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New Genus and Species of Fossil Dragonflies (Insecta: Odonata) from the Yixian Formation of Northeastern China

ZHANG Binglan[1], REN Dong[2,*], ZHOU Changqing[1] and PANG Hong[1]
1 *State Key Laboratory of Biocontrol and Institute of Entomology, Sun Yat-Sen University, Guangzhou, Guangdong 510275*
2 *College of Life Sciences, Capital Normal University, Beijing 100037*

Abstract: Two well-preserved fossil dragonflies from the Late Mesozoic Yixian Formation, Liaoning Province, China are described and assigned to a new genus, *Sopholibellula* gen. nov. in Araripelibellulidae Bechly, 1996, closely related to the type genus *Araripelibellula*. This new genus differs from *Araripelibellula* in the following characters: origins of RP and MA distinctly separated at arculus in both pairs of wings; anal loop wider and shorter, with Y-shaped veins inside; MA and IR2 not zigzag; several small intercalary veins present in the postdiscoidal area of hindwing; cells smaller and much more dense, especially in the apex and hind margin; bigger in size. Structures, including head, abdomen and parts of legs, were first described in details of this family.

Key words: Odonata, Anisoptera, Araripelibellulidae, new genus, fossil, Late Jurassic, Early Cretaceous, China

1 Introduction

Araripelibellulidae Bechly, 1996, an extinct fossil family, is comprised of five genera and five species (Bechly, 1996, 2002): *Araripelibellula martinesnetoi* Nel et Paicheler, 1994, *Mesocordulia boreala* Ren et Guo, 1996, *Cretaneophya strevensi* Jarzembowski et Nel, 1996, *Condalia woottoni* Whalley et Jarzembowski, 1985 and *Cratocordulia borschukewitzi* Bechly, 1998. Among them, the former three were assigned to Corduliidae originally, the fourth was first included in Libellulidae, and the position of *Cratocordulia borschukewitzi* was somewhat dubious due to five derived similarities with extant *Eurypalpida* Bechly 1996 (Bechly, 1998). Up to the present, this family has been described based on specimens from Spain, England, Brazil and China (Whalley and Jarzembowski, 1985; Nel and Paicheler, 1994; Jarzembowski and Nel, 1996; Ren and Guo, 1996; Bechly, 1998, 2002). Two new species of this fossil family from the Yixian Formation of northeastern China are described herein.

The age of the Yixian Formation was proved to be contentious. The viewpoint about the Yixian fossil beds belonging to the Early Cretaceous was recently most accepted (Xu et al., 2003; Ji et al., 2004; Ji and Ji, 2004; Xu and Wang, 2004; Lü and Ji, 2005; You and Xu, 2005). Wang et al. (2005) summarized and analyzed different reports about the age of the Yixian Formation ascribed by abundant fossil data from this locality, including birds, dinosaurs, insects, plants (including fossilized wood and sporopollens), mammalian, ostracodes and fishes, compared the Yixian biota with the Solnhofen biota in Germany, the Purbeck biota in England, Late Jurassic Teri-type and Ryoseki-type floras in Japan, and related it to the Middle Jurassic Yorkshire flora and the Great Estuarine conchostracans fauna, and finally considered that the synthetic age of the Yixian Stage may be determined as Late Tithonian to the Berriasian. We accept this opinion and regard the lower part of the Yixian Formation as the transition from Late Jurassic to Early Cretaceous.

The wing venation nomenclature used in this paper is based on the interpretation of Riek (1976) and Riek and Kukalová-Peck (1984), as amended by Kukalová-Peck (1991), Nel et al. (1993), Bechly (1996), and Bechly et al., (2001). Structures nomenclature (except wing) is based on the work of Asahina (1954) and Zhao (1990). The higher classification of fossil and extant Odonatoptera is based on the phylogenetic system of Bechly (1996, 2002). Figures were prepared with the aid of a camera lucida attached to a LEICA MI12.5 dissecting microscope and software Adobe Illustrator 10.

2 Systematic Paleontology

Odonata Fabricius, 1793
Anisoptera Selys in Selys et Hagen, 1854
Clade Euanisoptera Bechly, 1996

* Corresponding author. E-mail: rendong@mail.cnu.edu.cn.

Exophytica Bechly, 1996
Cavilabiata Bechly, 1996
Cristotibiata Bechly, 1997
Brachystigmata Bechly, 1996
Paneurypalpida Bechly, 1996
Araripelibellulidae Bechly, 1996
Sopholibellula gen. nov.

Etymology: From Greek "sopho" (clever) and the genus *libellula*. The gender is feminine.

Type species: *Sopholibellula eleganta* sp. nov.

Diagnosis: This new genus is rather similar to *Araripelibellula* Nel et Paicheler, 1994, but differs from the latter in the following characters: origins of RP and MA distinctly separated at the arculus in both pairs of wings; anal loop wider and shorter, with Y-shaped veins inside; MA and IR2 not zigzag; several small intercalary veins present in the postdiscoidal area of hindwing; cells smaller and much more dense, especially in the apex and hind margin; bigger in size.

Sopholibellula eleganta sp. nov. (Figs. 1, 3–6)

Etymology: After the Latin "elegans" = elegance.

Holotype: Specimen No. CNU-OD-LB2004002-1, part, No. CNU-OD-LB2004002-2, counterpart, male; specimen deposited in the College of Life Sciences, Capital Normal University, Beijing, China.

