ZOOSYSTEMATICA ROSSICA

ISSN 2410-0226 [online] 0320-9180 [print]

Zoological Institute, Russian Academy of Sciences, St Petersburg ▪ https://www.zin.ru/journals/zsr/

Vol. 31(1): 42–54 ▪ Published online 11 April 2022 ▪ DOI 10.31610/zsr/2022.31.1.42

RESEARCH ARTICLE

Eudiaptomus transylvanicus and *E. vulgaris* (Copepoda: Calanoida: Diaptomidae): comparative morphology, distribution and ecology

Eudiaptomus transylvanicus и *E. vulgaris* (Copepoda: Calanoida: Diaptomidae): сравнительная морфология, распространение и экология

V.N. Podshivalina, N.G. Sheveleva, A.S. Semenova & I.M. Mirabdullayev

В.Н. Подшивалина, Н.Г. Шевелева, А.С. Семенова, И.М. Мирабдуллаев

Valentina N. Podshivalina, Chuvash State University, 15 Moskovskiy Ave., Cheboksary 428015, Russia; Prisurskiy State Nature Reserve, 9 Lesnoy, Cheboksary 428034, Russia. E-mail: verde@mail.ru

Natalia G. Sheveleva, Limnological Institute, Siberian Branch of Russian Academy of Sciences, 3 Ulan-Batorskaya St., Irkutsk 664033, Russia. E-mail: shevn@lin.irk.ru

Anna S. Semenova, Atlantic Branch of the Russian Federal Research Institute of Fisheries and Oceanography VNIRO (AtlantNIRO), 5 Dmitriy Donskoy St., Kaliningrad 236022, Russia. E-mail: a.s.semenowa@mail.ru

Iskandar M. Mirabdullayev, Tashkent State Agrarian University, 2 Universitetskaya St., Tashkent 100140, Uzbekistan. E-mail: mirabdullayevi@umail.uz

Abstract. Two closely related, difficult to diagnose calanoid copepod species, *Eudiaptomus transylvanicus* (Daday, 1891) and *E. vulgaris* (Schmeil, 1898), were studied based on the new material from the Sura River floodplain (the Middle Volga region, European Russia). The redescriptions and illustrations of two species are provided. The main diagnostic differences between these species are refined. New characters useful in the identification of *E. transylvanicus* are proposed. The data on distribution and habitats of the two species are reviewed and briefly analysed.

Резюме. Изучен новый материал двух близких, трудноразличимых видов каланоидных ракообразных *Eudiaptomus transylvanicus* (Daday, 1891) и *E. vulgaris* (Schmeil, 1898), собранный в пойме реки Суры (Среднее Поволжье, европейская часть России). Представлены переописания и иллюстрации двух видов. Определены основные диагностически значимые отличия между ними. Обнаружены новые признаки, полезные для определения *E. transylvanicus*. Приведен обзор и краткий анализ данных по распространению и биотопам двух видов.

Key words: zooplankton, morphology, biogeography, habitats, diagnostic characters, Copepoda, Calanoida, Diaptomidae, *Eudiaptomus transylvanicus*, *Eudiaptomus vulgaris*

Ключевые слова: зоопланктон, морфология, биогеография, биотопы, диагностические признаки, Copepoda, Calanoida, Diaptomidae, *Eudiaptomus transylvanicus*, *Eudiaptomus vulgaris*

ZooBank Article LSID: urn:lsid:zoobank.org:pub:041CC6C4-A1DC-42A8-8FEB-7F6F183CA0F3

Introduction

The genus *Eudiaptomus* Kiefer, 1932 has a wide distribution in the Holarctic (Borutzky et al., 1991). It comprises 33 species and subspecies worldwide (Walter & Boxshall, 2018a) and eleven species in Europe (Błędzki & Rybak, 2016). Some

of them are widely distributed in Europe, namely *E. gracilis* (Sars, 1863), *E. graciloides* (Lilljeborg, 1888), *E. vulgaris* (Schmeil, 1898) and *E. transylvanicus* (Daday, 1891), while the others are rare and have limited distribution, i.e. *E. arnoldi* (Siewerth, 1928), *E. drieschi* (Poppe et Mrázek, 1895), *E. hadzici* (Brehm, 1933), *E. intermedius* (Steuer, 1897), *E. padanus* (Burckhardt, 1900), *E. siewerthi* (Smirnov, 1936) and *E. zachariasi* (Poppe, 1886). Kiefer (1968, 1978) has done the most recent revision of the genus *Eudiaptomus*.

Eudiaptomus transylvanicus is distributed in Europe and West Siberia (Borutzky et al., 1991). The species is rarely reported from the East European Plain and West Siberia (Borutzky et al., 1991). It can probably be overlooked in some areas (Błędzki & Rybak, 2016), because of difficulties in identification, due to the need of a detailed examination using high magnification. In the present study, we compare the morphological characteristics of *E. transylvanicus* with those of *E. vulgaris*, a closely related species widely distributed in the Palaearctic (Borutzky et al., 1991). The two species are often confused. We also consider the distribution of both species and some factors that govern it.

Material and methods

The material of the two species was collected in the Prisurskiy State Nature Reserve, the Middle Volga region (Chuvash Republic, Russia).

The specimens of *E. transylvanicus* were collected from a small (ca. 200 m^2) artificial reservoir for accumulating water, so-called "kopan'" (made in 2015), in July 2019 and from a nearby quarry pond (formed in 2015 in a sandpit) in May 2020 (Table 1 and Electronic supplementary material). The water depth in these reservoirs varies significantly (ca. 1 m) during the open water season. The species was also sampled from a carr lakelet in May 2020. All above-mentioned sites are located in the basin of the Sura River, which is the right tributary of the Volga River.

The material of *E. vulgaris* was collected from nine different-type water bodies (Table 1). For morphological study, we used only the specimens collected in May 2020 from one water body, a steppe shallow reservoir in the basin of the Sviyaga River, which is the right tributary of the Volga River.

The samples were obtained by filtering the water (50 liters) through an Apstein plankton net (mesh size 70 μm) and fixed using 40% formaldehyde, with its final concentration in samples ca. 4%. Adult specimens of *Eudiaptomus* were selected from samples for a morphological study under a stereomicroscope. Images were taken using a Philips 525 M scanning electron microscope (SEM) and a digital camera attached to an Olympus CX 41 optical microscope. For a study under SEM, specimens were transferred to pure methanol for an hour, then to hexamethyl disilazane for a day, and then were air-dried.

In the studied reservoirs, water surface temperature and water pH were measured using a Hanna HI-83141 pH-meter with an electrode and

Table 1. Environmental parameters of habitats of *Eudiaptomus transylvanicus* and *E. vulgaris* in the Middle Volga region.

Parameters	*E. transylvanicus* habitats	*E. vulgaris* habitats
Habitat types	"kopan'" water body (1), quarry pond (1), carr lakelet (1)	Steppe shallow pools (3), quarry pond (2), bog shallow pool (1), dam ponds on streams (3)
Water surface area (min–max), m^2	200–500	0 (dry period) – 650
Mean depth (min–max), m	0.3–0.8	0 (dry period) – 1.0
Water temperature in May, °C	11.5–16.3	11.1–23.9
in July, °C	21.1–24.5	no data
in September, °C	10.3–10.7	no data
Total dissolved solids (TDS), ppm	27–93	14–530
pH	6.0–8.4	6.4–7.7

Note. Number of water bodies of each type is given in parentheses.

temperature probe; total dissolved solids (TDS) were measured using a Hanna HI-98129 tester.

