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# **A new damsel-dragonfly of the small family Selenothemistidae from the earliest Late Jurassic of China (Odonata: Isophlebioptera)**

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## **Abstract**

*Jurathemis incompletus* gen. et sp. nov., sixth new genus and species of the small Jurassic family Selenothemistidae, is described from the earliest Late Jurassic of China. It differs from the other representatives in the narrower hindwing cubito-anal area. The fossil discovered from the Middle-Upper Jurassic Yangshuzhuang Fm. near the Anyao Village, Jiyuan City, China. The same layer have been yielded very rich insect fossils that reveal the distribution of the famous Yanliao biota in the central-east China. The present new species is the first formally described fossil insects from this locality.

**Key words:** Odonata; Eiproctophora; Isophlebiida; Yangshuzhuang Fm.; Yanliao biota

## **Introduction**

The Mesozoic ‘anisozygopteran’ clade Isophlebiida Bechly, 1996 is quite diverse with more than 48 described genera, especially the two families Campterothlebiidae Handlirsch, 1920 and Isophlebiidae Handlirsch, 1906 in which numerous new genera and species have been recently described, mainly from China (see Fossilworks: Gateway to the Paleobiology Database at <http://fossilworks.org/>). It is not the case for the more inclusive isophlebiopteran clades Euthemistidae Pritykina, 1968, Parazygoptera Bechly, 1997, and Selenothemistidae Handlirsch, 1939, that comprises ca. 25 described genera. These last groups comprise relatively small and delicate damsel-dragonflies, compared to the Isophlebiida. Thus their lower diversity is possibly the result of a taphonomic bias. They are mainly known from Europe, Central Asia and China.

Here we describe a new genus and species belonging to the small family Selenothemistidae, from the lowest Upper Jurassic Yangshuzhuang Formation at the locality near the Anyao Village, Chengliu Township, Jiyuan City, Henan Province, China (Fig. 1). The outcrop located at the top of Yangshuzhuang Fm. and very close to the boundary of the Yangshuzhuang and Ma’ao formations. Both Yangshuzhuang and Ma’ao formations. Have been considered as the Middle Jurassic (Deng et al., 2003). In recent research, Huang (2018) indicate Yangshuzhuang Fm. correlate to Haifanggou Fm. which yielded very rich exceptional fossil including various insects (Huang, 2016) and the Ma’ao Fm. correlate to Tiaojishan Fm. in north China. Therefore, the age of Yangshuzhuang Fm. would mainly assigned with the Middle Jurassic but its upper section is the earliest Late Jurassic. The Ma’ao Fm. correspond to Oxfordian and Kimmeridgian. The fossil insects from the Yangshuzhuang Fm. were assigned within the assemblage *Samarura – Necrocercopis yananensis* (Deng et al., 2003) including the insects from the Haifanggou Fm. at Liaoning Province, the Jiulongshan Fm. at Hebei Province, the Yan’an Formation at Shaanxi Province, and the Yangshuzhuang Fm. at Henan Province. Some contents from this fossil insect assemblage are likely found from the Yangshuzhuang Fm. such

as *Yangshuzhuangia jurassica* (Deng et al., 2003) but they are never described. Thus no any valuable information on fossil insects known from this locality to date.

## **Material and methods**

The type specimen was prepared with a sharp knife under microscope. Maps and line drawings were drafted with CorelDRAW X7 graphic software. Photographs were taken with a digital camera attached to a Zeiss Discovery V20 microscope.

We follow the wing venation nomenclature of Riek and Kukalová-Peck (1984) as modified by Nel et al. (1993) and Jacquelin et al. (2018), and the Epiroctophoran classification of Bechly (1995, 1997, 2016). Wing abbreviations are as follows: Arc= arculus; Ax = primary antenodal crossvein; C = costa; CuA = cubitus anterior; CuP = cubitus posterior; d = discoidal cell; IR = intercalary radial veins; MA = median anterior; MP = median posterior; N = nodus; 'O' = oblique vein; Pt = pterostigma; RA = radius; anterior; RP = radius posterior; sd = subdiscoidal space; Sn = subnodal crossvein. All measurements are given in millimeters

## **Systematic palaeontology**

### **Order Odonata Fabricius, 1793**

### **Suborder Epiroctophora Bechly 1996**

### **Clade Isophlebioptera Bechly, 1996**

### **Family Selenothemistidae Handlirsch, 1939**

**List of species.** *Caraphlebia antarctica* Carpenter, 1969 (Antarctica), *Paraliassophlebia chengdeensis* Hong, 1982 (China), *Selenothemis liadis* Handlirsch, 1920 (Germany), *Sinothemis difficilis* Huang et al. 2018 (China), *Turanothemis nodalis* Pritykina, 1968 (Kazakhstan), *Jurathemis incompletus* gen. et sp. nov. (China). The family is recorded from the Early to Middle-Late Jurassic.

