
Redescription of *Electrogena quadrilineata* (Landa, 1969) from Type Material (Ephemeroptera, Heptageniidae)

Małgorzata Kłonowska-Olejnik

Jagiellonian University, Kraków, Poland

Abstract

Electrogena quadrilineata (Landa) is redescribed from type material. The female imago and egg are described for the first time, the nymphs and male imago are redescribed. The diagnostic features and relationships are discussed. Some data on the distribution of this species are also presented.

Keywords: Ephemeroptera, Heptageniidae, *Electrogena*, taxonomy.

Introduction

The genus *Electrogena* was identified on the basis of electrophoretic similarities between *Ecdyonurus* species of the *lateralis* group by Zurwerra and Tomka (1985). Several *Electrogena* species have been described from Central Europe, but some of them are poorly known. The reasons are twofold: incomplete and mostly not sufficiently detailed descriptions of the species on the one hand, and substantial intraspecific variability of morphological characteristics on the other hand. Thus, a revision of some recently used morphological characteristics, as well as identification of new ones which are more appropriate and precise, is needed; the majority of *Electrogena* species was already subjected to detailed analysis. Belfiore (1994, 1995, 1996) proposed new taxonomic characteristics which apply to nymphal stages and allow for discrimination of some *Electrogena* species. However, equally important for verification and redescription of species is the type material, or material currently collected in type localities.

One of the poorly known *Electrogena* species is *E. quadrilineata* (Landa, 1969). This paper presents the results of the study of type material with a detailed description of the female imago and eggs analyzed by scanning electron microscopy (SEM).

Address correspondence to: Małgorzata Kłonowska-Olejnik, Department of Hydrobiology, Institute of Environmental Sciences, Jagiellonian University, Gronostajowa 3, 30-387 Kraków, Poland. E-mail: klon@eko.eko.uj.edu.pl

Material

In the original description of *E. quadrilineata*, Landa (1970) wrote under 'Material': 'Holotype (adult male), paratype (adult female), paratype (male subimago), paratype (male larva): Bohemia: Klíčava, deer park, Lány, 15. 5. 1947, leg. Landa, coll. Landa, Institute of Entomology, Czechoslovak Academy of Science, Prague. Further paratypes from the localities listed under Distribution.' The material designated as holotype or paratypes was most likely lost from the collection of Landa and Soldán in České Budějovice. Neither the adult male referred to as holotype nor any other male imago from the type material were found. Only one microscope slide labeled 'E. quadrilineatus, Klíčava, 1947' with male genitalia of the holotype specimen (Landa, pers. comm.) was available. Slides labeled 'Klíčava, Lány, leg. Landa, 09.05.1947' seem to present the 'further paratypes' or paratopotypes mentioned by Landa. Additionally, I found three larvae with the label 'Šembera, Doubravčice, 27.04.1960, leg. Landa.' This material was not referred to in the original description under 'Distribution', but was cited in later studies concerning the distribution of this species (Landa & Soldán, 1985, 1989). The material was included in the present study because *E. quadrilineata* was not found at the type locality during the past 15 years, probably due to significant changes in environment, mainly pollution. It is therefore virtually impossible to collect any 'topotypes' (Soldán, pers. comm.).

Material examined: Microscope slide with male genitalia, Klíčava, 1947; three female imagines, Klíčava, Lány (Bohemian Cretaceous Plateau, Berounka Basin), 09.05.1947, leg. V. Landa; one male mature nymph, two female mature nymphs, idem.; one nymph, idem.; about 10 male and female subimagines (without label); three nymphs, Šembera, Doubravčice, (Bohemia, upper Elbe Basin), 27.04.1960, leg. V. Landa. Material in V. Landa's and T. Soldán's collections, some parts of female and larvae (microscope slides) in M. Kłonowska's collection.

Electrogena quadrilineata (Landa, 1969)

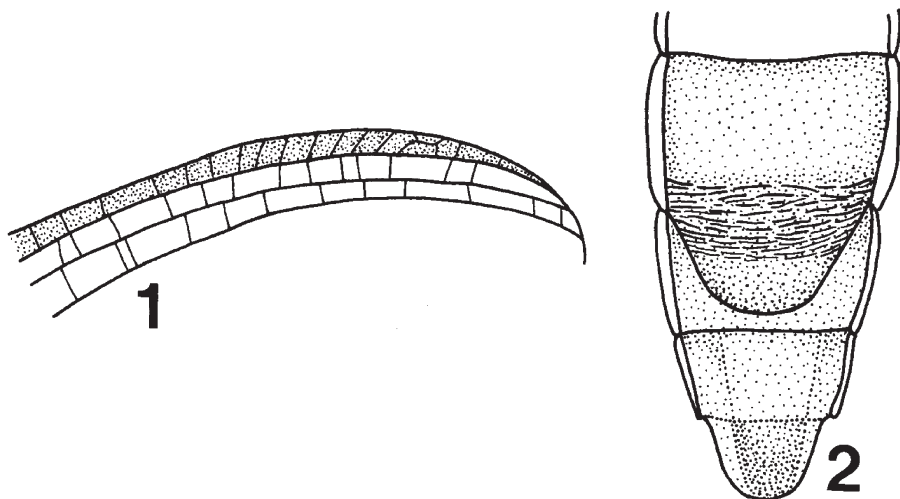
Heptagenia quadrilineata Landa, 1969; 1970.