Occurrence of species in the potential habitats was assessed as a relative number of samples in which the species occurs to the total number of samples taken from the potential habitats in the studied region (Pesenko, 1982). In total, we used the samples of planktonic fauna taken 2–5 times from shallow permanent (33) and temporary water bodies and pools (6), ponds (16), bogs and dystrophic waters (3), all situated in the territory of the Prisurskiy State Nature Reserve and its buffer zone in 2018–2020 (May–September), obtained by filtering water as described above.

Results

Redescriptions

Order **Calanoida** G.O. Sars, 1903

Family **Diaptomidae** Baird, 1850

Genus ***Eudiaptomus*** Kiefer, 1932

Eudiaptomus transylvanicus (Daday, 1891)

(Figs 1, 2)

Material examined. **Russia**, *Chuvash Republic*, near Atrat Vill., "kopan'" water body, 54.9991°N 46.6685°E, 3 July 2019, 9 males, 8 females; same locality, quarry pond, 54.97798°N 46.72082°E, 26 May 2020, 2 males, 2 females; same locality, carr lakelet, 54.97798°N 46.72082°E, 26 May 2020, 4 males (all E. Osmelkin leg.).

Redescription. *Female* (Fig. 1a). Body length 1.60–1.66 mm (n = 8). Last thoracic segment with well-developed asymmetrical wings. Genital compound somite gently dilated in central part, with medium-sized hyaline spines (Fig. 1b, arrowed). Antennules extending closely to apices of apical caudal setae (Fig. 1a). Rostrum with two strong long curved asymmetrical processes (Fig. 1d). Edge of mandibular incision with single-vertex teeth: one ventral and six or seven central (Fig. 1c, 1c′). Ventral tooth separated from other teeth by a deep diastema (Fig. 1c′). Rather deep diastema present between outer ventral central tooth and other teeth. Central teeth acute, with wide base (Fig. 1c′). Dorsal teeth double-vertex, acute, with narrow base. Maxilla and maxilliped with long plumose setae increasing filtration; these setae situated on sympodite compounds (precoxopodite, coxopodite), basipodite and endopodite. In leg 2, endopod segment 2 with Schmeilsche lobus (Fig. 1e, arrowed). In leg 5, coxa with triangular lateral projection, with wide base, nearly as large as basipod (Fig. 1f); exopod segment 1 rectangular; exopod segment 2 with spine (bearing row of spinules) at base of segment 3 (Fig. 1g′) and with terminal claw bearing row of spinules on lateral and medial margins (Fig. 1g); exopod segment 3 with two apical spines (Fig. 1g), longest spine extending to apex of terminal claw; endopod two-segmented, as long as exopod segment 1 or even longer, with distal row of setulae and with relatively long unequal setae: one apical and one subapical (Fig. 1h).

Male (Fig. 2a). Body length 1.40–1.55 mm (n = 9). Rostrum with two strong long curved processes and one distinct lateral process (Fig. 2c). Left antennule extending to middle of urosome. Right antennule with spiniform projections on segments 10, 11 and 13–16; segment 13 with longest projection (Fig. 2b); antepenultimate segment with small hyaline process (Fig. 2b′, arrowed). In right leg 5 (Fig. 2d), coxa with elongate projection supplied with hyaline spine; basis with two well-visible hyaline processes in proximal and distal parts of medial margin and with a small hook-shaped process between them (Fig. 2e, arrowed), with granulate (not spinulate) surface near distal process (Fig. 2e); exopod segment 1 wider than long, with distinct acute dilation at outer distal corner; exopod segment 2 about 1.7 times as long as wide, with strong slightly curved claw and granulate (not spinulate) surface near it (Fig. 2f, arrowed), with lateral dentate spine inserted in distal part of lateral margin (Fig. 2f); endopod two-segmented, reaching one-third of proximal part of exopod segment 2, with distal brush of setulae and three apical setulae (Fig. 2g). In left leg 5 (Fig. 2d), basis slightly narrowing distally, with small lateral process near distal margin; exopod two-segmented, with thick setae in middle of segment 1 and in proximal part of segment 2; proximal part of exopod segment 1 wider than its distal part; exopod segment 2 with long dentate spine (exopod 3, according to Dussart & Defaye, 2001) being slightly curved in proximal part, with tiny hairs on anterior surface and with five overlapping membranous folds on distomedial surface (Fig. 2h); endopod two-segmented, weak.