**Note.** Cowley (1942) indicated that the two genera *Dialothemis* Cowley, 1942 (*D. dubia* (Handlirsch, 1939)) and *Liadothemis* Handlirsch, 1906 could belong to the Selenothemistidae, but Bechly (2016) excluded them from this family.

**Genus *Jurathemis* gen. nov.**

**Type species.** *Jurathemis incompletus* sp. nov.

**Etymology.** Named after the Jurassic age of the fossil and the suffix –themis (ancient Greek Titaness, personification of the divine order), frequently employed for taxa in this family. Gender masculine.

**Diagnosis.** Hindwing characters only. Subdiscoidal cell enlarged and with a bulged posterior margin; a large cell basal of subdiscoidal cell in anal area; postdiscoidal space between MP and MA narrow, with only one row of cells between them; no secondary antenodal crossveins; distal side (MAb) of discoidal cell 3.6 as long as basal side); a long space between CuP and distal crossvein between AA and MP+CuA; narrow anal area with only one cell below subdiscoidal cell; RP2 arising distinctly distal of subnodus; no antefurcal crossveins in space between RP and MA basal of midfork; nodal and subnodal veinlets aligned and oblique; MA not zigzagged distal of level of nodus.

***Jurathemis incompletus* sp. nov.**

Figure 2

**Material.** Holotype NIGP169577, stored at the Nanjing Institute of Geology and Palaeontology CAS, Nanjing, China. Only holotype was found, an incomplete hindwing, without counterpart. The fossil preserved in the green-grayish mudstone.

**Etymology.** Named after the incomplete state of preservation of the type specimen.

**Diagnosis.** Wing rather small, ca. 5 mm wide.

**Age and outcrop.** The earliest Late Jurassic (early Oxfordian); uppermost of the Yangshuzhuang Fm. near the Anyao Village, Chengliu Township, Jiyuan City, Henan Province, China.

**Description.** The basal half of a hindwing, without trace of coloration, probably hyaline. Length of fragment 15.7 mm, probable length of wing ca. 21 mm, width of wing 4.8 mm; distance from base to arculus 3.5 mm, from arculus to nodus 6.2 mm; petiole short but distinct, 0.75 mm long, 1.2 mm wide; base of RP<sub>3/4</sub> (midfork) 3.4 mm from arculus and 3.0 mm from nodus, base of IR<sub>2</sub> very close to it; only the primary antenodal crossveins Ax<sub>0</sub>, Ax<sub>1</sub> and Ax<sub>2</sub> present, so secondary antenodals, distance from wing base to Ax<sub>1</sub> 2.5 mm, from Ax<sub>1</sub> to Ax<sub>2</sub> 1.3 mm; arculus between Ax<sub>1</sub> and Ax<sub>2</sub>, closer to Ax<sub>2</sub>; nodal Cr and subnodus well aligned and oblique; four postnodal crossveins preserved, not aligned with the three preserved postsubnodals; base of RP<sub>2</sub> two cells, 3.1 mm distal of subnodus; MAa not zigzagged below nodus and even more distally in its preserved part; no crossvein between arculus and midfork in space between RP and MA; only three antesubnodal crossveins; median and submedian space free, CuP opposite Ax<sub>1</sub>; AA bent distal of CuP, crossvein distally closing submedian space well distal of CuP, 0.75 mm distal; submedian cell large and broad, 1.3 mm long, 0.75 mm wide, with a bulged posterior margin; free CuA before its fusion with AA short, 0.2 mm long; postdiscoidal area narrow, 0.9 mm wide distal of discoidal cell, with one row of cells; space between MP and CuA slightly broader than postdiscoidal space; a large cell basal of subdiscoidal cell in anal area; only one row of cells between subdiscoidal cell and posterior wing margin; two rows of cells between CuA and posterior wing margin in its distal part; one row of cell between RP<sub>3/4</sub> and MAa in their preserved parts; discoidal cell large, broad, quadrangular, with distal side (MAb) 3.6 times as long as basal side, basal side 0.25 mm long, MAb 0.9 mm long; oblique vein 'O' and pterostigma not preserved.

## Discussion

Although fragmentary, this fossil can be attributed to the Isophlebioptera Bechly, 1996 because of the following characters: hindwing subdiscoidal cell enlarged and with a bulged posterior margin, correlated with a unique course of the anal vein AA ('pseudo-anal-loop') which is strongly bent towards the posterior wing margin at the CuP-crossing; postdiscoidal space between MP and MA very narrow, with only one row of cells between them; distal of Ax2 all antenodal crossveins between the costal margin and ScP are suppressed. *Jurathemis* gen. nov. shares with the Selenothemistidae Handlirsch, 1939 the distal side (MAb) of the hindwing discoidal cell twice (or more) as long as basal side (= posterior part of arculus), but it differs from all the genera currently in this family in the shape of the hindwing subdiscoidal cell that has a long space between CuP and distal crossvein between AA and MP+CuA, plus a narrow anal area with only one cell below subdiscoidal cell (Hong, 1983; Nel et al., 1993; Kelly and Nel, 2018; Huang et al., 2018).

