



Description of *Ecdyonurus solus* sp. nov., a new species of the *Ecdyonurus venosus* species-group (Ephemeroptera: Heptageniidae) from the Crimean Peninsula, Ukraine

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Abstract

The larvae and adults of *Ecdyonurus solus* sp. nov., are described and illustrated. This species is found in the mountainous region of the Crimean Peninsula, and belongs to the *Ecdyonurus venosus* species-group. SEM photographs of the eggs of new species are presented. The distinguishing characteristics separating this *E. solus* sp. nov. from closely related species of the *E. venosus* species-group are discussed. Detailed data on the biology and distribution of the new species are presented.

Key words: *Ecdyonurus venosus* species-group, Ephemeroptera, Heptageniidae, new species, description, taxonomy, Crimean Peninsula, Ukraine

Introduction

So far little is known about the genus *Ecdyonurus* Eaton, 1868 from the Crimean Peninsula. It was first identified in the 1980's by R. Sowa who described the species *Electrogena braaschi* (Sowa, 1984) (originally *Ecdyonurus braaschi* from the *Ecdyonurus lateralis* species-group) from the Bel'bek Stream on the northern slopes of Aipetryns'ka Yaila (Sowa 1984). This region is in the height climatic subalpine belt, and is typical of the Crimean Mountains (Godunko *et al.* 2002). *Ecdyonurus venosus* (Fabricius, 1775) and *E. fluminum* (Pictet, 1843) were reported in the rivers on northern slopes of the Crimean Mountains and their foothills such as the Angara River, the Kirliuk-Su River, the Eni-Sala River, the Kyzyl-Koba River, the Aian River, the Tavel' River, the Dzhalman River and the Salgir River (Kiseleva & Ezernitskii 1985; Kiseleva 1992, 1993). Verification of the material collected by G. A. Kiseleva in 1984, 1985 and 1989 from the Eastern Ulu-Uzen' River and the Skel'skii Stream showed that the species that had been named "*Ecdyonurus fluminum*" and "*Heptagenia sulphurea*" are in fact *E. braaschi*. In our taxonomic studies, carried out in Crimea from 1999 through 2003, we identified the previously undescribed *Ecdyonurus* species, *E. solus* sp. nov. Also, there are three larvae of this species found in G. A. Kiseleva's material from Stilia river in 1989. It is highly conceivable that Kiseleva and Ezernitskii (1985) identified it as "*E. venosus*".

E. solus sp. nov. is now the only one species representative of the genus *Ecdyonurus* s. str. on the Crimean Peninsula. It is likely that *E. solus* sp. nov. used to be more common but now its habitat is very limited as a result of increasing river pollution, river regulation, dams and reservoirs, particularly in the pre-mountain part of the Crimea.

In nearby the Caucasus there are two species belonging to the *E. venosus* species-group. *E. ornatipennis* Tshernova, 1938 was described on the basis of a single male imago from the Eastern Caucasus Mts. in the Nakhichevan' Republic (Tshernova 1938). Braasch (1980a) described larvae of the genus *Ecdyonurus* collected close to a type locality of *E. ornatipennis* as this species. The shape of pronotum projections clearly differentiated these larvae from other species of the *Ecdyonurus venosus* species-group. Braasch (1980b) at the same time described *E. autumnalis* Braasch, 1980 on the basis of a male imago from the Amtkel River (right tributary of the Kodori River, the Kodori Gorge, the Western Caucasus Mts.).

In this paper, the mature larvae and adults of *E. solus* sp. nov. are described and illustrated. The distinguishing characteristics separating this species from closely related representatives of the *E. venosus* species-group is given. Detailed data concerning the distribution and biology of the new species are also presented.

***Ecdyonurus solus* Godunko, Kłonowska-Olejnuk and Prokopov, sp. nov.**
(Figs 1–25)

Ecdyonurus venosus: Kiseleva and Ezernitskii 1985: 112; Kiseleva 1993: 163; Godunko 2001: 81

Ecdyonurus fluminum: Kiseleva and Ezernitskii 1985: 112; Kiseleva 1992: 116; Kiseleva 1997: 39

