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## Contribution to the taxonomy of Est-European species of the *Ecdyonurus helveticus*-group (Ephemeroptera, Heptageniidae)<sup>1</sup>

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Five East-European members of the *Ecdyonurus helveticus*-group are redefined and redescribed. They occur in the south-eastern Alps, in the Balkans and in the Carpathians. The systematic status of each species is discussed and a differential diagnosis is proposed for the nymphs and the imagines.

### INTRODUCTION

In some previous papers (HEFTI *et al.*, 1986, 1987; HEFTI & TOMKA, 1986), a taxonomical revision of the alpine species belonging to the *Ecdyonurus helveticus*-group was presented. The following study presents a systematic revision of further taxa of the *E. helveticus*-group: *E. epeorides* DEMOULIN, 1955; *E. krueperi* (STEIN, 1863) with the sub-species *E. krueperi krueperi* (STEIN, 1863) and *E. krueperi albanicus* PUTHZ, 1980; *E. carpathicus* SOWA, 1973 with the sub-species *E. carpathicus carpathicus* SOWA, 1973 and *E. carpathicus vitoshensis* JACOB & BRAASCH, 1984; *E. subalpinus* (KLAPALEK, 1907); *E. siveci* JACOB & BRAASCH, 1984.

The taxa mentioned are distributed in the extreme south-eastern Alps, in the Balkans and in the Carpathians. On the basis of type material and of samples collected by ourselves a brief systematic characterization of the species is given. Then a differential diagnosis and a discussion concerning the systematic status of the species is presented.

### MATERIAL

*E. epeorides*: E. Zagora, Mt-Pélon, Greece, 350 m, 8.1953 (type material, Demoulin Collection, Institut Royal des Sciences Naturelles de Belgique).

*E. krueperi*: Landona, Magougliana, Peloponnesus, Greece, 1100 m (*E. krueperi krueperi*, material from the Aubert Collection, Museum of Natural History, Lausanne). Erseke, Albania, 1036 m (type material *E. krueperi albanicus*, British Museum of Natural History, London). Tributary of the Thyamis/Kucis by Vrusina, Greece, 200 m, 4.1983 (leg. Hefti, Tomka, Zurwerra). Tributary of the Thyamis/Kucis by Vrusina, Greece, 350 m, 4.1983 (leg. Hefti, Tomka, Zurwerra).

*E. carpathicus carpathicus*: Tributary of the Olt at Madaras/Kis Madaras, Rumania, 700 m, 7.1982 (leg. Tomka, Zurwerra). Tributary of the Olt near the source above Baraolt/Kormos Köves, Rumania, 940 m, 7.1982 (leg. Tomka, Zurwerra).

*E. carpathicus vitoshensis*: Tributary of the Spreca near Tuzla/Preodovice, Croatia, Yugoslavia, 400 m, 4.1983 (leg. Hefti, Tomka, Zurwerra).

*E. subalpinus*: Tributary of the Olt at Madaras/Varpatak, Rumania, 1300 m, 7.1982 (leg. Tomka, Zurwerra). Tributary of the Olt at Madaras/Nagy Madaras, Rumania, 1140 m, 7.1982 (leg.

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Tomka, Zurwerra). 100 m below Mavroska Lake near Mavrovi Anovi, Kosovo, Yugoslavia, 700 m, 4.1983 (leg. Hefti, Tomka, Zurwerra).

*E. siveci*: Tributary of the Mura at Zgornja Scavnica by Maribor, Slovenia, Yugoslavia (type locality), 250 m, 4.1987 (leg. Tomka).

#### DESCRIPTIONS

The following species exhibit the morphological characteristics of the *E. helveticus*-group: Imago, male: the apical sclerites of the penis lobes are laterally expanded (Figs. 2–7). Nymph: the distal borders of the hypopharynx are not covered with a dense and long pilosity (fig. 1a).