An attribution of *Jurathemis* to the Parazygoptera Bechly, 1997 could be supported by the RP2 arising distinctly distal of subnodus, but this character is also present in the Chinese genus *Paraliassophlebia* Hong, 1983, currently attributed to the Selenothemistidae. Within the Parazygoptera, the Sphenophlebiidae Bechly, 1997 have hindwing discoidal cells narrower than in *Jurathemis*, while *Jurathemis* shares with the Euparazygoptera Bechly, 1997 the absence of antefurcal crossveins in the space between RP and MA basal of the midfork (a character also present in the Selenothemistidae). *Jurathemis* has not the main synapomorphy of the Triassolestoidea Tillyard, 1918, viz. nodal and subnodal veinlets not aligned and separated by a short kink in RA (in the subgroup Triassolestinae, the nodus and subnodus are more or less aligned but perpendicular to RA, unlike in *Jurathemis*). Note that *Sogjutella mollis* Pritykina, 1980 has MAb twice as long as basal side of discoidal cell, a MAa not zigzagged, an anal area similar to that of *Jurathemis*, but it differs from *Jurathemis* in the nodal and subnodal veinlets

not aligned, and the base of IR2 below nodus (Pritykina, 1980). In the other subclade of the Euparazygoptera, *Jurathemis* shows strong similarities with the Asiopteridae Pritykina, 1968 (especially a similar shape of cubito-anal area), but the synapomorphy of this family ‘IR2 distally zigzagged’ is unknown in *Jurathemis*. The synapomorphy ‘MA distally zigzagged’ (distal of level of nodus) is absent in *Jurathemis*. The third synapomorphy ‘hindwing discoidal cell quadrangle-like, with an oblique distal side Mab’ is present in *Jurathemis* but also in the Selenothemistidae. Furthermore, all the Asiopteridae for which the hindwing discoidal cells are known (*Asiopterum* Pritykina, 1968, *Oreopterella* Pritykina, 1968, *Oreopteron* Pritykina, 1968), have a distal side MAb less than twice as long as basal side, while it is three times as long in *Jurathemis* (Pritykina, 1968).

Similar discoidal cells are also present in the two Cenozoic zygopteran families Sieblosiidae Handlirsch, 1907, Dysagrionidae Cockerell, 1908, and in the isophlebiopteran Pseudostenolestidae Garrouste and Nel, 2015. In these three families, the subdiscoidal cell is quite narrower than in *Jurathemis* and in the Selenothemistidae, and the cubito-anal area is quite broad (Garrouste and Nel, 2015). Also the Sieblosiidae have a very particular subnodus vertical or of inverted obliquity.

## **Conclusion**

If *Jurathemis* shares some similarities with the Asiopteridae, it currently better fits in the Selenothemistidae for the shared specialized discoidal cell. It is the sixth genus currently attributed to this Jurassic family, in accordance with the earliest Late Jurassic of the type outcrop.

The new species *Jurathemis incompletus* gen. et sp. nov. is the first fossil insects described from the Yangshuzhuang Fm. We recently discovered a very diverse and rich palaeoentomofauna in this locality. Its age corresponds to the Daohugou biota, the early



assemblage of the famous Yanliao biota (Huang, 2015, 2016). Therefore, the further study of the insects of the Yangshuzhuang Fm. would be very helpful for understanding the distribution and evolution of the insects from Yanliao biota.

