

Description of the last stadium larva of *Somatochlora borisi*, with comparison to that of *Somatochlora metallica meridionalis* (Odonata: Corduliidae)

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Key words: Odonata, dragonfly, Anisoptera, Corduliidae, *Somatochlora borisi*, *S. metallica meridionalis*, larva, Bulgaria, Greece, Turkey.

ABSTRACT

The last instar larva of *Somatochlora borisi* is described and illustrated from a set of exuviae. It is compared to that of *S. metallica meridionalis*, which is morphologically close and syntopic. A key is provided which allows the determination of the exuviae of all West Palaearctic *Cordulia* and *Somatochlora* spp.

INTRODUCTION

According to present knowledge, *Somatochlora borisi* Marinov is an endemic corduliid confined to a small part of the Balkan area. All published records (Marinov 2001; Boudot et al. 2004; Grebe et al. 2005; Lopau 2005) originate from an area extending from the eastern Rhodopes in Greece and Bulgaria to the Black Sea coast in Bulgaria and Turkey, north and south of the Istranca range. Here we describe the last stadium larva of *S. borisi*, based on a set of exuviae collected in NE Greece and SE Bulgaria, and compare it to that of *S. metallica meridionalis* Nielsen.

MATERIAL AND METHODS

Thirty corduliid exuviae were first collected on the Diavolorema River near Mikron Dherion, NE Greece, 27-31 May 2003. Although the exuviae collected after completion of emergence could not be identified with certainty, two species were assumed at first sight, based on their general pattern, structure and size: presumably *Somatochlora borisi*, having some structural features unknown in other European corduliid and patrolling adults being present, and *S. m. meridionalis*, attested by ongoing

emergences. Later, 5-11 May 2004, 28 exuviae of Corduliidae were collected at the same locality, and also at another site on the Diavolorema River near Dadia. No ongoing emergence was observed. Some exuviae were somewhat old and corrupted, suggesting an emergence period starting around 20-25 April. However, only imagines of *S. borisi* could be observed at this period. The syntopic summer species *S. meridionalis* could not be traced, neither at emergence nor as maturing or reproducing adults, therefore all corduliid exuviae were provisionally ascribed to the spring species *S. borisi*. Lastly, three exuviae of *S. borisi*, two of which were collected during emergence, were provided from SE Bulgaria by V. Kalkman and M. Marinov. They proved to be conspecific with the 29 Greek exuviae collected in 2004, giving confirmation of the identity of the latter.

The terminology used is that of Levine (1957) for the larval morphology and that of Watson (1956) for the mandibles. All drawings are from the first author.

Specimens studied

Somatochlora borisi — 28 exuviae from Diavolorema River near Mikron Dherion (41°17'N, 26°05'E, alt. 130-190 m), NE Greece, 05-10 v 2004, J.-P. Boudot, D. Grand leg.; — 1 exuvia from Diavolorema River near Dadia (41°08'N, 26°09'E, alt. 150 m), Greece, 11 v 2004, J.-P. Boudot, D. Grand leg.; — 1 exuvia from Veleka River near Sinemorets (42°03'N, 27°57'E, alt. 30 m), SE Bulgaria, 13 v 2005, M. Marinov leg.; — 2 exuviae from the same locality, 07 v 2006, V. Kalkman leg.

Somatochlora metallica meridionalis — 9 exuviae from Porto-Vecchio (41°35'N, 9°10'E), Muratellu, Corse-du-Sud department, Corsica, France, 20 vii 2002, D. Grand leg.; — 31 exuviae from Bagnols-en-Forêt (43°32'N, 6°39'E), Var department, SE France, 20 vii 1996, D. Grand leg.; — 12 exuviae from Mikron Dherion (41°17'N, 26°05'E), NE Greece, 27-31 v 2003, J.-P. Boudot, D. Grand leg. — The taxon *meridionalis* is treated here as a subspecies of *S. metallica* due to the well-known occurrence of intermediate specimens in its contact area with the nominate subspecies.

DESCRIPTION OF THE EXUVIA OF *Somatochlora borisi*

General: Moderately robust larva, fairly elongated (Fig. 1a), hardly compressed dorso-ventrally, with sparse long and slender setae and a rather dense cover of small spine-like setae. Overall colour fairly uniform, light brown to dark brown, with weakly differentiated darker areas: two brown rings on the tibiae, a brownish patch on the latero-dorsal part of the mesepisternum, a darkened area at the base of the wing sheaths, and a weak progressive darkening of the last tergites on the postero-dorsal part of the abdomen.