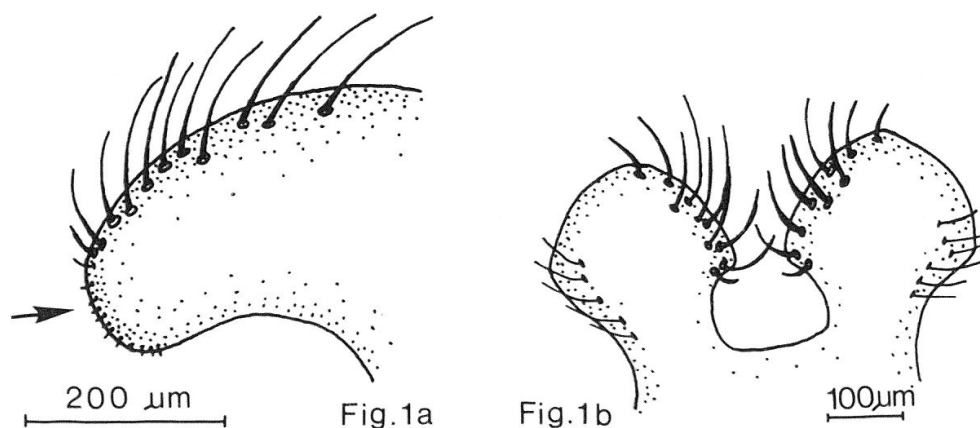


Fig. 1. Nymphal characteristics of the species *E. krueperi*. 1a. Distal end of the hypopharynx. 1b. Glossa.

#### *Ecdyonurus epeorides* DEMOULIN, 1955

*Imago, male*: Length of the body (without cerci): 10–11 mm. Length of the anterior wings: 13–14 mm. *Head*. Brown with yellowish tinges. The eyes are uniformly grey with a dark band at the base. *Thorax*. The thoracic segments are yellowish brown. The forewings are hyaline but exhibit a dark brown coloration on the costal and subcostal fields. The hindwings show a slight brownish tinge. *Genitalia*. The penis lobes are short with curved outer lateral borders. The apical sclerites are rounded distally (Fig. 2). Ventrally, the genital plate presents two lateral protuberances.

*Nymph*: Length of the body: 12 mm. The lateral pronotum expansions are rounded distally (Fig. 8). The nymph is characterized by the narrow shape of its gill plates, which exhibit a length-width ratio  $\geq 2.2$  (DEMOULIN, 1955).

#### *Ecdyonurus krueperi* (STEIN, 1863)

*Imago, male*: Length of the body (without cerci): 12–14 mm. Length of the anterior wings: 13–15 mm. *Head*. Fuscous in the ocelli area. The eyes are uniformly grey with a dark band at the base. *Thorax*. The thoracic segments are fuscous to black. The forelegs are darker than the other ones. The tarsi and the tibio-femoral articulations present some brownish tinges. The forewings are