Female imago

Size: body length 12.0–14.0 mm; forewing 12.0–13.0 mm; cerci 22.0 mm. General body coloration yellow-brown. Head light brown, antennae yellowish brown. Eyes black. Prothorax yellow-brown, mesothorax brown, metathorax light brown. Forewings opaque, pterostigma pale, 14–16 straight cross veins connected at costa in pterostigma (in original description 18–20 veins) (Fig. 1). Longitudinal and cross veins brown, R also brown, C and Sc slightly lighter. Legs light brown, tibiae yellow. In middle of femora a dark brown band, particularly well visible on fore and middle legs. Abdominal tergites yellow-brown with brown markings on each tergite: in lateral view, two spots in the anterior and two in the posterior part. Abdominal sternites yellow-brown, with light posterior margins. Nerve ganglia poorly visible, white-yellow. Ventral view of terminal part of abdomen with subgenital plate as in Fig. 2. Subgenital plate rather wide, posterior margin slightly rounded. Subanal plate quite long and rounded in the middle part. Cerci brown, basal part dark brown.

Egg

Egg oval (Fig. 3). Length 180–200 µm; width 130–150 µm. Eggs characterized by a distinctive chorionic pattern. Chorionic surface rugose, with numerous small round tubercles (diameter 0.50–0.75 µm). Chorionic surface and tubercles covered by granular ground matrix visible at high magnification (Fig. 6). Attachment structures, characterized by knob-terminated coiled threads (KCT) (Koss & Edmunds, 1974), are of two different kinds. The first are larger (diameter about 4 µm) and concentrated at one egg



Figures 1–2. *Electrogena quadrilineata*, female imago: (1) pterostigma on forewing; (2) posterior part of abdomen, ventral view.

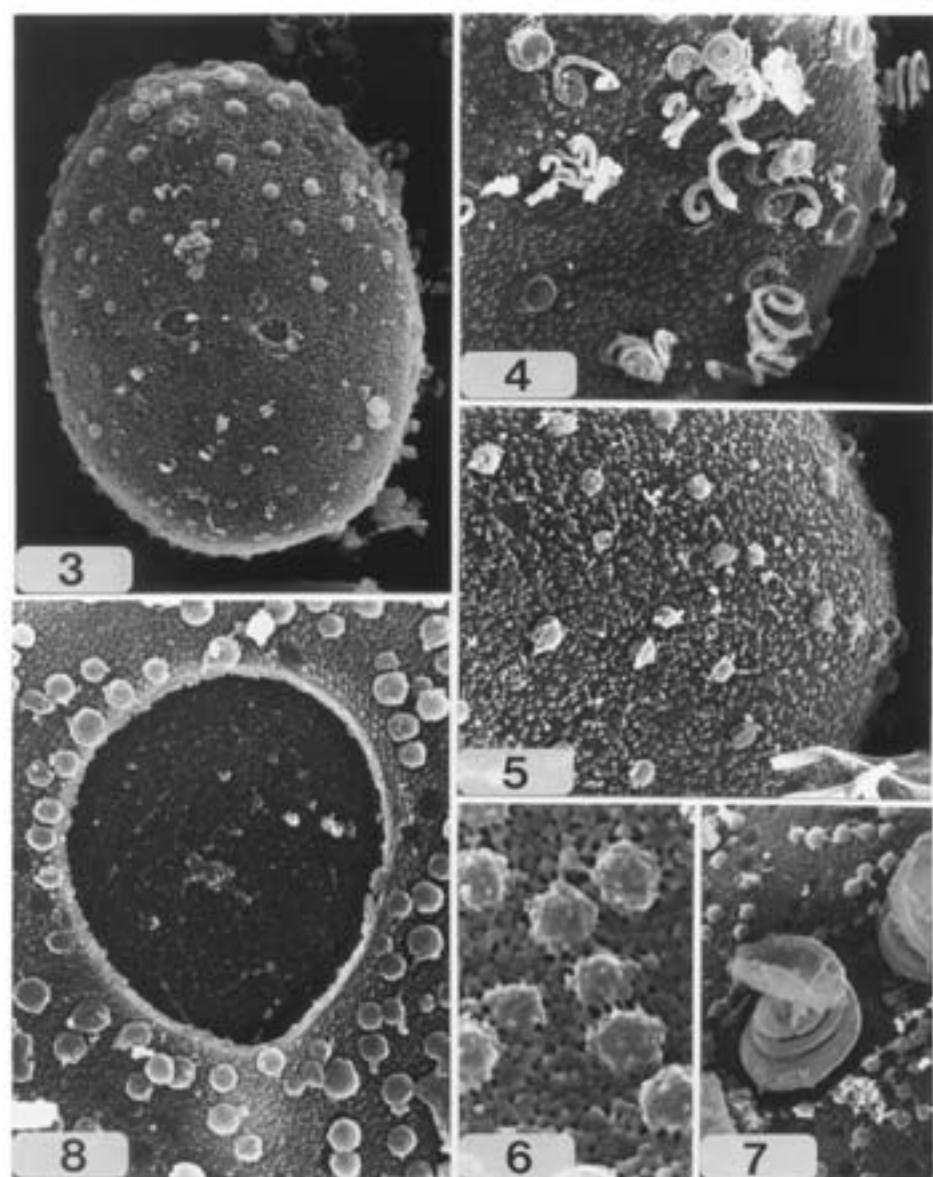
pole (Figs. 4, 7). This aggregation is rather sparse (small area, relatively long distances between adjacent KCT: from 8 to 10 μm , occasionally 4–6 μm). Those of the second kind are smaller (diameter 3 μm), and sparsely distributed all over the chorion surface (Fig. 5). Two to three micropyles in subequatorial area (Fig. 8). Sperm guide ovoidal, 10–12 μm in length and 7–8 μm in width (micropylar opening situated at the side). Micropylar rim thin, surrounded by tubercles similar to those from chorion surface.

