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► **To cite this version:**

Stefan Pinkert, André Nel, Di-Ying Huang. A new hawker dragonfly from the Middle Jurassic of China (Odonata: Aeshnoptera). *Comptes Rendus. Palevol*, 2017, 10.1016/j.crpv.2017.01.006 . hal-01512672

HAL Id: hal-01512672

<https://hal.sorbonne-universite.fr/hal-01512672>

Submitted on 24 Apr 2017

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1 A new hawker dragonfly from the Middle Jurassic of China

2 (Odonata: Aeshnoptera)

3

4 Stefan Pinkert^a, André Nel^{b,*} & Di-ying Huang^c

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6 ^a Faculty of Biology, Department of Ecology – Animal Ecology, Philipps-Universität Marburg,

7 Karl-von-Frisch-Strasse 8, 35043 Marburg, Germany; e-mail: StefanPinkert@posteo.de

8 ^b Institut de Systématique, Évolution, Biodiversité, ISYEB - UMR 7205 – CNRS, MNHN,

9 UPMC, EPHE, Muséum national d'Histoire naturelle, Sorbonne Universités, 57 rue Cuvier,

10 CP 50, Entomologie, F-75005, Paris, France; e-mail: anel@mnhn.fr

11 ^c State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and

12 Palaeontology, Chinese Academy of Sciences, Nanjing, People's Republic of China; e-mail:

13 dyhuang@nigpas.ac.cn

14

15 *Corresponding author

16

17 **ABSTRACT**

18 The new genus and species *Linqibinia panae* of paracymatophlebiid hawker dragonfly is
19 described from the Middle Jurassic Haifanggou Formation (Inner Mongolia, China). Previously
20 only known from Karatau in Kazakhstan, the discovery of another member of this family
21 extends its range across Central Asia. It confirms that the Aeshnoptera was among the most
22 diverse odonatan clades during the Middle-Late Jurassic.

23

24 **Résumé**

25 Le nouveau genre et la nouvelle espèce *Linqibinia panae* de Aeshnoptera Paracymatophlebiidae
26 est décrit du Jurassique moyen (Haifanggou Formation, Mongolie intérieure, Chine). Cette
27 famille n'était connue que de Karatau au Kazakhstan ; cette découverte étend sa distribution au
28 travers de l'Asie centrale. Elle confirme que les Aeshnoptera étaient parmi les clades d'Odonata
29 les plus diversifiés au Jurassique moyen-supérieur.

30

31 *Keywords:* Odonata, Paracymatophlebiidae, Middle Jurassic, Haifanggou Formation,
32 Daohugou, systematics, palaeodiversity.

33

34 *Mots clés:* Odonata, Paracymatophlebiidae, Jurassique moyen, Haifanggou Formation,
35 Daohugou, systématique, paléodiversité.

36

37

38 **1. Introduction**

39 The clade Aeshnoptera was very diversified during the Late Jurassic and the Cretaceous,
40 with numerous families now extinct (Bechly et al., 2001; Nel et al., 2008). China is a diversity
41 'hot spot' for this group during the Mesozoic, with several new families and genera recently
42 described (see references in Nel and Huang, 2009, 2010; Li et al., 2011). Some of these taxa
43 from the Haifanggou Fm. in Inner Mongolia are closely related to the aeshnid fauna of the
44 Karatau outcrop (Kazakhstan). Herein we describe a new Chinese genus and species belonging
45 to a family, till now, only known from Karatau, which provides further support for the initial
46 hypothesis of a close relation between these two faunas and the high diversity of hawker
47 dragonflies during the Jurassic times.