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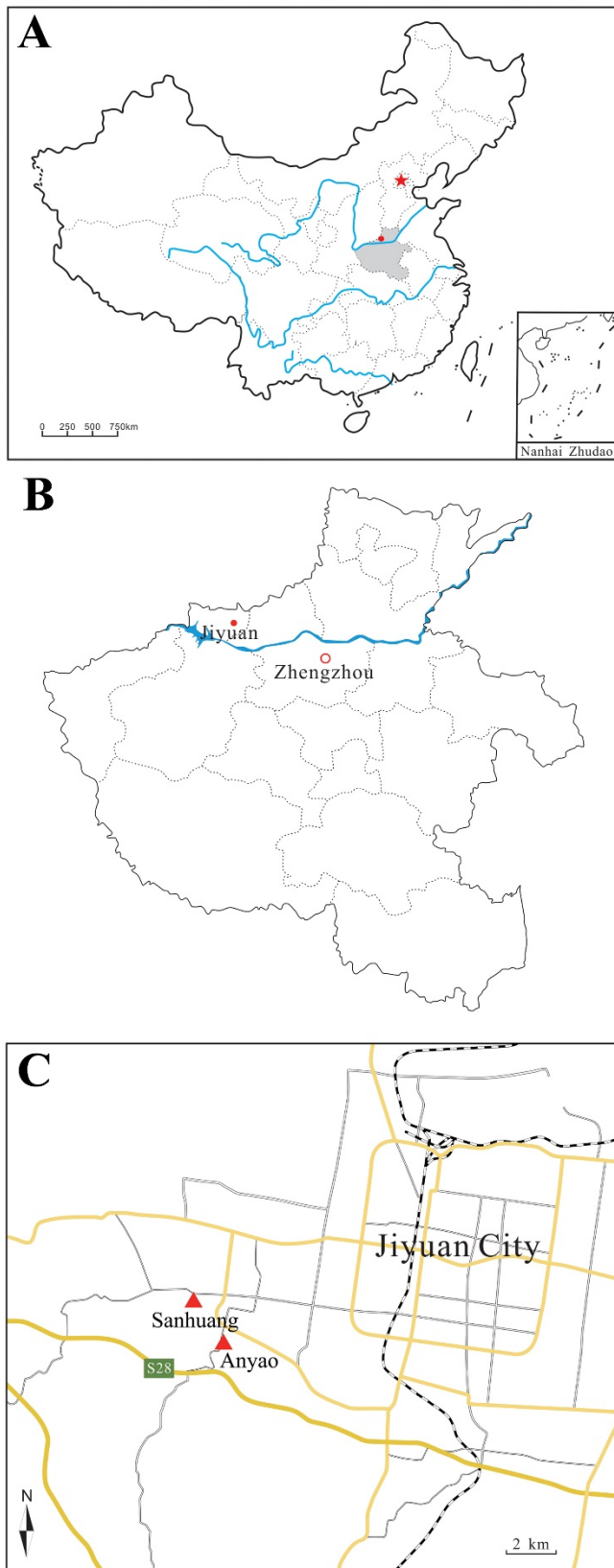
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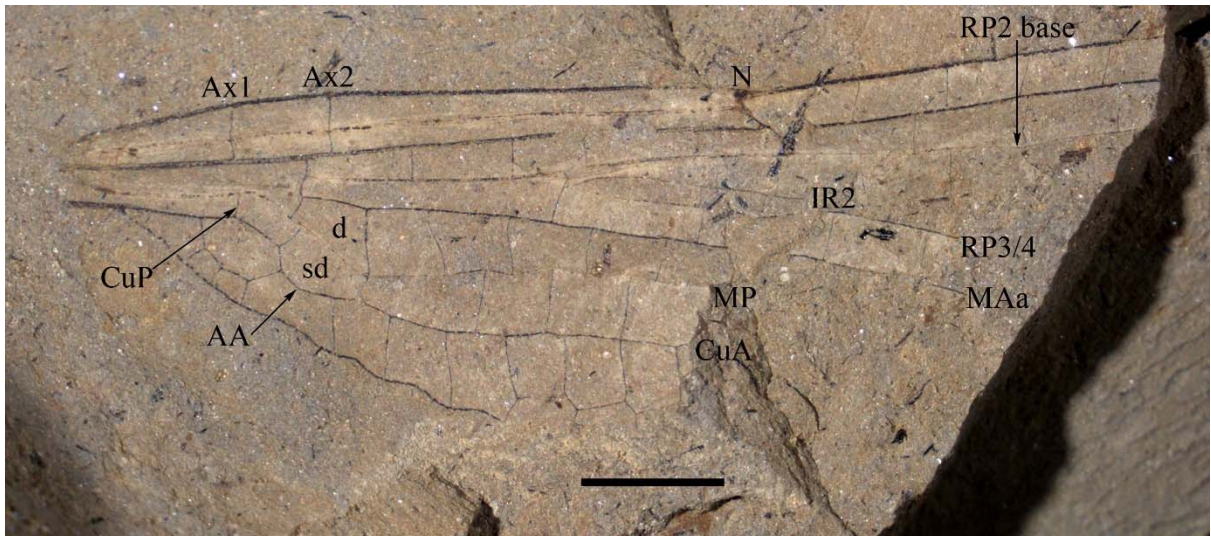
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**FIGURE 1.** The fossil locality maps of *Jurathemis incompletus* gen. et sp. nov. A, the position of fossil locality in China; B, enlargement from A, showing the location in Henan Province; C, the detailed map of the fossil locality.



**FIGURE 2.** *Jurathemis incompletus* gen. et sp. nov., holotype NIGP169577, photograph of hindwing (scale bar = 2 mm).

