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New Tertiary dragonflies from Lower Oligocene of the České středohoří Mts and Lower Miocene of the Most Basin in the Czech Republic (Odonata: Anisoptera)

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Abstract. Two new representatives of the clade Aeshnoptera are described from the Lower Oligocene and Lower Miocene of northern Bohemia (Czech Republic), i. e. *Kvacekia infuscata* gen. n. et sp. n. (Aeshnidae) and *Gomphaeschna miocenica* sp. n. (Gomphaeschnidae). *Kvacekia* gen. n. seems to be closely related to the Cenozoic genus *Oligaeschna* Piton et Théobald, 1939 and the recent genus *Oplonaeschna* Selys, 1883. *Gomphaeschna miocenica* sp. n. wing venation has particular wing coloration and distinctly different characters from all previously described species of the genus. A holarctic distribution in fossil history is proposed for both Oplonaeschninae and Gomphaeschninae.

Taxonomy, fossil, description, Insecta, Anisoptera, Odonata, Aeshnoptera, Gomphaeschnidae, Aeshnidae, *Kvacekia infuscata* gen. n. et sp. n., *Gomphaeschna miocenica* sp. n., Tertiary, Lower Oligocene, Lower Miocene, Central Europe, Palaearctic region

INTRODUCTION

Tertiary fossil dragonflies have been recorded from several sites such as Pochlovice near Kynšperk, Sokolov, Jehličná near Sokolov belonging to Cypris Shale and from Bílina mine of Most Formation in northwestern Bohemia (Bachmayer 1952, Heer 1849, Handlirsch 1907, Kukalová 1962, Říha 1977, 1979, Prokop & Nel 2000). Up till now all these recorded fossils, both larvae and adults, belong to Libellulidae and Aeshnidae (Prokop 2002).

Cenozoic insect fauna of northwestern Bohemia is preserved in fluvio-lacustrine deposits of the Krušné hory piedmont basins and the České středohoří Mts. About 16 localities representing several different palaleoenvironments dated from Upper Eocene to Lower Miocene are investigated. The relatively diverse insect fauna from Lower Oligocene (Ruppelian/Chattian) of Kundratice near Litoměřice is preserved in several interbeds of the brownish diatomite of Ústí Formation (Fig. 1b). The site is well known because of studied palaeobotanical and palaeoichthyological records (Kvaček & Walther 1998, Obrhelová 1979). Another famous site is the Bílina mine (the former Maxim Gorkij mine) situated in the Most Basin near the town of Bílina (Fig. 1b). The stratigrafical attribution is to the Most Formation of the Lower Miocene (Eggenburgian/Ottnangian) and insects are preserved in three fossiliferous horizons (Clayey Superseam Horizon, Delta Sandy Horizon, Lake Clayey Horizon) (Prokop 2002). The site has been observed from other paleoscientific aspects as palaeobotany, palynology and sedimentology (Bůžek et al. 1992, Dašková 2000, Kvaček 1998, Rajchl & Uličný 1999, Sakala 2000).

In the following study we use the wing venation nomenclature of Riek & Kukalová-Peck (1984), amended by Kukalová-Peck (1991), Nel et al. (1993), Bechly (1996) and Bechly et al. (2001). We follow the phylogenetic classification of Anisoptera proposed by Bechly et al. (1996, 2002).

SYSTEMATIC PALAEONTOLOGY

Aeshnoptera Bechly, 1996

Family Aeshnidae Leach, 1815

Genus *Kvacekia* gen. n.

Type Species. *Kvacekia infuscata* sp. n.
Diagnosis. The new genus very similar and probably closely related to recent genus *Oplonaeschna* Selys, 1883 and fossil genus *Oligaeschna* Piton et Théobald, 1939. It differs from these genera by the following combination of characters (fore wing structures): (1) pterostigma elongate, covering 5–6 cells; (2) cubito-anal area very broad, with more than 9 rows of cells between CuA and posterior wing margin (possible autapomorphy, but character unknown in some *Oligaeschna* species); (3) 5 rows of cells in area between IR2 and RP2; (4) hypertriangle with 4 or more cross-veins; (5) wing dark infuscate; (6) about 18–20 postnodal cross-veins (14 to 16 in the *Oplonaeschna* and *Oligaeschna* species, but character state unknown in *Oligaeschna lapidaria*). Characters (2) and (5) are probably autapomorphies of *Kvacekia* gen. n., but no relative autapomorphy of *Oligaeschna* is known. Only the discovery of better-preserved specimens of both taxa will permit to solve the problem of the possible paraphyly of *Oligaeschna* relatively to *Kvacekia* gen. n.
Etymology. *Kvacekia* gen. n. (feminine in gender), named in honour of Prof. Zlatko Kvaček, palaeobotanist from Charles University in Prague.

Kvacekia infuscata sp. n.

