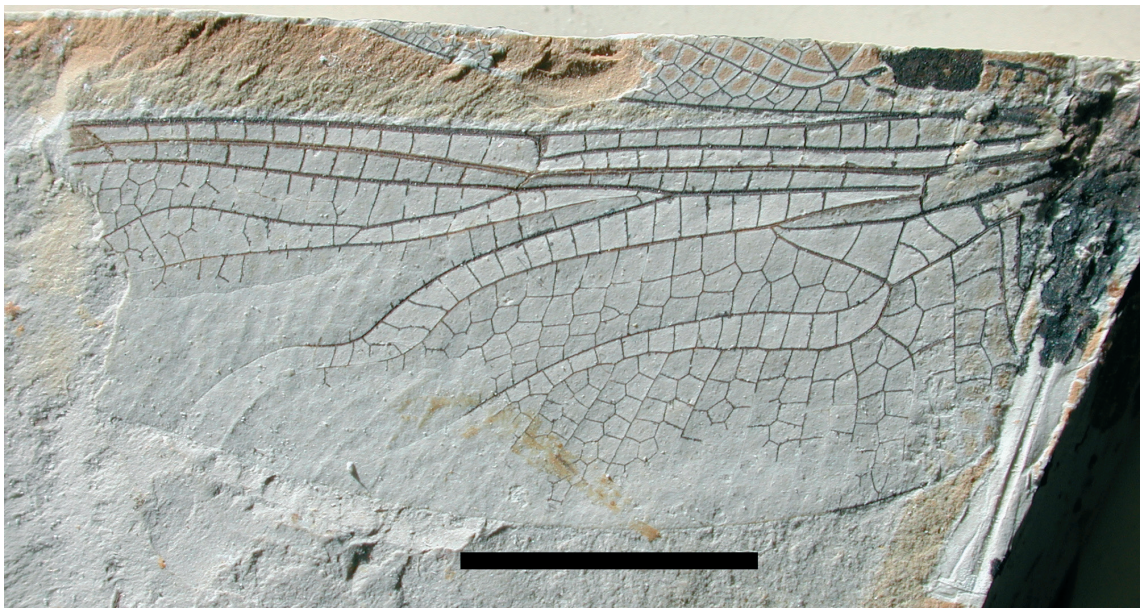

Fig. 3. *Sinacymatophlebia mongolica* n. gen., n. sp., holotype NIGP 148312, photograph of counterprint. – Scale bar = 10 mm.

cells; IR1 short; Rspl well defined with two rows of cells between it and IR2; RP3/4 and MA with a strong double curve and with space between them widened near posterior wing margin; pterostigma rather short, 4.3 mm long, 1.0 mm wide, covering two cells; pterostigmal brace oblique and aligned with basal side of pterostigma; 11 postnodal cross-veins not aligned with ten postsubnodal cross-veins; one row of cells between MP and CuAa, with a strong narrowing of area between these veins opposite base of RP3/4; median area free; submedian area crossed by CuP-crossing; subdiscoidal space crossed by one cross-vein, PsA weakly curved; posterior wing margin angular at base with a long anal triangle (male specimen); anal area broad, with two posterior branches of AA directed towards posterior wing margin, and eight rows of cells between AA and posterior wing margin; anal loop rather small, not elongate, pentagonal, posteriorly closed, divided into four cells; cubito-anal area broad, with six rows of cells between CuAa and posterior wing margin; CuAa with nine posterior branches.