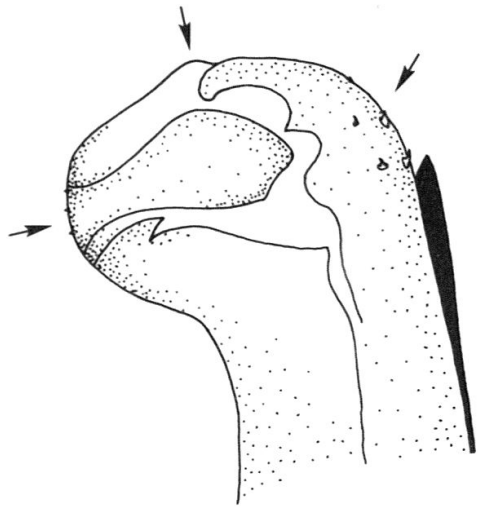


Fig. 2

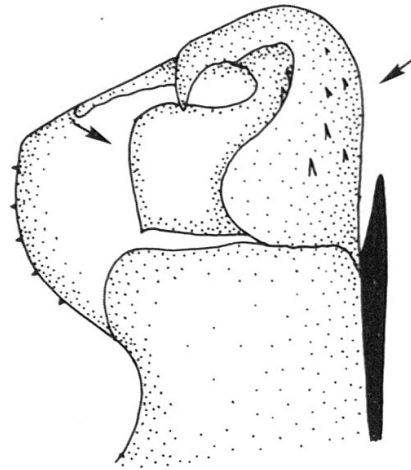


Fig. 3

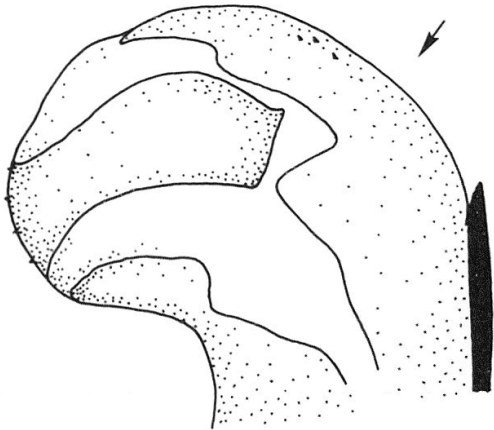


Fig. 4



Fig. 5

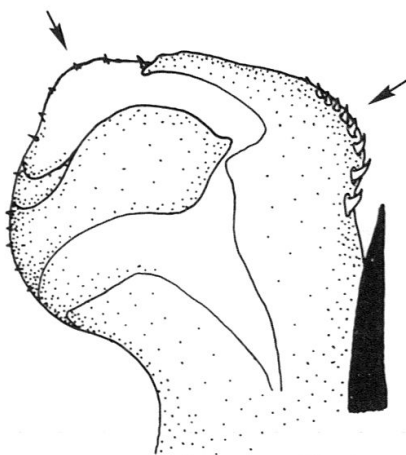


Fig. 6

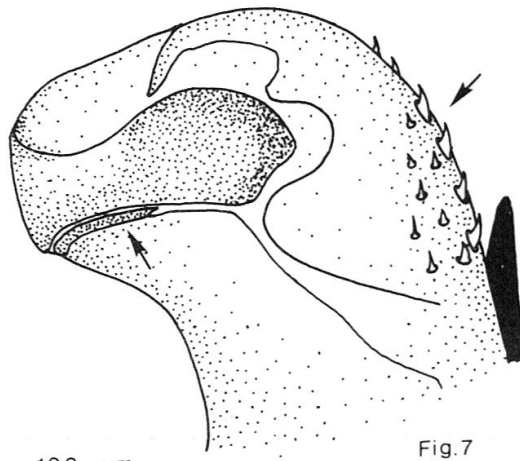


Fig. 7

100  $\mu$ m

Figs. 2–7. Genitalia: dorsal view of the penis lobe of the species *E. epeorides* (2), *E. krueperi* (3), *E. carpathicus carpathicus* (4), *E. carpathicus vitoshensis* (5), *E. subalpinus* (6) and *E. siveci* (7). The arrows indicate the most important morphological characteristics.

hyaline with opaque and brownish pterostigma. The hindwings exhibit a uniform brownish coloration on the external part. *Abdomen*. All the tergites are yellowish with the exception of the last one which is darker. The ganglionic chain is visible on the sternites. The *cerci* are brown yellowish. *Genitalia*. The penis lobes are almost triangular, each lobe with a short and rectangular lateral sclerite (Fig. 3). Ventrally, the genital plate exhibits two strong lateral protuberances.

*Nymph*: Length of the body: 13–16 mm. *Head*. The maxillary palpi exhibit almost the same coloration as the galea-lacinia complex. The species is easily recognizable because of the quadrangular morphology of the glossa (Fig. 1b). *Thorax*. The lateral pronotum expansions are pointed at their apices (Fig. 9) and directed parallel to the longitudinal axis of symmetry of the body. The femoral spines of the forelegs are elongated and almost pointed (Fig. 14). *Abdomen*. The general color is yellowish brown with some slight orange tinges at the level of the tergites.