(Figs 2, 3)

Diagnosis. That of the genus.
Description. A nearly complete fore wing, broken in nodal region and with part basal of arculus missing; whole wing surface dark fuscous with some lighter zones (see Fig. 2); fore wing, about 52 mm long (assumed from fragment) and 12 mm wide; distance from estimate base to nodus, about 25 mm; distance from nodus to wing apex, about 27 mm; nodus nearly midway between base and apex; distance from nodus to pterostigma, 12.4 mm; distance from pterostigma to apex, 5.6 mm; pterostigma rather long, 5.3 mm long and 0.9 mm wide, covering approximately 5–6 cells; pterostigmal brace slightly obliquely aligned with proximal side of pterostigma; 19 visible antenodal cross-veins of first row between C and ScP not aligned with the 16 visible corresponding antenodal cross-veins of second row between ScP and RA; 18 visible postnodal cross-veins, not well aligned with 19 visible subpostnodal cross-veins, maybe 1–2 missing postnodal cross-veins close to nodus; more than 12 secondary antenodal cross-veins visible between Ax2 and nodus; more than 4 antenodal cross-veins of second row between Ax2 and Ax1; Ax1 being 6.2 mm and Ax2 12.9 mm from wing base; hypertriangle crossed by 4–5 cross-veins; arculus, anal area, median and submedian space, and subdiscoidal triangle not preserved; discoidal triangle elongate and divided into 7 smaller cells, its costal side being 9.2 mm long, distal side 8.3 mm long and proximal side 3.1 mm long; width of postdiscoidal area just behind discoidal triangle, 4 mm, probable width along posterior wing margin, 11.4 mm; 3 rows of cells in postdiscoidal area just distal of discoidal triangle; a short convex supplementary sector (trigonal planate) in postdiscoidal area, beginning one cell

before distal angle of discoidal triangle, and aligned with concave Mspl; Mspl well defined, nearly strait in its basal half but slightly curved in distal part; 2 rows of cells between Mspl and MP and 5 rows between Mspl and MA; 2 rows of cells and a zigzagged supplementary vein in distal part of area between MA and RP3/4; bulge in distal part of MA ("aeshnid bulla") weak; 2 preserved Bq cross-veins; oblique vein 'O' not preserved; Rspl well defined and slightly anteriorly curved in its distal part; area between Rspl and IR2 very wide, with about 5 rows of cells in its widest part; space between IR2 and Rspl basally divided by oblique intercalary veinlets; IR2 smoothly curved distally but not forked; a long and rather straight intercalary vein, close and well parallel to RP2, proximally not branching on IR2 but vanishing in area between RP2 and IR2; RP2 strongly curved posteriorly opposite proximal side of pterostigma; 5 rows of cells between RP2 and IR2 in widest part; IR1 present but zigzagged, 6.8 mm long, beginning just below proximal side of pterostigma; one row of cells between MP and CuAa; CuAa with more than 8 posterior branches directed towards posterior wing margin; cubito-anal area very broad.

TYPE MATERIAL. **Holotype**: specimen P1193 (National Museum coll., Praha, Czech Republic), medio-distal part of fore wing (imprint) with venation well preserved, only posterior part of wing preserved in counter imprint.

TYPE LOCALITY. Kundratice near Litoměřice, Czech Republic.
TYPE STRATA. Lower Oligocene (Ruppelian/Chattian), Ústí Formation (Středohoří Complex).
ETYMOLOGY. Named after the dark infuscate wing of the type specimen.
DISCUSSION. *Kvacekia* gen. n. fits into the Aeshnidae because of the presence of several potential autapomorphies (after Bechly 1996): "Rspl and Mspl distinctly curved, with more than 3 rows of

