An interesting new fossil relict damselfly (Odonata: Zygoptera: Coenagrionoidea) from Eocene Baltic amber

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Abstract

A new fossil genus and species of damselfly, *Balticoagrion paulyi* n. gen., n. sp. (Odonata: Zygoptera: Coenagrionoidea: Familia incertae sedis) is described from Eocene Baltic amber. This fossil taxon does not fit into any known fossil or Recent family-group taxon and is here tentatively considered as relict taxon and potential stem group representative of Coenagrionoidea. The same piece of amber also contains a piece of skin from a small reptile as syninclusion.

Keywords: Baltic amber, Eocene, fossil damselfly, Odonata, Zygoptera.

Zusammenfassung

Eine neue fossile Gattung und Art von Kleinlibellen, *Balticoagrion paulyi* n. gen., n. sp. (Odonata: Zygoptera: Coenagrionoidea: Familia incertae sedis), wird aus dem eozänen Baltischen Bernstein beschrieben. Das Fossil passt in keines der bekannten Familiengruppentaxa und wird hier vorläufig als Relikttaxon und möglicher Stammgruppenvertreter der Coenagrionoidea angesehen. Im selben Bernsteinstück befindet sich als Syninkluse auch noch ein Hautfragment einer kleinen Echse.

Contents

1. Introduction

Inclusions of fossil damselflies are not as rare in Tertiary amber as often supposed. Bechly (1993, 1996b, 1998) provided the first comprehensive lists of all fossil odonates in amber, while Bechly & Wichard (2008) revised all 16 known specimens of odonate larvae in Baltic amber, of which all but one belong to Zygoptera (Calopterygidae, Hypolestidae, Megapodagrionidae, and Synlestidae). Meanwhile, there are numerous further specimens known (Bechly, unpublished data), even though most of them are not yet scientifically described.

The first damselfly described from Baltic amber was *Agrion antiquum* Pictet & Hagen, 1856, which is today often classified as *Platycnemis antiqua*. However, the attribution to the family Platycnemididae is only weakly supported, and the attribution to the modern genus *Platycnemis* must be rejected, because *A. antiquum* lacks the apomorphic rectangular discoidal cell of the subfamily Platycnemidinae. Therefore, this fossil taxon is better considered as a Coenagrionoidea incertae sedis. Only three other species have yet been described from adult damselflies in Baltic amber: *Litheuphaea ludwigi* Bechly, 1998 (Epallagidae); *Pamita hannahdaltonae* May & Carle, 2005 (Amphipterygidae); and *Electrophenacolestes serafini* Nel & Arillo, 2006 (Thaumatoneuridae: Dysagrioninae; maybe rather a Diphlebiidae). Pfau (1975) figured two undescribed species of coenagrionoid damselflies from Baltic amber as "Spezies A" and "Spezies B". Still undescribed adult Calopterygidae and Synlestidae have been figured by Bechly & Wichard (2008).

The present study describes an interesting new genus and species of damselflies from Baltic amber.

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2. Material and methods

The drawing was made with a camera lucida on a Leica M80 stereo microscope with 1.6 Plan Achromat lens. Microphotos were made with a Leica DFC490 digital

macro camera on a Leica Z16-Apo microscope with Leica Application Suite 3.1.0 software for focus stacking. All figures have been subsequently edited and polished with the Adobe Photoshop CS3® imaging software.

The terminology of odonate wing venation is based on Riek & Kukalová-Peck (1984), as modified by Nel et al. (1993) and Bechly (1996a). The used phylogenetic classification of the order Odonata is mainly based on Bechly (1996a, 2003) and on new phylogenomic studies cited in the text below.

3. Systematic palaeontology

Order Odonata Fabricius, 1793
Suborder Zygoptera Selys, 1854
Superfamily Coenagrionoidea Kirby, 1890
Familia incertae sedis

Genus *Balticoagrion* n. gen.

Typus generis: *Balticoagrion paulyi* n. sp.

Derivatio nominis: Named after Baltic amber and the generic damselfly name *Agrion*.

Diagnosis. – Same as type species since monotypic.

Balticoagrion paulyi n. sp.
Figs. 1–5

Holotype: Specimen no. SMNS BB-2550, Staatliches Museum für Naturkunde in Stuttgart (Germany). For the purpose of the donation of the holotype to SMNS, the amber piece was divided into two pieces, so that the part with the reptile skin could remain in private collection.

