Corduliochlora gen. nov. from the Balkans (Odonata: Corduliidae)

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Abstract

The adult morphology of the recently established species *Somatochlora borisi* Marinov, 2001 is outlined. The species has a unique combination of features, especially when compared to representatives of the two closest European genera, *Cordulia* Leach, 1815 and *Somatochlora* Selys, 1871 but also compared to other Holarctic genera and species within the Corduliinae (sensu Garrison et al. 2006). The extent of these morphological differences suggests that the species can not be assigned to any of the extant genera, and therefore the new genus *Corduliochlora* is being established.

Key words: Balkan Peninsula, Bulgaria, Odonata, dragonfly, taxonomy, Corduliochlora, Cordulia, Somatochlora.

Introduction

Somatochlora borisi Marinov, 2001 has been described as the eighth (*S. arctica* (Zetterstedt, 1840), *S. alpestris* (Selys, 1840), *S. flavomaculata* (Vander Linden, 1825), *S. metallica* (Vander Linden, 1825), *S. meridionalis* Nielsen, 1935, *S. sahlbergi* Trybom, 1889, *S. metallica abocanica* Belyshev, 1955) representative of the genus in Europe. Its currently known distribution is restricted to southeastern Balkans that comprises parts of Bulgaria, Greece and Turkey (Boudot et al. 2004). The species was assigned to the genus *Somatochlora* because of two main morphological features found in the type series, i.e. the lack of mesotibial keels (see Fig. 1) and the presence of two cubitoanal crossveins on the hindwings (see Fig. 2).

However, in other morphological features as well as in ecological respect it deviates from *Somatochlora*. For example, the species has an early flying season between mid-May and late June and prefers shaded rivers ca 1-5 m wide and 0.50-1.50 m deep (Marinov 2001a). Recent investigations reveal more morphological features, which shed new light on the generic assignation of this species. Here we present the results that we interpret in favour of a newly established genus.

Material and methods

The study was carried out during the spring and summer of 2003-2005. Imagoes of *Somatochlora borisi* (n = 4) and *S. meridionalis* (n = 3) were collected in the Eastern Rhodopes, Bulgaria. For comparison, individuals of three related species, *Cordulia aenea* (Linnaeus, 1758) (n = 1) from the Vitosha Mountain, *S. arctica* (n = 2) and *S. metallica* (n = 2) from the Rila Mountain, were also collected. All *borisi* specimens were compared with the aforementioned Bulgarian corduliid species as well as with the Nearctic Corduliinae genera *Cordulia* Leach, 1815, *Dorocordulia* Needham, 1901, *Epicordulia* Selys, 1871, *Helocordulia* Needham, 1901, *Neurocordulia* Selys, 1871, *Somatochlora* Selys, 1871, *Tetragoneuria* Hagen, 1861 and *Williamsonia* Davis, 1913 using the descriptions in Needham et al. 2000 and Garrison et al. 2006. It should be noted that, in the present paper, the Corduliinae are treated as a subfamily of the Corduliidae (e.g. Davies and Tobin 1985, Bridges 1994) rather than as a member of the Libellulidae (Needham et al. 2000, Garrison et al. 2006). East Palaearctic species of the Corduliinae were briefly compared to the descriptions in Schmidt (1957), Belyshev (1973) and Hamada and Inoue (1985) but were not included in the detailed analysis, because the relevant *Somatochlora* species are morphologically and ecologically unlike *S. borisi*.

Terminology for wing venation follows Riek and Kukalovà-Peck (1984).

Results

Morphologically the taxon *borisi* fitted well the description of the Corduliinae (sensu Davies and Tobin 1985, Bridges 1994). A comparison with European representatives of the genera *Cordulia* and *Somatochlora* showed that *borisi* differs in most of 17 key characters (Table 1). Furthermore, borisi also shows a unique combination of characters when compared to eight Nearctic genera (Table 2). Therefore, we suggest establishing a new genus named *Corduliochlora* with *borisi* as the type species.