Male imago

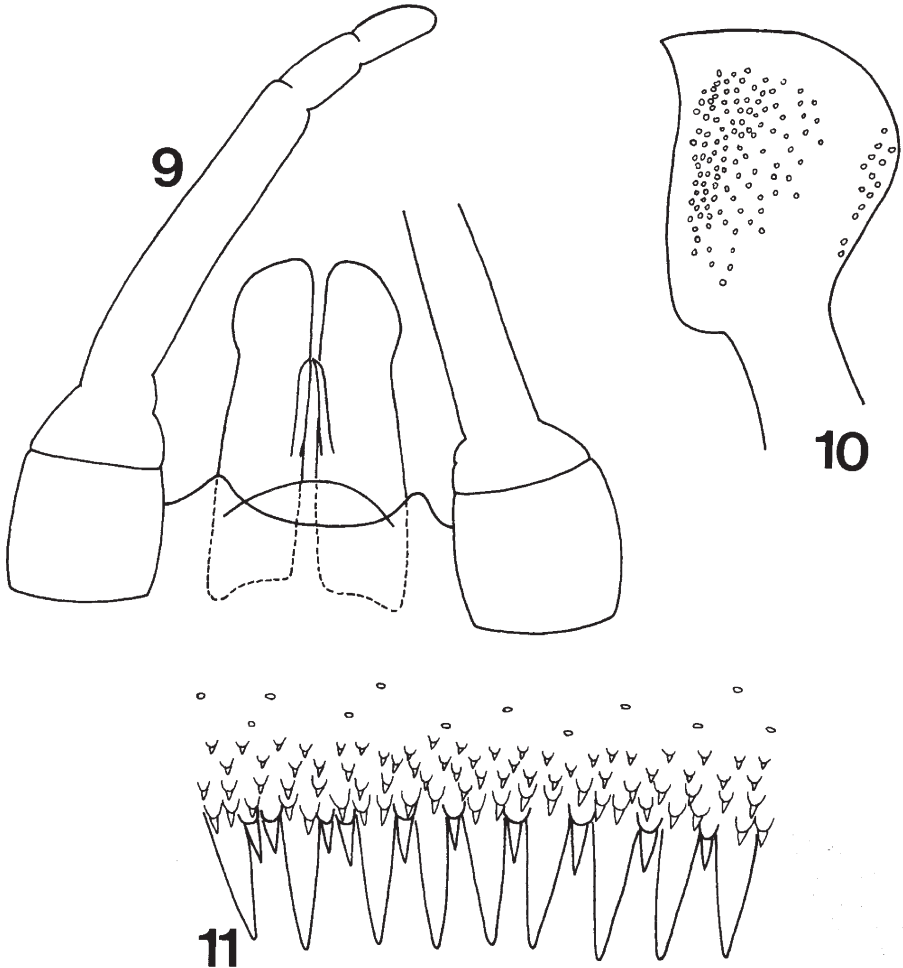
The genitalia of the holotype male imago (on slide) are slightly deformed because they were on a regular slide instead of a depression slide. Its schematic drawing is presented in Landa (1969, 1970). In fact, the penis lobes are rather narrow, not widened in the basal part. The apical part is slender and slightly excised in outer margin (Fig. 9) (see also: Bauernfeind, 1994; Bauernfeind & Humpesch, 2001).