Derivatio nominis: Named after Mr. Alfredo Pauly (Bad Neuenahr), who kindly donated the holotype to SMNS.

Fig. 1. *Balticoagrion paulyi* n. gen., n. sp., female, basal part of wing; holotype, SMNS BB-2550; Eocene Baltic amber. – Scale: 1 mm.

Stratum typicum and Locus typicus: Baltic amber, Eocene.

Diagnosis. – Wing length about 16–17 mm; only two antenodal cross-veins; arculus slightly distal of Ax2;

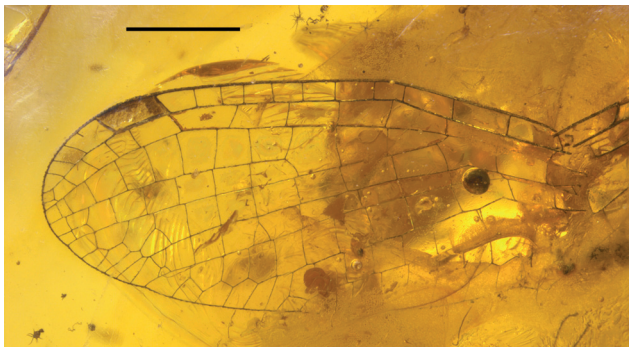

Fig. 2. *Balticoagrion paulyi* n. gen., n. sp., female, distal part of wing; holotype, SMNS BB-2550; Eocene Baltic amber. – Scale: 2 mm.

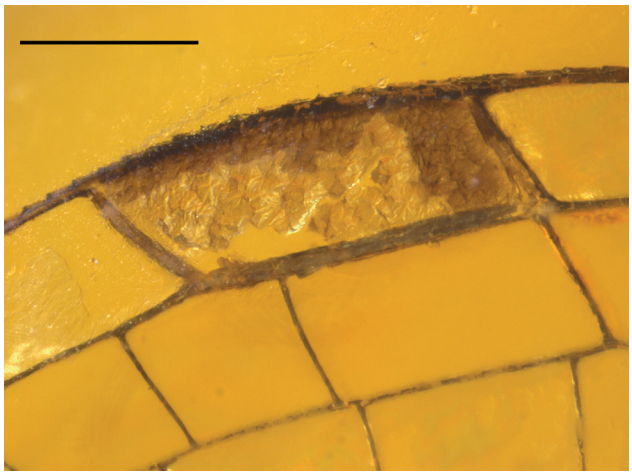

Fig. 3. *Balticoagrion paulyi* n. gen., n. sp., female, detail of pterostigma; holotype, SMNS BB-2550; Eocene Baltic amber. – Scale: 0.5 mm.

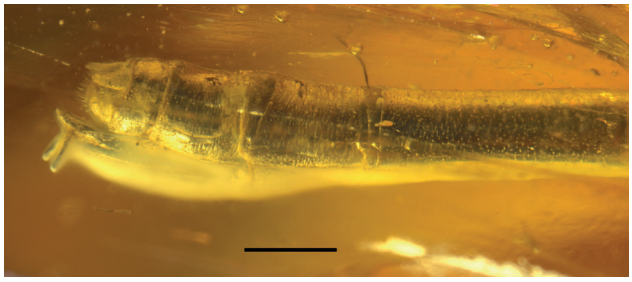

Fig. 4. *Balticoagrion paulyi* n. gen., n. sp., female, abdomen with ovipositor; holotype, SMNS BB-2550; Eocene Baltic amber. – Scale: 1 mm.