Type locality and horizon: Yixian Formation, Late Jurassic to Early Cretaceous, near Chaomidian Village, Beipiao City, Liaoning Province, China.

Diagnosis: Male hindwings with anal triangle only divided into two cells by a longitudinal crossvein; no secondary antenodal crossveins between Ax1 and Ax2; Ax2 of forewing at the station close to the distal side of discoidal triangle; long "cordulegastrid gap" (sensu Bechly, 1996) and "libellulid gap" (sensu Bechly, 1996) in both pairs of wings; pterostigmal brace veins is strictly aligned with the basal side of the pterostigma; origins of RP and MA distinctly separated at the arculus in all wings; anal loop four-celled, without midrib; costal side of both hypertriangle and discoidal triangle distinctly curved; two rows of cells present in the postdiscoidal area of the forewings; arculus more straight in the forewings; PsA suppressed in the hindwing, thus subtriangle absent.

Description: A very well-preserved male dragonfly with all four wings outspread. Head, thorax, abdomen and parts of legs are preserved. Only metathoracic legs and the apex of the left hindwing are missing. All wings were hyaline, without marking.

Forewing: Length 23.9 mm; width at nodus 6.1 mm; Ax1 and Ax2 aligned and stronger than the secondary antenodal crossveins; no secondary antenodal crossveins between Ax1 and Ax2; Ax2 at the station close to the distal side of discoidal triangle; distal of Ax2, there are three secondary antenodal crossveins between the costal margin (C) and ScP, not strictly aligned with the two corresponding antenodals crossveins between ScP and RA; only one antesubnodal crossveins in the position about 1/3 distance from the arculus, thus a long "cordulegastrid gap" present; four postnodal crossveins, non-aligned with the two corresponding postsubnodal crossveins; distinct " Libellulid gap" present; the pterostigma is 1.6 mm long and max. 0.6 mm wide, covers one and a half cells, and distinctly braced by an oblique crossvein that is aligned with its basal side; costal margin and RA thickened along the pterostigma; arculus is totally straight; origins of RP and MA (sectors of arculus) are distinctly separated at the arculus; median space free; CuP-crossing (=anal crossing sensu Tillyard and Fraser, 1940) well-defined; hypertriangle free and its costal side (basal of MA) is distinctly curved; discoidal triangle free, wide and nearly equilateral; MAb is distinctly angled; a very well-defined pseudo-anal vein PsA (=AA0, sensu Nel and Martínez-Delclòs, 1993) delimits a unicellular subdiscoidal triangle; the hind margin of the subdiscoidal triangle angled; postdiscoidal area narrow, distally even more narrow than basally (width near discoidal triangle 1.8 mm, min. distal width 1.0 mm); Mspl absent and no other intercalary veins in the postdiscoidal area; well-defined straight pseudo-IR1 originates on RP1 beneath the middle of pterostigma with two or three rows of cells between it and RP1 and two or four rows of cells between it and RP2; RP2 aligned with subnodus; only one lestine oblique vein "O" between RP2 and IR2; no bridge crossveins (Bqs); the area between RP2 and IR2 is very narrow at the oblique vein "O", but distinctly widened distally; Rspl absent; RP3/4 and MA are somewhat undulating, parallelled with only one row of cells between them, except at the hind margin (four cells).

Hindwing: Length 22.8 mm; width at nodus 7.7 mm; Ax1 and Ax2 aligned and stronger than the secondary antenodal crossveins; no secondary antenodal crossveins between Ax1 and Ax2; distal of Ax2, there is only one secondary antenodal crossvein; all antenodal crossveins aligned; none (left wing) or one (right wing) antesubnodal crossvein in the middle of the antesubnodal area and a long "cordulegastrid gap" present; four postnodal crossveins, not strictly aligned with the three corresponding postsubnodal crossveins; distinct "libellulid gap"; the perostigma is 2.2 mm long and max. 0.6 mm wide, covers a long cell, and braced by an oblique crossvein that is aligned with its basal side; costal margin and RA thickened along the pterostigma; arculus not straight like that of the forewing; origins of RP and MA are distinctly separated at