Nymph

Description of nymph: body length 10.5–11.5 mm; cerci 10.0 mm. Coloration of body brown, with numerous markings (pale, light spots), typical of the genus *Electrogena*. Head brown, antennae yellow-brown. Mandibles rather massive, prostheca with 5–7 long setae. Pronotum brown, mesothorax and metathorax yellow-brown. Femora of all legs with very characteristic bright cross-like pattern on a dark background. In some cases the cross-like pattern is not clearly expressed. Tibiae light brown with dark band in the middle. Tarsi brown, distal part paler. Abdominal tergites brown, with pale spots, as generally in *Electrogena*. Hind margins of abdominal tergites with rather thin, long and pointed teeth, with 1–2 short and small ones interspaced



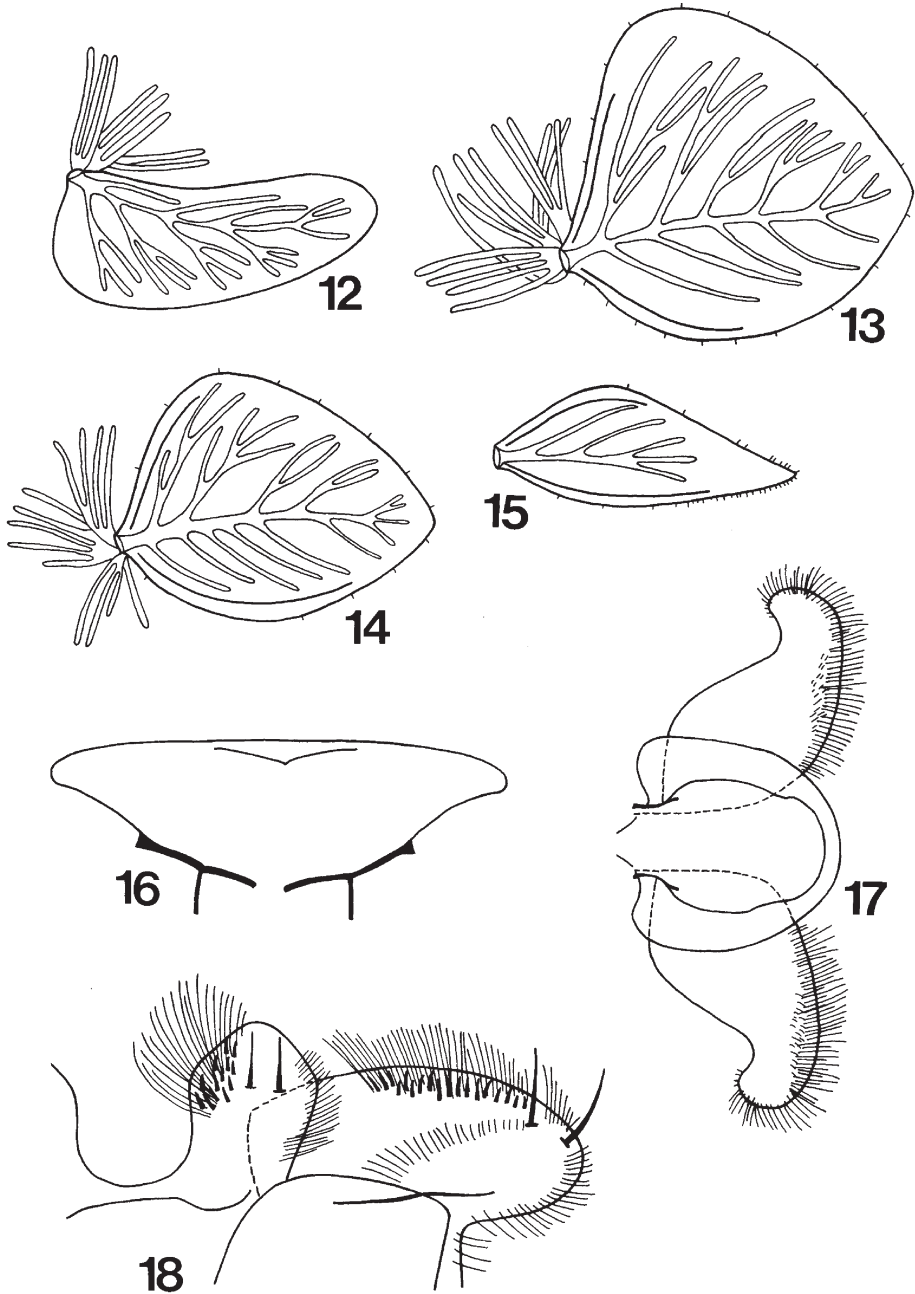
Figures 3–8. *Electrogena quadrilineata*, egg: (3) general outline (580 \times); (4) egg pole with large knob-terminated coiled threads (KCTs) (1500 \times); (5) chorionic surface with small KCT and tubercles (1300 \times); (6) chorionic surface at high magnification (ground matrix visible) (15625 \times); (7) large KCT attachment structures (4080 \times); (8) micropyle with tubercles (5800 \times) (JEOL JSM 5410 scanning microscope).