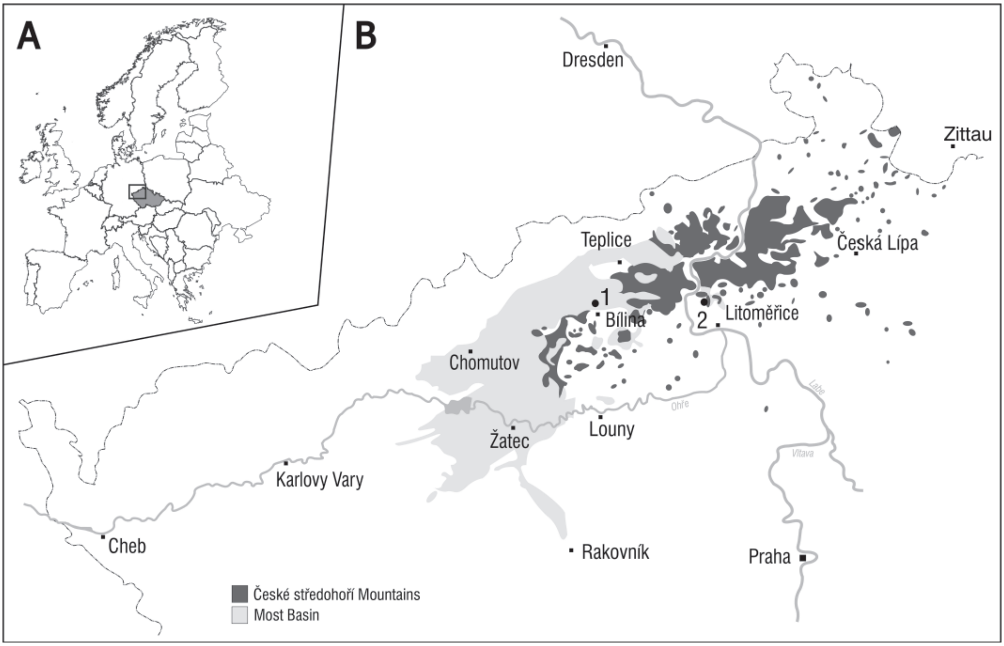

Fig. 1. Geographical position of northwestern Bohemia within Europe (A), detailed map of the Most Basin and the České středohoří volcanic areas (B), 1 – Bílina mine, 2 – Kundratice near Litoměřice.

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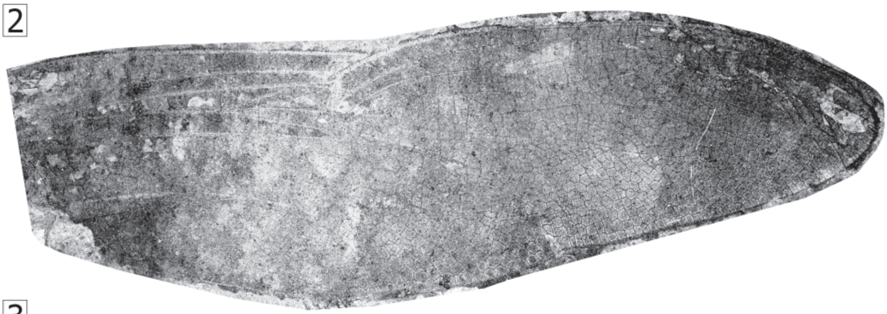

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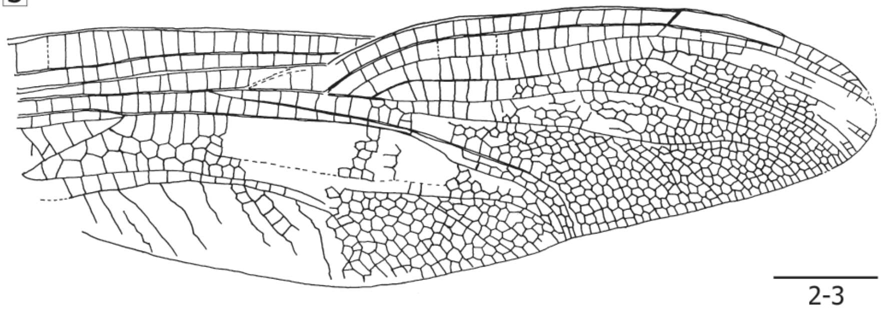

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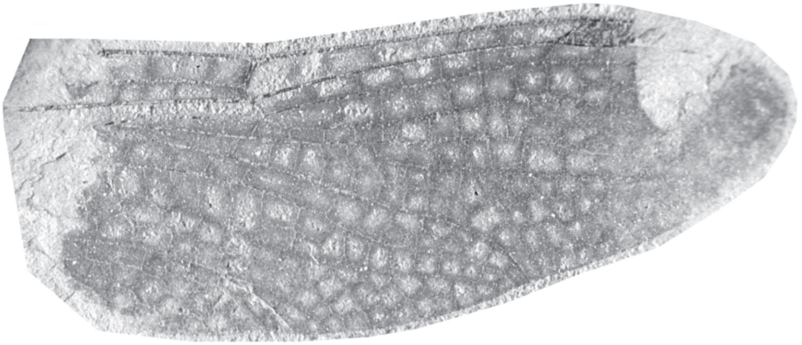

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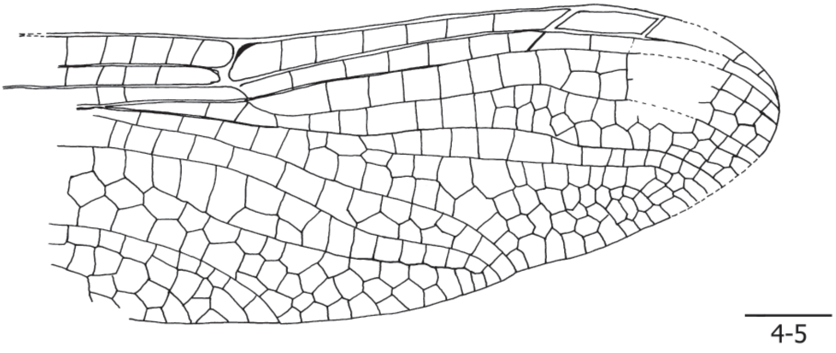