Head: Head decidedly transverse, pentagonal, its length barely exceeding its half-width; frontal shield moderately developed, more or less triangular and fairly densely furnished with long and slender setae on its distal side (Fig. 1b); antennae long, robust, 7-segmented, with the three first and the penultimate of almost equal length, extensively covered with long and slender setae which are at least as long as their own antennal segment (Fig. 2a); eyes small and laterally prominent; occiput well de-

veloped, with the lateral sides progressively converging backwards and the posterior edge clearly concave; upper part of the occiput with a small clump of mediocre strong setae on both sides of the sagittal suture, immediately behind the eyes, the rest of the occiput covered with series of long setae alternating with series of short setae, except at the muscles insertion areas that remain almost glabrous (Fig. 1b); labial mask strong, with the articulation submentum-mentum and the ending part of the submentum reaching just to the level of the mesocoxae, fringed with the long setae implanted on the thoracic ventral side; mentum wide with the latero-dorsal parts furnished with mediocre strong spine-like setae, preceded in a forwards position by two series of 10-11 mental setae (Fig. 1c); distal side of mentum fringed with numerous fairly strong spine-like setae (Figs 1c, 2b); on the latero-distal parts of the mentum, just below the internal condyles of the mentum-palp articulation, occurrence of a small clump of 4-6 very thin spine-like setae (Fig. 1c); labial palps wide, each with 6 long palpal setae near their outer edge, below them occurrence of mediocre spine-like setae, more numerous below the most proximal palpal setae, then becoming increasingly scarce and vanishing towards the inner and distal edges; outer edges almost regularly fringed along their two proximal thirds with long and strong setae, first spiny, then becoming increasingly slender; distal margin of labial palps generally having 9 rounded crenations, most of them hardly asymmetric con-

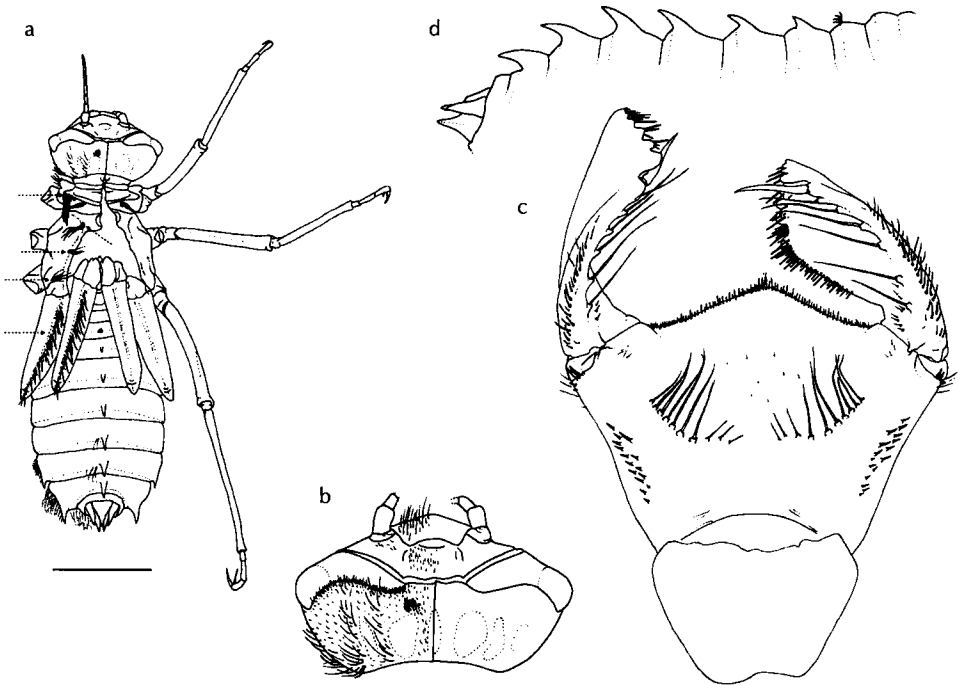
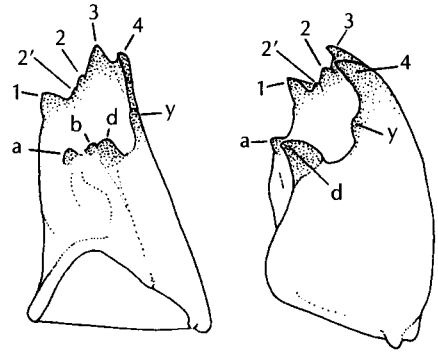