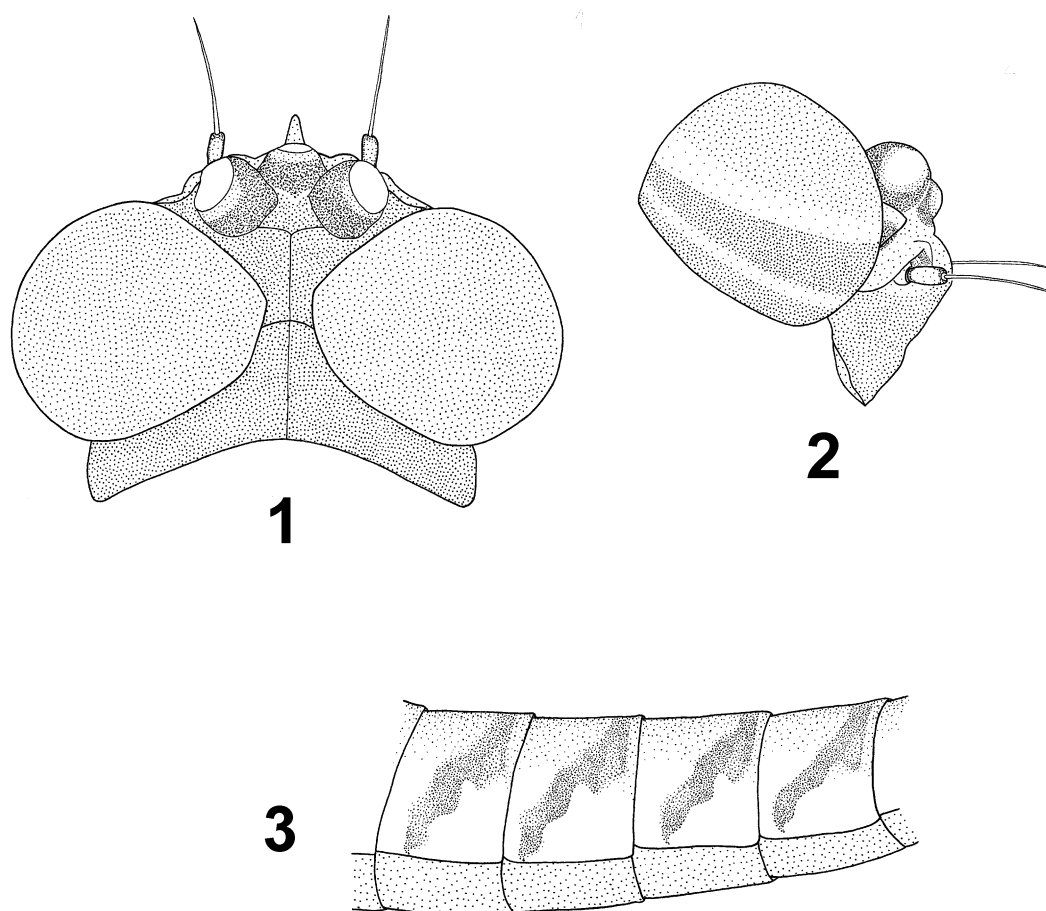
Description. *Male imago* (all adults were reared from larvae). Size: body 10.0–10.4 mm; fore wing 11.0–11.2 mm; hind wings 3.9–4.3 mm; fore legs 10.2–10.9 mm (femur 2.6–2.7 mm; tibia 2.5–2.7 mm; tarsal segments: T1 = 0.8–1.0 mm; T2 = 1.4–1.5 mm; T3 = 1.3–1.4 mm; T4 = 1.1 mm; T5 = 0.5 mm; gradation of tarsal segments: 2>3>4>1>5); cerci 29.6–30.5 mm. General color of body yellow to brown.

Head yellowish with brownish and brownish-gray smudges on short facial keel. Antennae brown. Ocelli black basally with subapical yellowish-brown ring and whitish or white-gray apically. Eyes are separated by a distinct gap comparable in size with the central ocellus, gray-blackish, with light gray ring around of margin. Lateral portion of eyes with two light gray rings (Figs 1, 2).

Thorax yellow to brown, dorsally with dark brown maculation on metanotum and hind part of mesonotum. Pronotum light yellowish-brown. Lateral part of thorax generally whitish to yellowish-brown. Ventral part of thorax distinctly brown to brownish-black. Wing hyaline, transparent, unicolorous. Pterostigmatic area clearly yellow, costal area yellowish-white. Venation brown to blackish, lighter basally. Fore legs distinctly darker than middle and hind legs: femora dark brown; tibiae and tarsi brown, with slightly dark last tarsal segment. Middle and hind legs with yellow femora and tibiae; tarsi yellowish-brown basally with brownish last segment.

Abdominal terga yellow to yellowish-brown. Tergum 1 brown, with blackish-brown strips near hind margin of segment; tergum 2 with central longitudinal light band and two brownish paramedian bands; terga 3–10 yellowish, with two longitudinal narrow paramedia bands (terga 7–10 slightly darker than others ones). Laterally terga 2–8 with distinct blackish-brown stripes connected dorsally in posterior part of segments (Fig. 3). Sterna 1 and 9 brown, sterna 2–8 uniformly yellowish with two unclear brownish spots. Violet or blackish nerve ganglia well visible on the sterna 2–8. Cerci brownish, lighter apically. Joints of segments blackish.

Styliger plate light brown, with two small and rounded apically protuberance near forceps base (Fig. 4). Forceps brown. Penis lobes light brown, slightly stretched laterally and convergent toward outer margins, with rounded distal part. Penis light brown. Basal sclerite large, partially cover the basal part of lateral sclerite. Lateral sclerite narrow and curved, distinctly convergent distally. Apical sclerite relatively wide, not convergent apically. Titilators wide, brown (Fig. 5).



FIGURES 1–3. *Ecdyonurus solus* sp. nov., male imago, paratype: 1, head, dorsal view; 2, head, lateral view; 3, abdominal segments 4–7, lateral view.

Female imago. Size: body 12.2 mm; fore wing 12.0 mm; hind wings 4.0 mm; cerci 19.5 mm. Head yellow with blackish smudges on facial keel. Eyes and apical part of ocelli grayish-black. Central part of ocelli light yellow; apical part whitish. Antennae light brown.