cells between them and IR2 or MA"; "space between IR2 and Rspl basally divided by oblique intercalary veinlets";"more than 2 rows of cells in basal part of postdiscoidal area between level of distal angle of discoidal triangle and level of midfork"; "hypertriangles traversed by at least 3 cross-veins in forewings". As all these characters are convergently present in some other aeshnopterid groups, it is difficult to consider them as very accurate characters. Nevertheless, their combination is only present in Aeshnidae. Within this family, *Kvacekia* gen. n. shares with the Oplonaeschninae Bechly, 1996 the unique autapomorphy of this subfamily, "IR2 unbranched", that Bechly (1996, 2002) considered as a reversion. Note that some *Aeshna* spp. (among others, *A. coerulea* (Ström, 1783); *A. septentrionalis* Burmeister, 1839; *A. ollivieri* Nel, 1986) have a very rudimentary division of IR2 into a strong posterior branch and a weak more or less zigzagged anterior branch (Nel et al. 1994). *Kvacekia* gen. n. has no trace of such an anterior branch of IR2. Bechly (1996, 2002) included in this group the recent genus *Oplonaeschna* Selys, 1883 (plus maybe *Basiaeschna* Selys, 1883). *Kvacekia* gen. n. differs from *Basiaeschna* and *Oplonaeschna* in the following characters: "presence of 4 cross-veins in fore wing hypertriangle, instead of 2 in *Basiaeschna* and 3 in *Oplonaeschna*', "broader postdiscoidal area with 3 rows of cells just distal of discoidal triangle, instead of 2 in both *Basiaeschna* and *Oplonaeschna*", "broader areas between Mspl and MA and between Rspl and IR2, with 5 rows of cells, instead of 3–4 rows in *Oplonaeschna* and 2–3 rows in *Basiaeschna*". Furthermore, it differs from *Oplonaeschna* in the following characters: "pterostigma distinctly longer covering 5–6 cells instead of 3 in *Oplonaeschna*". The pterostigma of *Basiaeschna* is covering 4 cells. Nel et al. (1994) revised the Oligocene genus *Oligaeschna* Piton and Théobald, 1939 (type species *O. jungi* Piton et Théobald, 1939) and considered it as closely related to *Oplonaeschna* (maybe its sister genus). They also transferred 4 fossil species from *Oplonaeschna* into *Oligaeschna*, i. e. *O. separata* (Scudder, 1890), *O. lapidaria* (Cockerell et Counts, 1913), *O. ashutasica* (Martynov, 1929) and *O. palaeocoerulea* (Timon-David, 1946). *Kvacekia* gen. n. shares with *Oligaeschna* its long pterostigma (plesiomorphy), and its postdiscoidal area with 3 rows of cells just distal of discoidal triangle (synapomorphy) (Nel et al. 1994). It differs from *Oligaeschna jungi* Piton et Théobald, 1939 and O. *separata* in its distinctly broader cubito-anal area, with about 9 rows of cells between CuA and posterior fore wing margin, instead of 5 in *O. jungi* and *O. separata* (Scudder 1890: Pl. 13, Fig. 15). Unfortunately, this structure is missing in the type specimen of *O. palaeocoerulea*. Nevertheless, this last species is characterized by its very broad area between IR2 and RP2, with 9 rows of cells along posterior wing margin, instead of 5 rows in *Kvacekia* gen. n. and *O. jungi* (direct exam of type specimen, Timon-David, 1946). *Oligaeschna lapidaria* is based on a hind wing. Thus, it is not possible to compare the width of its cubito-anal area to that of the fore wing of *Kvacekia* gen. n. Nevertheless, it differs from *Kvacekia* gen. n. in its pterostigma covering only 3 cells, instead of 5–6 in *Kvacekia* gen. n. and in its hyaline wing (Cockerell 1913). *Oligaeschna ashutasica* is based on a hind wing. Nevertheless its pterostigma is covering 4 cells instead of 5–6 in *Kvacekia* gen. n., and it has 3 rows of cells between IR2 and RP2, instead of 5 in *Kvacekia* gen. n. (Martynov 1929: text and fig. 4).

Nothing is known about the wing coloration of *Oligaeschna jungi* because no trace of coloration is preserved in all known specimens, and of *O. ashutasica*, as Martynov (1929) indicated nothing about this point. All other *Oligaeschna* species have hyaline wings, as many recent Aeshnidae. Some recent Aeshnidae (among others, *Subaeschna francesca* Martin, 1909 and *Agyrt-*

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Figs 2–5. 2, 3 – *Kvacekia infuscata* gen. n. et sp. n., holotype specimen P1193 – photo and line drawing of forewing venation. Scale 5 mm. 4–5 – *Gomphaeschna miocenica* sp. n., holotype specimen ZD0184 – photo and line drawing of forewing venation. Scale 3 mm.

acantha disrupta (Karsch, 1889) have a wing coloration very similar to that of *Kvacekia* gen. n. (Martin 1908).