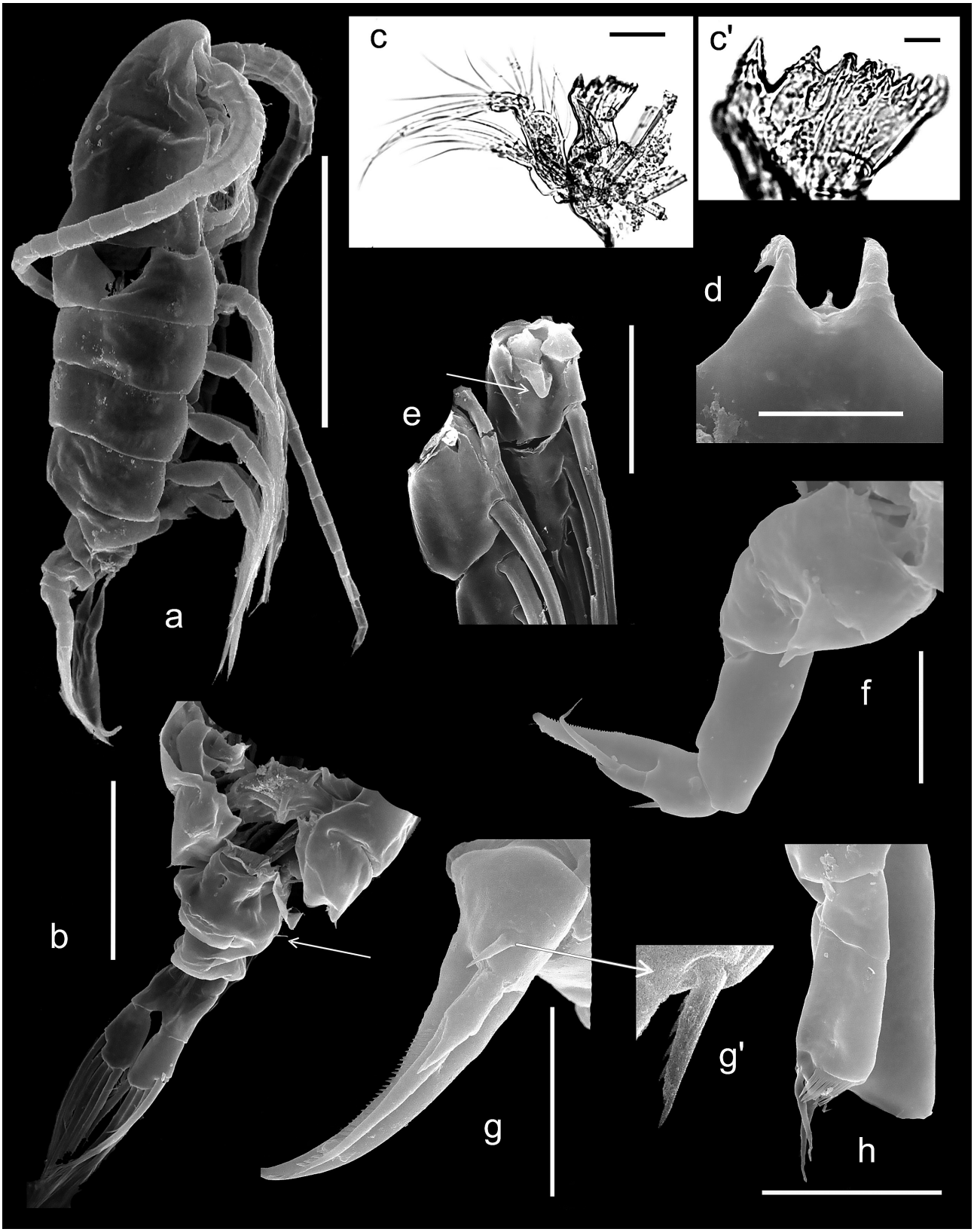

Fig. 1. *Eudiaptomus transylvanicus* (Daday, 1891), female. **a** – habitus, lateral view; **b** – genital compound somite; **c**, **c′** – mandible; **d** – rostrum; **e** – endopod of leg 2, with Schmeilsche lobus; **f** – leg 5; **g** – exopods 2 and 3 of leg 5; **h** – endopod of leg 5. Scale bars: 0.5 mm (a), 200 μm (b), 50 μm (c, e), 40 μm (d, g), 10 μm (c′, f, h).

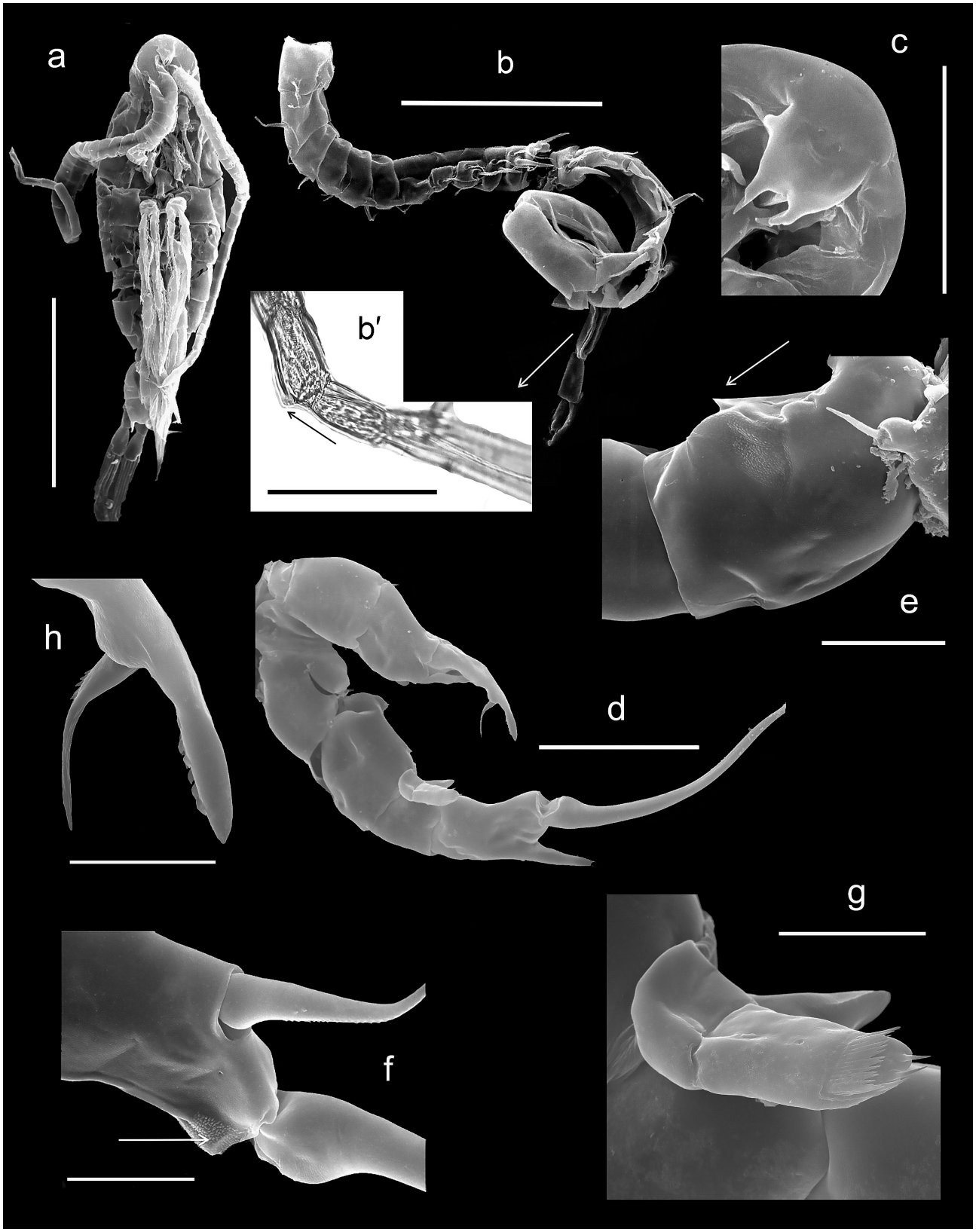

Fig. 2. *Eudiaptomus transylvanicus* (Daday, 1891), male. **a** – habitus, ventral view; **b**, **b′** – right antennule; **c** – rostrum; **d** – leg 5; **e** – basis of right leg 5; **f** – exopod 2 of right leg 5; **g** – endopod of right leg 5; **h** – exopod 2 of left leg 5. Scale bars: 500 μm (a), 200 μm (b), 100 μm (b′, c, d), 40 μm (e), 30 μm (f), 20 μm (g, h).

Eudiaptomus vulgaris (Schmeil, 1898)
(Figs 3, 4)

Material examined. **Russia**, *Chuvash Republic*, near Malye Shikhirdany Vill., shallow water body, 55.08648°N 47.779366°E, 28 May 2020, 4 males, 3 females (E. Kuz'min leg.).

Redescription. *Female* (Fig. 3a). Body length 1.40–2.01 mm (n = 8). Last thoracic segment with distinct, slightly asymmetrical wings. Genital compound somite dilated in upper part, with middle-sized hyaline spines (Fig. 3b, arrowed). Rostrum with two long acuminate curved processes (Fig. 3c). Antennule extending to apices of apical caudal setae (Fig. 3a) or even longer. Edge of mandibular incision with single-vertex teeth: one ventral and seven central. Ventral tooth separated from other teeth by deep, gently sloping diastema (Fig. 3d). Rather deep diastema also present between outer ventral central tooth and six other teeth. Ventral teeth single-vertex, with wide base. Three central teeth rounded, others acute (Fig. 3d). Dorsal teeth double-vertex, acute, with narrow base. Maxilla and maxilliped with long plumose setae increasing filtration capacity; these setae situated on sympodite compounds (precoxopodite, coxopodite), basipodite and endopodite. In leg 2, endopod segment 2 with Schmeilsche lobus (Fig. 3i, arrowed). In leg 5, coxa with short thin lateral projection (Fig. 3e); exopod segment 1 rectangular, elongate, twice as long as wide (Fig. 3f); exopod segment 2 with spine at base of segment 3 (Fig. 3h) and with terminal claw bearing row of spinules on lateral and medial margins (Fig. 3h); exopod segment 3 with two apical spines, longest spine extending to three-fourths or to apex of terminal claw (Fig. 3h); endopod about two-thirds of exopod segment 1 length, with one subapical and one lateral (distal) setulae, and with one apical and one subapical relatively long unequal setae (Fig. 3f).