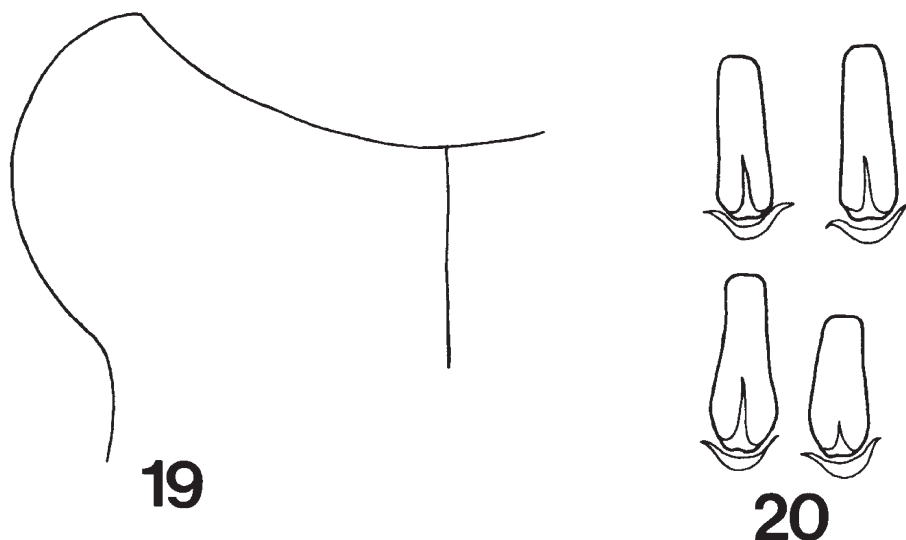
Figures 9–11. *Electrogena quadrilineata*: (9) Male imago, genitalia, ventral view (from type material). Nymph: (10) arrangement of long bristles on outer margin of galea-lacinia; (11) central part of posterior margin of fifth abdominal tergum.

(Fig. 11). Nervous ganglia well visible, light brown. All gills except 7th asymmetrical, with tufts. First gill rather narrow, elliptical, with rounded apex (Fig. 12); third and sixth broad, heart-shaped, distally pointed (Figs. 13, 14); seventh slender with narrow and pointed apex (Fig. 15). Caudal filaments brown, paler in distal part, without swimming hairs.

All the quantitative characters (meristic and ratios) listed by Belfiore (1994, 1995, 1996, 1997), Belfiore and Desio (1995), Belfiore and Sartori (1999) and Belfiore et al. (1999) were used in the present study.



Figures 12–18. *Electrogena quadrilineata*, nymph: (12) first gill; (13) third gill; (14) sixth gill; (15) seventh gill; (16) outline of labrum; (17) hypopharynx; (18) fragment of labium with glossa and paraglossa.



Figures 19–20. *Electrogena quadrilineata* nymph: (19) outline of lateral part of pronotum; (20) spines of central part of dorsal surface of fore femora.

Diagnostic character states

Since only four nymphs were available, the characters of every individual are provided in square brackets; the first three nymphs were from Klíčava, the last nymph was from Šembera:

Quantitative characters (N_ = meristic characters; R_ = ratio characters):

1. N_PLP — maxilla: number of hairs on fore margin and ventral surface of the first segment of maxillary palpus; [45, 44; 38, 36; 37, 34; 28, 25; mean = 36]; the number of hairs is very high. Closest species are *E. affinis* (Eaton, 1883), mean = 35 (Belfiore et al., 1999) and *E. ujhelyii* (Sowa, 1981), mean = 20–20.3 (Belfiore & Desio, 1995; Belfiore, 1996).
2. N_OUT — maxilla: number of long bristles on outer margin of galea-lacinia; [13, 16; 14, 16; 14, 13; 14, 14; mean = 14.3] (Fig. 10); *E. quadrilineata* belongs to the group of species with several bristles on outer margin of galea-lacinia, like *E. gridellii* (Grandi, 1953), mean = 12 (Belfiore, 1996, 1997).
3. N_CBS — maxilla: number of comb-shaped bristles of galea-lacinia; [16, 16; 16, 15; 16, 15; 16, 16; mean = 15.8]; the number of comb-shaped bristles on maxilla is the smallest among all examined species. The closest species by this character are *E. affinis*, mean = 17.3 (Belfiore et al., 1999), *E. lateralis* (Curtis, 1834), mean = 17.5, *E. hyblaea* Belfiore, 1994 and *E. lunaris* Belfiore & Scillitani, 1997, mean = 17.6 (Belfiore, 1996, 1997; Belfiore et al., 1997).
4. N_TCB — maxilla: number of pointed teeth on the fifth (starting from inner side) comb-shaped bristle of galea-lacinia; [8, 8; 8, 8; 7, 7; 7, 7; mean = 7.5]; the