NOTE. Three fossil species *Oplonaeschna vectensis* Cockerell et Andrews, 1916, *Oplonaeschna staurophlebioides* Henriksen, 1922 and *Oplonaeschna metis* (Heer, 1849) are based on rather poorly preserved specimens. Nel et al. (1994) considered them as Aeshnidae of uncertain position.

Family Gomphaeschnidae Tillyard et Fraser, 1940 (sensu Bechly 1996 and Bechly et al. 2001)

***Gomphaeschna miocenica* sp. n.**

(Figs 4, 5)

DIAGNOSIS. This species differs from all other described *Gomphaeschna* in the following points: (1) wing not hyaline but with all veins underlined by dark coloration and central part of each cell hyaline; (2) undulated IR2; (3) area between IR2 and RP2 not narrowed near wing margin, with 3 rows of cells; (4) only 3 rows of cells between RP1 and RP2 along wing margin; (5) pterostigma relatively long, covering 2 cells.

DESCRIPTION. Distal part of a forewing (wing rather narrow below nodus); with all veins underlined by dark coloration and central part of each cell hyaline; probable length, about 40 mm; distance between nodus and apex, 19.0 mm, between nodus and pterostigma, 11.1 mm, between pterostigma and apex, about 4.3 mm; pterostigma, 3.3 mm long and 1.1 mm wide, with its costal and posterior sides slightly widened in middle; pterostigmal brace not elongate, straight and only slightly oblique; pterostigma covering 2 cells; 6 postnodal cross-veins not aligned with the corresponding postsubnodal cross-veins; 5 antenodal cross-veins of first row preserved, not aligned with those of second row, last antenodal cross-vein of first row incomplete, i. e. with no corresponding cross-vein of second row; 2 preserved cross-veins between RA and RP basal of subnodus, presence of the antesubnodal gap; 2 Bq cross-veins between IR2 and RP2; MP curved and reaching posterior wing margin opposite nodus; 3 rows of cells in postdiscoidal area just basal of Mspl; Mspl slightly curved, distally weakly zigzagged, with 1–2 row of cells between it and MA; RP3/4 and MA are basally nearly straight but distally curved and nearly perpendicular to posterior wing margin; a short zigzagged intercalary vein between RP3/4 and MA in their distal part, but not ending on posterior wing margin; RP2 aligned with subnodus; oblique cross-vein 'O' 1.1 mm distal of subnodus; IR2 nearly straight; RP2 with 2 weak but distinct undulations; IR2 and RP2 distally curved and nearly perpendicular to posterior wing margin; area between IR2 and RP2 rather widened in its distal half, with 2–3 rows of cells between them; a nearly straight vein Rspl, slightly curved in its distal end, with one row of cells between it and IR2; area between RP1 and RP2 rather wide, with 3 rows of cells between them, but incompletely preserved, with a rather short and zigzagged IR1.

TYPE MATERIAL. **Holotype**: specimen ZD0184 (Bílina mine coll., Czech Republic), distal half of fore wing (imprint) with venation well preserved.

TYPE LOCALITY. Bilina mine, Czech Republic.

TYPE STRATA. Lower Miocene (Eggenburgian/Ottnangian), Most Formation, Clay Superseam Horizon.

ETYMOLOGY. Named after the Miocene age of the fossil.

DISCUSSION. The specimen is clearly attributable to the clade Aeshnoptera because of the presence of a clear vein Rspl, undulation of RP3/4 and MA and the narrow area between RP1 and RP2 basal of pterostigma. It can be included in Gomphaeschnidae Tillyard et Fraser, 1940 (sensu Bechly 1996 and Bechly et al. 2001) because it has one of its main synapomorphies, viz. "the most distal part of the antesubnodal area between RA and RP is free of antesubnodal cross-veins", although this character is less pronounced in *Oligoaeschna* Selys, 1889 (in other *Gomphaeschna* Selys, 1871 species and *Gomphaeschna miocenica* sp. n., the most distal cross-vein of this area is opposite the base of IR2, but there is one more in a slightly distal position at least in *Oligoaeschna pryeri* (Martin, 1909) and *Oligoaeschna modigliani* (Selys, 1889).

Within this family, the autapomorphy of the fossil subfamily Gomphaeschnaoidinae Bechly et al., 2001 that could be visible in *G. miocenica* sp. n. is absent in this taxon: its pterostigmal brace vein is not very oblique. The other autapomorphies of the Gomphaeschnaoidinae are unknown in *G. miocenica* sp. n.: "only a single secondary antenodal cross-vein between Ax1 and Ax2 aligned like a primary antenodal bracket" and "in forewing, Ax2 shifted basally on level of basal angle of discoidal triangle". As *G. miocenica* sp. n. has a plesiomorphic state of character, it is not sufficient to exclude it from this subfamily. Also, the other subfamily "Gomphaeschninae" (sensu Bechly et al. 2001) has no known autapomorphy and could be paraphyletic. Nevertheless, *G. miocenica* sp. n. is very different from all Gomphaeschnaoidini in its pterostigmal brace not undulating, the absence of any basally widened cell below pterostigma, its cross-veins between RP2 and RP1 all similar, not oblique. It also differs from the unique representative of the Sinojagorini Bechly et al., 2001 (*Sinojagoria* Bechly et al., 2001) in its less numerous postnodal cross-veins and in the basal part of area between RP2 and RP1 (6 against 10–12). Lastly, it differs from the Lower Cretaceous *Anomalaeschna berndschusteri* Bechly et al., 2001 in its distinctly longer pterostigma, covering 2 cells instead of only one.