Male (Fig. 4a). Body length 1.40–1.50 mm (n = 5). Rostrum with two long acuminate curved processes and one lateral process (Fig. 4e). Left antennule extending to apex of caudal ramus. Right antennule with spiniform projections of variable shape and size on segments 10, 11 and 13–16; antepenultimate segment with small hyaline membrane and hook-shaped process (Fig. 4b, arrowed). In right leg 5 (Fig. 4c), coxa with large rounded well-sclerotised distolateral projection (Fig. 4d, arrowed); basis with small hyaline process in proximal part and with well-visible hyaline process in central part of medial margin (Fig. 4d); exopod segment 1 wider than long, with distinct acuminate dilation at outer distal corner and with dilation of lateral inner margin; exopod segment 2 about 1.3–1.5 times as long as wide, with strong subapically curved claw, with lateral spine inserted in middle of lateral margin; endopod one-segmented, reaching exopod segment 2, with several distal setulae. In left leg 5 (Fig. 4d), basis with large hook-shaped lateral process (Fig. 4d, arrowed); exopod two-segmented, with setulae in middle of segment 1 and in proximal part of segment 2; proximal part of exopod segment 1 wider than its distal part; exopod segment 2 with long spine (exopod 3, according to Dussart & Defaye, 2001) being slightly curved; endopod weak and long, reaching spine of exopod segment 2 (Fig. 4d).

Comparison of *Eudiaptomus transylvanicus* and *E. vulgaris*

Diagnostic characters. *Eudiaptomus transylvanicus* was described by Daday (1891), with the main diagnostic features in male right leg 5. *Eudiaptomus vulgaris*, described by Schmeil (1898), was distinguished from the related diaptomids by the claw on exopod segment 2 of male right leg 5 and by the length of the antennule. In the review of the genus *Eudiaptomus*, Kiefer (1968) compared the morphological features for all relative species of *Eudiaptomus* and defined the differences between the species, in the antennule and appendages of leg 5 in males and females.

According to our data, *Eudiaptomus transylvanicus* and *E. vulgaris* differ from each other in the features given in Table 2.

The females of *E. transylvanicus* examined in our study differ from those of *E. vulgaris*, *E. gracilis*, *E. siewerthi*, *E. arnoldi* and *E. drieschi* in having the endopod of leg 5 longer (*vs.* shorter) than exopod 1 (Borutzky et al., 1991; Błędzki & Rybak, 2016). The endopod of leg 5 in females of *E. graciloides*, *E. intermedius* and *E. padanus* is equal to or slightly (less than 10% of endopod length) longer than exopod 1, whereas in *E. transylvanicus* and *E. zachariasi* it is noticeably (ca. 15% and 20–30% of its length, respectively) longer than exopod 1 (Borutzky et al., 1991; Błędzki & Rybak, 2016).

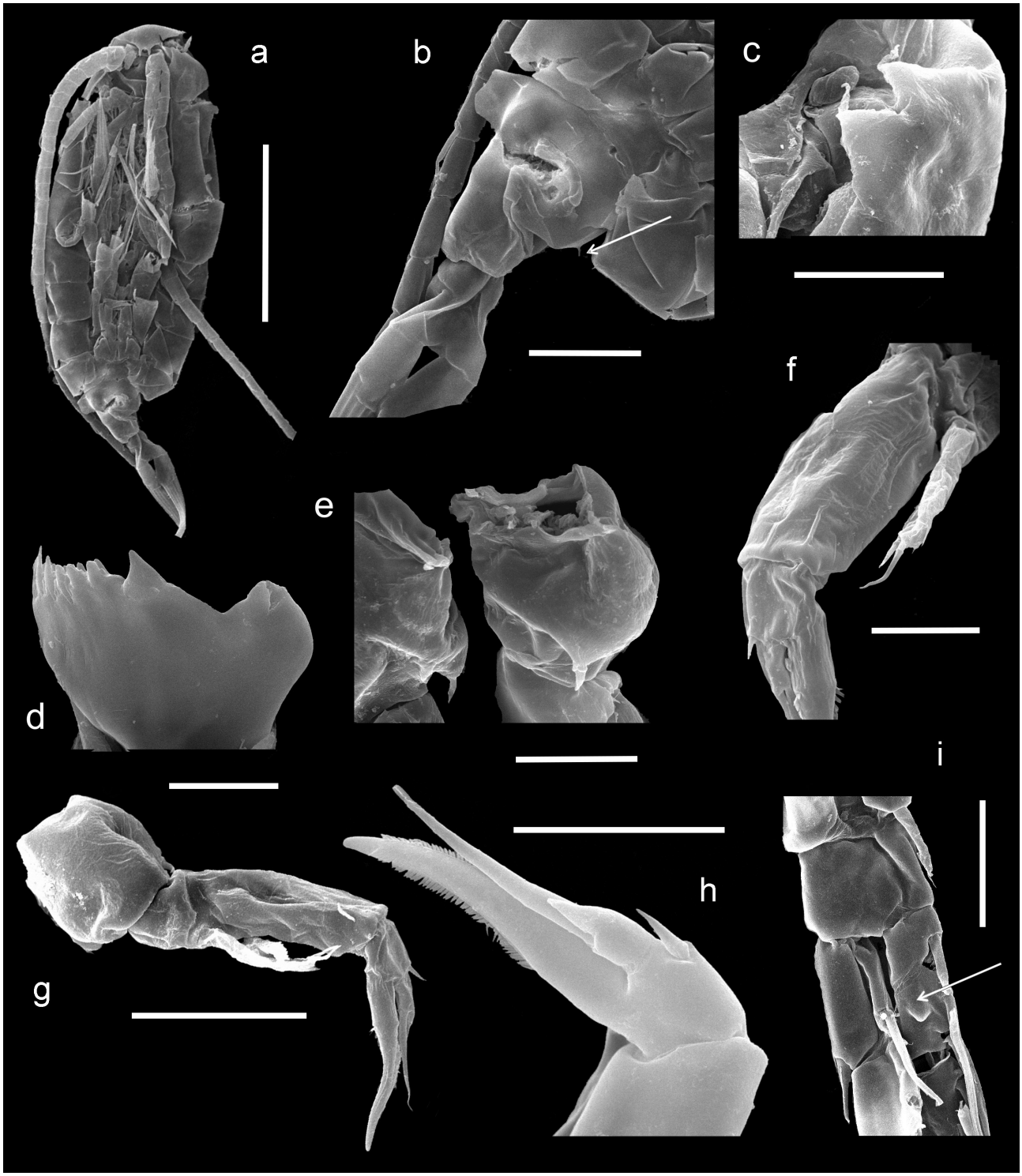

Fig. 3. *Eudiaptomus vulgaris* (Schmeil, 1898), female. **a** – habitus, ventral view; **b** – genital compound somite; **c** – rostrum; **d** – mandible; **e** – coxa of leg 5; **f** – exopod 1 and endopod of leg 5; **g** – leg 5; **h** – exopods 2 and 3 of leg 5; **i** – endopod of leg 2, with Schmeilsche lobus. Scale bars: 0.5 mm (a), 100 μm (b), 50 μm (c, e, f, g, h, i), 20 μm (d).