- number of teeth is low, the smallest among all examined species. The closest species are *E. lateralis*, mean = 8.4, *E. grandiae* (Belfiore, 1981), mean = 8.6 (Belfiore, 1996) and *E. lunaris*, mean = 6.0 (Belfiore et al., 1997).
5. N_CLW — legs: number of teeth on tarsal claw (modal number among the legs) = 2; all claws of each examined specimen have two teeth, like *E. calabra* Belfiore, 1995, *E. fallax* (Hagen, 1864), *E. grandiae*, *E. gridelli*, *E. hyblaea* Belfiore, 1994 and *E. malickyi* (Braasch, 1983) (Belfiore, 1996, 1997).
 6. N_BVF — legs: number of bristles on ventral surface of femora, near the hind edge (fore leg); [35; 30, 32; 35, 36; 35, 38; mean = 34]; many bristles are present on ventral surface of femora, therefore *E. quadrilineata* belongs to the group of species with >10 bristles on margin of femora, like *E. ujhelyii*, *E. zebrata* (Hagen, 1864) and *E. fallax* (Belfiore, 1997; Belfiore et al., 1999).
 7. N_HFF — legs: number of setae (long and tiny hairs) on the fore (ventral) margin of fore femora; [all nymphs = 0]; the hairs are as long as bristles along the fore margin of femora.
 8. R_1GI — gills: 1st gill length/width; [2.1; 2.2; 2.7; 2.3; mean = 2.3]; the first gill is intermediate between broad and slender, like *E. gridellii* (Belfiore, 1996) and *E. lunaris* (Belfiore et al., 1997).
 9. R_7GI — gills: 7th gill length/width; [2.4; 2.4; 2.4; 2.4; mean = 2.4]; the seventh gill is also intermediate between broad and slender, like *E. malickyi*, mean = 2.4, *E. gridellii* and *E. ujhelyii*, mean = 2.3 (Belfiore, 1996).
 10. R_LBR — labrum: total length/length of lateral projection; [4.4; 5.0; 4.1; 4.5; mean = 4.5] (Fig. 16); the labrum is slender, with intermediate long lateral projections; the closest species are *E. calabra*, *E. fallax* and *E. hyblaea* (Belfiore, 1994, 1995, 1996).
 11. R_GLA — labium: distance between outer margins of glossae/distance between inner margins of glossae; [3.1; 3.1; 2.9; 3.0; mean = 3.0]; glossae are close together; the nearest relatives are *E. fallax*, *E. lunaris* and *E. malickyi* (Belfiore, 1995, 1996; Belfiore et al., 1997).
 12. R_GLB — labium: distance between outer margins of glossae/width of glossa; [2.8; 2.7; 3.0; 2.8; mean = 2.8]; glossae are narrow, like *E. ujhelyii* (Belfiore & Desio, 1995) and *E. affinis* (Belfiore et al., 1999).

Qualitative characters:

13. S_HLB — hypopharynx: extension of pilosity on lateral lobes (Fig. 17); long hairs extend over the apex of lobes, like in all examined *Electrogena* species except *E. lateralis*, *E. ujhelyii* (Belfiore, 1997) and *E. lunaris* (Belfiore et al., 1997).
14. S_PGL — labium: shape of paraglossae (Fig. 18): paraglossae are asymmetrically rounded.
15. S_PNT — pronotum shape (Fig. 19); pronotum is wide, hind corners smoothly rounded, like another examined *Electrogena* species except *E. fallax* (Belfiore, 1997).
16. S_BFE — legs: shape of distal bristles on upper surface of femora (Fig. 20); bristles on surface of femora are rather long and blunt.

17. S_TAR — legs: marking of tarsus; tarsi are darkened at apex only.
18. S_7GI — 7th gill shape (Fig. 15); seventh gill rather slender and gradually narrowing before apex.
19. S_PLB — maxilla: length of bristles on hind margin of the first segment of maxillary palpus; these bristles are long (about 1/3 of the segment width).
20. S_LBB — labrum: arrangement of paramedian bristles on ventral side of labrum, near the fore margin; these bristles are arranged in a single row.

Affinities

E. quadrilineata can be distinguished from other European species of *Electrogena* in both the nymphal and adult stages.

Diagnostic characters of the nymph of *E. quadrilineata* are as follows: N_CLW = 2; N_OUT > 2 (mean 14.3); N_BVF — several bristles are present on ventral surface of femora (mean 34); N_PLP > 12 (mean 36) and S_HLB — long hairs extend over the apex of lobes. The combination of the last two characters allows one to distinguish *E. quadrilineata* from *E. fallax* (N_PLP < 10) and *E. ujhelyii* (N_PLP > 12, S_HLB — short hairs). N_CBS (mean 15.8) of *E. quadrilineata* is the smallest among the species studied so far. In the adult stage, male *E. quadrilineata* can be distinguished by the shape of the penis lobes, which are slim and do not widen in apical part.