Thorax yellow to dark brown. Pronotum yellowish-gray with two brownish spots centrally. Mesonotum yellowish-brown with brown to dark brown distal part. Metanotum dark brown. Lateral part of thorax yellowish-brown. Sterna of thorax brown to dark brown. Wings transparent, hyaline slightly yellowish color. Pterostigmatic area yellowish, opaque. Venation yellow to dark brown. Fore legs with light brown femora, and brown to dark brown tibiae and tarsi. Middle and hind legs with unicolorous yellow femora and yellowish-brown tibiae. Tarsi brown to dark-brown.

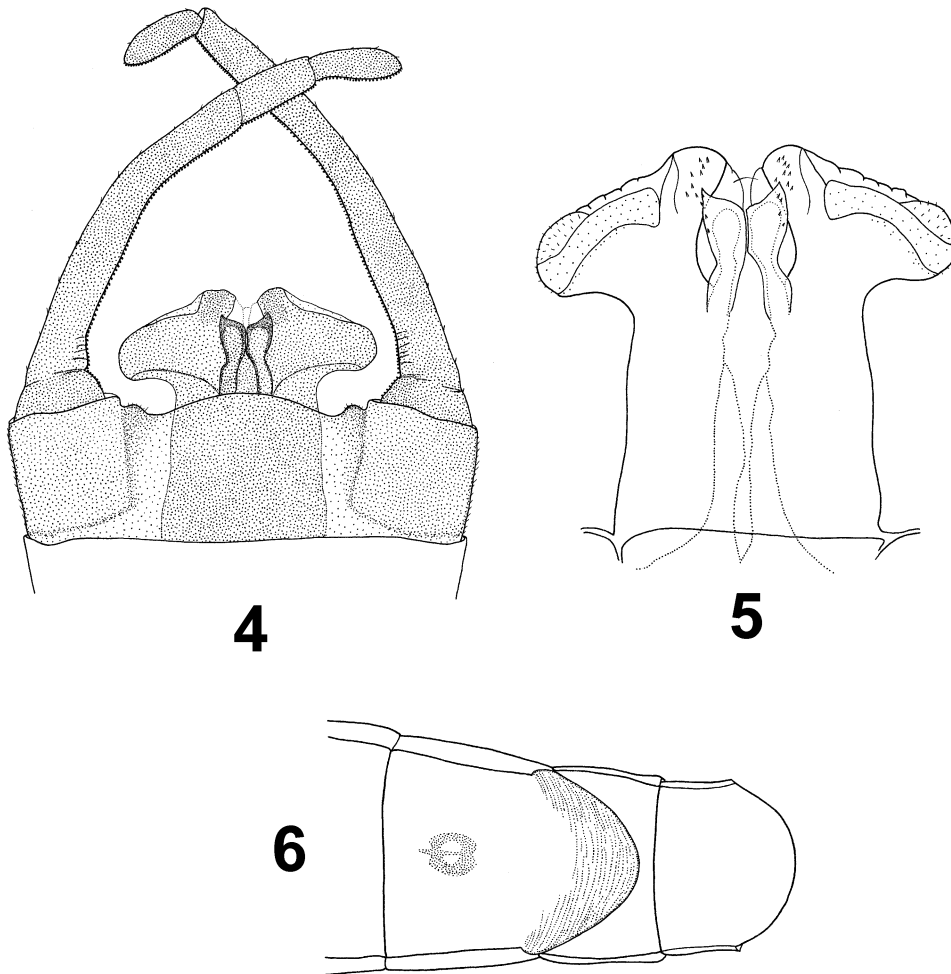
Abdominal terga with central longitudinal bands and two short reddish strokes on the segments. Two distinct triangular reddish or brownish spots are present on central part of tergum 1; lateral part of terga 2–8 with blackish stripes. Abdominal sterna yellow to reddish-brown, with uniformly pattern on the segments 1–7 (generally present two central light short strokes). Sterna 2–8 with visible violet or blackish nerve ganglia. Subgenital and subanal plates as in Fig. 6.

Male subimago. Size: body 9.5 mm; fore wing 12.0 mm; hind wings 4.0 mm; cerci 19.5 mm. General color of body yellow and yellowish-gray to brown and dark brown.

Head grayish brown, antennae brownish. Eyes grayish-black with one hard visible grayish-white ring laterally. Ocelli blackish basally, with grayish-white tip.

Pronotum brownish-gray. Mesonotum and metanotum yellowish-white with distinct dark brown bands. Wings unicolorous yellowish, relatively transparent. Venation whitish-gray to brownish. Transversal veins

darker than longitudinal with grayish-brown smudges around veins. Fore legs dark: femora brown slightly darker distally; tibiae dark brown; tarsi unicolorous brown. Middle and hind legs: femora yellow with elongate brownish spot apically; tibiae yellowish-brown; tarsi yellowish.



FIGURES 4–6. *Ecdyonurus solus* sp. nov. Figs 4–5, male imago, holotype: 4, male genitalia, ventral view; 5, penis lobe, dorsal view. Fig 6, female imago, paratype: tip of abdomen, ventral view.