Figure 1: Exuvia of *Somatochlora borisi* — (a) general habitus of female; some strong setae represented on the left side; scale bar: 5 mm; (b) head of female, dorsal view; setae represented only on the left side; (c) labium of male, dorsal view; (d) abdomen of male, right lateral view, note the brush of setae on S3 instead of a mid-dorsal hook.

trarily to the majority of Corduliidae, each tooth generally with 7-9 (sometimes 6 or 10) setae raptores in two rows, the distal row with shorter setae than the inner one (Fig. 2c); movable hooks strong and rather short; left mandibular formulae 1(2'-)234 y- abd, with molar teeth close to each other, d massive, b poor and merged with d, y hardly distinct, 2' very poor, 3 > 4 > 2 > 1 (Figs 2d, e); right mandibular formulae: 1234 y abd, with molar teeth close to each other and placed on a distinctly sclerotized plate, d massive, b poorly developed and merged with d, y strong and pointed, 4 > 3 > 2 > 1 (Figs 2f, g).



Terminology for the mandibles after Watson (1956)

Thorax: Prothorax moderately developed, with a pronotal shield widened and ending on each outer side with a fairly strong lateral tubercle, the latter furnished with very long (up to 2 mm) and strong setae (arrow on Fig. 1a); propleuron with both an episternum and an epimeron well differentiated, the proepisternum with long and strong setae near its ventral edge (Fig. 1a); pterothorax with clumps of very long (up to 2 mm) and strong setae on the dorsal part of the mesepisternum, near its posterior border, on the dorsal part of the area situated between the mesepimeron and the metepisternum, and on the metepimeron in close vicinity to the posterior wing sheath (arrows on Fig. 1a); wing sheaths with a dense row of setae on their costal edge, some setae being particularly long (Fig. 1a); legs long and slender, femurs hardly depressed and without carina, tarsus relatively short and tarsal claws long and rather thin.

Abdomen: Abdomen roughly oval-shaped in dorsal view; dorsum first with a rounded transversal section, then becoming progressively triquetral posteriorly; S4-9 with mid-dorsal hooks inclined backwards and increasing progressively in size (Fig. 1d); S3 without mid-dorsal hook but with a small mid-dorsal clump of setae (Fig. 1d); S8-9 with lateral spines and long and slender setae on the outer sides; lateral spines of S8 distinctly shorter than that of S9 (Fig. 1a); female genital print (gonapophyses) very small, resembling two trilobate knobs, well visible on exuviae but possibly concealed under the intersternal membrane in living larvae (Fig. 2h); tergites covered by small and rather scattered setae, and posterior edge with longer setae (Fig. 2i); ante-pleurites lacking on S7 and S9; posterior edge of S9 fringed with very long and slender setae; S10 short, more or less ring-shaped and built-in in S9; anal pyramid rather short, cerci wide, about as long as the epiproct, paraprocts slightly longer than the epiproct; dorsal projection of the male epiproct well developed, very wide, almost truncated and ending abruptly, showing two ill-defined rounded sub-apical bulges, which fit the structure of the male inferior appendage (Fig. 2k).

Dimensions [mm]: Total length (without antennae) – males ($n = 11$) 18.9–20.6 (mean = 20.0); females ($n = 17$) 19.9–21.7 (mean = 20.9). Maximal width of head – males ($n = 7$) 5.5–6.0 (mean = 5.7); females ($n = 7$) 5.3–5.8 (mean = 5.5). Maximal width of abdomen – males ($n = 10$) 6.0–8.0 (mean = 6.7); females ($n = 15$) 6.3–6.9 (mean = 6.5).

COMPARISON OF THE LARVAE OF *Somatochlora borisi*
AND *S. metallica meridionalis*

Due to its general pattern, the exuvia of *S. borisi* resembles that of the sympatric and syntopic *S. m. meridionalis*, and both are difficult to differentiate at first sight. As compared to *S. m. meridionalis*, the exuvia of *S. borisi* shows the following particularities:

- Antennae slightly shorter and more stocky, with setae on average longer and more numerous (Fig. 2a)
- Distal margin of the mentum with more numerous and stouter setae (Fig. 2b)
- Presence of 10-11 mental setae vs 11 (~20%), 12 (~50%) or 13 (~30%) in *S. m. meridionalis*
- Distal margin of labial palps with more rounded crenations, most of them much less asymmetric than those of *S. m. meridionalis* and most of Corduliidae; setae raptores longer, more heavily-built and generally less numerous (currently 7–9) than in *S. m. meridionalis* (9–12) (Fig. 2c). Note that the latter has a higher number of setae raptores than claimed by Seidenbusch (1996), due to the fact that those of the first rank, either shorter or longer but often in close contact with those of the second rank, are frequently overlooked and omitted (Fleck 2002).
- Mandibular organisation quite different: the molar teeth are more closely grouped and the b and d teeth are merged. In *S. m. meridionalis*, they are distinctly further apart and b and d are poorly, or not at all, merged. In addition, d appears to be consistently stronger in *S. borisi* than in *S. m. meridionalis*. Lastly, the γ tooth of the left mandible is hardly differentiated in *S. borisi* but well marked and sharp in *S. m. meridionalis*. There is no clear difference in the incisors (Figs 2d-g).
- Clumps of very long setae present on the lateral tubercles of the pronotal shield, on the upper side of the mesepisternum close to its posterior limit, on the dorsal area between the mesepimeron and the metepisternum, on the metepimeron close to the posterior wing sheaths (arrows on Fig. 1a) and on the costal edge of the wing sheaths. These setae are generally either lacking or very reduced in *S. m. meridionalis*, except for one female from SE France.
- S3 only with a clump of setae, a mid-dorsal hook only on S4-9. In *S. m. meridionalis*, the dorsal hooks are present on S3-9.
- Lobes of the female genital print each roughly trilobate and very small in *S. borisi*, while they are entire, more or less rounded and larger in *S. m. meridionalis* (Fig. 2h).
- Spine-like setae covering the surface of the tergites are small, and always smaller than those lined up on their distal edge. In *S. m. meridionalis*, they are larger and both are the same size (Fig. 2i).
- Dorsal projection of the male epiproct very wide and apically abruptly narrowed, almost truncated, with two ill-defined rounded subapical bulges. In *S. m. meridionalis*, it is less widened at the base and is nearly regularly narrowed and triangle-shaped (Fig. 2k).
- Overall size, often smaller. A strong local variability is evident for both species, however, and *S. m. meridionalis* suffers from an additional variability, depending on the locality (Fig. 3). Female exuviae of *S. borisi* are significantly larger than male exuviae ($p = 0.05$); however this is not true in *S. m. meridionalis*. Male and female exuviae of *S. borisi* are significantly smaller than the related ones of *S. m.*