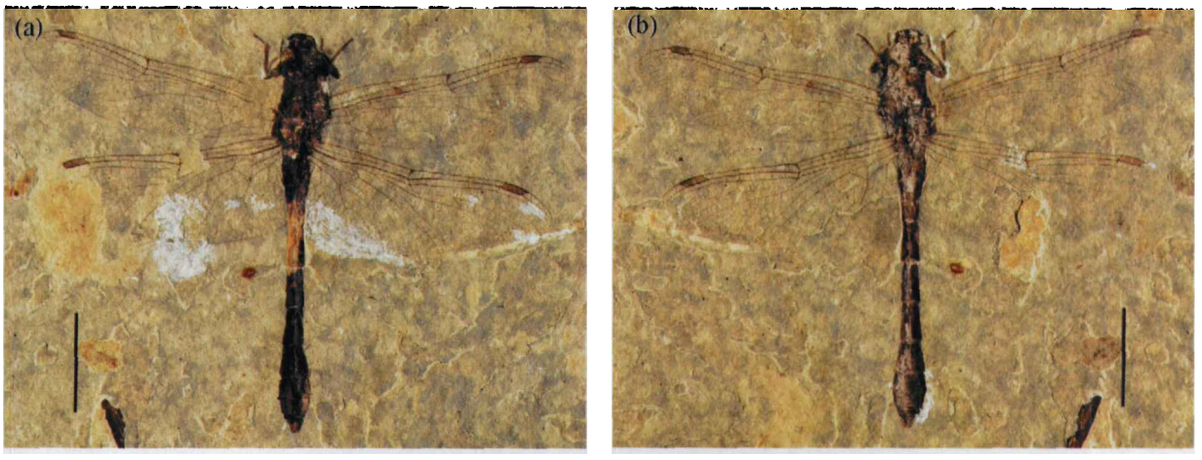

Fig. 1. *Sopholibellula eleganta* gen. et sp. nov., photographs of holotype specimen.
(a) part (CNU-OD-LB2004002-1); (b) counterpart (CNU-OD-LB2004002-2). Scale bar represents 10 mm.

Fig. 2. *Sopholibellula amoena* sp. nov., photographs of holotype specimen.
(a) part (CNU-OD-LB2004003-1); (b) counterpart (CNU-OD-LB2004003-2). Scale bar represents 10 mm.

the arculus; median space free; submedian space only traversed by the CuP-crossing (in left wing) or divided by an accessory cubito-anal crossvein between CuP-crossing and the basal side of the discoidal triangle (in right wing); hypertriangle distinctly shorter than that in the forewing, free and its costal side is strongly curved; discoidal triangle free, nearly equilateral, the costal side of the discoidal triangle is somewhat curved; MAb is straight; pseudo-anal vein PsA is lacking (completely suppressed), thus there is no subdiscoidal triangle; postdiscoidal area distally strongly widened (width near discoidal triangle 1.39 mm, width at hind margin 5.2 mm), with only one row of cells in the basal part and more than ten small cells along the posterior wing margin; Mspl absent, but one intercalary vein present only two (right wing) or three (left wing) cells distal of the MAb (distal side of discoidal triangle) and several small intercalary veins in the distal part of the postdiscoidal area; RP1 and RP2 basally relatively parallel with only one row of cells between them up to the 2/3 distance from nodus to pterostigma; well-defined straight pseudo-IR1 originates on RP1 beneath the middle of pterostigma with two or four rows of cells between it and RP1 and two or three rows of cells between it and RP2; RP2 aligned with subnodus; only one lestine oblique vein "O" between RP2 and IR2; no bridge crossveins; RP2 and IR2 with a single row of cells in-between up to the level of the distal of pterostigma and about two rows of cells distally; area between IR2 and RP3/4 distally distinctly expanded with several unconspicuous intercalary veins present and nineteen small cells along the hind margin; Rspl absent; RP3/4 and MA relatively straighter than that of the forewing and parallel with only one row of cells in-between, except at the hind margin (two cells); subdiscoidal veinlet (sdv) strongly reduced; gaff very long and somewhat curved; CuA with only a single dichotomic branching into CuAa and CuAb; CuAa and CuAb strongly zigzagged; anal loop well-defined, divided into four cells by Y-shaped crossveins; MP is strongly curved and thus shortened; the area between CuA and MP is basally somewhat wider than distally, with only one row

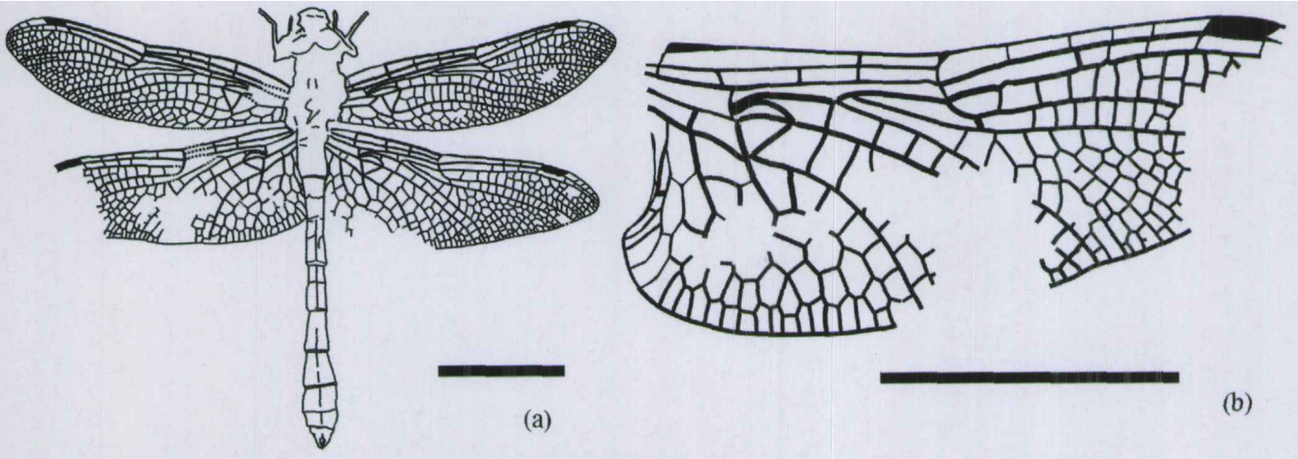

Fig. 3. *Sopholibellula eleganta* gen. et sp. nov., outline of holotype specimen.
(a) part (CNU-OD-LB2004002-1); (b) right hindwing of counterpart (CNU-OD-LB2004002-2). Scale bar represents 10 mm.