Table 2. Comparative morphology of *Eudiaptomus transylvanicus* and *E. vulgaris*.

	E. transylvanicus	*E. vulgaris*
Female		
Genital compound somite	dilated in central part	dilated in upper part
Leg 5:		
coxa	with triangular lateral projection	with short thin lateral projection
endopod	as long as exopod segment 1 or longer	about two-thirds as long as exopod segment 1
	apical and subapical setae slightly unequal	apical setae much longer (up to twice as long) than subapical
Male		
Right leg 5:		
coxa	with elongate projection supplied with hyaline spine	with large rounded well-sclerotised distolateral projection
basis	three processes; with granulate surface	two processes
exopod segment 2 (length : width)	1.7	1.3–1.5
lateral spine of exopod segment 2	in distal part of lateral margin	in middle of lateral margin
endopod	reaching proximal third of exopod segment 2	reaching base of exopod segment 2
Left leg 5:		
basis	with small lateral process	with large hook-shaped lateral process
exopod segment 2	overlapping membranous folds present on distomedial surface	membranous folds absent
endopod	reaching the middle of exopod segment 2	reaching spine of exopod segment 2

The females of *E. vulgaris* examined in our study differ from those with short endopod of leg 5 (*E. gracilis*, *E. siewerthi* and *E. arnoldi*) in having long (ca. 40–50% of endopod length) apical setae on the endopod, and from those of *E. drieschi* in having short antennule (reaching the tip of the last thoracic segment, *vs.* long, reaching the tip of caudal ramus) (Borutzky et al., 1991).

The males of *E. transylvanicus* examined in our study differ from those of *E. intermedius*, *E. siewerthi* and *E. padanus* in having three processes on the basis of right leg 5 (two well-visible and a small one between them, *vs.* two in *E. intermedius* and one in *E. siewerthi* and *E. padanus*) and granulate surface (missing in other species of *Eudiaptomus*) near distal process on the basis of right leg 5 (Kiefer, 1978; Borutzky et al., 1991). The examined males of *E. transylvanicus* differ from those of *E. graciloides* and *E. arnoldi* in the relatively short (about 1.7 times as long as wide *vs.* twice as long as wide) exopod segment 2 of right leg 5 and from those of *E. gracilis* and *E. zachariasi* in having a spine inserted in distal part (instead of the middle) of the lateral margin of this segment (Borutzky et al., 1991).

The examined males of *E. vulgaris* have a large hook-shaped lateral process on the basis of left leg 5, as distinct from *E. drieschi*, in which it is absent, and a large, rounded, well-sclerotised distolateral projection on the coxa of right leg 5, as distinct from *E. gracilis*, *E. graciloides*, *E. zachariasi*, *E. arnoldi*, *E. siewerthi*, *E. intermedius* and *E. padanus* (Borutzky et al., 1991).

Distribution. Eudiaptomus vulgaris is widely distributed in the European (Borutzky et al., 1991; Błędzki & Rybak, 2016) and Asian (Borutzky et al., 1991) parts of the Palaearctic and has a continuous range. It is distributed from Spain

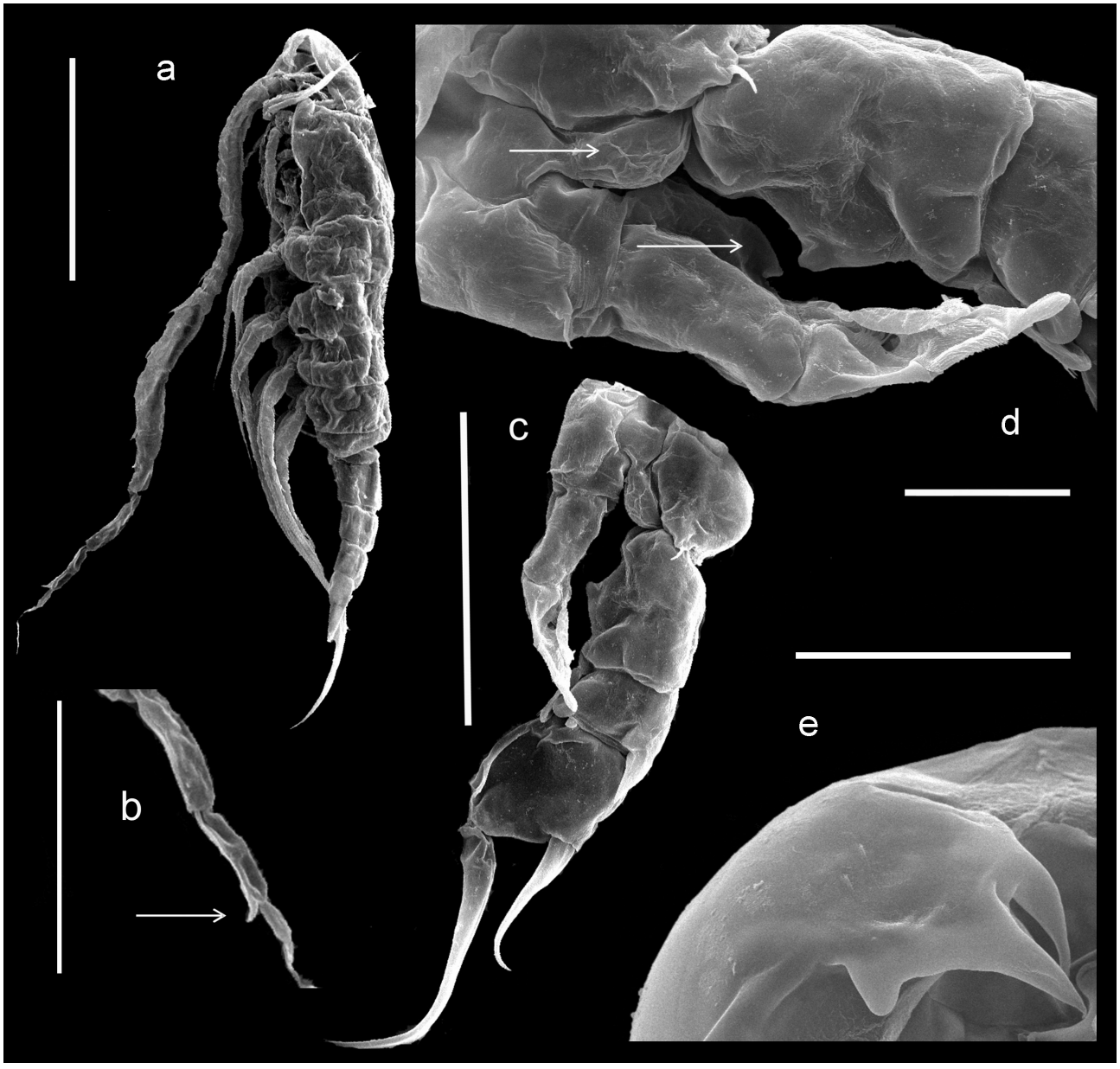

Fig. 4. *Eudiaptomus vulgaris* (Schmeil, 1898), male. **a** – habitus, lateral view; **b** – ultimate segments of right antennule; **c** – leg 5; **d** – right leg 5 (coxa and basis) and left leg 5; **e** – rostrum. Scale bars: 0.5 mm (a), 200 μm (c), 300 μm (b), 50 μm (d, e).