Within "Gomphaeschninae", the recent genus *Linaeschna* Martin, 1909 is very different from *G. miocenica* sp. n. in its very long postnodal area with numerous cross-veins and its absence of gap in the distal part of antesubnodal area (Martin 1909). Bechly et al. (2001) considered that this genus could belong to a different family of the clade Aeshnoptera. The remaining genera are *Gomphaeschna*, *Oligoaeschna*, *Alloaeschna* Wighton et Wilson, 1986 and *Cretalloaeschna* Jarzembowski et Nel, 1996.

The Lower Cretaceous *Cretalloaeschna* differs from *G. miocenica* sp. n. in the following characters: (1) presence of one row of cells between RP3/4 and MA, (2) a straight IR2, (3) only 2 rows of cells between IR2 and RP2, (4) 4–5 rows of cells between RP2 and RP1, instead of 3 in *G. miocenica* sp. n. (Bechly et al. 2001). These authors indicated that character (1) could represent a synapomorphy of *Cretalloaeschna* with *Gomphaeschna*, *Gomphaeschnoides* Carle et Wighton, 1990 (in Gomphaeschnaoidini), and *Alloaeschna*, but some specimens attributed to *Alloaeschna paskapooensis* Wighton et Wilson, 1986 have 2 rows of cells defining a long zigzagged vein between RP3/4 and MA. Thus, this character is at least not so important, if subject to intraspecific variation.

The Late Paleocene genus *Alloaeschna* (at least *A. paskapooensis* and maybe *A. marklae* Wighton et Wilson, 1986) shares the autapomorphies proposed by Bechly et al. (2001) for the Gomphaeschnaoidini, i. e. "presence of a characteristic elongate distal paranal cell in hindwing, longer than wide, directly basal of the anal loop" (see Wighton & Wilson 1986: Figs 1–10). In *Oligoaeschna* and *Gomphaeschna*, the corresponding cell is quadrate or transverse, wider than long; "pterostigmal brace vein somewhat undulating"; "basally widened cell bellow pterostigma, caused by a curvature of RP1 at pterostigmal brace"; "posterior branches of CuAa relatively weakly defined in hind wing" (at least in some specimens of *Alloaeschna paskapooensis*). Thus, we propose to transfer *Alloaeschna* to this tribe, previously only known in Lower Cretaceous. It would be its most recent representative in Early Cenozoic. As noted above, the preserved corresponding characters of pterostigmal region are different in *Gomphaeschna miocenica* sp. n.

It is extremely difficult to separate the two genera *Gomphaeschna* and *Oligoaeschna* on the sole basis of the wing venation characters. Madsen & Nel (1997) proposed to use the presence of only 1–2 Bq cross-veins in *Gomphaeschna* instead of 3 in *Oligoaeschna*. Bechly et al. (2001: 197) attributed the two Cretaceous species ?*Gomphaeschna inferna* Pritykina, 1977 and ?*G. sibirica* Bechly et al., 2001 to the genus *Gomphaeschna* on the basis of "a reduced wing venation with fewer rows of cells between the main veins, and a short pterostigma with only one or two cells beneath it." *G. miocenica* sp. n. has 2 Bq cross-veins and a short pterostigma covering only 2 cells. Thus, we tentatively attribute it to *Gomphaeschna* rather than to *Oligoaeschna*.

Gomphaeschna miocenica sp. n. differs from ?*G. inferna* in its undulated IR2 and area between IR2 and RP2 not narrowed near wing margin, with 3 rows of cells, instead of 2 in ?*G. inferna*. *G. miocenica* sp. n. differs from ?*G. sibirica* in the presence of only 3 rows of cells between RP1 and RP2 along wing margin, instead of 7. *G. miocenica* sp. n. differs from recent *Gomphaeschna furcillata* (Say, 1839) in its longer pterostigma covering 2 cells, instead of one cell and a half, the presence of 3 rows of cells between IR2 and RP2, instead of 1–2 rows and its IR2 distinctly undulated. *G. miocenica* sp. n. also differs from the two Paleocene/Eocene *Gomphaeschna paleocenica* Madsen et Nel, 1997 and ?*Gomphaeschna danica* Madsen et Nel, 1997 in its IR2 undulated, instead of being straight. Another important difference with all species of *Gomphaeschna* is the particular wing coloration of *G. miocenica* sp. n. All recent and fossil *Gomphaeschna* have hyaline wings (maybe except ?*G. sibirica* only known after a fossil with no preserved coloration).