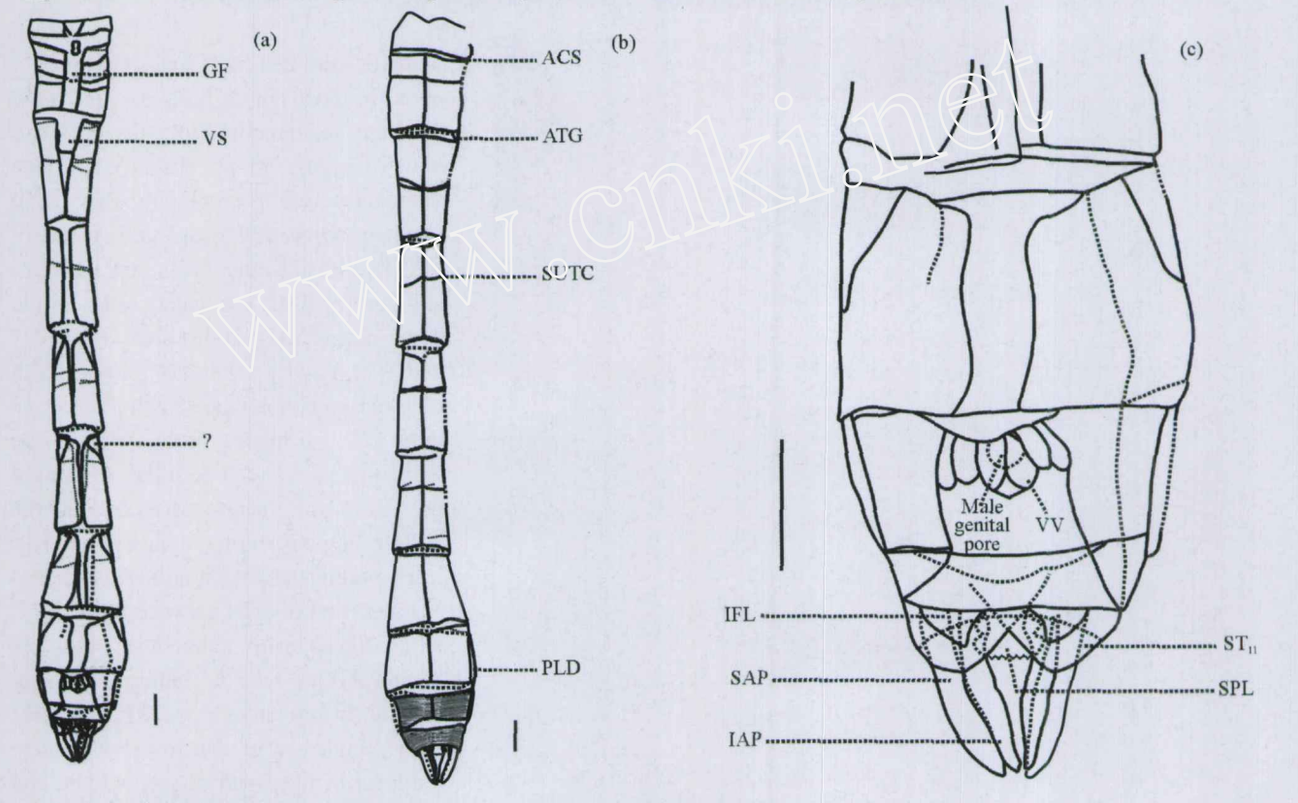

Fig. 4. *Sopholibellula eleganta* gen. et sp. nov., reconstruction of abdomen after part and counterpart.
(a) ventral view; (b) dorsal view; (c) ventral view of end segment. Scale bar represents 1 mm.

of cells, except at the hind margin (two cells).

Abdomen: Beefy, 26.1 mm long, max. width (eighth segment) 3.0 mm, min. width (third segment) 1.4 mm; with symmetrical glossy brown; transverse carina and ventral carina visible; slightly constrict at the third segment and distinctly expanded at the eighth segment; copulatory apparatus jumbled, only the genital fossa (GF) was subtil visible and the large vesicle (VS) distinctly visible; from the fourth to the eighth segment, on the basal part of each segment, there is a pair of triangle structures on both sides, with distinct concave edge; antecostalsuture (ACS), acrotergite (ATG), supplementary transverse carina (SUTC, from T_2 to T_7), paseudolateral dilation (PLD) of T_8 and T_9 visible; T_9 and T_{10} intensively ossification; base of ST_9 weakly ossificate and lobately beside the olivary valvule (VV); male genital pore round in shape; two rounded protuberances side by side at the center of T_{10}; end segments (sensu Tillyard, 1917) complex, ST_{11} large, nearly triangle; superior anal lamina (SPL) in flat "8" shape, with a row of little protuberances at the hind edge; inferior anal lamina (IFL) trianglar, about half of ST_{11} in size, with sharp tip bended to SPL; superior anal appendage