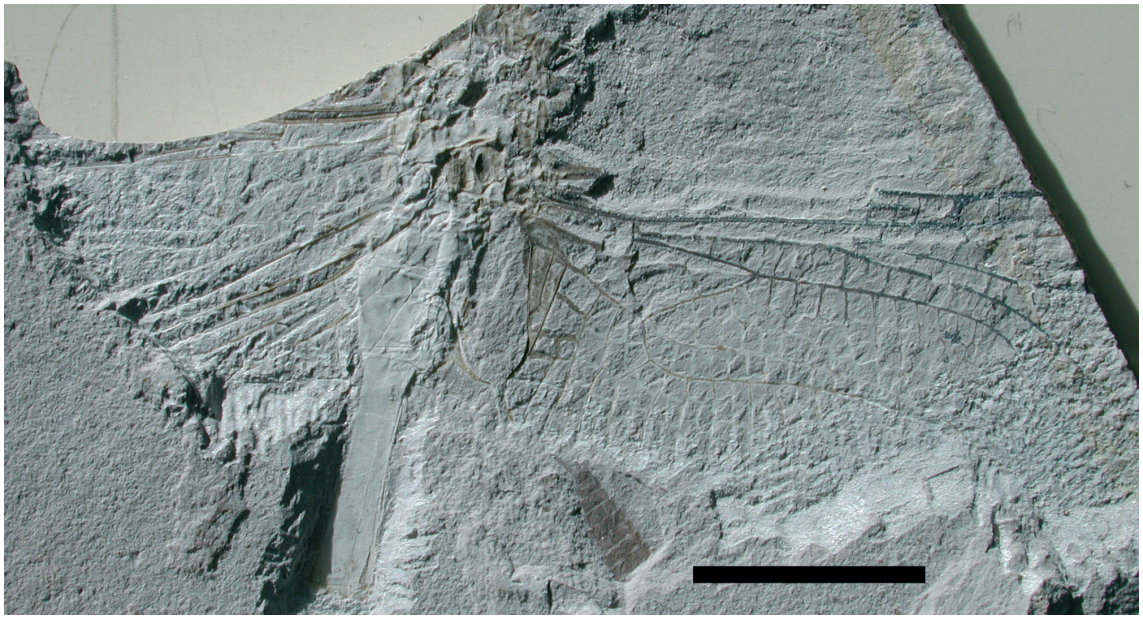

Fig. 4. *Sinacymatophlebia mongolica* n. gen., n. sp., paratype NIGP 148313, photograph of print. – Scale bar = 10 mm.

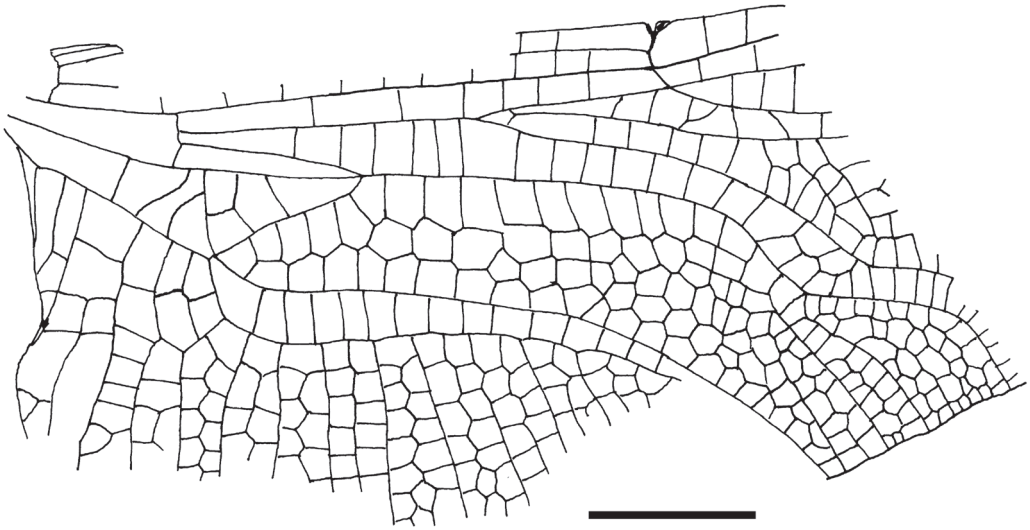

Fig. 5. *Sinacymatophlebia mongolica* n. gen., n. sp., paratype NIGP 148313, reconstruction of hindwing. – Scale bar = 5 mm.

Forewing (Fig. 6). Only the posterior part of base is preserved; specimen with an aberrant discoidal triangle with a 'secondary' triangle, divided into ten cells; hypertriangle with a cross-vein; subdiscoidal space divided into four cells; two to three rows of cells in anal area.

Male abdominal segment 3 simple, without any secondary sexual structure.

D i s c u s s i o n . – We attribute the two specimens to the same species because of their nearly identical wing venation and similar wing dimensions. This fossil taxon falls in the Aeshnoptera Bechly, 1996 for the following characters: RP1 and RP2 basally parallel up to pterostigma, thus the area between these two veins is basally distinctly narrowed; at least a weakly defined (zigzagged) Rspl present; RP3/4 and MA undulating, and in the groundplan RP3/4 and MA distally diverging.

Sinacymatophlebia n. gen. shares some characters with *Cymatophlebiella* Pritykina, 1968, an aeshnopteran of uncertain affinities, viz. pterostigma short and weakly braced; subdiscoidal triangle two-celled; two rows of cells

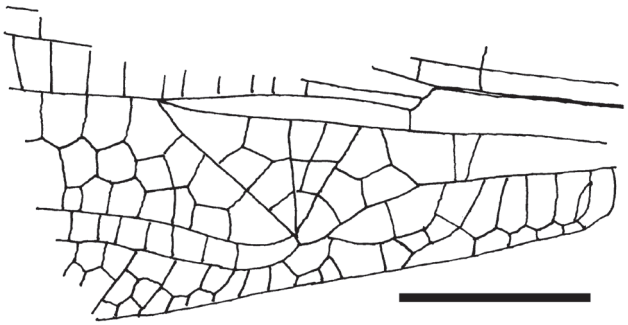

Fig. 6. *Sinacymatophlebia mongolica* n. gen., n. sp., paratype NIGP 148313, reconstruction of forewing base. – Scale bar = 5 mm.

between RP1 and RP2. Nevertheless *Sinacymatophlebia* n. gen. differs from this genus in that the anal loop is present and posteriorly closed, although small, instead of being completely reduced.