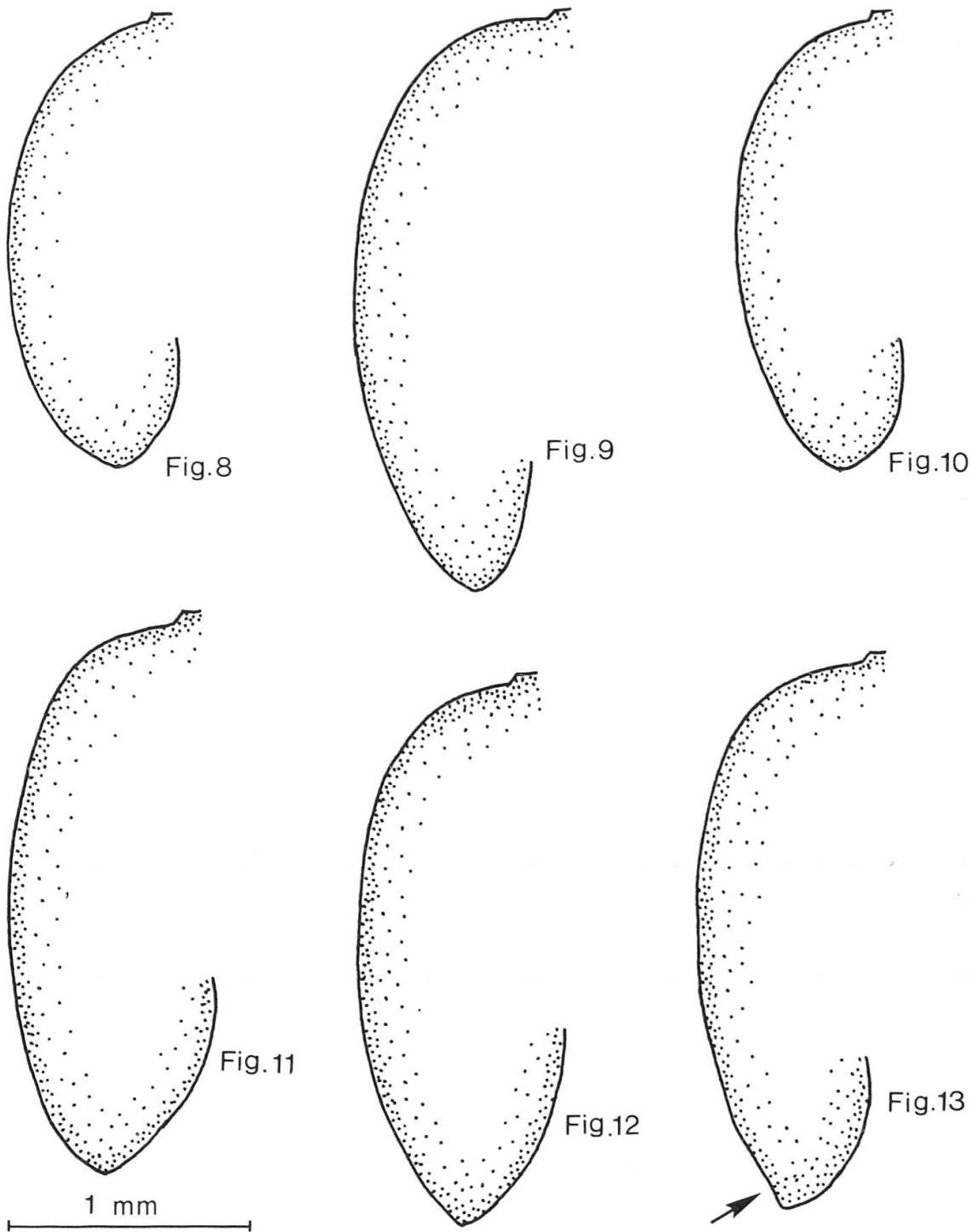
*Ecdyonurus carpathicus carpathicus* SOWA, 1973 and *E. carpathicus vitoshensis* JACOB & BRAASCH, 1984

*Imago, male*: Length of the body (without cerci): 11–13 mm. Length of the anterior wings: 11–14 mm. *Head*. Fuscous in the ocelli area; the eyes are uniformly grey with a darker band at the base. *Thorax*. The thoracic segments are dark brown with yellowish tinges. The forelegs are darker than the other ones. The forewings present a hyaline surface with a brownish and opaque pterostigma. The hindwings are hyaline. *Cerci*. Brown to fuscous at the base, they become yellow at their distal end. *Genitalia*. The penis lobes are rounded laterally for both taxa (Figs. 4–5). The subspecies *E. carpathicus vitoshensis* can be differentiated from the nominal form by the presence of a strong denticulation on the inner border of the apical sclerite and because of the concave inner edge of the lateral sclerite with two prominent tips (Fig. 5). Ventrally, both taxa exhibit two strong lateral protuberances.

*Nymph*: Length of the body for both taxa: 11–15 mm. *Head*. The maxillary palpi are distinctly darker than the galea-lacinia complex in the subspecies *E. carpathicus carpathicus*. *Thorax*. The distal ends of the lateral pronotum expansions of *E. carpathicus carpathicus* are slightly less pointed than in the subspecies *E. carpathicus vitoshensis* (Figs. 10–11). In both taxa, the femoral spines of the forelegs are distally rounded with convergent longitudinal borders. A dark coloration is visible on the femora at the base of each spine (Fig. 15). *Abdomen*. The general color is brown to fuscous. The gill plates exhibit a violet tinge.