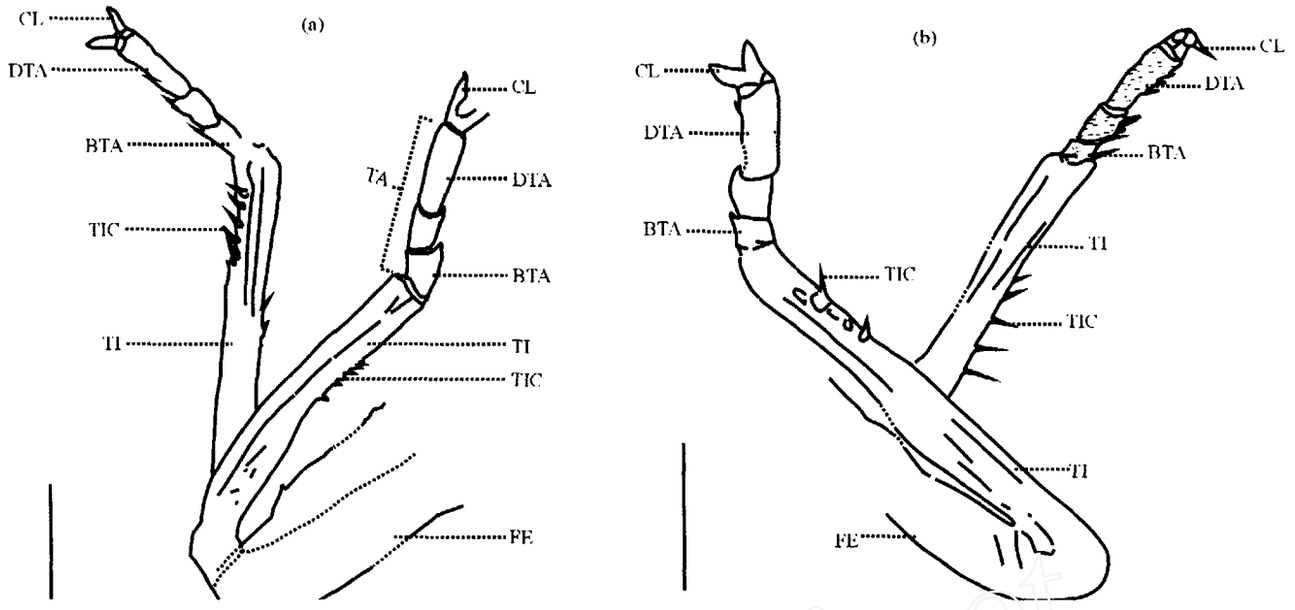

Fig. 5. *Sopholibellula eleganta* gen. et sp. nov., reconstruction of legs after part and counterpart
(a) left prothoracic and mesothoracic legs; (b) right prothoracic and mesothoracic legs. Scale bar represents 1 mm.

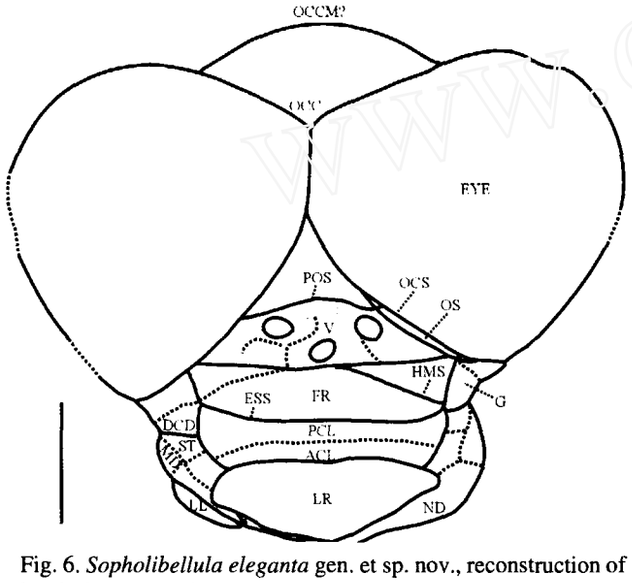

Fig. 6. *Sopholibellula eleganta* gen. et sp. nov., reconstruction of head after part and counterpart.
Scale bar represents 1 mm.

(SAP) columnar, 1.7 mm long, terminal obtuse, distal half part bend entad in some sort; inferior anal appendage (IAP) 1.5 mm long, terminal black, basal part stick up entad.

Legs: Coxa (CX) and trochanter(TR) of all legs were covered and invisible; part of femur (FE) of prothoracic leg visible, tibia (TI) 3.1 mm long, tibial comb (TIC) distinct, six inboard (about 0.1 mm long, at the middle station) and four outboard (close with the terminal); femur is about 1.5 times wider than tibia; tarsus (TA) 1.2 mm long, among which, basitarsus (BTA) 0.3 mm long and distitarsus (DTA) 0.6 mm long; pretarsus (PTAR) well preserved, claw (CL) strong and sharp, 0.4 mm long; femur (FE) and part of tibia (TI) of mesothoracic leg invisible; tibial comb (TIC) distinct, five inboard (about 0.2 mm long, at the terminal part) and five outboard (at the basal part); tarsus (TA) 1.0 mm long, in which, basitarsus (BTA) 0.2 mm long and distitarsus (DTA) 0.6 mm long; tarsus covered by small setae, with ragged spines aligned inboard; pretarsus (PTAR) well preserved, claw (CL) 0.2 mm long, strong and sharp.

Thorax is preserved, but jumbled and rather useless.