(Miracle, 1982) in the west to the Far East of Russia (Smirnov, 1929), but was not recorded from Slovenia, Bosnia, Lithuania, Moldavia and Scandinavia (Błędzki & Rybak, 2016). *Eudiaptomus transylvanicus* is known from most parts of the West Palaearctic: from Bulgaria (Naidenow, 1994), Romania (temporary waterbodies; Demeter & Marrone, 2009), Slovenia (Lake Bled; Simčič & Brancelj, 2001), Croatia (Lake Vrana; Sket, 1988), Slovakia (Cierny Vah River; Kokavec et al., 2017), Ukraine (temporary and perennial waters with varying salinity; Samchyshyna, 2008), Belarus (ponds and temporary and fishery waterbodies; Solov'yov, 1927), European Russia (Spanovskaya & Grigorash, 1962; Evdokimov & Ermokhin, 2009; Krylov & Zhgareva, 2016; Kurbatova et al., 2018), Kazakhstan (Krupa et al., 2012) and from the West Siberian Plain in Asian Russia: the Ob' River (Semyonova & Aleksyuk, 2010), its tributary Chulym (Kukharskaya &

Dolgin, 2011), the Vilyuy River (Ogay & Sokolova, 1972), and the Irtysh River basin (Klebanovsky, 1986). Thus, the species is rather widespread, but only few records are available from each area.

Bionomics. In the Middle Volga region, we found the populations of *E. transylvanicus* in shallow perennial water bodies of natural or artificial origin (see Electronic supplementary material), similar to other European populations of this species (Błędzki & Rybak, 2016). The water bodies inhabited by *E. transylvanicus* are partially overgrown by macrophytes, and their surface area and depth varies substantially (about 0.8–1.0 m) during the ice-free period due to natural reasons (surface water feeding and high evaporation). According to our data, *E. vulgaris* in the Middle Volga region occurs in shallow water bodies of various origin, both perennial and temporary, which are similar to those of *E. transylvanicus*.

Both species prefer warm waters with pH values close to neutral or slightly varying. They appear as a part of the spring plankton at water temperature more than 10 ºC (Table 1). *Eudiaptomus transylvanicus* occurs in waters with low salinity, while *E. vulgaris* occurs in both fresh and brackish waters (Table 1).

According to our data, the species occurrence in the potential habitats (shallow permanent and temporary water bodies, pools, ponds, bogs and dystrophic water bodies, according to Błędzki & Rybak, 2016) of the Middle Volga region is about 0.05 (5%) for *E. transylvanicus* and 0.10 (10%) for *E. vulgaris*. Thus, *E. transylvanicus* is relatively rare in the study region, while *E. vulgaris* is more common but its occurrence is still low. According to our data, the two species do not coexist in the study region, i.e. they were not found in the same water bodies. We could not find published records of both *E. transylvanicus* and *E. vulgaris* from the same bodies of water, suggesting that they do not coexist in other regions either.

Discussion

Diagnostic characters. We did not find any significant morphological differences between the examined specimens of *E. vulgaris* and *E. transylvanicus* and the published descriptions of these species (Dussart, 1967; Kiefer, 1978; Borutzky et al., 1991; Krupa et al., 2016). At the same time, we found several morphological characteristics, which were not used by the previous authors, namely, the following ones. In the females of *E. transylvanicus*, the endopod of right leg 5 has both setae and setulae (setulae were not mentioned in the descriptions by Kiefer, 1978, Borutzky et al., 1991, and Krupa et al., 2016). In the males of *E. transylvanicus*, the basis and exopod segment 2 of right leg 5 have granulate surfaces (not spinulate, as described by Borutzky et al., 1991; the character is absent in *E. vulgaris*), exopod segment 2 also has overlapping membranous folds on the distomedial surface (this character was not mentioned by Kiefer, 1978, Borutzky et al., 1991, and Krupa et al., 2016), the spine of exopod segment 2 is dentate (not haired, as depicted by Kiefer, 1978). Some structures, e.g. the mandible, maxilla and maxilliped, cannot be compared with those in other populations, as they have not been described in the previous publications.

Bionomics. The occurrence and abundance of *E. transylvanicus* depend on locality and available habitats. The species is abundant and dominates in zooplankton of various water bodies: alkaline (pH 9.2) lakes in Mongolia (Krylov, 2012, 2013), bog lakes (Dvinskikh & Larchenko, 2019) and ponds (Kurbatova et al., 2018), small lakes and bog water bodies in the Ukrainian Carpathians at 1460–1793 m (Mykitchak, 2016), the large subalpine Lake Bled (Brancelj & Blejec, 1994), and floodplain lakes of the Khoper River basin (Krylov & Zhgareva, 2016). It is rather rare in floodplain lakes in the Krasnoyarsk Territory (occurrence 0.056; Kukharskaya & Dolgin, 2011) and in the Danube River basin (Vranovsky, 1997), in the Kama Reservoir (Lazareva, 2020), in temporary shallow steppe water bodies (occurrence 0.03; Evdokimov & Ermokhin, 2009) as well as in the studied shallow perennial and temporary waterbodies in the Middle Volga region (our data).

Eudiaptomus vulgaris is known from small permanent and temporary water bodies (Kiefer, 1978; Samchyshyna, 2008; Evdokimov & Ermokhin, 2009; Podshivalina, 2013; Krupa et al., 2016), reservoirs with fluctuating water mineralisation and water level (Krylov et al., 2020), rivers (Semyonova & Aleksyuk, 2010), bogs, acidified and dystrophic waters (Lazareva et al.,

2003; Derevenskaya et al., 2019). *Eudiaptomus vulgaris* is distributed wider and more frequent, as compared to *E. transylvanicus*. Both species inhabit various water bodies with similar conditions and do not coexist. *Eudiaptomus vulgaris* frequently inhabits temporary waterbodies, as it is well adapted to low winter temperatures and intermittent water bodies, having the egg number of 12–44 and thick chorion (Samchyshyna & Santer, 2010). *Eudiaptomus transylvanicus* has subitaneous and resting eggs, with a resistant external shell (Wolf, 1905) and is also typical of temporary waters, but inhabits such water bodies in the absence of *E. vulgaris*, whose life cycle (with 3–4 generations per year; Maier, 1990) is better adapted to such conditions. *Eudiaptomus transylvanicus* occurs in various water bodies and is able to dominate by abundance in the zooplankton in both acidified bog lakes and alkaline lakes, deep and shallow waters over a wide altitude range.

Difficulties in species identification due to incomplete morphological descriptions, unreasonable synonymy of *E. transylvanicus* (Walter & Boxshall, 2018b; corrected in Walter & Boxshall, 2021) and ignoring the most recent revision of the genus *Eudiaptomus* (Kiefer, 1968) prevent accurate description of the bionomics and ranges of *E. transylvanicus* and *E. vulgaris*. It is necessary to conduct further studies on the ecology and distribution of these species in different types of water bodies, using new diagnostic characters.

Addenda

Electronic supplementary material. Map with the study area indicated by dot (A) and habitats of *Eudiaptomus transylvanicus* (B–D). B, "kopan'" water body; C, quarry pond; D, carr lakelet. Photos by E.M. Kuz'min. File format: JPEG. Available from: https://doi.org/10.31610/zsr/2022.31.1.42

Acknowledgements

We thank E.V. Osmelkin, E.M. Kuz'min and A.N. Aleksandrov (all representing the Prisurskiy State Nature Reserve) for their valuable logistic support in collecting this material.

The work was made using the equipment of the Electronic Microscopy Centre of the Limnological Institute (Irkutsk).