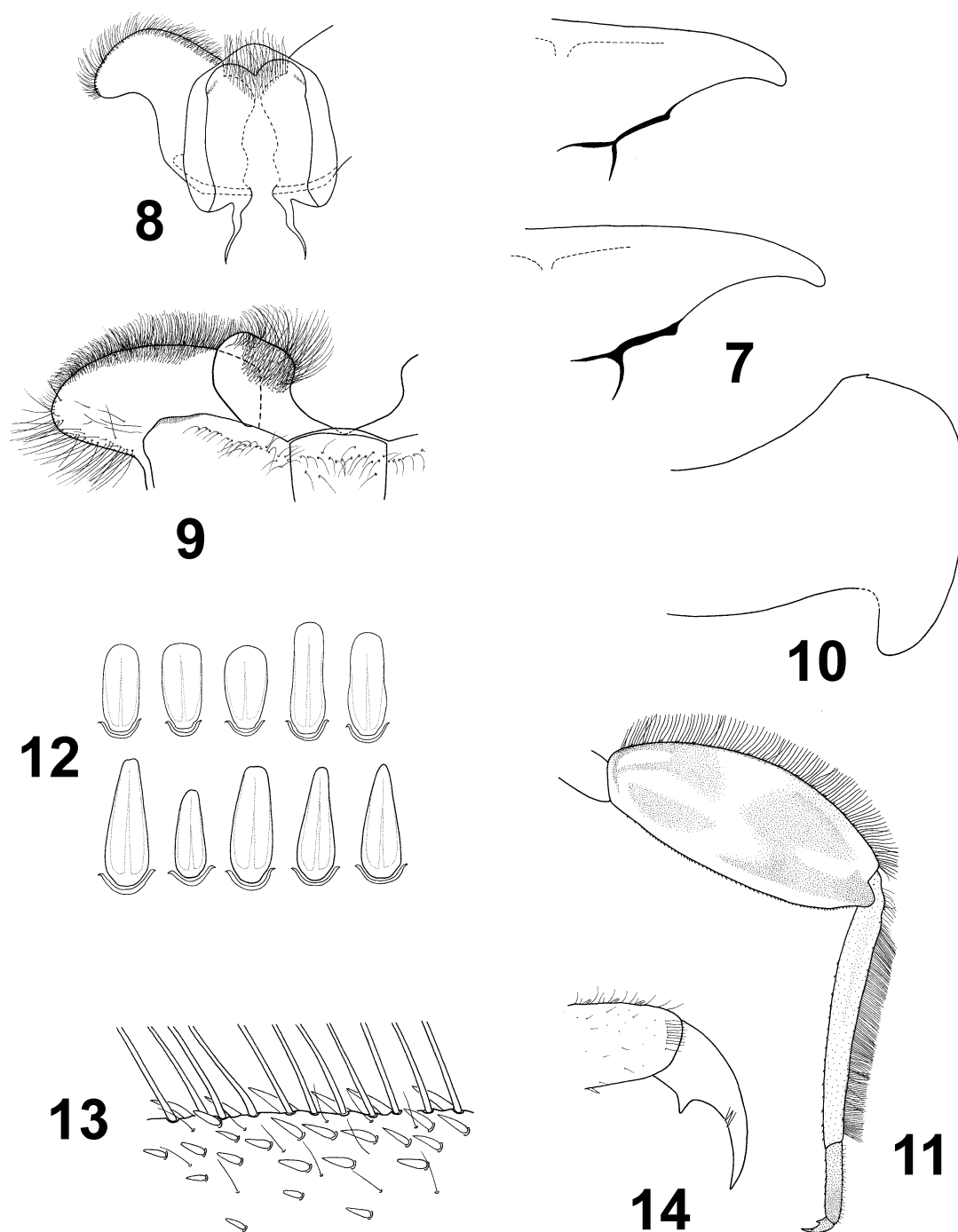
Abdominal terga yellow to yellowish-brown. Sterna 1–8 slightly darker than terga with two light short strokes and two light spots centrally. Sternum 8 with violet nerve ganglia. Lateral part of terga 1–8 with distinct blackish-brown stripes connected distally in posterior part of segments. Styliger plate yellowish-brown, forceps slightly darker. Cerci light brown. Joints of segments blackish.

Female subimago. Size: body 12.7–13.8 mm; fore wing 13.0–14.2 mm; hind wings 4.2–5.0 mm; cerci 12.2–13.7 mm. General color of body very similar to those of female imago except wings and legs.

Thorax yellow to dark brown. Wings distinctly yellowish to light brown, slightly opaque, especially in pterostigmatic area. Veins dark brown to black. Brownish smudges around veins are presented. Fore legs unicolorous dark brown with black tarsi. Middle and hind legs light brown. Tarsi dark brown to black.

Abdominal terga with distinct drawing: tergum 1 with diffuse central brownish spots; terga 2–3 with central diffuse brownish and two yellow spots; terga 4–5 with longitudinal brownish spot; terga 6–7 with two pair of small brownish spots near anterior part of segment; terga 8–10 uniformly yellowish with central brownish smudges. Lateral side of terga 1–8 with distinct dark brown strips. Sternum 8 with violet nerve ganglia. Cerci dark brown.