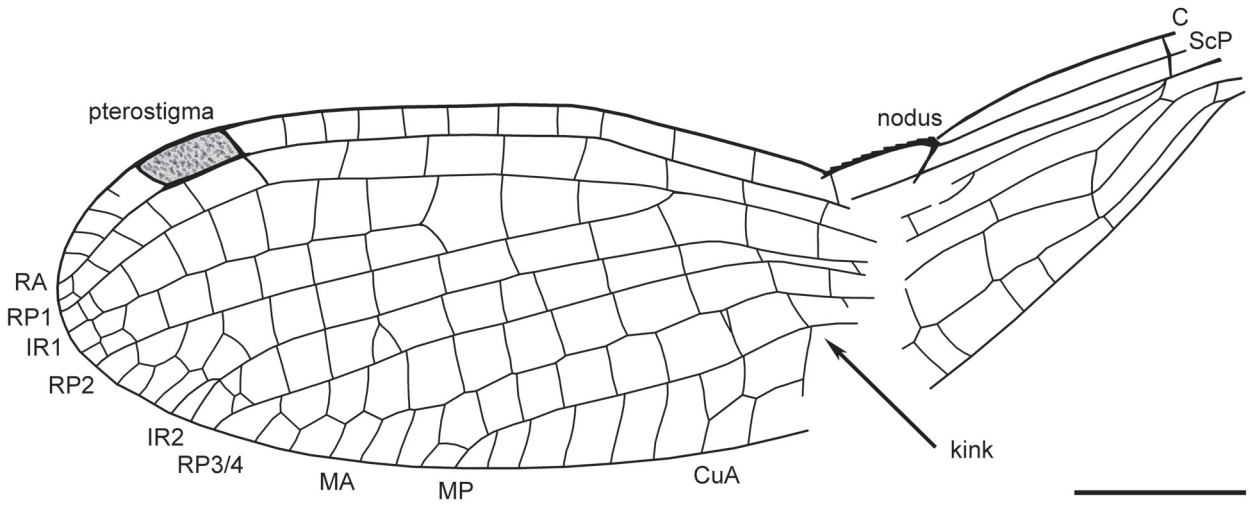

Fig. 5. *Balticoagrion paulyi* n. gen., n. sp., female, drawing of wing venation; holotype, SMNS BB-2550; Eocene Baltic amber. – Scale: 2 mm.

subdiscoidal cell undivided; discoidal cell distally acute; discal brace well developed; 11 postnodal cross-veins and 7 postsubnodal cross-veins are not aligned; no lestine oblique vein; IR1 originates three cells distal of RP2; pterostigma with wrinkled micro-sculpturing, 1.5 cells long, and braced; CuA fuses with hind margin basal of discoidal cell; five pectinate "branches" of MP distal of the end of CuA.

Description of holotype (Figs. 1–5). – A piece of clear Baltic amber (45 × 24 mm) with an isolated, nearly complete wing and distal half of the abdomen of a small female damselfly, and as syninclusions a skin fragment of a small reptile (Fig. 6), a Formicidae, a Mycetophilidae, a mite, and numerous stellate hairs.

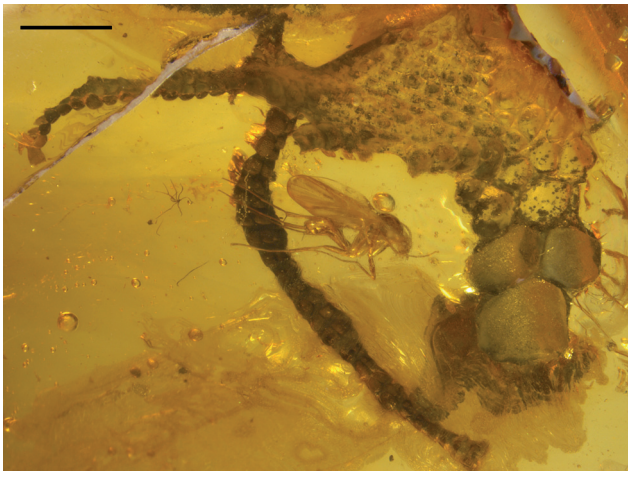

Fig. 6. Skin fragment of small reptile as syninclusion of SMNS BB-2550; private collection Pauly. – Scale: 2 mm.

Length from nodus to apex, 10.7 mm; estimated total wing length, 16–17 mm; maximum width, 4.3 mm. In the antenodal space only Ax2 is visible, thus there were only the two primary antenodal cross-veins but no secondary antenodals. The arculus is slightly distal of Ax2. The discoidal cell is elongate with an acute distal angle and a well-developed discal node; the subdiscoidal cell is long and undivided. The nodus is of typical coenagrionoid shape with an oblique nodal veinlet. The 11 postnodal crosveins are not aligned with the 7 postsubnodal cross-veins. The pterostigma is elongate, 1.5 cells long, braced, and with wrinkled micro-sculpturing on the surface. IR1 long, originating three cells distal of RP2; IR2 aligned with subnodus; no supplementary intercalary veins and no lestine oblique vein 'O'. MA distally more zigzagged than the other longitudinal veins; MP with five pectinate posterior "branches". Only a single row of cells in the cubito-anal area. CuA fuses with hind margin basal of discoidal cell near CuP-crossing, so that the wing base was stalked.