References

Błędzki L.A. & Rybak J.I. 2016. *Freshwater crustacean zooplankton of Europe: Cladocera & Copepoda (Calanoida, Cyclopoida). Key to species identification, with notes on ecology, distribution, methods and introduction to data analysis*. Springer Publishers. xv + 918 p. https://doi.org/10.1007/978-3-319-29871-9

Borutzky E.B., Stepanova L.A. & Kos M.S. 1991. *Opredelitel' Calanoida presnykh vod SSSR* [Key to the freshwater calanoids of the USSR]. *In*: *Opredeliteli po faune SSSR, izdavaemye Zoologicheskim institutom Akedemii Nauk SSSR* [Guides to the fauna of the USSR published by the Zoological Institute of the Academy of Sciences of the USSR], **157**: 1–504. St Petersburg: Nauka. (In Russian with English summary).

Brancelj A. & Blejec A. 1994. Diurnal vertical migration of Daphnia hyalina Leydig, 1860 (Crustacea: Cladocera) in Lake Bled (Slovenia) in relation to temperature and predation. *Hydrobiologia*, **284**: 125–136. https://doi.org/10.1007/BF00006884

Daday E. 1891. A Magyarországi Diaptomus-fajok ätnézete [A conspect of Diaptomus of the Hungarian fauna]. *Természetrajzu Füzetek*, *Kiadja a Magyar Nemzeti Múzeum*, **13**: 114–143. (In Hungarian).

Damian-Georgescu A. 1966. Calanoida. *Fauna Republicii Socialiste România*, **4**(8): 1–30. Bucaresti: Editura Academiei Republicii Socialiste România. (In Romanian).

Demeter L. & Marrone F. 2009. Updated checklist and distribution of the inland-water calanoid copepods (Copepoda: Calanoida) of Romania. *North-western Journal of Zoology*, **5**(2): 370–378.

Derevenskaya O.Yu., Unkovskaya E.N. & Mingazova N.M. 2019. Zooplankton under the conditions of lake eutrophication and acidification. *Uchenye Zapiski Kazanskogo Universiteta*, *Seriya estestvennye Nauki*, **161**(4): 521–537. (In Russian). https://doi.org/10.26907/2542-064X.2019.4.521-537

Dussart B.H. 1967. *Les Copepodes des Eaux continentales d'Europe occidentale*, **I**: *Calanoides et Harpacticoides*. Paris: N. Boubée & Cie. 500 p.

Dussart B.H. & Defaye D. 2001. Introduction to the Copepoda (2nd edition, revised and enlarged). *In*: **Dumont H.J.F.** (Ed.). *Guides to the identification of the microinvertebrates of the continental waters of the World*, **16**: 1–344. Leiden: Backhuys Publishers.

Dussart B. & Defaye D. 2002. Calaniformes. *World directory of Crustacea Copepoda of inland waters*, **1**: 1–276. Leiden: Backhuys Publishers.

Dvinskikh S.A. & Larchenko O.V. 2019. Ecological characteristic of the specially protected natural

area of local significance "Utinoe Boloto". *Vestnik Udmurtskogo Universiteta*, **29**(1): 63–70. (In Russian).

Einsle U. 1993. Crustacea: Copepoda. Calanoida und Cyclopoida. *Süsswasserfauna von Mitteleuropa*, **8**(4–1): 1–209. Heidelberg, Berlin: Gustav Fischer Verlag.

Evdokimov N.A. & Ermokhin M.V. 2009. Crustaceans of zooplankton in temporary water bodies of the Saratov Province in the territory of different natural zones. *Biologiya vnutrennikh Vod*, **2009**(1): 62–69. (In Russian; English translation: *Inland Water Biology*, 2009, **2**(1): 59–66. https://doi.org/10.1134/S199508290901009X).

Kiefer F. 1932. Versuch eines Systems der Diaptomiden (Copepoda Calanoida). *Zoologische Jahrbücher, Abteilung für Systematik, Okologie und Geographie der Tiere*, **63**(4): 451–520.

Kiefer F. 1968. Versuch einer Revision der Gattung Eudiaptomus Kiefer (Copepoda, Calanoida). *Memorie dell'Istituto Italiano di Idrobiologia dott. Marco de Marchi*, **24**: 9–160.

Kiefer F. 1978. Das Zooplankton der Binnengewässer, 2. Freilebenden Copepoda. In: *Die Binnengewässer*, **26**(2): 1–343. Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung.

Klebanovsky V.A. 1986. *Usovershenstvovanie taktiki bor'by s difillobotriozom na osnove tipizatsii ochagov i opytnykh protivoepidemicheskikh meropriyatiy* [Improvement of fight tactics against diphyllobothriasis based on classification of niduses and pilot epidemiological measures]. Doctor of medical sciences dissertation, Supplement. Omsk. 298 p. (In Russian).

Kokavec I., Navara T., Beracko P., Derka T., Handanovičová I., Rúfusová A., Vráblová Z., Lánczos T., Illyová M. & Šporka F. 2017. Downstream effect of a pumped-storage hydropower plant on river habitat conditions and benthic life – a case study. *Biologia*, **72**(6): 652–670. https://doi.org/10.1515/biolog-2017-0077

Krupa E.G., Dobrokhotova O.V. & Stuge T.S. 2016. *Fauna Calanoida (Crustacea: Copepoda) Kazakhstana i prilegayushchikh territoriy* [Fauna of Calanoida (Crustacea: Copepoda) of Kazakhstan and adjacent territories]. Almaty: Etalon Print. 208 p. (In Russian).

Krupa E.G., Stuge T.S. & Dobrokhotova O.V. 2012. On the Calanoida fauna of Kazakhstan. *In*: **Meldebekov A.M.** (Ed.). *Materialy Mezhdunarodnoy nauchnoy konferentsii, posvyashchennoy 80-letiyu Instituta zoologii Respubliki Kazakhstan "Zhivotnyy mir Kazahstana i sopredel'nykh territoriy". Almaty, 22–23 Noyabrya 2012 g.* [Materials of the international conference "Wildlife of Kazakhstan and adjacent areas" dedicated to the 80th anniversary of the Institute of Zoology. Almaty, 22–23 November 2012]: 128–130. Almaty: Nur-Print. (In Russian).

Krylov A.V. 2012. The species composition of zooplankton in waterbodies and watercourses of the Great Lakes Depression. *Biologiya vnutrennikh Vod*, **2012**(3): 43–51. (In Russian; English translation: *Inland Water Biology*, 2012, **5**(3): 266–273. https://doi.org/10.1134/S1995082912030078).

Krylov A.V. 2013. Quantitative development of zooplankton in waterbodies and watercourses of the Great Lakes Depression. *Biologiya vnutrennikh Vod*, **2013**(1): 39–45. https://doi.org/10.7868/S0320965212040109 (In Russian; English translation: *Inland Water Biology*, 2013, **6**(1): 32–38. https://doi.org/10.1134/S1995082912040098).

Krylov A.V., Mendsaihan B., Ayushsuren Ch. & Tsvetkov A.I. 2020. Zooplankton of pulsating lakes Orog and Tatsyn-Tsagaan (West Mongolia) in the period of the beginning of the stabilisation of water level regime. *Biologiya vnutrennikh Vod*, **2020**(3): 289–297. https://doi.org/10.31857/S0320965220030109. (In Russian; English translation: *Inland Water Biology*, 2020, **13**(2): 242–250. https://doi.org/10.1134/S1995082920020248).