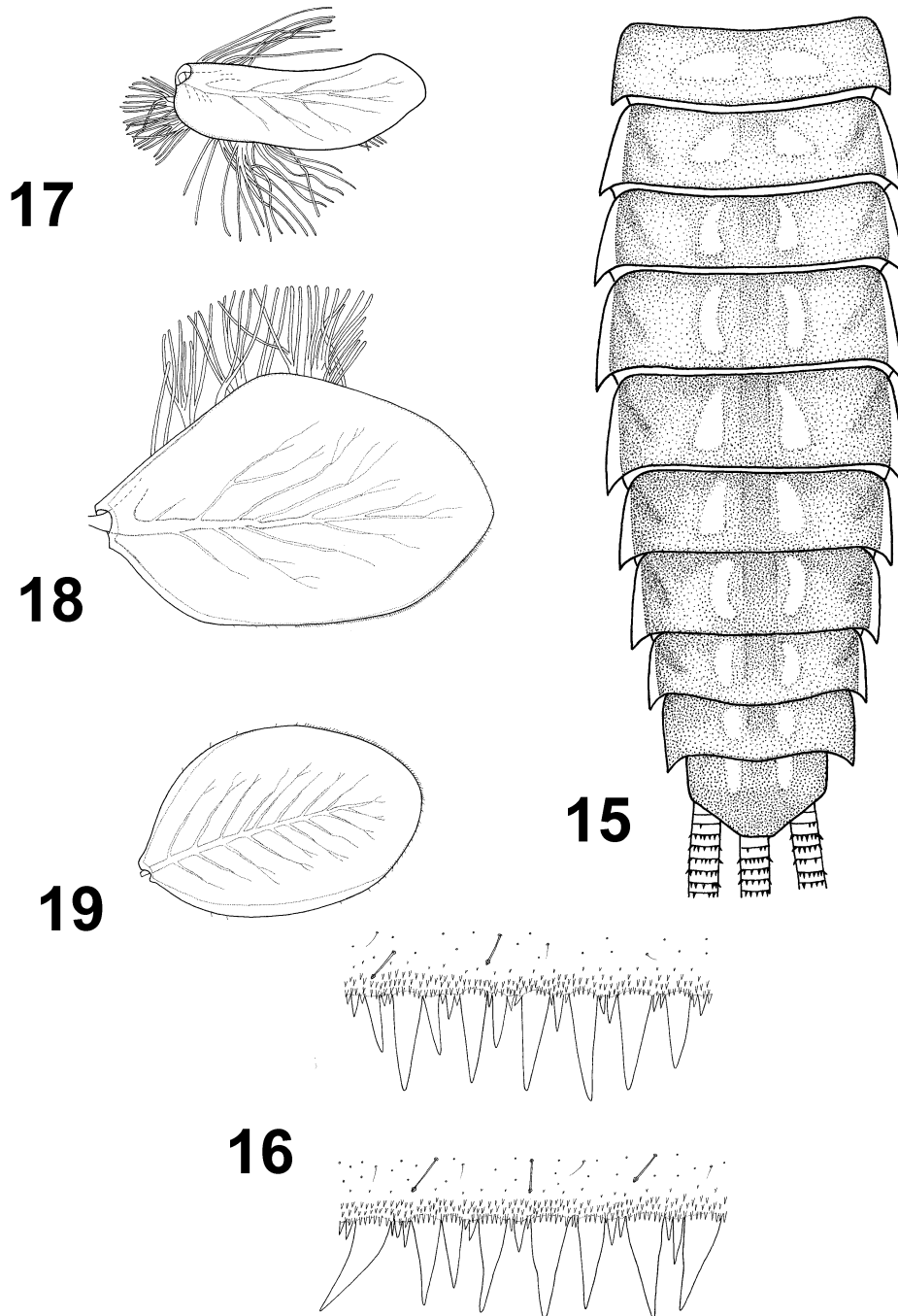
Mature larva. Body length 11.2–13.5 mm; caudal filaments 7.4–10.0 mm. General color yellow to light brown. Abdominal segments of mature larvae with well visible pattern similar to adults.



FIGURES 7–14. *Ecdyonurus solus* sp. nov., larva, paratype: 7, two kinds of lateral part of labrum; 8, hypopharynx; 9, glossa and paraglossa; 10, pronotum; 11, hind leg; 12, shape of femoral scales; 13, outer margin of femur; 14, tarsal claw.

Head yellow, oval, relatively large, the part at the eyes level not widest. Antennae yellow to light brown. Mouthparts: Labrum not large, slightly stretched laterally, dorsally with one row of 7–9 median strong bristles (Fig. 7), typical for the *E. venosus* species-group (Belfiore & Buffagni 1994). Hypopharynx without specific features, generally with long hair on the outer margin and distal part, typical for the *E. venosus* species-group (Fig. 8). Mandibles ($n = 20$) with 6–9 prosthecal bristles. Maxillae ($n = 20$) (characters listed by Haybach (1999)): number of comb-shaped bristles (N_{CBS}) = 17–22; number of teeth on 5th comb-shaped bristle (N_{TCB5}) = 14–17; number of hairs on dorsal upper side (N_{DOR}) = 14–18; outer margin of maxillae without hairs ($N_{OUT} = 0$); number of hairs on ventral basal part of maxillae (N_{VEN}) = 21–24; number of hairs

at the base of maxillary palps (N_PLBas) = 16–20; outer base of the first segment of maxillary palps without hairs (N_PLH = 0); number of setae on the outer margin of the first segment of maxillary palps (N_PLS) >50; number of setae on the inner side of the first segment of maxillary palps (N_PLP) >40. Labial palps with numerous hairs of the group on the dorsal side of its first segment (N_LPH = 28–36) arranged on 2–3 rows. Glossae slightly stretched laterally (Fig. 9).



FIGURES 15–19. *Ecdyonurus solus* sp. nov., larva, paratype: 15, abdomen, dorsal view; 16, two kinds of posterior margin of terga; 17, gill 1; 18, gill 4; 19, gill 7.