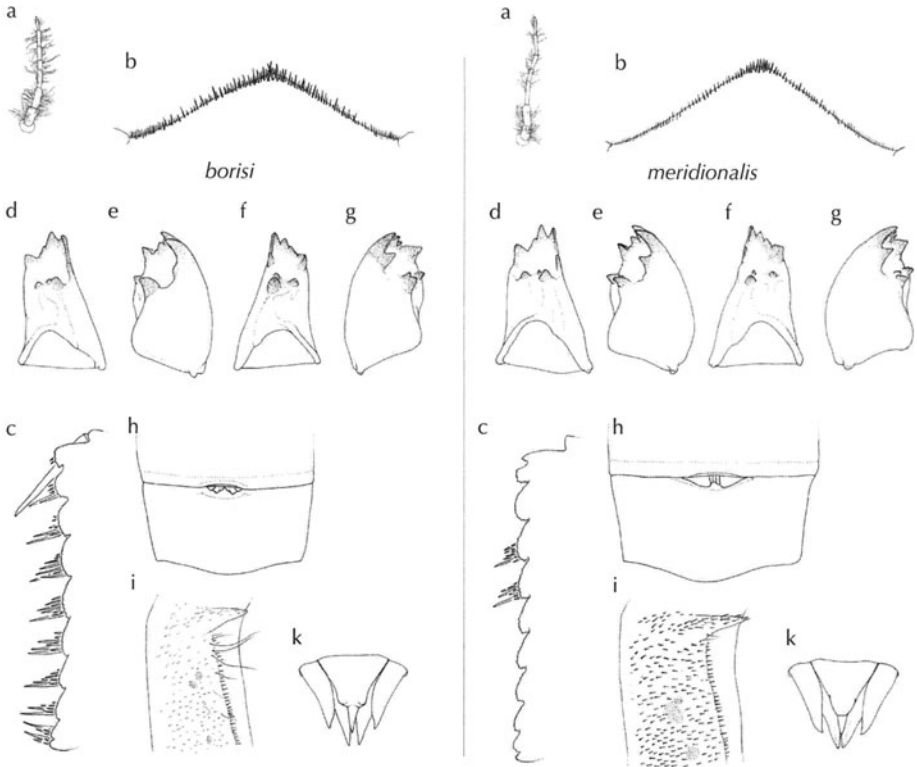


Figure 2: Larval details of *Somatochlora borisi* and *S. metallica meridionalis* in comparison — (a) right antennae; (b) distal margin of the mentum; (c) distal margin of the left labial palp, frontal view; (d) left mandible, internal view, (e) left mandible, ventral view, (f) right mandible, internal view, (g) right mandible, ventral view; (h) distal part of S8-9 of female, ventral view, setae omitted; (i) part of the left side of S8, dorso-lateral view; (k) anal pyramid of male, dorsal view.

meridionalis from both SE France and NE Greece ($p = 0.05$), but are of the same size as those from Corsica. A strong overlap occurs in individual values of female exuviae of *S. borisi*, and those of *S. m. meridionalis* from every locality. Apparently, exuviae of *S. borisi* fall into the lowest range of the size variability of *S. m. meridionalis*, therefore this parameter cannot be retained to discriminate both species.

DIFFERENTIAL DIAGNOSIS: KEY TO THE EXUVIAE OF THE WEST PALAEARCTIC *Cordulia* AND *Somatochlora* SPECIES

This key includes *S. graeseri* Selys, due to recently published precise localities in Bashkiriya (European Russia) (Yanybaeva 1999; Kosterin 2005; Yanybaeva et al. 2006). *S. metallica abocanica* Belyshev is omitted, as its redescription by Kosterin & Zaika (2003) gave evidences that the European populations of *S. metallica* with black perostigmas cannot be ascribed to this taxon, of which the last stadium larva remains apparently undescribed.

1. Abdomen with mid-dorsal hooks and lateral spines, segments only slightly hairy 2
- 1'. Abdomen without mid-dorsal hooks, exuviae very hairy 7
2. S9 without a mid-dorsal hook, at most with a minute vestigial tooth .. *C. aenea*
- 2'. S9 with a large mid-dorsal hook 3
3. S3 with a fairly acute and erected mid-dorsal hook 4
- 3'. S3 either with a vestigial, blunt and curved mid-dorsal hook, or without a mid-dorsal hook 5
4. Lateral spines of S9 shorter or hardly longer than those of S8, reaching only the basis of the cerci *S. metallica metallica*
- 4'. Lateral spines of S9 clearly longer than those of S8 and reaching about from the middle to the tip of the cerci *S. metallica meridionalis*
5. Mid-dorsal hook on S3 generally reduced to a rounded tubercle, scarcely lacking or with a sharp vestigial tooth, those on S4-5 blunt and curved. Mentum with 13-16 mental setae and 8-9 palpal setae *S. graeseri*
- 5'. Mid-dorsal hook on S3 lacking, those on S(4-)5 acute and poorly curved, the first one small. Mentum with 10-11 mental setae and 5-7 palpal setae 6
6. Lateral spines of S8 clearly differentiated: > 1/3 of the length of the sides of the segment. Distal margin of the labial palps with most of the teeth almost symmetric. Dorsal expansion of the male epiproct abruptly restricted at apex, with two ill-defined rounded subapical bulges. Lobes of the female genital print minute, digitate and more or less trilobate *S. borisi*
- 6'. Lateral spines of S8 tiny and reaching at most 1/6 of the length of the sides of the segment, sometimes lacking. Distal margin of the labial palps with nearly all teeth clearly asymmetric. Dorsal expansion of the male epiproct triangle-shaped and almost regularly narrowed from base to apex, without subapical bulges. Lobes of the female genital print minute to small but rounded and entire. *S. flavomaculata*
7. S8-9 with well developed lateral spines *S. sahlbergi*
- 7'. S8-9 without any lateral spines 8
8. Abdominal tergites and sternites covered with unapplied short and long setae. S4-8 with a small triangular ventral ante-pleurite on their lateral margins. Anal pyramid shorter than the sides of S9 or of the same length and exceeding only slightly the posterior edge of S10 *S. arctica*
- 8'. Abdominal tergites and sternites with short and applied setae on their surface and long setae only on their posterior and lateral edges. S4-6 and S8 with a small triangular ventral ante-pleurite on their lateral margins, S7 without. Anal pyramid slightly longer than the sides of S9 and exceeding of its half-length the posterior edge of S10 *S. alpestris*