Table 1: Differences between the taxon borisi and the genera *Somatochlora* and *Cordulia*.

Diagnostic feature	borisi	Somatochlora	Cordulia
Head: Coloration of frons	Yellow on both sides with inner lower edges closing towards each other	Yellow spots or transverse bar	Totally green; no yellow marks
Head: Occipital triangle	Dorsally convex wide triangular, flat and medially notched	Broad ovoid protruding and scarcely notched	Dorsally convex wide triangular, flat and medially notched
Head: Ratio frons width: tibia 3 length	approx. 1:1,9	approx. 1:1,8	approx. 1:2,0
Fw: Cross vein at origin of arculus	Straight	Mostly kinked	About straight
Fw: Triangle distal side	More oblique	More oblique	Less oblique
Hw: Anal triangle separated by the cross vein	Deeper= 1,5 : 1	Higher= 1.5 : 1	Deeper= 1,5 : 1
Hw: cubito-anal cross veins	2	2	1
Hw: Discoidal cell	Crossed or uncrossed	Crossed or uncrossed	Uncrossed
Hw: Arculus contacts	Distally at the end of triangle	Mostly at the end of the triangle	Distally at the end of triangle
Coloration of base	Slightly yellow-orange	Slightly yellow-orange	Strongly yellow-orange
Male appendages: tip of superior	Blunt	Acute	Blunt
Ventrobasal teeth of superior	Strong	Strong	Reduced
Length of inferior compared with superior	Shorter	Shorter	Same
Distal end of inferior	Slightly divided	Narrowed	Strongly divided
Male secondary genitalia: genital lobe	Almost rectangular shaped with strong projection at the distal angle	Widely rounded at the top	Elongated pointed at the top
Male secondary genitalia: hamulus	Short strongly acute at the top	Long and wide slightly acute at the top	Long and narrow at the top
Female vulvar scale	Short semicircular with a deep narrow cleft to its base	Short or long, acute or with slight notch	Short with a deep wide cleft not reaching the base

Table 2: Differences between the imagoes of taxon *borisi* and the Nearctic Corduliinae genera - MA/MP: these veins parallel in Fw; App.: blunt male appendages; Keel: presence of mesotibial keels; Vein: number of cubito-anal cross veins in Hw; Vulv. - female vulvar scale very deeply or completely clefted.

Taxon/diagnostic features	MA/MP	App.	Keel	Vein	Vulv.
Corduliochlora	Yes	Yes	No	2	Yes
Cordulia	Yes	Yes	Vestigial	1	Yes
Dorocordulia	Yes	No	Vestigial	1	No
Epicordulia	Yes	Yes	Yes	1	Yes
Helocordulia	Yes	Yes	Yes	1	Yes
Neurocordulia	No	No	Yes	2	No
Somatochlora	Yes	No	No[1]	2	No
Tetragoneuria	Yes	Yes	Yes	1	Yes
Williamsonia	No	Yes	No	1	Yes

1 Some *Somatochlora linearis* only have short, but defined mesotibial keels, approximately half the length of the protibial keels.

Etymology

The feminine name is based on the shape and colour of the body. It has two stem components, "cordulius (-a, -um)" = club-shaped and "chloros (-a, -on)" = green. The name is used as a feminine noun.

Type species

Somatochlora borisi Marinov, 2001, now *Corduliochlora borisi* (Marinov, 2001). No other species is known to science so far.

Description

Species of moderate size, total length incl. appendages 45-49 mm; Hw 31-33.5 mm, a typical dark green corduliine dragonfly with metallic shine.

Head: Frons metallic green with yellow markings.

Legs: Male tibial keels in fore legs reduced, absent in middle legs (Fig. 1) and well developed in hind legs.