PALAEOGEOGRAPHIC REMARKS

Recent species of *Oplonaeschna* and *Basiaeschna* are North American. The fossil genus *Oligaeschna* is known from the Oligocene of France, USA and Siberia. This suggests a Holarctic distribution of the Oplonaeschninae but little is known about the Cenozoic record of Gondwanian Aeshnoptera.

Recent species *G. furcillata* (Say, 1839) and *G. antillope* Hagen, 1874 are distributed in the North America (USA), fossil members are known from Lower Cretaceous (?*G. inferna* – Baissa in Buryat Republic, Sibieria and ?*G. sibirica* – Chita region, Siberia, Russia) and Upper Paleocene/Lower Eocene (*G. paleocenica*, ?*G. danica* – Moclay in Denmark). Other related genus *Oligoaeschna* is recently living in South-east Asia and fossil representatives are known from Upper Eocene: *O. anglica* Cockerel et Andrews, 1916 – Gurnet Bay, Isle of Wight, UK; Lower Oligocene: *O. needhami* (Cockerell, 1913) – Florissant, Colorado, USA, *O. oligocenica* (Nel et Papazian, 1983) – Aix-en-Provence, France, *O. conjuncta* (Martynov, 1929) – Ashutas Mountains, Zaisan, Siberia; Lower Miocene: '*Projagoria conjuncta* Martynov, 1929' (*sensu* Zeuner 1938) – "Mainzer Hydrobienkalks", Germany, *Oligoaschna sinica* (Zhang, 1989) comb. nov. – Miocene, Shanwang, Shandong, China, and Upper Pliocene: *Oligoaeschna* sp. (Esaki & Asahina 1957, Nel et al. 1994) – Nagasaki Prefecture, Japan. The fossil genus *Alloaeschna* is known from Paleocene (*A. paskapooensis*, *A. marklae* Wington et Wilson, 1986, *A. quadrata* Wighton et Wilson, 1986 – Blackfalds in Alberta, Canada). All other representatives of the Gomphaeschnaoidinae are from the Lower Cretaceous of China, Mongolia, UK and Brazil. From these palaeogeographical data we can assume a very wide, maybe almost cosmopolitan distribution of the family during the Lower Cretaceous, a wide Holarctic distribution of the subfamily Gomphaeschninae during the Tertiary and a more marginal occurrence of the taxa present today.

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REFERENCES

Bachmayer F. 1952: Fossile Libellenlarven aus miozänen Süßwasserablagerungen. *Sitzungsber. Oesterreich. Akad. Wiss., Math.-Naturwiss. Kl.* **161**: 135–140.

Bechly G. 1996: 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* **2** (Spec. Vol): 1–402.

Bechly G. 2002: *Phylogenetic systematics of Odonata*. Homepage on the Internet: http://members.tripod.de/GBechly/phylosys.htm

Bechly G., Nel A., Martínez-Delclňs X., Jarzembowski E. A., Coram R., Martill D., Fleck G., Escuillié F., Wisshak M. M. & Maisch M. 2001: A revision and phylogenetic study of Mesozoic Aeshnoptera, with description of several new families, genera and species (Insecta: Odonata: Anisoptera). *N. Paläontol. Abh.* **4**: 1–219.

Bůžek Č., Dvořák Z., Kvaček Z. & Prokš M. 1992: Tertiary vegetation and depositional environments of the "Bílina delta" in the North-Bohemian brown-coal basin. *Čas. Mineral. Geol.* **37:** 117–134.

Cockerell T. D. A. 1913: Two fossil insects from Florissant with a discussion of the venation of the aeschnine dragon-flies. *Proc. U. S. Natl. Mus.* **45**: 577–583.

Dašková J. 2000: [Preliminary micropaleobotanical characterization of a sample from the roof of the main brown-coal seam from the Bílina Mine (North Bohemia)]. *Zpr. Geol. Výzk. v Roce* **1999**: 128–129 (in Czech).

Handlirsch A. 1906–1908: *Die fossilen Insekten und die Phylogenie der rezenten Formen. Ein Handbuch für Paläontologen und Zoologen*. Leipzig: V. W. Engelmann Publ., 1430 pp. [published in parts between 1906 and 1908 as follows: pp. i–vi, 1–160, pls. 1–9 (May 1906); pp. 161–320, pls. 10–18 (June 1906); pp. 321–480, pls. 19–27 (August 1906); pp. 481–640, pls. 28–36 (October 1906); pp. 641–800, pls. 37–45 (February 1907); pp. 801–960, pls. 46–51 (June 1907); pp. 961–1120 (November 1907); pp. 1121–1280 (January 1908); pp. vii–ix, 1281–1430 (July 1908). Dated from publication information given on p. ix.]

Heer O. 1849: Die Insektenfauna der Tertiärgebilde von Śningen und von Radoboj in Croatien. Zweite Abtheilung: Heuschrecken, Florfliegen, Aderflüger, Schmetterlinge und Fliegen. *Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für der Gesammten Naturwissenschaften* (Zürich) **11**: iv + 1–264.