Pronotum yellow with some light central smudges. Lateral projection of pronotum short, distinctly asymmetrical, with apical part curved towards the body (Fig. 10). The width/length ratio of semipronotum to caudal projection (see Bauernfeind & Humpesch 2001) is 3.8–4.2. Mesonotum yellow to yellowish-brown, with whitish spots laterally. Legs yellow to light brown. Femora relatively slender and long. The length/width ratio

of metafemora on average 2.67. Dorsal surface of femora mainly with distinct pattern (four yellowish lateral spots on a dark field) (Fig. 11). Femoral scales of various types (Fig. 12). Outer margin of femora with row of long slender bristles and small pointed spines; subapical spines is pointed or bluntly pointed (Fig. 13). Tibiae yellow. Tarsi yellow to light brown basally with brown or dark brown apical ring. Tarsal claw brown to dark brown with 2–3 teeth (Fig. 14).

Abdominal terga yellow to light brown. Tergum 1 uniformly light; terga 2–7 and 10 (sometime 8) with two light central longitudinal spots (sometimes, with two pair of light spots); Tergum 9 with wide central light spot (Fig. 15). Posterior margins of terga with large pointed marginal teeth (Fig. 16). Sterna unicolorous yellowish-brown with well visible violet nerve ganglia on the segments 2–8. Gills yellowish to light brown. Gill 1 relatively long with broadly rounded apical part (Fig. 17). Gill 4 distinctly wide and asymmetrical (Fig. 18). Gill 7 as in Fig. 19, without tuft. Cerci yellow to yellowish brown.

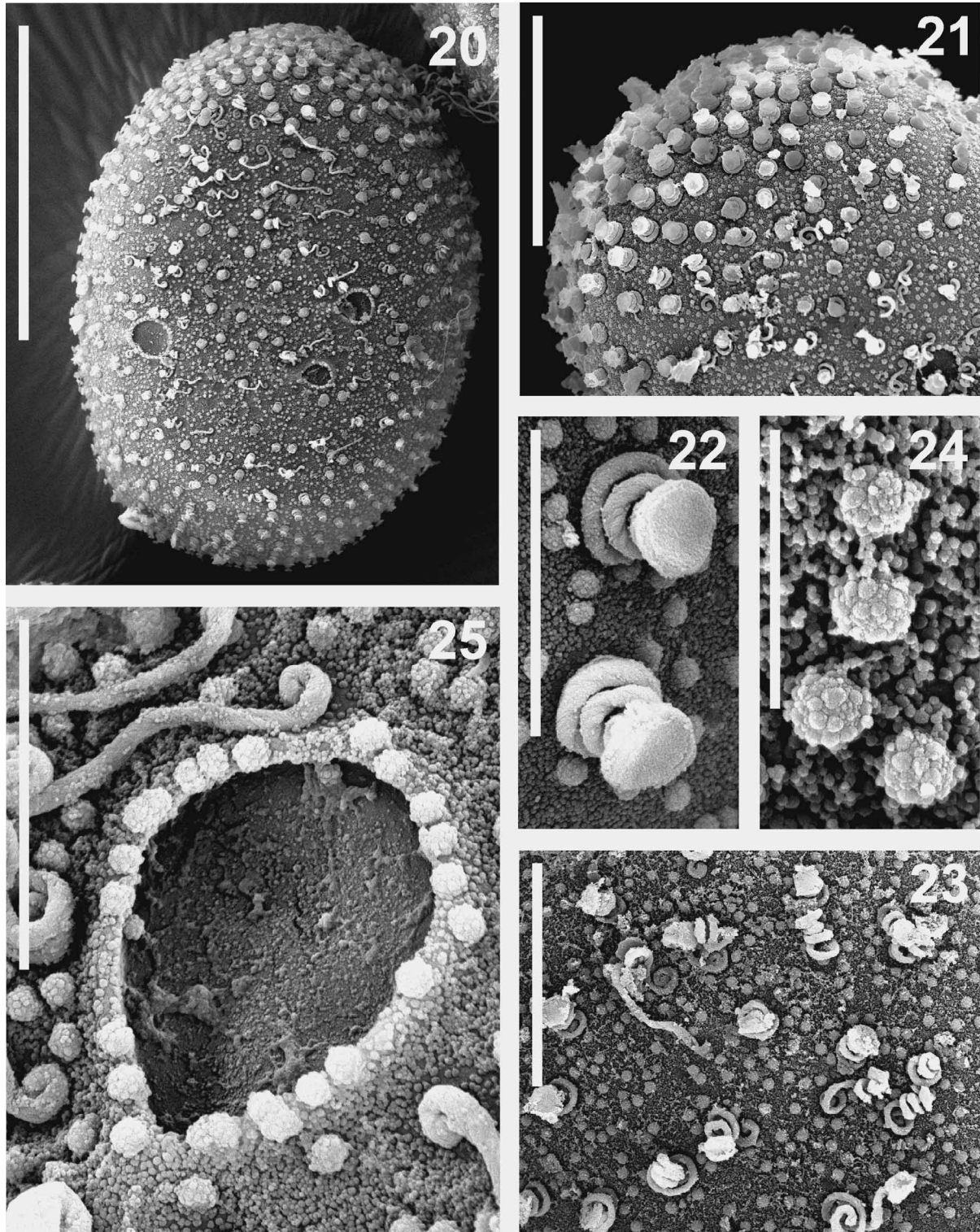
Egg. Size: length: 164–171 μm ; width 108–116 μm . Egg oval. The eggs are characterized by attachment structures, tubercles, and very small granules (Fig. 20). The attachment structures are represented by knob-terminated coiled threads (KCTs) (Koss & Edmunds 1974) and are of two different kinds. The first are larger (diameter 3.9–5.3 μm) and concentrated (aggregated) at one egg pole, covering a densely chorionic surface (spaced at a distance of 2.6–3.9 μm) (Fig. 21). This structure is similar to that of *E. venosus* KCTs (Gaino & Rebora 2003) (Fig. 22). The second attachment structure is slightly smaller (diameter 2.7–3.3 μm) and is regularly distributed over the chorion surface (spaced at a distance of 6.7–12.0 μm) (Fig. 23). The chorionic surface has many small rounded tubercles (0.7–0.9 μm), spaced at a distance of 0.4–1.3 μm . The chorionic surface and tubercles are covered by very small granules (granular ground matrix) 0.09–0.17 μm in diameter (Fig. 24). Five to eight micropyles are visible in the subequatorial area. The sperm guide ovoidal is 11.1–11.8 μm in length and 7.9–9.0 μm in width (micropylar opening situated at the side). The micropylar rim is narrow with tubercles similar to those found on the chorionic surface (Fig. 25).