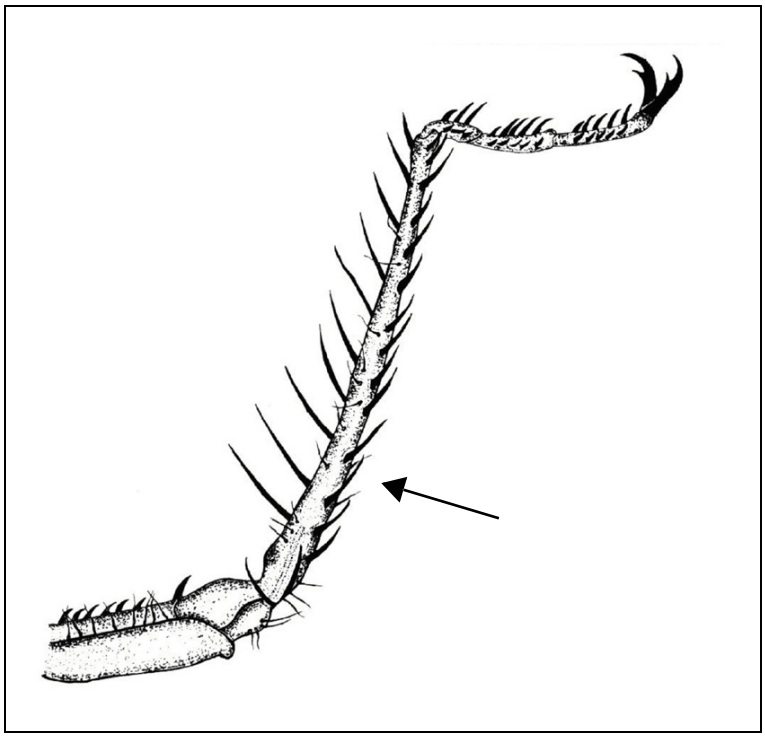

Figure 1: Mesotibia of the male of *Corduliochlora borisi*, ventral view.

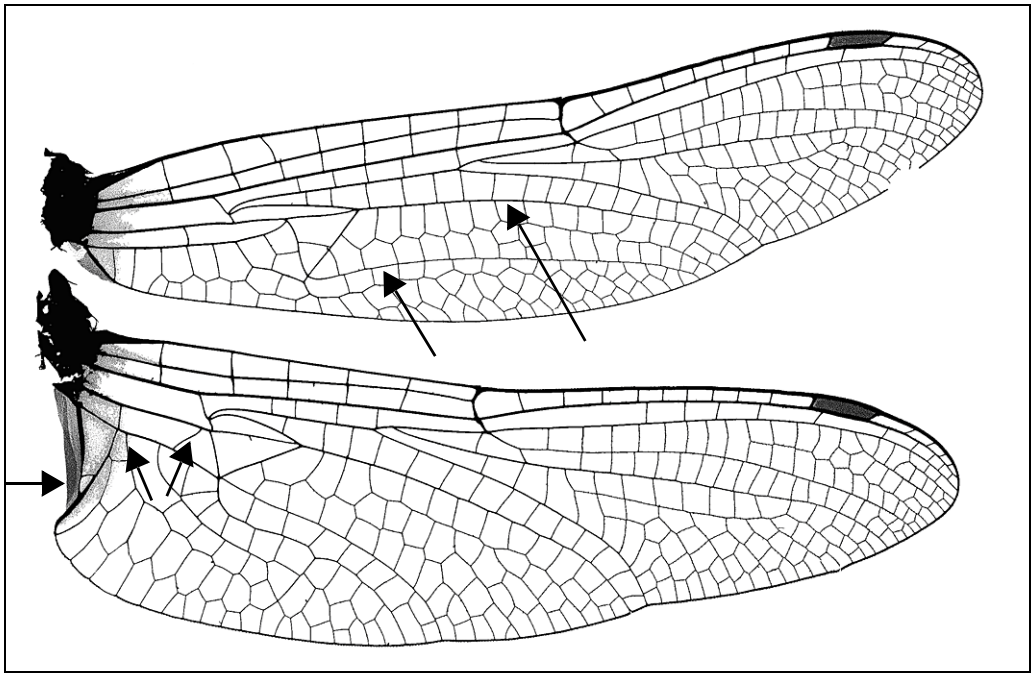

Figure 2: Wing venation of *Corduliochlora borisi*.