The circumstance that an abdomen of a female damselfly with endophytic ovipositor is embedded close to the inclusion of the damselfly wing strongly suggests that both fragments belong to the same female specimen that was possibly trapped by resin during oviposition or while at rest.

Discussion (Fig. 7). – The combination of wing venational characters (wing stalked, no secondary antenodal cross-veins, no lestine oblique vein, no supplementary intercalary veins, discoidal cell acute, pterostigma short and braced and with wrinkled micro-sculpturing) clearly suggests that the new taxon belongs to Coenagrionoidea (Isostictidae, Platycnemididae incl. Protoneurinae,

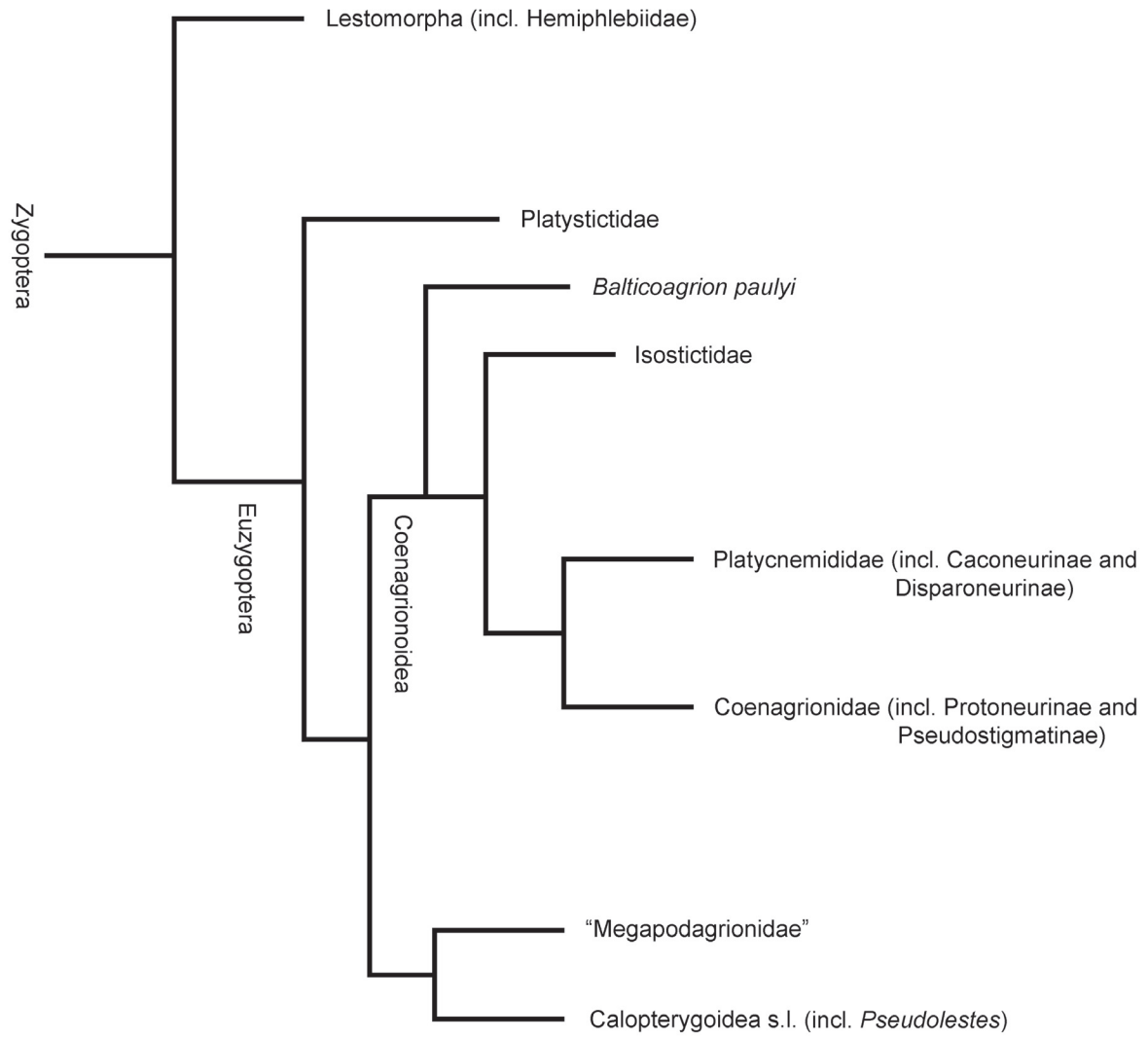

Fig. 7. Phylogenetic tree of Zygoptera with putative position of the new taxon.

and Coenagrionidae incl. Pseudostigmatinae). The completely non-aligned postsubnodal cross-veins represent a plesiomorphic character state that is only retained in Calopterygoidea s. l. (also incl. Philogangidae, Diphlebiidae, Amphipterygidae, and the enigmatic taxon *Pseudolestes mirabilis*) among Recent Zygoptera. The results of modern phylogenomics suggest that the alignment of the postnodal cross-veins occurred convergently in Lestinoidea, Platystictidae, Megapodagrionidae, and Coenagrionoidea, because these four lineages with aligned postnodals do not seem to form a monophyletic group (Rehn 2003; Bybee et al. 2008; Carle et al. 2008; Dumont et al. 2005).

If this character state should not turn out to be a strange reversal, it suggests a position of the new taxon in the stem group of Coenagrionoidea (Fig. 7). Consequently, this fossil represents a relict taxon in the Paleogene, which has symplesiomorphic similarities with *Cretarchistigma greenwoodi* Jarzembowski et al., 1998, which is one of the few known putative Mesozoic Coenagrionoidea and most probably does not belong to the Euarchistigmatinae (contra Jarzembowski et al. 1998) but to the stem group of Coenagrionoidea. The only other Mesozoic representatives of