*Ecdyonurus subalpinus* (KLAPALEK, 1907)

Length of the body (without cerci): 10–13 mm. Length of the anterior wings: 14–15 mm. *Head*. Fuscous in the ocelli area. The eyes are uniformly grey at the top with a dark band at the base. *Thorax*. The thoracic segments present a brownish coloration with some yellowish tinges. The forelegs are darker than the other ones. The forewings exhibit a hyaline structure with brown venation, particularly well marked at the level of the costa and subcosta. The pterostigma is opaque and brownish, the hindwings are hyaline. *Abdomen*. Each tergite shows a yellowish coloration with a diffuse red-brown band on the posterior margin. The ganglionic chain is visible on the sternites. *Cerci*. Uniformly brown at their base,



Figs. 8–13. Lateral pronotum expansions of the species *E. epeorides* (8), *E. krueperi* (9), *E. carpathicus carpathicus* (10), *E. carpathicus vitoshensis* (11), *E. subalpinus* (12) and *E. siveci* (13).

they become clearer at their distal end. *Genitalia*. The penis lobes are rounded and present a typical hump on the outer margin of each lobe (Fig. 6). The apical sclerite bears a strong denticulation on the inner border of the penis stem. Ventrally, the genital plate shows two strong lateral protuberances.

*Nymph*: Length of the body: 11–14 mm. *Head*. The distal part of the maxillary palpi is slightly darker than the galea-lacinia complex. *Thorax*. The lateral expansions of the pronotum are pointed distally (Fig. 12) and directed parallel to the longitudinal axis of symmetry of the body. The femoral spines are flattened distally and their longitudinal borders are divergent (Fig. 16). The surface of the femora shows a dark coloration at the root of each spine. *Abdomen*. Coloration brownish.

*Ecdyonurus siveci* JACOB & BRAASCH, 1984

*Imago, male*: Length of the body (without cerci): 12–15 mm. Length of the anterior wings: 13–15 mm. *Head*. Fuscous to black in the ocelli area. The eyes are uniformly grey. *Thorax*. The thoracic segments are fuscous, contrasting with the yellowish brown coloration of the abdomen. All segments of the forelegs exhibit a uniform fuscous tinge. The middle- and hindlegs are yellower with the exception of the brownish tarsi and tibio-femoral articulations. The forewings are hyaline with dark venations and the opaque pterostigmatic area. Hindwings also hyaline. *Abdomen*. The general color is brown-yellowish, the last segment usually being darker. The ganglionic chain is visible on the sternites. *Cerci*. Dark brown at their base, they become uniformly yellowish at their distal end. *Genitalia*. In dorsal view (Fig. 7), the interior edge of the apical sclerite of the penis is regularly curved like in *E. carpathicus carpathicus*. In contrast, the penis lobes are cut laterally and the internal border of each one exhibits a strong denticulation. Ventrally the genital plate presents two dark and strong protuberances.

*Nymph*: Length of the body: 11–14 mm. *Head*. All the surface of the maxillary palpi is distinctly darker than the galea-lacinia complex. *Thorax*. The lateral expansions of the pronotum are pointed distally with a small concavity on the outer distal margin (Fig. 13). The foreleg spines on the femora are elongated and rounded distally with two parallel longitudinal borders (Fig. 17). The gill plates exhibit a violet tinge.