Wings: Hyaline with slight amber covering the anal triangle; supratriangles free of crossveins (Fig. 2). In the forewing the veins MA and MP converge to the wing margin and run parallel for most of the distance. These two veins enclose two rows of cells with some extra cells, occasionally with an additional (up to 5-celled) row.

The discoidal cell is divided by one or two crossveins, the subtriangles consist of 3 cells. The crossvein at the origin of arculus is straight. The hindwing has two cubito-anal crossveins. The discoidal cell free, rarely crossed by one vein, thus the triangle consists of 2 cells. The arculus contacts the triangle distally of its base. There is a well developed foot-shaped anal loop. The wide anal triangle at the proximal end has a ratio of width: length = 1 : 1.16-1.25. The triangle is crossed distally by one vein. The membranule ends far below the tip of anal triangle.

Abdomen: Male cerci are blunt and curved outwards and downwards at their tip (Fig. 3). The epiproct, slightly bifurcate at the tip, is curved up and slightly backwards. The female vulvar scale is deeply and narrowly divided (Fig. 4).

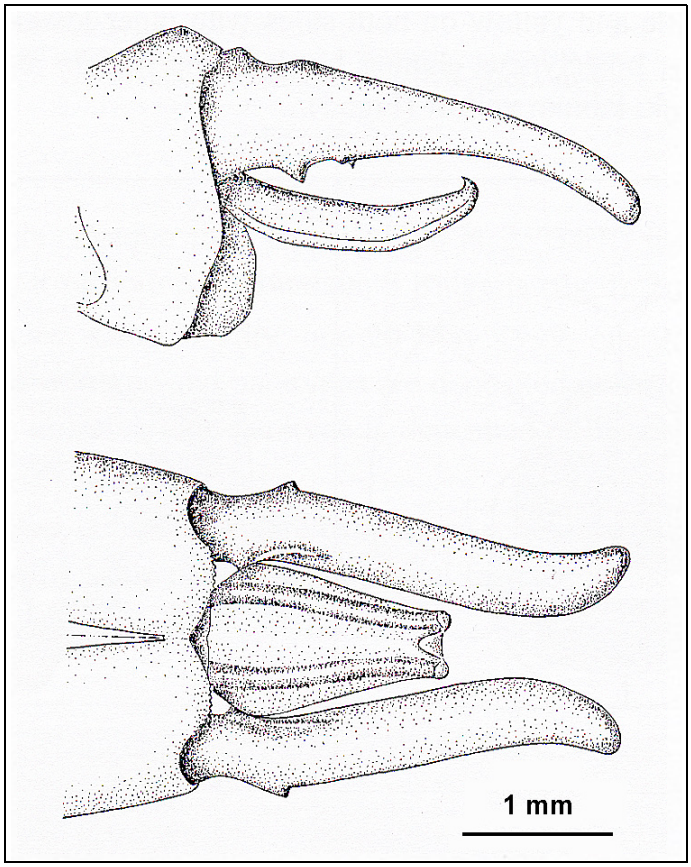

Figure 3: Male cerci of *Corduliochlora borisi*. Drawing by H. Wildermuth.