Coenagrionoidea are *Eoprotoneura hyperstigma* Carle & Wighton, 1990 from the Lower Cretaceous of Brazil and *Palaeodisparoneura burmanica* Poinar et al., 2010 from Burmese amber, which both already belong to derived modern subgroups of Coenagrionoidea (Poinar et al. 2010). All other Mesozoic damselfly taxa that were originally described as Coenagrionoidea have later been transferred to other zygopteran superfamilies (e. g., *Cretacoenagrion* to Lestinoidea).

The only other Coenagrionoidea from Baltic amber are *Agrion antiquum* and "Spezies A" and "Spezies B" of PFAU (1975). The lectotype of *Agrion antiquum* differs from the new taxon in the alignment of the five basal postnodal cross-veins, the origin of IR1 two cells distal of RP2, vein MA distally more distinctly zigzagged, and only three pectinate "branches" of MP. The size is more or less similar (largest width of wing 4.0 mm in *A. antiquum*, instead of 4.3 mm in the new taxon).

It cannot be totally excluded that the new taxon is conspecific with PFAU's "Spezies B" because size (wing length 17.9 mm, length nodus-apex 11.5 mm instead of 10.7 mm) and most characters are very similar. However, in "Spezies B" at least the two most basal postnodals are strictly aligned, the arculus is aligned with Ax2, and there are only 2 (instead of 5) pectinate "branches" of MP. PFAU's "Spezies A" agrees in the arculus slightly distal of Ax2 and five pectinate branches of MP, but differs by the basal five postnodal cross-veins being strictly aligned and distinctly larger wing length of 23.3 mm.

4. References

BECHLY, G. (1993): Fossil odonates in Dominican and Baltic amber. – Argia, **5** (1): 13–15.

BECHLY, G. (1996a): Morphologische Untersuchungen am Flügelgeäder der rezenten Libellen und deren Stammgruppenvertreter (Insecta; Pterygota; Odonata), unter besonderer Berücksichtigung der Phylogenetischen Systematik und des Grundplanes der *Odonata. – Petalura, (Spec. Vol.), **2**: 1–402.

BECHLY, G. (1996b): Fossil Odonates in Tertiary amber. – Petalura, **2**: 1–15.