Kukalová J. 1962: *Třetihorní hmyz* [*Tertiary Insects*]. Geofond, Unpublished MS. Praha: Charles University, 3 pp (in Czech).

Kukalová-Peck J. 1991: Fossil history and the evolution of hexapod structures. Pp.: 141–179. In: CSIRO (ed.): *The insects of Australia, a textbook for students and research workers (2nd ed.) Vol. 1*. Melbourne: Melbourne University Press, 542 pp.

Kvaček Z. 1998: Bílina: a window on Early Miocene marshland environments. *Rev. Palaeobot. Palynol.* **101**: 111–113.

Kvaček Z. & Walter H. 1998: The Oligocene vocanic flora of Kundratice near Litoměřice, České středohoří volcanic complex (Czech Republic). *Acta Mus. Natl. Pragae, Ser. B, Histor. Natur.* **54**: 1–42.

Madsen H. O. R. & Nel A. 1997: Two new fossil species of Gomphaeschna Selys, 1871 in the Paleocene/Eocene of Denmark. *Ann. Soc. Entomol. Fr. (N. S.)* **33**: 285–293.

Martin R. 1908. Aeschnines. *Collections zoologiques du Baron Edm. de Selys Longchamps, Catalogue systématique et descriptif* (Haye and Brussels) **18**: 1–84.

Martin R. 1909. Aeschnines. *Collections zoologiques du Baron Edm. de Selys Longchamps, Catalogue systématique et descriptif* (Haye and Brussels) **19**: 85–156.

Martynov A. 1929: Fossil insects from Tertiary deposits in Ashutas Saisan district. *Tr. Geol. Mus. Akad. Nauk SSSR* **5**: 173–216.

Nel A., Martínez-Delclňs X., Escuillé F. & Brisac P. 1994: Les Aeshnidae fossiles. Un inventaire critique (Odonata, Anisoptera). *N. Jahrb. Geol. Paläontol. Abh.* **194**: 143–186.

Nel A., Martínez-Delclňs X., Paicheler J. C. & Henrotay M. 1993: Les "Anisozygoptera" fossiles. Phylogénie et classification. (Odonata). *Martinia, Num. Hors. Ser.* **3**: 1–311.

Obrhelová N. 1979: Süsswasser-Ichthyofauna im Tertiär der ČSSR. *Čas. Mineral. Geol.* **24**: 135–146.

Prokop J. 2002: Remarks on palaeoenviromental changes based on reviewed Tertiary insect associations from the Krušné hory piedmont basins and the České středohoří Mts. in northwestern Bohemia (Czech Republic). *Acta Zool. Cracov.* **45**: in press.

Prokop J. & Nel A. 2000: New fossil dragonflies from the Lower Miocene of the northern Bohemia (Odonata: Aeshnidae). *Eur. J. Entomol.* **97**: 427–431.

Rajchl M. & Uličný D. 1999: Sedimentární model bílinské delty (Miocén, Mostecká Pánev) [Deposital model of the Bílina Delta (Miocene, Most Basin, Czech Republic)]. *Zpravod. Hnědé Uhlí* **1999**(3): 15–42.

RIEK F. & KUKALOVÁ–PECK J. 1984: A new interpretation of dragonfly wing venation based upon early Upper Carboniferous fossils from Argentina (Insecta: Odonatoidea) and basic character states in pterygote wings. *Can. J. Zool.* **62**: 1150–1166.

ŘÍHA P. 1977: Tercierní hmyz chebské a sokolovské pánve. Pp.: 19–22. In: HOLÝ F. (ed.): *Sborník 8. celostátní paleontologické konference v Sokolově*. Sokolov: Propag.

ŘÍHA P. 1979: Katalog der Tertären und Quartären fossilen insekten der Tsechoslowakei *Entomol. Probl.* **15**: 13–32.

SAKALA J. 2000: Flora and vegetation of the roof of the main lignite seam in the Bílina Mine (Most Basin, Lower Miocene). *Acta Mus. Natl. Pragae, Ser. B, Hisort. Natur.* **56**: 49–84.

SCUDDER S. H. 1890: The fossil insects of North America (with notes on some European species). 2. The Tertiary insects. *Rep. U. S. Geol. Surv. Territ.* **13**: 1–734.

TIMON-DAVID J. 1946: Insectes fossiles de l'Oligocčne inférieur des Camoins. 3. Description d'une nouvelle espčce d'Odonate. *Bull. Soc. Entomol. Fr.* **51**: 94–96.

WIGHTON D.C. & WILSON M. V. H. 1986: The Gomphaeschninae (Odonata: Aeshnidae): new fossil genus, reconstructed phylogeny, and geographical history. *Syst. Entomol.* **11**: 505–522.

ZHANG J. F. 1989: [*Fossil insects from Shanwang, Shandong, China*]. Jinan: Shandong Science and Technology Publ. House, 459 pp (in Chinese, Engl. abstr.).