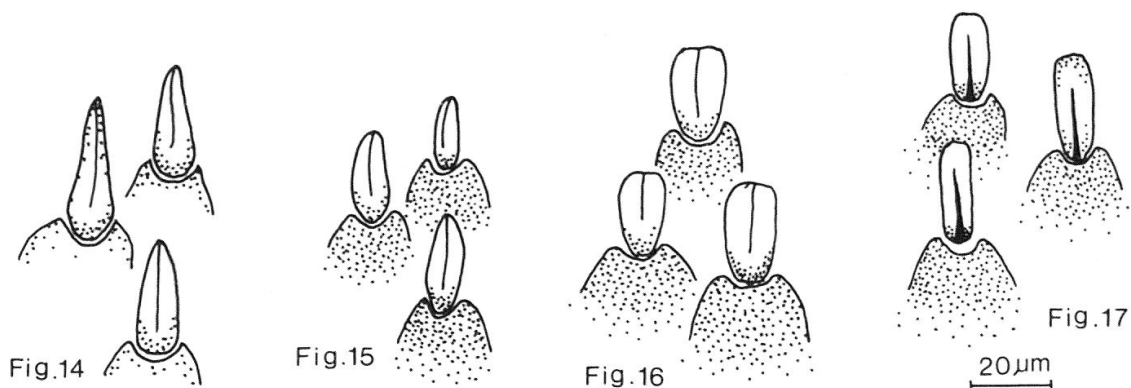
#### DIFFERENTIAL DIAGNOSIS

##### *Imagines*

The members of the *E. helveticus*-group can be separated in two sub-groups, each characterized by the distal edges of the apical sclerites of their penis lobes: –In the first one, the distal end of the apical sclerite is rounded. This sub-group includes the species *E. alpinus* HEFTI *et al.*, 1987, *E. austriacus* KIMMINS, 1958, *E. epeorides*, *E. helveticus* (EATON, 1885), *E. parahelveticus* HEFTI *et al.* 1986, *E. picteti* (MEYER-DÜR, 1864) and *E. zelleri* (EATON, 1885). –In the second one, the distal end of the apical sclerite is pointed. This sub-group includes the species *E. carpathicus*, *E. krueperi*, *E. siveci* and *E. subalpius*.

In the first sub-group: –*E. epeorides* can be separated from the other species because of its short penis lobes with regularly curved external borders (Fig. 2).

In the second sub-group: –*E. krueperi* shows trapezoidal penis lobes with short lateral sclerites which do not reach the outer lateral edge of the penis lobes (Fig. 3). – *E. carpathicus carpathicus* exhibits regularly curved medio-apical bor-



Figs. 14–17. Forelegs: femoral spines of the species *E. krueperi* (14), *E. carpathicus* (both subspecies) (15), *E. subalpinus* (16) and *E. siveci* (17).

ders of the penis lobes without large teeth on the apical sclerites (Fig. 4).—*E. carpathicus vitoshensis* presents two small prominent tips on the inner edge of each lateral sclerite (“vogelschnabelartig”, JACOB & BRAASCH, 1984) and a strong denticulation on the internal margin of each apical sclerite (Fig. 5).—*E. subalpinus* exhibits rounded penis lobes which are not elongated laterally and a small hump situated on each superior border of the penis lobes (Fig. 6).—*E. siveci* is differentiable because of its laterally “cut” penis lobes with curved interior edges of the apical sclerites, carrying a strong denticulation. Every basal sclerite bears a broad tooth, the tip of which is directed perpendicularly to the axis of symmetry of the penis lobe (Fig. 7).

### Nymph

In contrast to the imagines, it was not possible to find nymphal characters which separate all the members of the *E. helveticus*-group in alpine and East-European species. For this reason, we give a differential diagnosis of the East-European species regarding the whole *E. helveticus*-group.

Because of the morphology of their tergo-abdominal spines, all the East-European species may be differentiated from *E. alpinus*, *E. austriacus* and *E. parahelveticus*.

*E. krueperi* is separable from all the other members of the group because of the morphology of the glossa (Fig. 1b), the pointed distal end of the femoral spines (Fig. 14) and the large size of the gill plate (JACOB & BRAASCH, 1984).

*E. epeorides* exhibits narrow gill plates (DEMOULIN, 1955) with a length-width ratio of the fourth gill which is  $\geq 2.2$ .

*E. subalpinus* can be separated by a combination of the following characters: the pronotum expansions are pointed distally (Fig. 12); the tergo-abdominal spines are elongated and sharp and the femoral spines are divergent towards the apex (Fig. 16).

The three taxa: *E. carpathicus carpathicus*, *E. carpathicus vitoshensis* and *E. siveci* can be differentiated from all the other species belonging to the *E. helveticus*-group because of a violet tinge diffusely distributed on the surface of the gill plates. *E. siveci* has femoral spines with parallel longitudinal margins (Fig. 17) in

contrast to the ones of *E. carpathicus* (both sub-species) with convergent longitudinal borders (Fig. 15). The two sub-species of *E. carpathicus* can be differentiated because of the slightly more pointed pronotum expansion of *E. carpathicus vitoshensis* (Fig. 11), but the difference is not obvious to recognize.