Krylov A.V. & Zhgareva N.N. 2016. Impact of flooding period on summer zooplankton of small lakes. *Izvestiya Rossiyskoy Akademii Nauk, Seriya geograficheskaya*, **2016**(1): 58–66. (In Russian). https://doi.org/10.15356/0373-2444-2016-1-58-66

Kukharskaya E.V. & Dolgin V.N. 2011. Results of the zooplankton study in the Chulym River basin. *Vestnik Tomskogo Gosudarstvennogo Pedagogicheskogo Universiteta*, **2011**(5), 107: 77–83. (In Russian).

Kurbatova S.A., Mylnikova Z.M., Yershov I.Yu., Bykova S.N. & Vinogradova O.G. 2018. Influence of aquatic plants of different ecological groups on zooplankton distribution and abundance. *Sibirskiy ekologicheskiy Zhurnal*, **2018**(1): 56–66. https://doi.org/10.15372/SEJ20180105 (In Russian; English translation: *Contemporary Problems of Ecology*, 2018, **11**(1): 45–53. https://doi.org/10.1134/S1995425518010080).

Lazareva V.I. 2020. Long-term changes in the composition and abundance of zooplankton community in the Kama River reservoirs. *Biologiya vnutrennikh Vod*, **2020**(3): 260–275. https://doi.org/10.31857/S0320965220030110 (In Russian; English translation: *Inland Water Biology*, 2020, **13**(2): 214–229. https://doi.org/10.1134/S199508292002025X).

Lazareva V.I., Zhgareva N.N., Gusakov V.A. & Ivanov V.K. 2003. Food web structure of invertebrate

communities in three small lakes with different water pH level: zooplankton. *Biologiya vnutrennikh Vod*, **2003**(1): 49–57. (In Russian).

Maier G. 1990. The life-history of 2 copepods with special reference to Eudiaptomus vulgaris Schmeil, 1898. *Crustaceana*, **59**: 204–212. https://doi.org/10.1163/156854090X00679

Miracle M.R. 1982. Biogeography of the freshwater zooplanktonic communities of Spain. *Journal of Biogeography*, **9**(6): 455–467. https://doi.org/10.2307/2844613

Mykitchak T. 2016. Checklist and distribution of Cladocera and Copepoda (Calanoida, Cyclopoida) from the Ukrainian Carpathians. *Journal of Wetlands Biodiversity*, **6**: 109–121.

Naidenow W. 1994. Wandel in der Zusammensetzung der Cladocera- und Copepoda-Fauna des Süßwassers in Bulgarien im letzten Jahrhundert. *Lauterbornia*, **19**: 95–106.

Ogay R.I. & Sokolova V.A. 1972. Development of zooplankton and zoobenthos in the Vilyuy Reservoir. *In*: **Cherepanov A.I.** (Ed.). *Zoologicheskie problemy Sibiri*: *Materialy IV soveshchaniya zoologov Sibiri* [Zoological problems of Siberia: Proceedings of the fourth conference of zoologists in Siberia]: 150–151. Novosibirsk: Nauka. (In Russian).

Pesenko Yu.A. 1982. *Printsipy i metody kolichestvennogo analiza v faunisticheskikh issledovaniyakh* [Principles and methods of quantitative analysis in faunistic studies]. Moscow: Nauka. 287 p. (In Russian).

Podshivalina V.N. 2013. Faunal composition of zooplankton and water quality assessment in a quarry in the territory of the Prisurskiy State Nature Reserve. *Nauchnye Trudy Gosudarstvennogo Prirodnogo Zapovednika "Prisurskiy"*, **28**: 3–5. (In Russian).

Rylov V.M. 1935. Das Zooplankton der Binnengewässer. Einführung in die Systematik und Ökologie des tierischen Limnoplanktons mit besonderer Berücksichtigung der Gewässer Mitteleuropas. *Binnengewässer*, **15**: 1–272.

Samchyshyna L.V. 2008. Ecological characteristic of calanoids (Copepoda, Calanoida) of the inland waters of Ukraine. *Vestnik Zoologii*, **42**(2): 123–128. https://doi.org/10.2478/v10058-008-0007-1

Samchyshyna L. & Santer B. 2010. Chorion structure of diapause and subitaneous eggs of four diaptomid copepods (Calanoida, Diaptomidae): SEM observations. *Vestnik Zoologii*, **44**(3): 26–32. https://doi.org/10.2478/v10058-010-0015-9

Schmeil O. 1898. Copepoda: I. Gymnoplea. *Das Tierreich. Crustacea. Copepoda*: 1–169. Berlin: Verlag von R. Friedländer und Sohn.

Semyonova L.A. & Aleksyuk V.A. 2010. Zooplankton of the lower Ob' River. *Vestnik Ekologii, Lesovedeniya i Landshaftovedeniya*, **10**: 156–169. (In Russian).

Simčič T. & Brancelj A. 2001. Seasonal dynamics of metabolic activity of the Daphnia community in Lake Bled (Slovenia). *Hydrobiologia*, **442**: 319–328. https://doi.org/10.1023/A:1017542401205

Sket B. 1988. Zoogeography of the freshwater and brackish Crustacea in the Kvarner-Velebit Islands (NW Adriatic, Yugoslavia). *Biološki Vestnik*, **36**: 63–76.

Smirnov S.S. 1929. Beiträge zur Copepodenfauna Ostasiens. *Zoologischer Anzeiger*, **81**(11–12): 317–329.

Solov'yov P.F. 1927. Hydrobiology in Belorussia. *Russkiy gidrobiologicheskiy Zhurnal*, **6**(8–10): 201–202. (In Russian).

Spanovskaya V.D. & Grigorash V.A. 1962. The ichthyofauna of the Spas-Klepiki lakes and its aspects. *Trudy Okskogo gosudarstvennogo Zapovednika*, **5**: 27–56. (In Russian).

Vranovsky M. 1997. Impact of the Gabcikovo hydropower plant operation on planktonic copepods assemblages in the River Danube and its floodplain downstream of Bratislava. *Hydrobiologia*, **347**: 41–49. https://doi.org/10.1023/A:1002990705205

Walter T.C. & Boxshall G. 2018a. Eudiaptomus Kiefer, 1932. *World of Copepods Database* [online]. https://www.marinespecies.org/copepoda/aphia.php?p=taxdetails&id=149689 [viewed 14 October 2020]. https://doi.org/10.14284/356

Walter T.C. & Boxshall G. 2018b. Eudiaptomus transylvanicus (Daday, 1891). *World of Copepods Database* [online]. https://www.marinespecies.org/copepoda/aphia.php?p=taxdetails&id=358617 [viewed 14 October 2020]. https://doi.org/10.14284/356

Walter T.C. & Boxshall G. 2021. Eudiaptomus transylvanicus (Daday, 1891). *World of Copepods Database* [online]. https://www.marinespecies.org/copepoda/aphia.php?p=taxdetails&id=358617 [viewed 30 April 2021]. https://doi.org/10.14284/356

Wolf E. 1905. Die Fortpflanzungsverhältnisse unserer einheimischen Copepoden. *Zoologische Jahrbücher. Abteilung für Systematik, Geographie und Biologie der Tiere*, **22**: 101–280.

Received 2 January 2021 / Accepted 31 March 2022. Editorial responsibility: M.E. Daneliya, A.A. Przhiboro