48

49 **2. Material and method**

50 Only one specimen was examined. It is a nearly complete hindwing that preserved in the greyish
51 tuffaceous shale from the locality near the Daohugou Village. The abundantly co-occurring
52 conchostracans indicated that the specimen collected in the middle-up shale section of the
53 Daohugou beds (Huang 2015). Its geological age could be close to the Middle-Late Jurassic
54 boundary but slightly earlier than the Karatau fauna from Kazakhstan (Huang 2015).
55 The specimen was examined with a Nikon SMZ1500 dissecting microscope and illustrated
56 using a drawing tube attached to the microscope. Line drawings were made using Adobe
57 Photoshop CS6 and Inkscape graphic software. The wing venation nomenclature used in this
58 paper follows Riek & Kukalová-Peck (1984), as amended by Nel et al. (1993) and Bechly
59 (1996). We use the following standard abbreviations: AA anal vein, AP anal posterior, Ax0
60 Ax1 Ax2 primary antenodal cross-veins, CuAa distal branch of cubitus anterior, CuAb proximal
61 branch of cubitus anterior, IR1, IR2 intercalary radial veins, MAa distal branch of median
62 anterior, MAb posterior branch of median anterior, MP median posterior, N nodus, 'O' oblique
63 veins, Pt pterostigma, RA radius anterior and RP radius posterior. We follow the classification
64 of Bechly et al. (2001) to compare our fossil to the Mesozoic Aeshnoptera.

65

66 **3. Systematic Paleontology**

67 Order Odonata Fabricius, 1793

68 Clade Aeshnoptera Bechly, 1996

69 Family Paracymatophlebiidae Bechly et al., 2001

70 Genus: *Linqibinia* gen. nov.

71 **Type species.** *Linqibinia panae* sp. nov.

72 **Etymology.** Named after our friend and colleague Prof. Lin Qi-bin. Gender feminine.

73 **Diagnosis.** Hindwing characters only. Anal loop posteriorly closed; two rows of cells between
74 RP1 and RP2 well basal of pterostigma; Msp1 and Rspl present, but rudimentary, with two rows

75 of cells above them; strongly curved RP3/4 and MA; RP3/4 and MA not widely separated near
76 posterior wing margin; IR2 distinctly curved; RP2 only weakly curved; up to three rows of cells
77 between IR2 and RP2 in mid part; very short pseudo-IR1; antenodals of first and second rows
78 not well aligned; postnodals and postsubnodals not well aligned either; two oblique veins;
79 subdiscoidal space two-celled; only one Bqs vein.

80

81 *Linqibinia panae* sp. nov. (Figs. 1-2)

82 **Etymology.** Named after the first author's daughter, Lotta Pan Pinkert.

83 **Material.** Holotype NIGP165027, stored at the Nanjing Institute of Geology and
84 Palaeontology.

85 **Diagnosis.** As for the genus.

86 **Type stratum and locality.** Hiafanggou Formation, Middle Jurassic; near Daohugou Village,
87 Wuhua Township, Ningcheng County, Inner Mongolia, China.

88 **Description.** Hindwing hyaline, pterostigma dark brown; wing 46.0 mm long, 15.0 mm wide;
89 distance between base and arculus 18.7 mm, between arculus and nodus 26.0 mm; distance
90 from nodus to mid of pterostigma 17.8 mm; distance between Ax1 and Ax2 6.0 mm, between
91 Ax1 and wing base 3.5 mm; eight secondary antenodal cross-veins of first row, not aligned with
92 those of second row between ScP and RA, three of them being between Ax1 and Ax2; Ax2 lies
93 opposite distal angle of discoidal triangle; arculus straight; pterostigma elongated, 4.0 mm long
94 and 0.8 mm wide, covering two and a half cells, not basally recessed; pterostigmal brace slightly
95 oblique and aligned with basal side of pterostigma; 12 postnodal cross-veins between nodus
96 and pterostigma not well-aligned with postsubnodal cross-veins; median space free of cross-
97 veins; submedian space only traversed by CuP-crossing; PsA straight; hypertriangle free;
98 discoidal triangle elongated, divided into three cells; MAb straight, about 4.5 mm long; a well-
99 defined two-celled subdiscoidal triangle; bases of IR2 and of RP3/4 in distal third of space