Head: Libelluloid-type (sensu Stanislaw, 1993), large and trapeziform in some sort, about 3.0 mm long and 4.6 mm wide; eyes large, about 2.5 mm long and 2.2 mm wide, meeting dorsally for a distance about 0.6 mm long; mandible (MD) long and partly visible; labrum (LR) nearly trianglar, anteclypeus (ACL) and postclypeus (PCL) much narrower than frons (FR), with blurry boundary between them; frons trapeziform, about 1.8 mm long and 0.4 mm wide; verter (V) nearly triangle; three ocelli (OC) differentiable for their sandy beige and rounded shape; a hollowness was formed on the occiput (OCC); gena (G) partly visible; occipital margin (OCCM), postocellar suture (POS), ocular sclerite (OCS), ocular suture (OS) and epistomal suture (ESS) were discernable; two indistinct protuberances near by the POS; on the dorsal view, left lateral lobe (LL) large, partly visible; hypostomal suture (HMS), disticardo (DCD), stipes (STI) and squame of labium (SQ) were differentiable.

Sopholibellula amoena sp. nov. (Figs. 2 and 7)

Etymology: After the Latin "amoenus" =lovely.

Holotype: Specimen No. CNU-OD-LB2004003-1, part, No. CNU-OD-LB2004003-2, counterpart, male; deposited

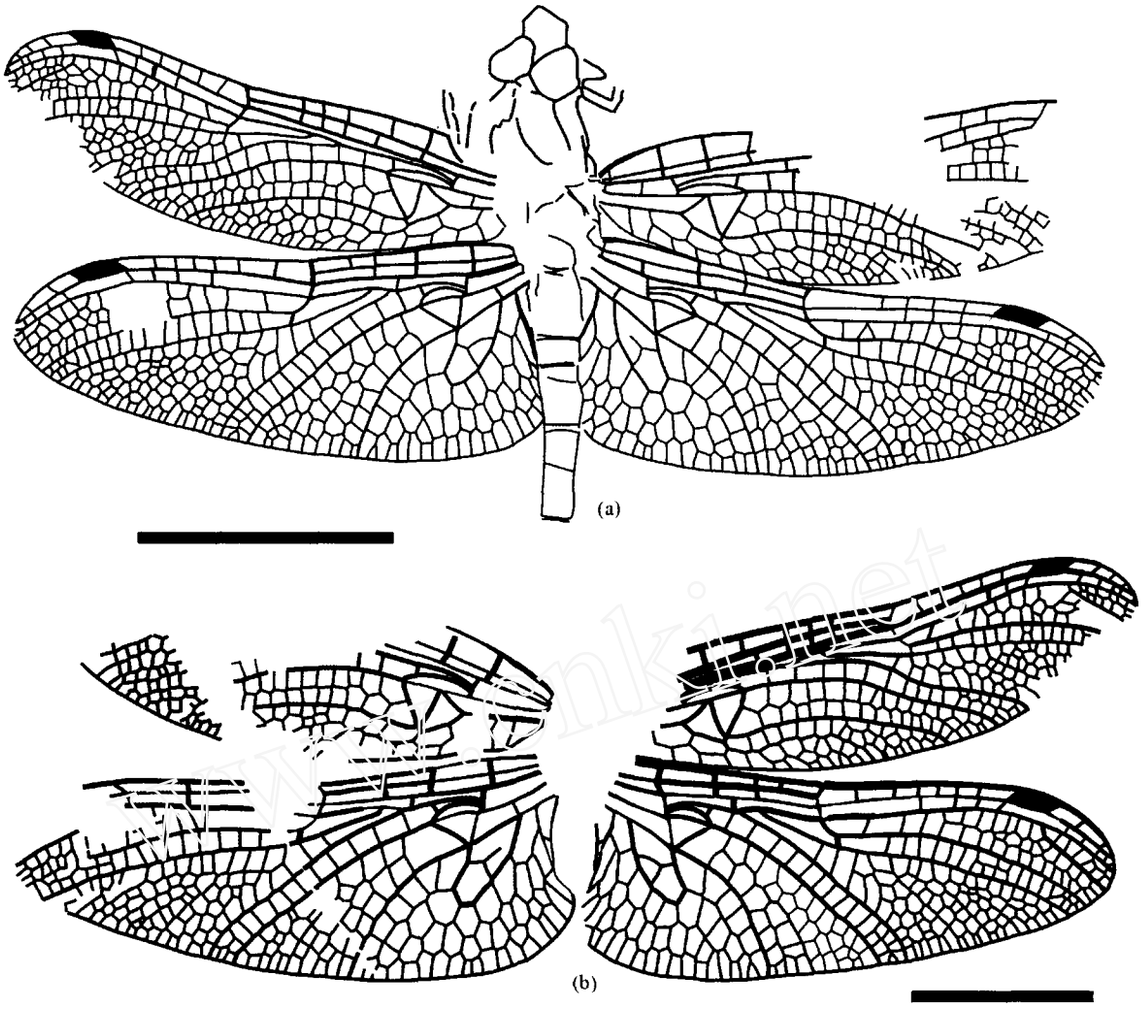

Fig. 7. *Sopholibellula amoena* sp. nov., outline of holotype specimen.
(a) part (CNU-OD-LB2004003-1); (b) wings of counterpart (CNU-OD-LB2004003-2). Scale bar represents 10 mm.

in the College of Life Sciences, Capital Normal University, Beijing, China.

Type locality and horizon: Yixian Formation, Late Jurassic to Early Cretaceous, near Chaomidian Village, Beipiao City, Liaoning Province, China.