Etymology. The species name originates from the Latin noun *solus*, i.e. single, solitary. It is the only one species of the genus *Ecdyonurus* living in the Crimea.

Specimens examined. HOLOTYPE: male imago, UKRAINE, Autonomous Republic of the Crimea, Chorna River, Chornorichens'kyi gap, 8.06.2003, 300 m. a.s.l., Long. 33°46'19" E, Lat. 44°30'23" N, leg. G.A. Prokopov. PARATYPES: 3 larvae (two on slides), ibid, Stilia River, 7.07.1989, 150 m. a.s.l., Long. 34°02'50" E, Lat. 44°38'11" N, leg. G.A. Kiseleva; 2 larvae, ibid, Upper Chorna River, Chornorichens'kyi gap, 15.06.1998, 300 m. a.s.l., Long. 33°46'19" E, Lat. 44°30'23" N, leg. G.A. Prokopov; 5 larvae, ibid, Upper Chorna River, Chornorichens'kyi gap, 3.01.2001, 250 m. a.s.l., Long. 33°46'19" E, Lat. 44°30'23" N, leg. G.A. Prokopov; 6 larvae, ibid, Upper Chorna River near Chornorichens'kyi gap, 4.01.2001, 300 m. a.s.l., Long. 33°46'19" E, Lat. 44°30'23" N, leg. G.A. Prokopov; 9 larvae, ibid, Al'ma River, downstream of "Asport" Boundary, 29.06.2001, 450 m. a.s.l., Long. 34°14'21" E, Lat. 44°43'14" N, leg. G.A. Prokopov; 29 larvae, ibid, Al'ma River downstream of "Tar'er" Boundary, 30.06.2001, 400 m. a.s.l., Long. 34°10'43" E, Lat. 44°43'11" N, leg. G.A. Prokopov; 4 larvae, ibid, Al'ma River downstream of "Sosnovyi" Boundary, 1.07.2001, Long. 34°08'04" E, Lat. 44°45'33" N, 350 m. a.s.l., leg. G. A. Prokopov; 1 larva, ibid, Al'ma River near Partyzans'ke Reservoir, 1.07.2001, 300 m. a.s.l., Long. 34°05'43" E, Lat. 44°47'30" N, leg. G.A. Prokopov; 1 larva, ibid, Upper Chorna River, Chornorichens'kyi gap, 16.08.2001, 300 m. a.s.l., Long. 33°46'19" E, Lat. 44°30'23" N, leg. G.A. Prokopov; 6 larvae, ibid, Chorna River near Chornorichyns'ke vilage, 17.08.2001, 200 m. a.s.l., Long. 33°41'23" E, Lat. 44°32'12" N, leg. G.A. Prokopov; 1 male subimago, 1 female imago, 3 female subimagines, 25 larvae, Ukraine, Autonomous Republic of the Crimea, Chorna River, Chornorichens'kyi gap, 8.06.2003, 300 m. a.s.l., Long. 33°46'19" E, Lat. 44°30'23" N, leg. G.A. Prokopov.

All specimens were preserved in 75% alcohol. All adults were reared from larvae. The holotype and part of the paratypes are housed in the collection of the State Museum of Natural History, National Academy of

Sciences of Ukraine (Lviv, Ukraine). The other paratypes are stored in the Biology Centre of the Academy of Science of the Czech Republic, Institute of Entomology (České Budějovice, Czech Republic) and in the first and second author's collections.



FIGURES 20–25. *Ecdyonurus solus* sp. nov., egg: 20, general outline of the egg, scale bar = 100 μ m; 21, egg pole with gather of large KCTs attachment structures, scale bar = 50 μ m; 22, detail of large KCTs, scale bar = 10 μ m; 23, chorionic surface with KCTs attachment structures, tubercles and small granules, scale bar = 20 μ m; 24, tubercles and small granules at high magnification, scale bar = 3 μ m; 25, micropyle, scale bar = 10 μ m (HITACHI S-4700 scanning electron microscope).