## DISCUSSION

The species *E. epeorides* is actually so restricted in material (Demoulin Collection: one damaged imago and one damaged nymph, Braasch Collection: one imago and 2 nymphs) that its systematic definition is still dubious. The definitive taxonomical status of the species can only be elucidated when more material becomes available.

To clear the taxonomical status of *E. krueperi albanicus*, we examined type material from the British Museum in London (*E. krueperi albanicus*) and material from the Aubert Collection in Lausanne (*E. krueperi krueperi*). In contrast to PUTHZ's drawings (1980), our microscopic observations revealed that both taxa exhibit a denticulation on the apical sclerite of their penes. Another difference which is discussed by PUTHZ is the small size of the subspecies *E. krueperi albanicus*. As PUTHZ stated, the holotype is dried and the last body segments (including genitalia) are kept in glycerine. The comparison of the two preparates revealed that the small body size of the subspecies *E. krueperi albanicus* is only a drying artefact (the last body segments of *E. krueperi albanicus*, which are preserved in glycerine, are of a similar size as the ones of the subspecies *E. krueperi krueperi*). The last difference mentioned by PUTHZ is the coloration of the hindwings. Considering the large range of phenotypical variation recorded in the *E. helveticus*-group, it seems difficult to interpret this slight coloration difference. On the basis of the present knowledge we propose to reject the subspecies status of *E. krueperi albanicus*.

The populations of the species *E. carpathicus* investigated by us present morphological differences in the apical and lateral sclerites of the male genitalia. The penes of the Rumanian populations do not show any strong denticulation pattern on the apical sclerites. The specimens of these populations exhibit closed morphological affinities with the original description of the species *E. carpathicus* (SOWA, 1973). The specimens of a Yugoslavian population, however, present a strong denticulation pattern on the inner margin of the apical sclerite of the penis lobes. Furthermore the inner border of the lateral sclerite shows a typical "vogelschnabelartige" morphology, related in the original description of *E. carpathicus vitoshensis* (JACOB & BRAASCH, 1984). Unfortunately, it was not possible to analyse the morphological variation of this Yugoslavian population because of lack of material (only one male and three female imagines). Biochemical studies (starch gel electrophoresis) revealed a genetic distance of  $I = 0.98$  between the Rumanian populations and the population from Yugoslavia. This value is only due to slight intraspecific variation of some polymorphic enzymes and is not in contradiction with the subspecies status of *E. carpathicus vitoshensis*.

The systematic status of the species *E. subalpinus* does not seem to be definitively elucidated. SOWA (personal communication) believes that another form of the mentioned species exists in Poland and Czechoslovakia (Carpathians). This presumption will be investigated in the future by collecting more material from the Carpathians.

The species *E. siveci* was sampled in the type locality in Zgornja Scavnica. The identity of our larval material was confirmed by rearing experiments. In the Savinja at Luce, from where the original larval material is reported, we could only sample the species *E. picteti*. Our morphological analysis of the penes (scanning electron microscope, SEM) did not confirm the presence of a deep concavity at the level of each lateral sclerite, related in the original description of *E. siveci* (JACOB & BRAASCH, 1984). This misinterpretation can be explained as follows: in the light microscope, the inner part of the lateral sclerite exhibits a dark pigmentation, which is not present in the outer area. This may rise the impression of a deep incision where the light area starts. The SEM pictures (which will be published in a following paper) show that the lateral sclerites of the species *E. siveci* are not "gestuft" (JACOB & BRAASCH, 1984), but present the typical sinuous outlines recorded for all the members of the *E. helveticus*-group. The nymphs of the species *E. siveci* present an ethological singularity inside the genus *Ecdyonurus*. In contrast to the other species of the genus which migrate to the slow-flowing borders of the stream for the emergence, *E. siveci* was emerging equally in the middle of the stream.

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#### RÉSUMÉ

Une brève description morphologique de cinq espèces de l'Europe de l'Est appartenant au genre *Ecdyonurus* du groupe *helveticus* est tout d'abord présentée. Elle est suivie d'un diagnostic différentiel permettant l'identification des nymphes et imagines ainsi que d'une discussion portant sur le statut systématique des espèces considérées.

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