Diagnosis: Similar to *S. eleganta* sp. nov., but differs in the following characters: Ax2 of forewing in the more basal position; anal loop three-celled; pseudo-IR1 originates on RP1 below the distal side of pterostigma; pseudo-IR1 of hindwing more or less zigzag; intercalary vein in the postdiscoidal area zigzag and inconspicuous; only one long cell (1.5 times of that of pterostigma) below pterostigma in all wings; cells (especially those in the apex and along the hind margin) larger and sparser.

Description: Male dragonfly specimen with all four wings outspread. Apex of left forewing, nodus and apex of the right forewing are missing. There is no trace of marking preserved. The wing is hyaline to all appearances. Head, thorax, parts of legs and the one to four abdomen segments are preserved.

Forewing: Length about 23.0 mm; width at nodus 6.0 mm; Ax1 and Ax2 aligned and stronger than the secondary antenodal crossveins, with no crossveins between them; Ax2 at the station close to the basal side of discoidal triangle; distal of Ax2: there are three secondary antenodal crossveins between the costal margin (C) and ScP, not strictly aligned with the four corresponding antenodals crossveins between ScP and RA; none (left wing) or one (right wing) antesubnodal crossveins in midway from arculus to the nodus, thus a long "cordulegastrid gap" present; five postnodal crossveins, non-aligned with the four corresponding postsubnodal crossveins; distinct "Libellulid gap" present; the pterostigma is 1.6 mm long and max. 0.6 mm wide distinctly braced by an oblique crossvein that is aligned with its basal side; the cell beneath the pterostigma is very long (half as much again about the length of pterostigma); costal margin and RA thickened along the pterostigma; arculus is straight; origins of RP and

MA (sectors of arculus) are distinctly separated at the arculus; median space free; submedian space traversed only by CuP-crossing; the hypertriangle free and its costal side (basal of MA) is distinctly curved; discoidal triangle free, wide and nearly equilateral; MAb is somewhat angled; a very well-defined pseudo-anal vein PsA delimits a unicellular subdiscoidal triangle; the hind margin of the subdiscoidal triangle angled; postdiscoidal area narrow with only about two rows of cells, distally even more narrow than basally (min. width near discoidal triangle 2.0 mm, min. distal width 1.2 mm); Mspl absent and no other intercalary veins in the postdiscoidal area; well-defined straight pseudo-IR1 originates on RP1 below the distal side of pterostigma with two rows of cells between it and RP1 and two or three rows of cells between it and RP2; RP2 aligned with subnodus; only one lestine oblique vein "O" between RP2 and IR2; no bridge crossveins (Bqs); the area between RP2 and IR2 is very narrow at the oblique vein "O", but distinctly widened distally; Rspl absent; RP3/4 and MA undulating, parallel with only one row of cells between them.

Hindwing: Length 22.0 mm; width at nodus 8.0 mm; Ax1 and Ax2 aligned and stronger than the secondary antenodal crossveins, with no crossveins between them; distal of Ax2, there is only one secondary antenodal crossveins (one and a half in the left hindwing); only one antesubnodal crossvein in the middle of the antesubnodal area, thus a long "cordulegastrid gap" present; six (left wing) or four (right wing) postnodal crossveins, not strictly aligned with the three corresponding postsubnodal crossveins; distinct "libellulid gap"; the perostigma is 1.9 mm long and max. 0.6 mm wide, covers a long cell (one and a half times longer than pterostigma), and braced by an oblique crossvein that is aligned with its basal side; costal margin and RA thickened along the pterostigma; arculus straight; origins of RP and MA are distinctly separated at the arculus; median space free; submedian space traversed only by the CuP-crossing; the hypertriangle distinctly shorter than that in the forewing, free and its costal side is strongly curved; discoidal triangle free with the costal side somewhat curved, MAb is straight; pseudo-anal vein PsA is lacking (completely suppressed), thus there is no subdiscoidal triangle; postdiscoidal area distally strongly widened (width near discoidal triangle 1.9 mm, width at hind margin 5.8 mm), with only one row of cells in the basal part and nine small cells along the posterior wing margin; Mspl absent, intercalary vein zigzag and inconspicuous; RP1 and RP2 basally relatively parallel with only one row of cells between them up to the 2/3 distance from nodus to pterostigma; pseudo-IR1 not straight like that of forewings, even somewhat zigzag, originates on RP1 below the distal side of pterostigma with one or two rows of cells between it and RP1 and two or three rows of cells between it and RP2; RP2 aligned with subnodus; only one lestine oblique vein "O" between RP2 and IR2; no bridge crossveins; RP2 and IR2 with a single row of cells in-between up to the level of the distal of pterostigma and about two rows of cells distally; area between IR2 and RP3/4 distally distinctly expanded with several unconspicuous intercalary veins present and eighteen small cells along the hind margin; Rspl absent; RP3/4 and MA relatively straighter than that of the forewing and parallel with only one row of cells in-between, except at the hind margin (two cells); subdiscoidal veinlet (sdv) strongly reduced; gaff very long and somewhat curved; MP is strongly curved and thus shortened; CuA with only a single dichotomic branching into CuAa and CuAb; CuAa and CuAb strongly zigzagged; anal loop well-defined, divided into three cells by a Y-shaped crossvein; the area between CuA and MP is basally wider than distally, with only one row of cells, except at the hind margin (two cells).