Females can be distinguished by their wide subgenital plate.

Eggs are typical of genus *Electrogena*: chorionic surface rugose with small tubercles, KCT attachment structures, oval micropyles. However, the eggs of *E. ujhelyii* (Sowa, 1981; Landolt et al., 1991; Belfiore & Desio, 1995), *E. samalorum* (Landa & Soldán, 1982), *E. grandiae*, *E. lateralis* (Gaino et al., 1987) and *E. lunaris* (Belfiore et al., 1997) differ in size and both the number and distribution of attachment structures at the chorion surface. By the poorly developed concentration of large KCT on one egg pole, eggs of *E. quadrilineata* most closely resemble those of *E. ujhelyii* and *E. samalorum*.

Notes on distribution

The actual distribution of *E. quadrilineata* is not well known because many past literature records of *E. quadrilineata* are questionable and possibly misidentified. *E. quadrilineata* was first described from Bohemia and from Slovakia (Landa, 1970; Landa & Soldán, 1985, 1989). According to early papers by Landa and Soldán (1985, 1989) this is a Hercynian endemic species. Puthz (1978) maintains that *E. quadrilineata* reaches the Central Sub-alpine Mountains, Carpathian, Central and Eastern Lowlands. In Poland, Sowa (1975), Kukuła (1991) and Kłonowska-Olejnik (2000) found this species in several localities in Carpathian and sub-Carpathian streams. The species is also known from Austria (Weichselbaumer & Sowa, 1990), Slovakia (Deván, 1991, 1993, 1994), Ukraine (Godunko, 2000a, b) and Bulgaria (Russev et al., 1991). Thus, *E. quadrilineata* seems to be a Central European species (Soldán et al., 1998).

Acknowledgments

My great appreciation is expressed to Dr. T. Soldán is for facilitating my studies of the type material of *E. quadrilineata* and for providing access to some specimens from his collection, as well as for his generous hospitality during my visit to his laboratory in České Budějovice. The SEM photographs (JEOL JSM 5410) of the eggs were made in the Department of Cytology and Histology, Jagiellonian University, Cracow. I am indebted to Mrs. J. Faber for technical assistance.

References

- Bauernfeind E (1994): Bestimmungsschlüssel für die österreichischen Eintagsfliegen. Insecta, Ephemeroptera. *Wasser Abwasser Suppl 4*: 1–92.
- Bauernfeind E, Humpesch U (2001): *Die Eintagsfliegen Zentraleuropas (Insecta, Ephemeroptera): Bestimmung und Ökologie*. Wien, Naturhistorisches Museum Wien, 239 pp.
- Belfiore C (1994): Taxonomic characters for species identification in the genus *Electrogena* Zurwerra and Tomka, with a description of *Electrogena hyblaea* sp. n. from Sicily (Ephemeroptera, Heptageniidae). *Aquat Insects 16*: 193–199.
- Belfiore C (1995): Description of *Electrogena calabra* n. sp., a new species from Southern Italy (Ephemeroptera, Heptageniidae). *Annls Limnol 31*: 29–34.
- Belfiore C (1996): Identification and discrimination of *Electrogena* species by numerical methods (Ephemeroptera: Heptageniidae). *Syst Entomol 21*: 1–13.
- Belfiore C (1997): Taxonomic characters and discrimination of species in the genus *Electrogena* Zurwerra & Tomka, 1985 (Ephemeroptera, Heptageniidae). In: Landolt P, Sartori M, eds, *Ephemeroptera & Plecoptera: Biology–Ecology–Systematics*. Fribourg, MTL, pp. 427–433.
- Belfiore C, Desio F (1995): Taxonomy and distribution of *Electrogena ujhelyii* (Sowa, 1981) (Insecta: Ephemeroptera: Heptageniidae). *Ann Naturhist Mus Wien 97*: 151–154.
- Belfiore C, Sartori M (1999): Redescription of *Electrogena galileae* (Demoulin, 1973) (Ephemeroptera, Heptageniidae). *Rev Suisse Zool 106*: 1025–1034.
- Belfiore C, Scillitani G, Picariello O, Cataudo A (1997): Morphological and electrophoretic evidence for a new species of *Electrogena* from Central Italy: description of *E. lunaris* sp. n. (Ephemeroptera: Heptageniidae). *Aquat Insects 19*: 129–140.
- Belfiore C, Haybach A, Klonowska-Olejnik M (1999): Taxonomy and phenetic relationships of *Electrogena affinis* (Eaton, 1883) (Ephemeroptera: Heptageniidae). *Annls Limnol 35*: 245–256.
- Deván P (1991): Nové a vzácne druhy podeniak (Ephemeroptera) fauny Slovenska. *Biol Bratislava 46*: 509–511. (In Slovakian with English summary.)
- Deván P (1993): Ekológia podeniak podhorského toku. II. Heptageniidae a Epherrellidae. *Biol Bratislava 48*: 167–172. (In Slovakian with English summary.)
- Deván P (1994): Mayfly communities (Ephemeroptera) of the Myjava upper stream. *Biol Bratislava 49*: 211–222.
- Gaino E, Belfiore C, Mazzini M (1987): Ootaxonomic investigation of the Italian species of the genus *Electrogena* (Ephemeroptera, Heptageniidae). *Boll Zool 54*: 169–175.