100 between arculus and nodus; only 4-5 cross-vein between RP and IR2 basal of first oblique vein
101 'O₁', only one Bqs basal of base of RP2; two oblique veins 'O₁' and 'O₂', 3.7 mm and 6.7 mm
102 distal of subnodus, 'O₂' much more oblique than 'O₁'; pseudo-IR1 very short, 2.8 mm distal of
103 pterostigma; area between RP1 and RP2 with two rows of cells between them in basal part;
104 base of RP2 just slightly distal to subnodus, RP2 smoothly undulate at its mid part; IR2 more
105 undulate, area between it and RP2 widened with three rows of cells at their undulate parts; IR2
106 and RP2 basally parallel, with five rows near posterior wing margin; a not very well-developed
107 and zigzagged Rspl with two rows of cells between it and IR2; no strongly convex oblique and
108 undulating secondary vein anastomosing between IR2 and RP3/4 directly basal of origin of
109 Rspl; RP3/4 and MA parallel and strongly undulate, with one row of cells between them basally
110 and two rows near posterior wing margin; MA and MP more or less parallel in their basal
111 halves, postdiscoidal area weakly widened at level of nodus; a rudimentary Mspl with two rows
112 of cells between it and MA; area between MP and CuA with only one row of cells basally and
113 distally divergent; CuAa with seven well-defined and parallel posterior branches; CuAb
114 directed towards posterior wing margin, anal loop posteriorly completely opened, gaff (basal
115 part of CuA) very short; four posterior branches of AA between AP and CuAb; no anal angle
116 and no anal triangle (female specimen); a long and broad, strongly sclerotized darkened
117 membranule.

118

119 **4. Discussion**

120 This fossil shares several characters with the genus *Paracymatophlebia*: anal loop
121 rudimentary (even if it is posteriorly closed in *Paracymatophlebia splendida*); two rows of cells
122 between RP1 and RP2 well basal of pterostigma; Mspl and Rspl present, even if they are rather
123 rudimentary (especially for Mspl that is zigzagged), with two rows of cells above them; strongly
124 curved RP3/4 and MA, IR2 distinctly curved while RP2 is only weakly curved; up to three rows

125 of cells between IR2 and RP2 in mid part; same shape of discoidal triangle and subtriangle;
126 very short pseudo-IR1; antenodals of first and second rows not well-aligned; postnodals and
127 postsubnodals not well-aligned too. Differences are very few, viz. the anal cell is closed in *P.*
128 *splendida*, whereas it is posteriorly opened in our fossil (plesiomorphy); our fossil has two
129 oblique veins (plesiomorphy), whereas *P. splendida* has only one, subdiscoidal space is two-
130 celled in our fossil, whereas it is unicellular in *P. splendida*, only one Bqs vein, whereas there
131 are four in *P. splendida*.

132 The aeshnopteran genus *Sinocymatophlebiella* (Li et al., 2011), also from Daohugou,
133 shows high similarities with our fossil, in the shape of the veins MAa, RP3/4, RP2, pseudo-
134 IR1, presence of two oblique veins, only one Bqs vein, opened anal cell (Li et al., 2011).
135 However *Sinocymatophlebiella* differs from our fossil in the absence of Mspl, more
136 rudimentary Rspl, with one row of cells between it and IR2, only one row of cells between RP2
137 and IR2 in their mid-parts, RP3/4 and MA more widely separated near posterior wing margin,
138 and one row of cells between RP2 and RP1 basal of pterostigma. *Sinocymatophlebiella* is an
139 aeshnopteran of uncertain affinities that could be related to *Paracymatophlebia*, but also to
140 *Cymatophlebiella* Pritykina, 1968 (Pritykina, 1968; Bechly et al., 2001).