Affinities. *E. solus* sp. nov. belongs to the *E. venosus* species-group by the presence of following characteristics: *in male imago*: (1) apical sclerite of penis subparallel to the body axis, straight, relatively short and blunt; (2) abdominal terga with mainly visible darker pattern; *in larva*: (3) superlinguae of hypopharynx with long fine setae on the anterior margin (up to the lateral tips); (4) labrum with one row of setae ventrally; (5) lateral prolongation of sterna are markedly visible. The new species can be easily distinguished from all other representatives of this species-group by the following features: *in male imago*: (1) eyes gray-blackish, with two light gray rings laterally, divided by a small gap; (2) wing hyaline, transparent and unicolorous; (3) venation brown to blackish, lighter basally, without maculation around veins; (4) color of abdominal terga and sterna; (5) styliger plate with two small rounded apically protuberance; (6) penis lobes slightly stretched laterally and convergent toward outer margins, with rounded distal part; (7) peculiarities of the penis structure; *in larva*: (8) number of some groups of setae, bristles and hairs on maxillae and labial palps (9) lateral projection of pronotum short, distinctly asymmetrical, with curved towards the body apical part; (10) femora relatively slender and long; (11) outer margin of femora with row of long slender bristles and small pointed spines; (12) coloration of abdominal terga and sterna; (13) coloration of tarsi; (14) denticulation of posterior margins of terga; (15) shape of scales of dorsal surface of femora and (16) shape of gills (especially gills 1, 4 and 7).

The penis structure discriminates the new species from the all other European species of the *E. venosus* species-group (except for *E. ornatipennis*, see below). Some aspects of the penis shape of *E. solus* sp. nov., are similar to *E. ruffii* Grandi, 1953 (Bauernfeind & Humpesch 2001: 139, Fig. 474), but the new species can be distinguished by its body coloration and especially by the pattern on the terga.

The male imago of *E. solus* sp. nov. can be easily distinguished from the two Caucasian species, viz. *E. autumnalis* and *E. ornatipennis*. By laterally stretched penis lobes the new species is similar in appearance to *E. ornatipennis*. The combination of following features markedly differs *E. ornatipennis* from *E. solus* sp. nov.: (1) unicolorous eyes without any rings, not close to each other; (2) penis lobes relatively square-shape distally; (3) abdominal sterna with brown longitudinal central band (Tshernova 1938, 57–58, Fig. 4, Kluge pers. com.). *E. autumnalis* differs from *E. solus* sp. nov. by (1) the distinctly darker color of body; (2) the presence one light ring on eyes; (3) the presence of brown longitudinal central band on abdominal sterna; (4) the shape of penis, with large and not stretched laterally lobes; (5) the distinctly convergent towards the tip apical sclerites; (6) the shape of lateral sclerites (Braasch 1980b, 103–104, Fig. 1, 1a, 2, Kluge pers. com.).

The larvae of *E. solus* sp. nov., partly resembles to *E. aurantiacus* (Burmeister, 1839), *E. belfiorei* Haybach and Thomas, 2002 and *E. dispar* (Curtis, 1834) by the structure of the pronotal projection and gills (especially gill 1). However, larval characteristics 8, 11, 14 and 16 easily differs new species from *E. aurantiacus*; characters 8, 10, 12, 13 and 14 from *E. dispar*; characters 8, 12 and 16 from *E. belfiorei* (see Haybach and Thomas 2002). The larvae of *E. solus* sp. nov. can be separated from larvae described as *E. ornatipennis* (see Braasch 1980a), by the shape of the pronotum expansion, femoral scales, gills and by the coloration of the abdominal terga.

Distribution and biology. The larvae of *E. solus* sp. nov. are found in metarithral and hyporithral rivers on the northern slopes of the Crimean mountains at altitudes of 150–450 m. a.s.l. In summer, the average water temperature is 12 °C and the water is of hydrogen carbonate type. The larvae inhabit the waters with current velocities of about 1 m/s. Width of river bed width is around 3–6 m, depth 0.3–0.5 m, with cobble and gravel bottoms. The banks of beds are partly shaded by *Fagus orientalis* Lipsky, *Carpinus betulus* Linnaeus and *Quercus pubescens* Willd. *E. solus* sp. nov. has a univoltine winter cycle (Uw), with one generation per year (Clifford 1982). The population overwinters in the nymphal stage and larval growth is very slow. The flying period extends from May to July, with most of the population emerging by the end of June or the beginning of July. Other insects groups found in these rivers with *E. solus* sp. nov. include: stoneflies *Nemoura cinerea* (Retzius, 1783); dragonflies *Calopteryx taurica* Selys, 1853, *Gomphus vulgatissima* (Linnaeus, 1758), *Onychogomphus forcipata* (Linnaeus, 1758); mayflies *Heptagenia samochai* (Demoulin, 1973) and *Baetis rhodani tauricus* Godunko and Prokopov, 2003, caddisflies *Halesus tessellatus* (Rambur, 1842), *Limnephilus*

lunatus Curtis, 1834, *Hydropsyche acuta* Martynov, 1909, *Wilhelmia balcanica* (Enderlein, 1924), *W. paraequinum* Puri, 1925 and blackflies *Simulium acutiphallus* (Rubtsov, 1956), *S. ponticum* (Rubtsov, 1956).

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