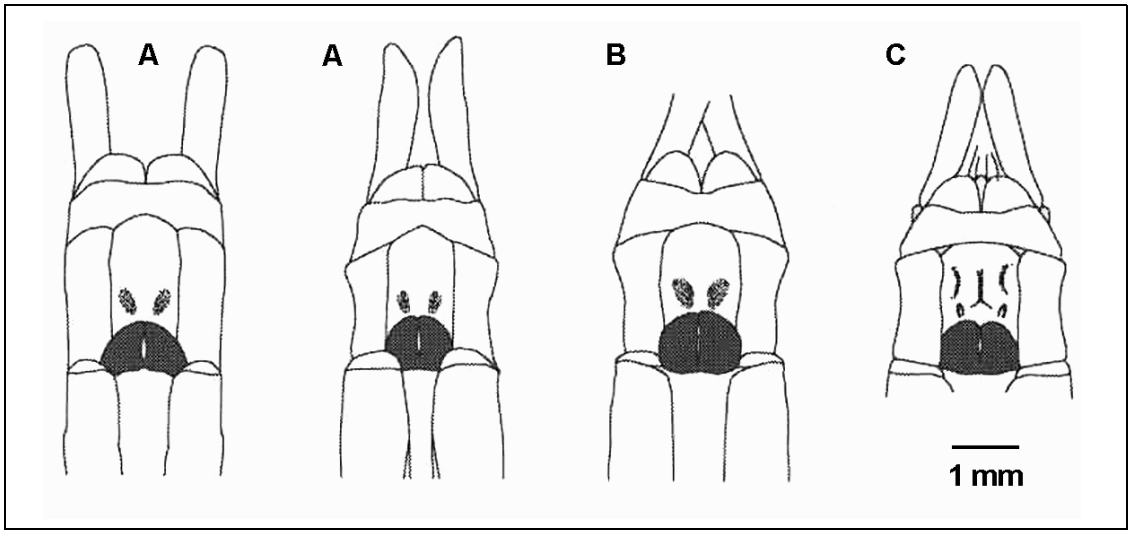

Figure 4: Female vulvar scale of *Corduliochlora borisi*. (A) Mikron Dherion - Greece, (B) Dadia - Greece, (C) Kiyiköj - Turkey. Figures with the permission of the editor of International Journal of Odonatology.

Diagnostic key

As the genus *Corduliochlora* is not known outside Europe, only the two closely related European corduliine genera with a metallic brownish green body are included.

(*Cordulia* seems to be to me more brown-metallic than green-metallic)

1. Frons green without yellow, in lateral view protruding prominently (Fig. 5a). Labium retracted to level of frontal border of eyes (Fig. 5a). One cubito-anal crossvein on Hw. Vesica spermalis S4 with a posterodorsal oblique hookshaped expression (arrestor hook) in males (Fig. 6) . . . . . *Cordulia*

- Frons green with large lateral spots, merging towards the middle or not, in lateral view less protruding, oblique (Fig. 5b). Labium surpasses level of frontal border of eyes (Fig. 5c). Two cubito-anal crossveins on Hw. Vesica spermalis S4 without a hookshaped expression (arrestor hook) in males 2

2. Male cerci blunt and curved downward. Female vulvar scale flat, short and semicircular in shape, deeply incised almost up to its base. . . . . *Corduliochlora* gen. nov.

- Male cerci acute, curved upward and in most species slightly backward. Female vulvar scale nearly as long as S9 or longer, acute or bilobed - concave or notched, but not cleft up to its base. . . . . *Somatochlora*

Discussion

This paper is the second one in a series of papers to demonstrate the unique generic characters of *Corduliochlora borisi*. It uses in a classic way morphological structures, measures and relations of morphological structures to support the generic character of *Corduliochlora*. Our arguments to establish a new genus are additionally supported by the analysis of the 18S rDNA gene (H.J. Dumont pers. comm., in prep.). More arguments are provided by cytogenetical data (Grozeva & Marinov 2007). *C. borisi* deviates widely from other corduliids, having unique for the family karyotype of 2n = 22 (neoXY). It is far different from the karyotype of 2n = 25 (X0) demonstrated in most corduliid species.