141 Similarities with *Cymatophlebiella* are: opened anal cell, two rows of cells between RP2
142 and RP1 basal of pterostigma, but it differs from it in the strongly curved RP3/4 and MAa, with
143 only one row of cells in between, a rudimentary but present Mspl, two of cells between IR2 and
144 RP2 basal of pterostigma level, only one Bqs vein instead of two in *Cymatophlebiella*.

145 The hindwing venation of our fossil is also similar to that of the Daohugou
146 cymatophlebiid genus *Sinacymatophlebia* (Nel and Huang, 2009), which shows some
147 similarities with our fossil especially in the strongly curved RP3/4 and MAa. They differ in the
148 presence of a strong widening of the area between these veins, and the absence of Mspl in the
149 latter (Nel and Huang, 2009).

150 The diagnosis for the Paracymatophlebiidae (Bechly et al., 2001) is based on the
151 following characters: (1) two rows of cells in the basal area between RP1 and RP2, (2) the distal
152 second oblique vein 'O' between RP2 and IR2 is secondarily absent, (3) RP3/4 and MA more
153 strongly undulated, (4) hypertriangles free (reversal), (5) secondarily no accessory cubito-anal
154 cross-veins in the submedian space between CuP-crossing and PsA, (6) anal loop posteriorly
155 weakly closed.

156 Characters (4), (5), and (6) are present in our fossil, in *Paracymatophlebia*,
157 *Sinomatophlebiella*, and *Cymatophlebiella*, but character (3) is only present in our fossil, in
158 *Paracymatophlebia*, and *Sinomatophlebiella*, while character (1) is present in our fossil, in
159 *Paracymatophlebia*, and *Cymatophlebiella*. Lastly character (2) is only present in
160 *Paracymatophlebia*. It seems that these taxa could belong to the same clade because the
161 distribution of these characters among these taxa is conflictual. The lack of information on the
162 body and forewing characters for many of them, however, forbids us to group them together.
163 Nevertheless, the presence of a Mspl vein constitutes a further synapomorphy of our fossil with
164 *Paracymatophlebia*, among these taxa. Thus we consider that our fossil is more closely related
165 to *Paracymatophlebia* than to *Sinomatophlebiella* and *Cymatophlebiella*.

166 There is a further difficulty in the relative position of our fossil as compared with
167 *Paracymatophlebia splendida*, because the differences that can be found between the two
168 justify the separations between *Paracymatophlebia*, *Sinomatophlebiella*, and
169 *Cymatophlebiella*. Therefore, we prefer to consider that it belongs to a new genus *Linqibinia*.

170 *Paracymatophlebia* and *Cymatophlebiella* are known from the Karatau outcrop
171 (Oxfordian Kazakhstan), while *Sinomatophlebiella* and *Linqibinia* come from Daohugou
172 (Callovian, Inner Mongolia, China). The new taxon provides further support for the ecological
173 and biological similarities between these two outcrops, already recorded for other insect taxa
174 (cf. Khramov et al., 2016).

175 *Linqibinia* shows more plesiomorphic characters in its venation than
176 *Paracymatophlebia*, which would fit in with the slightly older age for the Hiafanggou
177 Formation than for the Karatau Formation.

178

179 **Acknowledgements**

180 We sincerely thank two anonymous reviewers for the useful comments on the first version of
181 the paper. This work was supported by the Strategic Priority Research Program of the Chinese
182 Academy of Sciences (XDB18030501), the Ministry of Science and Technology
183 (2016YFC0600406), and the National Natural Science Foundation of China (41672011). This
184 study is a contribution to UNESCO-IUGS IGCP Project 632.

185

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221

222 **Fig. 1.** *Linqibinia panae* gen. et sp. nov., holotype NIGP165027, photograph of hindwing (scale
223 represents 2 cm).

224 **Fig. 2.** *Linqibinia panae* gen. et sp. nov., holotype NIGP165027, line drawing of hindwing
225 (scale represents 5 mm).

226