CONCLUSION

As evidenced by the previous descriptions and comparisons, the last stadium larva of *Somatochlora borisi* shares common features with that of *S. metallica meridionalis*, with which it is sympatric and syntopic in a part of the Balkans, and that of *S. flavomaculata*. The latter has its southern limit in the *S. borisi* range but, as *S. borisi* breeds in flowing water and *S. flavomaculata* in standing water, they are never syntopic. The most distinctive particularities of the exuvia of *S. borisi* is the lack of a mid-dorsal hook on S3, the size of the lateral spines on S8-9, the poor development of the y tooth on the left mandible, the shape of the male epiproct dorsal projection, which fits the structure of the slightly bilobed adult male abdominal inferior appendage, and the structure of the female genital print. These features allow a clear distinction against the exuviae of both *S. m. meridionalis* and *S. flavomaculata*. The shape of the male epiproct dorsal projection of *S. borisi* is not unique in *Somatochlora* and is reminiscent of what is observed in the larvae of the Nearctic *S. tenebrosa* (Say) and *S. cingulata* (Selys), in which the same structure fits likewise the 1- or 2-notched tip of the adult male inferior appendage (Walker & Corbet 1975; Needham et al. 2000; Cashatt & Vogt 2001).

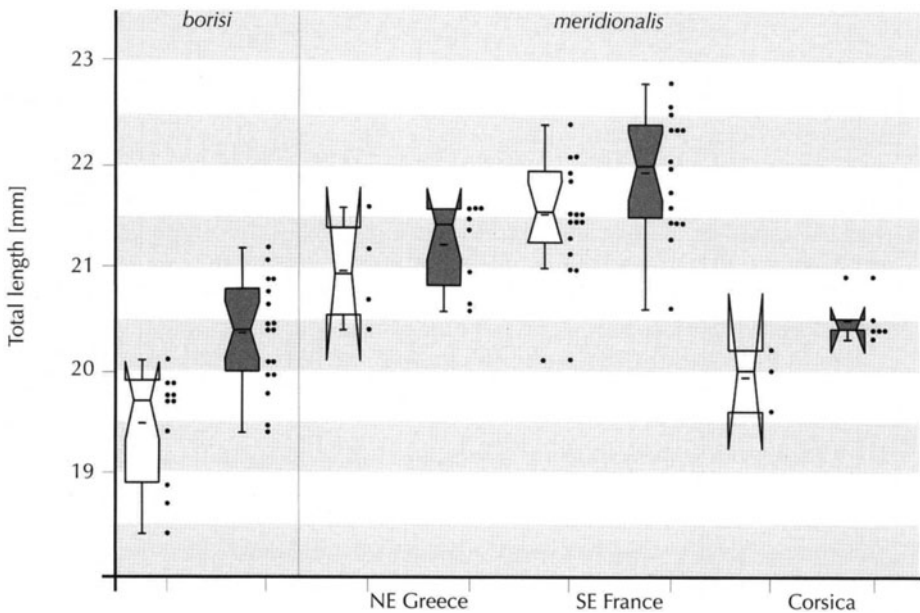


Figure 3: Total length of the exuviae of *Somatochlora borisi* and *S. metallica meridionalis* — *S. borisi* from NE Greece and SE Bulgaria; *S. m. meridionalis* from NE Greece, SE France and Corsica. The bottom and top lines of the boxes are the lower and upper quartiles, respectively. The middle line of the box is the median. The whiskers range delimit the non-aberrant values of each distribution, i.e. the quartile plus or minus 1.5 times the inter-quartile range. The height of the notch is the t -test confidence interval about the median ($p = 0.05$); □ males; ■ females.

All these features support the assignment of *S. borisi* to the genus *Somatochlora*. This species clearly pertains to the so-called ‘*metallica* group’, of which the main distinctive features against the ‘*arctica* group’ are both the occurrence of mid-dorsal hooks, and their almost glabrous appearance at first sight due to the lack of long setae on the abdomen.

ACKNOWLEDGEMENTS

Special thanks are expressed to Milen Marinov and Vincent Kalkman for the communication of attested *Somatochlora borisi* exuviae from S Bulgaria, and to Jean-Louis Dommaget for the loan of other comparative specimens. Helpful information, comments and suggestions were provided by Elena Malikova, Ole Müller and Hansruedi Wildermuth. Sarah Yeates improved the language. Thank you all.

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