Morphological characters and nomenclature

With its green shiny body *Corduliochlora borisi* much resembles the European representatives of *Cordulia* and *Somatochlora*. It lacks unique morphological features but combines different characters of both closely related genera (see Key). That unique combination makes it easily recognizable within the entire Holarctic region, as no other Nearctic corduliine genus combines all of them. The convergence of MA and MP in the forewing clearly separates *Corduliochlora* from *Williamsonia* and *Neurocordulia*. *Corduliochlora* shares the blunt male superior appendages with *Cordulia*, *Epicordulia*, *Helocordulia* and *Tetragoneuria*, but not with *Dorocordulia*, *Neurocordulia* and *Somatochlora*. Although *D. lepida* (Hagen in Selys, 1871) and some *Somatochlora* species have their tips of the male appendages nearly rounded, they always end with a small sharp projection in *S. calverti* Williamson & Gloyd, 1933, with a prominent, ventral, subapical tooth in *S. ensigera* Martin, 1907 or clearly acute at the final tip in *D. lepida*, *S. franklini* (Selys, 1878), *S. margarita* Donnelly, 1962, *S. ozarkensis* Bird, 1933 and *S. provocans* Calvert, 1903. Moreover, the appendages of *C. borisi* diverge towards their tips. That is not the case in *Dorocordulia* and almost all *Somatochlora* species. *S. filosa* (Hagen, 1861) is the only species whose appendages diverge at the final 1/3 part to the end. However they are very sharply pointed and slightly curved each other at the very tips. Among the species with blunt appendages mesotibial keels are well developed in *Epicordulia*, *Helocordulia* and *Tetragoneuria*, but only vestigial in *Cordulia*. That is why only *Cordulia* approaches the condition of *Corduliochlora*. Both genera are similar having the male inferior appendages bifurcated - deeply divided in *Cordulia*, less obvious in *Corduliochlora*. The female vulvar scale is also similar shaped being short semicircular, but narrowly deeply divided almost till its base in *Corduliochlora* and widely incised about half length in *Cordulia*. The same general morphological features are typical of both representatives of *Helocordulia* - *H. selysii* (Hagen in Selys, 1878) and *H. uhleri* (Selys, 1871).

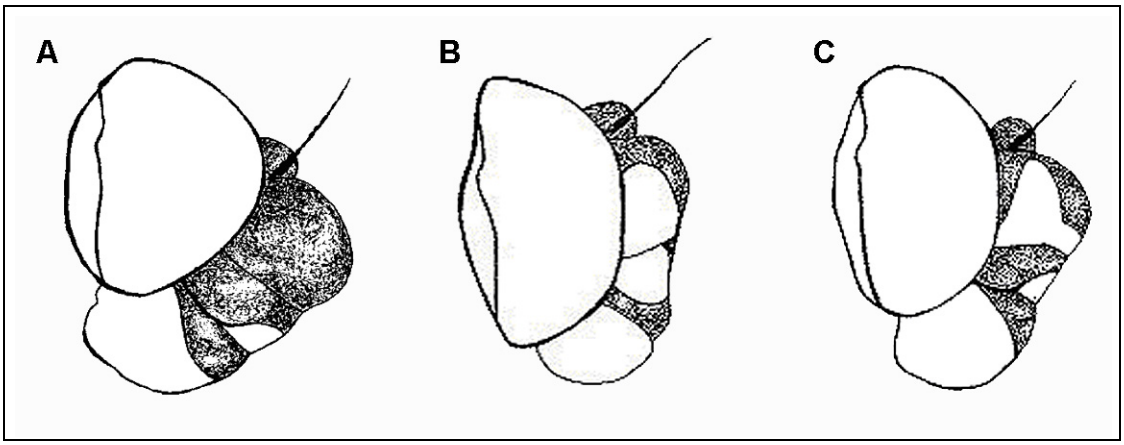

Figure 5: Comparison between heads of *Cordulia* vs *Corduliochlora* and *Somatochlora* - lateral view of heads of: (a) *Cordulia aenea*; (b) *Corduliochlora borisi*; (c) *Somatochlora metallica*.