BECHLY, G. (1998): New fossil damselflies from Baltic amber, with description of a new species, a redescription of *Litheuphaea carpenteri* FRASER, and a discussion on the phylogeny of Epallagidae (Zygoptera: Caloptera). – International Journal of Odonatology (Pantala), **1** (1): 33–63.

BECHLY, G. (2003): Phylogenetic Systematics of Odonata. – In: SCHORR, M. & LINDEBOOM, M. (eds.): Dragonfly Research 1.2003. Zerf – Tübingen (ISSN 1438-034×).

BECHLY, G. & WICHARD, W. (2008): Damselfly and dragonfly nymphs in Eocene Baltic amber (Insecta: Odonata), with aspects of their palaeobiology. – Palaeodiversity, **1**: 37–74.

BYBEE, S. M., OGDEN, T. H., BRANHAM, M. A. & WHITING, M. F. (2008): Molecules, morphology and fossils: a comprehensive approach to odonate phylogeny and the evolution of the odonate wing. – Cladistics, **23**: 1–38.

CARLE, F. L., KJER, K. M. & MAY, M. L. (2008): Evolution of Odonata, with special reference to Coenagrionoidea (Zygoptera). – Arthropod Systematics & Phylogeny, **66** (1): 37–44.

DUMONT, H. J., VANFLETEREN, J. R., DE JONCKHEERE, J. F. & WEEKERS, P. H. H. (2005): Phylogenetic relationships, divergence time estimation, and global biogeographic patterns of calopterygoid damselflies (odonata, zygoptera) inferred from ribosomal DNA sequences. – Systematic Biology, **54** (3): 347–362.

JARZEMBOWSKI, E. A., MARTÍNEZ-DELCLÓS, X., BECHLY, G., NEL, A., CORAM, R. & ESCUILLIÉ, F. (1998): The Mesozoic non-calopterygoid Zygoptera: description of new genera and species from the Lower Cretaceous of England and Brazil and their phylogenetic significance (Odonata, Zygoptera, Coenagrionoidea, Hemiphlebioidea, Lestoidea). – Cretaceous Research, **19**: 403–444.

MAY, M. L. & CARLE, F. L. (2005): *Pamita hannahdaltonae* gen. nov., sp. nov. from Baltic amber (Odonata: Amphipterygida). – International Journal of Odonatology, **8** (2): 213–221.

NEL, A. & ARILLO, A. (2006): The first Baltic amber dysagrionine damselfly (Odonata: Zygoptera: Thaumatoneuridae: Dysagrioninae). – Annales de la Société entomologique de France, (Nouvelle série), **42** (2): 179–182.

NEL, A., MARTÍNEZ-DELCLÒS, X., PAICHELER, J.-C. & HENROTAY, M. (1993): Les 'Anisozygoptera' fossiles. Phylogénie et classification (Odonata). – Martinia, Numéro Hors Série **3**: 1–311.

PFAU, H. K. (1975): Zwei neue Kleinlibellen (Odonata, Zygoptera – möglicherweise Platycnemididae) aus dem baltischen Bernstein. – Stuttgarter Beiträge zur Naturkunde, Serie A, **270**: 1–7.

PICTET-BARABAN, F. J. & HAGEN, H. A. (1856): Die im Bernstein befindlichen Neuropteren der Vorwelt (mit Zusätzen von A. MENZE). In: BERENDT, G. C. (ed.): Die im Bernstein befindlichen organischen Reste der Vorwelt gesammelt in Verbindung mit Mehreren bearbeitet und herausgegeben von Dr. Georg Carl Berendt. Vol. 2 (II. Abt.): 41–125; Berlin (Nicolai).

POINAR, G., BECHLY, G. & BUCKLEY, R. (2010): First record of Odonata and a new subfamily of damselflies from Early Cretaceous Burmese amber. – Palaeodiversity, **3**: 15–22.

REHN, A. C. (2003): Phylogenetic analysis of higher-level relationships of Odonata. – Systematic Entomology, **28**: 181–239.

RIEK, E. F. & KUKALOVÁ-PECK, J. (1984): A new interpretation of dragonfly wing venation based upon early Upper Carboniferous fossils from Argentina (Insects: Odonatoidea) and basic character states in pterygote wings. – Canadian Journal of Zoology, **62**: 1150–1166.

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