Other structures were jumbled and useless, but the head is clearly libelluloid-type.

3 Comparison and Discussion

The new genus undoubtedly fits into Paneurypalpida Bechly, 1996 (this taxon comprised of Eurypalpida and Araripelibellulidae) because it has all the synapomorphies of Paneurypalpida (after Bechly, 1996): male hindwings with anal triangle only divided into two cells by a longitudinal crossvein; the forewing subdiscoidal triangle widened with a curved or angled posterior margin; PsA and subdiscoidal triangle of hindwings more reduced than that in the groundplan of Cavilabiata; the subdiscoidal vein reduced in the hindwings; the hindwing CuA is further shortened with only one distinct dichotomic branching into CuAa and CuAb; RP3/4 and MA not secondarily undulating; antenodal crossveins more or less aligned, at least the hindwings with more than two aligned and bracket-like antenodal crossveins; basal part of postsubnodal area free of crossveins ("libellulid gap").

Eurypalpida can easily be excluded as it has the following important characters, which were dissimilar to *Sopholibellula*: sectors of arculus approximate, diverging from one point or even shortly fused basally; arculus strictly straight in both pairs of wings; pterostigmal brace vein shifted distally beneath the pterostigma, or reduced; Ax2 situated distinctly basal of the discoidal triangle in forewings; the forewing pseudo-anal vein PsA is hypertrophied; anal loop elongate and at least eight cells large; area between RP2 and IR2 not distinctly widened distally; strong tendency towards colored wings.

Sopholibellula has the main characters of Araripelibellulidae Bechly, 1996: no secondary antenodal crossveins between Ax1 and Ax2; only one or two antesubnodal crossveins; forewing with only about four postnodal crossveins; anterior side of hindwing hypertriangle very strongly curved, and posterior side at least slightly curved, too; postdiscoidal area very narrow in the forewing (distal part even narrower than basal part); anal loop very elongate. Two other characters (i.e. only two or three secondary antenodal crossveins distal of Ax2 and all antenodal crossveins strictly aligned) were not strictly followed because they are dubious (unknown in *Cretaneophya* because of the lacking of costal part of specimens; reversed in *Mesocordulia*). Antenodal crossveins were unequal in number even in the left wing and right wing of the same specimen, and only some of them were aligned strictly, therefore, we think maybe they are individual malformations.

S. eleganta is rather similar to *A. martinsnetoi*, Nel et Paicheler, 1994, the type species of *Araripelibellula* and Araripelibellulidae: Ax2 not situated rather distal of the discoidal triangle in the forewing; long "corrulegastrid gap" and "libellulid gap" in both pairs of wings; the pterostigmal brace veins strictly aligned with the basal side of the pterostigma; origins of RP and MA distinctly separated at the arculus in all wings; anal loop relatively small and without midrib; costal side of discoidal triangle curved; area between RP2 and IR2 very narrow near the oblique vein "O", but more distally distinctly widened; distal part of postdiscoidal area narrower than basal part. It differs from the latter in the following character: two rows of cells, unlike only one row of *A. martinsnetoi* in the postdiscoidal area of the forewings; arculus distinctly straighter in the forewings; anal loop larger, with more cells; distinct larger than *A. martinsnetoi* in size; cells markedly more dense, especially in the apex.

In Araripelibellulidae, *Cretaneophya*, *Condalia* and *Cratocordulia*, along with *Araripelibellula*, were included in a single subfamily Araripelibellulinae Bechly, 1996 by the following characters: anterior side of hindwing discoidal triangle more distinctly curved; postdiscoidal area with only a single row of cells in the basal half; area between RP2 and IR2 very narrow near the lestine oblique vein, but more distally distinctly widened; anal loop very narrow with only a single row of 2–4 cells; PsA suppressed in the hindwing. *Sopholibellula* does not fall into Araripelibellulinae because it has two rows of cells in the basal half of postdiscoidal area and the anal loop not much narrow like that of Araripelibellulinae. Furthermore, RP and MA have a common origin at the arculus in *Cretaneophya*; in *Condalia*, Mspl and Rspl present, arculus and main transverse veins distinctly more undulated; *Cratocordulia* can be distinguished by RP and MA having a common origin at the arculus, Ax2 at the basal position of the forewing discoidal triangle, MA and IR2 distally zigzagged and pterostigmal brace vein distally displaced. All these three genera appear to differ in above-mentioned characters from the fossils treated here.

Bechly (1996) erected a subfamily Mesocorduliinae for *Mesocordulia*, but gave no generally acceptable characters of the new taxon. Here, we described several characters, which were different to *Sopholibellula*, by observing the holotype and paratype specimens of *M. boreala*: large anal loop with two rows of cells (8–11 cells), and a midrib present weakly; 2–4 antesubnodal crossveins in hindwing; bridge crossveins present.

As noted above, the differences are sufficiently distinct to warrant the erection of a new genus.

4 Conclusions

Sopholibellula has nearly all the synapomorphies of Paneurypalpida and Araripelibellulidae, and shows similarities to *Araripelibellula*, the type genus of Araripelibellulidae, therefore it is referred to this family. More and more new genera and species of Araripelibellulidae have been described; this may suggest that these pint-size dragonflies were abundant during the period from the Late Jurassic to Early Cretaceous.

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