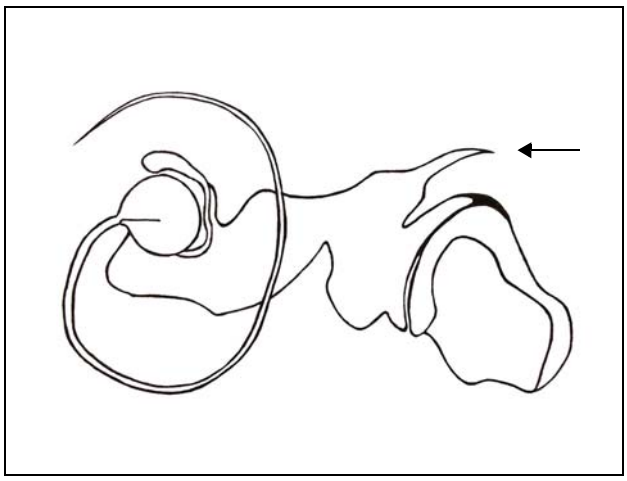

Figure 6: Vesica spermalis S4 of *Cordulia aenea*. Arrow points to the arrestor hook.

Especially striking is the similarity between *C. borisi* and *H. uhleri*. Big convergence is notable in the dorsal view of the male appendages and the shape of the female vulvar scale. However, other features, like the mesotibial keels, wing venation and general body coloration, distinguish well both genera. In spite of the similarities *Corduliochlora* can be distinguished by the number of cubito-anal crossvein on the hindwing (Tables 1, 2) and by some features of the head. *Cordulia* has a totally green frons prominently protruding in lateral view and the labium retracted to the level of the frontal border of the eyes (Fig. 3a). *Corduliochlora* has yellow margins on the frons, which is less protruding in lateral view, and its labium surpasses the level of the frontal border of the eyes (Fig. 3b).

Summarizing the analysis of morphological characters, *Corduliochlora* is closest to *Cordulia*, *Helocordulia* and *Somatochlora* but cannot convincingly assign to one of them. So we saw two possible solutions: (1) a new synopsis of all Corduliinae with a new generic conception, i.e. the grouping of *Cordulia*, *Helocordulia* and *Somatochlora* into one genus, which would also include the taxon *borisi*; or (2) the erection of a new genus *Corduliochlora* for the species borisi. We chose, in favour of a stable nomenclature, the second option.

Habitat and ecology

In addition to morphological deviation, *C. borisi* has been known for an ecological specialization compared to other members of the Corduliinae. All seven published localities (Boudot et al. 2004) and one additional - Veleka river close to the river's mouth and near the village of Sinemorets (42°04'N, 27°58'E), SE Bulgaria, May 2005 M. Marinov leg., May 2006 V. Kalkman leg. - are similar in their appearance. The rivers are elevated at 0-260 m a.s.l., shaded, and about 1-5 m wide and 0.50-1.50 m deep. The banks are overgrown with clusters of riparian vegetation. The bottom is muddy at most of the river's length with some stones at the faster stretches. Males patrol just over the water surface close to the banks, often hovering with their faces to the shore. Sunny parts of the river are avoided and passed with fast flight. S. meridionalis is the only European corduliid preferring similar places and behaving in a similar way. It also shares the same habitat with *C. borisi* but both species are phenologically well separated: the flying season of *C. borisi* comes to an end around the last decade of June, when that of S. meridionalis is just beginning. Both have been observed at the same time, but no aggressive interactions have been noticed (Marinov 2001a).