Affinities with the Mesuropetaloidea Bechly, 1996 (Mesuropetalidae Bechly, 1996 and Liupanshaniidae Bechly et al., 2001) are excluded because *Sinacymatophlebia* n. gen. lacks the apomorphies of these families: arculus shifted very close to first primary antenodal Ax1, RP3/4 and MA closely parallel up to the wing margin (Mesuropetaloidea); anal loop longitudinally elongate (Mesuropetalidae); unique shape of the very elongate and narrow hindwing discoidal triangle (Liupanshaniidae).

Sinacymatophlebia n. gen. shares with the Aeshnomorpha Bechly et al., 2001 the following synapomorphy: RP2 at least slightly undulating. It also differs from them in the free hypertriangle in the hindwing (but crossed in forewing as in Aeshnomorpha, also this structure is subject to homoplasy in the Aeshnomorpha). Within this clade, affinities with the Austropetaliida Bechly et al., 2001 are excluded due to the absence of their synapomorphies: pterostigmal brace vein not aligned with its basal side; IR1 very long; insertions of CuP-crossing and PsA on anal vein AA very close to each other; basal true lestine oblique vein reduced or completely suppressed.

Sinacymatophlebia n. gen. differs from the Progobiaeshnidae Bechly et al., 2001 in the following characters: pterostigmal brace vein oblique, not transverse; anal loop not very enlarged and divided into only four cells; only two rows of cells between IR2 and Rspl. *Sinacymatophlebia* n. gen. lacks the main synapomorphy of the Aeshnida Bechly, 1996, i. e. the presence of a more or less well defined Mspl.

Sinacymatophlebia n. gen. shares with the Paracymatophlebiidae Bechly et al., 2001 the presence of two rows of cells in the basal area between RP1 and RP2; RP3/4 and MA more strongly undulating; hypertriangles unicellular or nearly so; no accessory cubito-anal cross-veins in the submedian space between CuP-crossing and PsA; anal loop posteriorly poorly closed. But it differs from this family in the absence of the distal accessory oblique vein between RP2 and IR2, and absence of the Mspl.

Affinities with the Euaeshnida Bechly, 1996 (more advanced taxa) are excluded for the absence of Mspl, forewing discoidal triangle less elongate than that of the hindwing; distal side MAb of the discoidal triangles not bent, or angled, or sigmoidally curved. The Cretaceous family Enigmaeshnidae Nel et al., 2008 has a well developed trigonal planate, unlike *Sinacymatophlebia* n. gen. (Nel et al. 2008).

Differences of *Sinacymatophlebia* n. gen. from the Rudiaeschnidae are the pseudo-anal vein PsA of the hindwing not strongly zigzagged and not distinctly weaker than that of the forewing; and anal loop not enlarged.

Sinacymatophlebia n. gen. has one of the main synapomorphies of the Cymatophlebiidae Handlirsch, 1906, i. e. IR2 distinctly undulating and parallel to RP2. They also share the character of veins RP3/4 and MA being more strongly undulate than in other families, plus the second (more distal) accessory oblique vein between RP2 and IR2 being much more oblique and longer than the basal one. The Cymatophlebiidae also have weak to very rudimentary veins Mspl, not even discernable in some fossils, as in *Sinacymatophlebia* n. gen. But *Sinacymatophlebia* n. gen. differs from the Cymatophlebioidea (Cymatophlebiidae and Rudiaeschnidae) in its Rspl being separated by only two rows of cells from IR2 instead of more than three. Therefore we attribute *Sinacymatophlebia* n. gen. to this family.

Within this family, affinities with the Valdaeshninae Bechly et al., 2001 are excluded for the absence of a pseudo-ScP, plus RP2, RP3/4, and MA being strongly undulate. Nevertheless *Sinacymatophlebia* n. gen. differs from all Cymatophlebiinae in the complete absence of Mspl (Bechly et al. 2001; Bechly 2001). Also NIGP 148313 has no specialised secondary male genital structures of the third abdominal segment, unlike at least some *Cymatophlebia* spp. (see Bechly et al. 2001).

Among the Chinese Mesozoic Aeshnoptera described after Bechly et al. (2001), *Sinacymatophlebia* n. gen. differs from *Fuxiaeschna* Lin et al., 2004 in having a broader cubito-anal area, and the absence of the trigonal planate and Mspl (Lin et al. 2004). It differs from *Parapetala* Huang et al., 2003 in the curved MA, RP3/4 and RP2 and presence of an anal loop (Huang et al. 2003). It differs from the two gomphaeschnid genera *Falsisophoaeschna* Zhang et al., 2008 and *Sophoaeschna* Zhang et al., 2008 in the absence of Mspl (Zhang et al. 2008a). It differs from *Telmaeshna* Zhang et al., 2008 in the strongly curved MA, RP3/4 and RP2, and the very different shape of the anal loop (Zhang et al. 2008b).

The Cymatophlebiidae are known from the Late Jurassic to the Early Cretaceous of Europe, plus a dubious species ('*Cymatophlebia*' *mongolica* Cockerell, 1924 from the Early Cretaceous of Mongolia). Thus *Sinacymatophlebia mongolica* n. gen., n. sp. represents the first record of this family from China and its oldest record.

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