- Godunko RJ (2000a): Little known species of the genera *Rhithrogena* and *Electrogena* (Ephemeroptera, Heptageniidae) from Ukraine. *Vestn Zool* 14: 60–66.
- Godunko RJ (2000b): Historical changes of the fauna and questions of reservation of mayfly (Ephemeroptera, Insecta) of Ukrainian Carpathians. *Proc State Nat Hist Mus* 15: 158–168. (In Ukrainian with English summary.)
- Klonowska-Olejnik M (2000): Jętki (*Ephemeroptera*) Bieszczadów Zachodnich (Mayflies (*Ephemeroptera*) in the Western Bieszczady Mountains). *Monogr Bieszczadzkie VII*: 145–155. (In Polish with English summary.)
- Kukuła K (1991): Mayflies (Ephemeroptera) of the Wołosatka stream and its main tributaries (Bieszczady National Park, southeastern Poland). *Acta Hydrobiol* 33: 31–45.
- Koss RW, Edmunds GF Jr (1974): Ephemeroptera eggs and their contribution to phylogenetic studies of the order. *Zool J Linnol Soc* 55: 267–349.
- Landa V (1969): *Jepice — Ephemeroptera. Fauna ČSSR, 18*. Praha, Československé Akademie Věd, 350 pp.
- Landa V (1970): *Ecdyonurus submontanus*, *Heptagenia quadrilineata*, *Rhithrogena hercynia*-new species of mayflies (Ephemeroptera) of the family Heptageniidae from Czechoslovakia. *Acta Entomol Bohemoslov* 67: 13–20.
- Landa V, Soldán T (1982): *Ecdyonurus samalorum* sp. n. from Czechoslovakia (Ephemeroptera, Heptageniidae). *Acta Entomol Bohemoslov* 79: 31–36.
- Landa V, Soldán T (1985): Distributional patterns, chorology and origin of the Czechoslovak fauna of mayflies (Ephemeroptera). *Acta Entomol Bohemoslov* 82: 241–268.
- Landa V, Soldán T (1989): *Rozšíření Řádu Ephemeroptera v ČSSR s ohledem na Kvalitu Vody. Studie ČSAV, 17*. Praha, Československé Akademie Věd, 172 pp. (In Czech with English summary.)
- Landolt P, Dethier M, Malzacher P, Sartori M (1991): A new *Electrogena* species from Switzerland (Ephemeroptera, Heptageniidae). *Bull Soc Vaud Sci Nat* 80: 459–470.
- Puthz V (1978): Ephemeroptera. In: Illies J, ed., *Limnofauna Europaea*. Stuttgart, G. Fischer Verlag, pp. 257–263.
- Russev BK, Janeva IJ, Čankova MT (1991): Distribution and ecology of the larvae from order Ephemeroptera (Insecta) in the Bulgarian Black Sea tributaries. *Bulg Acad Sci, Hydrobiol* 36: 56–67.
- Soldán T, Zahrádková S, Helešic J, Dušek L, Landa V (1998): *Distributional and Quantitative Patterns of Ephemeroptera and Plecoptera in the Czech Republic: a Possibility of Detection of Long-Term Environmental Changes of Aquatic Biotopes*. Brno, Masaryk University, 298 pp.
- Sowa R (1975): Ecology and biogeography of mayflies of running waters in the Polish part of the Carpathians. 1: Distribution and quantitative analysis. *Acta Hydrobiol* 17: 223–297.
- Sowa R (1981): Taxonomy and ecology of *Ecdyonurus ujhelyii* sp. n. (Ephemeroptera, Heptageniidae) from the tributaries of Lake Balaton. *Acta Hydrobiol* 23: 375–380.
- Weichselbaumer P, Sowa R (1990): Beitrag zur Kenntnis der Eintagsfliegenfauna Österreichs (Insecta: Ephemeroptera). *Ber Nat-Med Ver Innsbruck* 77: 113–122.
- Zurwerra A, Tomka I (1985): *Electrogena* gen. nov., eine neue Gattung der Heptageniidae (Ephemeroptera). *Entomol Ber Luzern* 13: 99–104.