Several Nearctic relatives develop in rivers, too. All *Neurocordulia* species are known as fliers in shady places, often in twilight (Needham et al. 2000). They are often seen flying and females ovipositing mainly at dusk and until darkness (Glotzhober & McShaffrey 2002). Species from that genus also prefer moderately sized rivers. Sometimes they are seen over riffles of rivers, which are characterized with rocky banks (Dunkle 1989), which is not typical of *C. borisi*. Both *Helocordulia selysii* and *H. uhleri* prefer rivers, but with sunny areas and rocky places again. Males fly quite rapidly just above the water and even perch on stones (Glotzhober & McShaffrey 2002), which is also not typical of *C. borisi*. Running waters, like streams and seepages are used by some *Somatochlora* species, e.g. by *S. ensigera*, *S. hineana* Williamson, 1931, *S. linearis* (Hagen, 1861), *S. ozarkensis*, and *S. walshii* (Scudder, 1866). *S. tenebrosa* (Say, 1839) approaches *C. borisi* most in its habitat requirements - mainly shady forest streams, where males patrol over the water and are often seen flying in the evening even after sunset (Walker & Corbet 1975). However, *S. tenebrosa* apparently has a wider range of habitats than *C. borisi* as it has been found in shady fens and ponds, both acidic and alkaline (Kondratieff 2000).

Range

The range of distribution of *Corduliochlora* covers an area where other representatives of the Corduliidae have a patchy distribution. On the Balkan Peninsula they usually occur in mountainous regions, with the exception of *S. meridionalis*, the only other corduliid also occurring in lowlands and reproducing in rivers. Three other *Somatochlora* species and one *Cordulia* species are reported from these southern European latitudes: *S. arctica* occurs at high altitude in Rila Mountain around and above 2,000 m only, *S. metallica* has been recorded from mountaineous regions in Bulgaria (Rila and Rhodopes and their foothills - Marinov 2001b). *S. flavomaculata* (Vander Linden) is found further south from Bulgaria. It inhabits adjacent areas of Turkey and Greece (Dumont 1977; Lopau & Wendler 1995; Kalkman et al. 2003) and is also the only corduliid going further east and being reported from Iran (Schmidt 1954). However, it is strictly attached to stagnant water bodies like peat diggings, fenland puddles, ditches and edges of larger waters with lush riverine vegetation (e.g. Wildermuth 1997; Sternberg & Ullrich 2000). *C. aenea* also reproduces in stagnant water bodies and has a scattered distribution within the area. Seven localities in S Bulgaria (M. Marinov unpubl.) and a few in Albania (Dumont et al. 1993), Greece (Lopau & Wendler 1995; Kappes & Kappes 1995), Macedonia (Peters & Hacketal 1986) and Turkey (Kalkman et al. 2003) are known. Further south, it has been previously reported from the Algerian Numidia area, but is now considered as extinct in northern Africa (Samraoui & Corbet 2000; Jödicke et al. 2004).

The West Palaearctic distribution of recent Corduliinae specis is more or less confined of southern Europe, with a range of *C. borisi* at the southern edge. It therefore seems probable that the ancestors of the genus *Corduliochlora* have to be searched in other regions than the recent range of distribution. Belyshev and Haritonov (1981) supposed that the Corduliidae, coming from America at the end of the Neocene more than five millions years ago, colonized Europe and Asia along the northern part of the continent. These authors also considered the probable existence of two secondary centers of colonization in the genus *Somatochlora*, in eastern Asia and Europe. These considerations should be kept in mind when the true origin of *Corduliochlora* is discussed.

Acknowledgements

We thank to all specialist who assisted us on different stages throughout the research and preparation of the manuscript: Alexander Georgiev, Anna Ganeva, Borisslav Georgiev, Carl Cook, Hansruedi Wildermuth, Heinrich Fliedner, Henri Dumont, Hristina Etarska, Ivo Borissov, Ken Tennessen, Klaas-Douwe Dijkstra, Mario Langourov, Michail Josifov, Nikolai Simov, Reinhard Jödicke, Snejana Grozeva, Steven Butler, Stoyan Lazarov, Svetlana Trifonova, Teodora Ivanova, Timothy Vogt, Vincent Kalkman and Vladimir Trifonov. This study was partly supported by WDA and the PANDION-D tour operating firm.

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