ZOOSYSTEMATICA ROSSICA

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

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

Vol. 32(2): 223–230 ▪ Published online 4 November 2023 ▪ DOI 10.31610/zsr/2023.32.2.223

RESEARCH ARTICLE

First record of *Diaptomus zografi* (Copepoda: Calanoida) from Russia in a century

Первая находка *Diaptomus zografi* (Copepoda: Calanoida) в России за вековой период

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Abstract. The calanoid copepod species *Diaptomus zografi* Korchagin, 1887 is recorded from the East European Plain (Middle Volga Region, Russia) for the first time since the year 1925. A brief redescription and illustrations of the species are provided, and some precise details in its morphology are revealed. The studied population of *D. zografi* from the Middle Volga region is similar in morphological characters to populations from the environs of Moscow and Kostroma.

Резюме. На Восточноевропейской равнине (Среднее Поволжье, Россия) впервые с 1925 г. обнаружен вид каланоидных копепод *Diaptomus zografi* Korchagin, 1887. Представлены его краткое переописание и иллюстрации, уточнены некоторые особенности морфологии. По морфологическим признакам популяция *D. zografi* из Среднего Поволжья схожа с популяциями из окрестностей Москвы и Костромы.

Key words: zooplankton, morphology, Middle Volga region, Copepoda, Calanoida, Diaptomidae, *Diaptomus zografi*, new record

Ключевые слова: зоопланктон, морфология, Среднее Поволжье, Copepoda, Calanoida, Diaptomidae, *Diaptomus zografi*, новая находка

ZooBank Article LSID: CF548A3D-3368-49F7-A9A3-C4BCB55158E4

Introduction

The genus *Diaptomus* Westwood, 1836 comprises 11 (Błędzki & Rybak, 2016) or 12 (Borutzky et al., 1991) species in the waters of the Palaearctic region. Kiefer (1978) divided the genus into the subgenera *Diaptomus* Westwood, 1836 and *Chaetodiaptomus* Kiefer, 1978. The latter comprises *D. zografi* Korchagin, 1887 and five other species (Stepanova, 2008). *Diaptomus zografi* was mentioned as incertae sedis in several reviews (Guerne & Richard, 1889; Hilgendopf, 1891; Giesbrecht & Schmeil, 1898) or even was not included among the species of the genus (Rylov, 1922). Schmeil (1898) unsuccessfully tried to clarify information about the species and requested the specimens from the author (A.N. Korchagin), who did not respond. Kiefer described *D.* (*Ch.*) *kostromanus* in 1972 from specimens that were collected by S.S. Smirnov in May 1925 in the vicinity of Kostro-

ma and identified by him as *D. mirus* Lilljeborg in Guerne et Richard, 1889. The name of this Kiefer's species was later synonymised with *D.* (*Ch.*) *zografi* by Borutzky et al. (1991), and it is currently relevant. The species has not been recorded anywhere since 1925. It is recorded by us here for the first time in almost a century. In the present study, the morphological characters of the population of *D. zografi* from the Middle Volga region (Russia, East European Plain, Prisurskiy State Nature Reserve) are described and illustrated.

Material and methods

Specimens of *Diaptomus zografi* were collected from a steppe shallow reservoir in the Sviyaga River basin (the right tributary of the Volga River, the Middle Volga region, Prisurskiy State Nature Reserve, Chuvash Republic, Russia) in May 2021 .

The samples were obtained by filtering the water (50 liters) through an Apstein plankton net (mesh size 70 μm) and fixed using 40% formaldehyde (the final formaldehyde concentration in the probe reached the level of ca 4%). Adult males and females of *D. zografi* were selected from samples for a morphological study under a stereomicroscope. Images were taken using a Philips 525 M scanning electron microscope (SEM). For the study under SEM, specimens were transferred to pure methanol for an hour, then to hexamethyl disilazane for a day, and then air-dried. Morphological terminology follows Huys & Boxshall (1991).

In the studied reservoirs, the water surface temperature and water acidity (pH) were measured using a Hanna HI-83141 pH-meter with an electrode and temperature probe; total dissolved solids (TDS) were measured using a Hanna HI-98129 tester.

Results

Order **Calanoida** Sars, 1903

Family **Diaptomidae** Baird, 1850

Genus ***Diaptomus*** Westwood, 1836

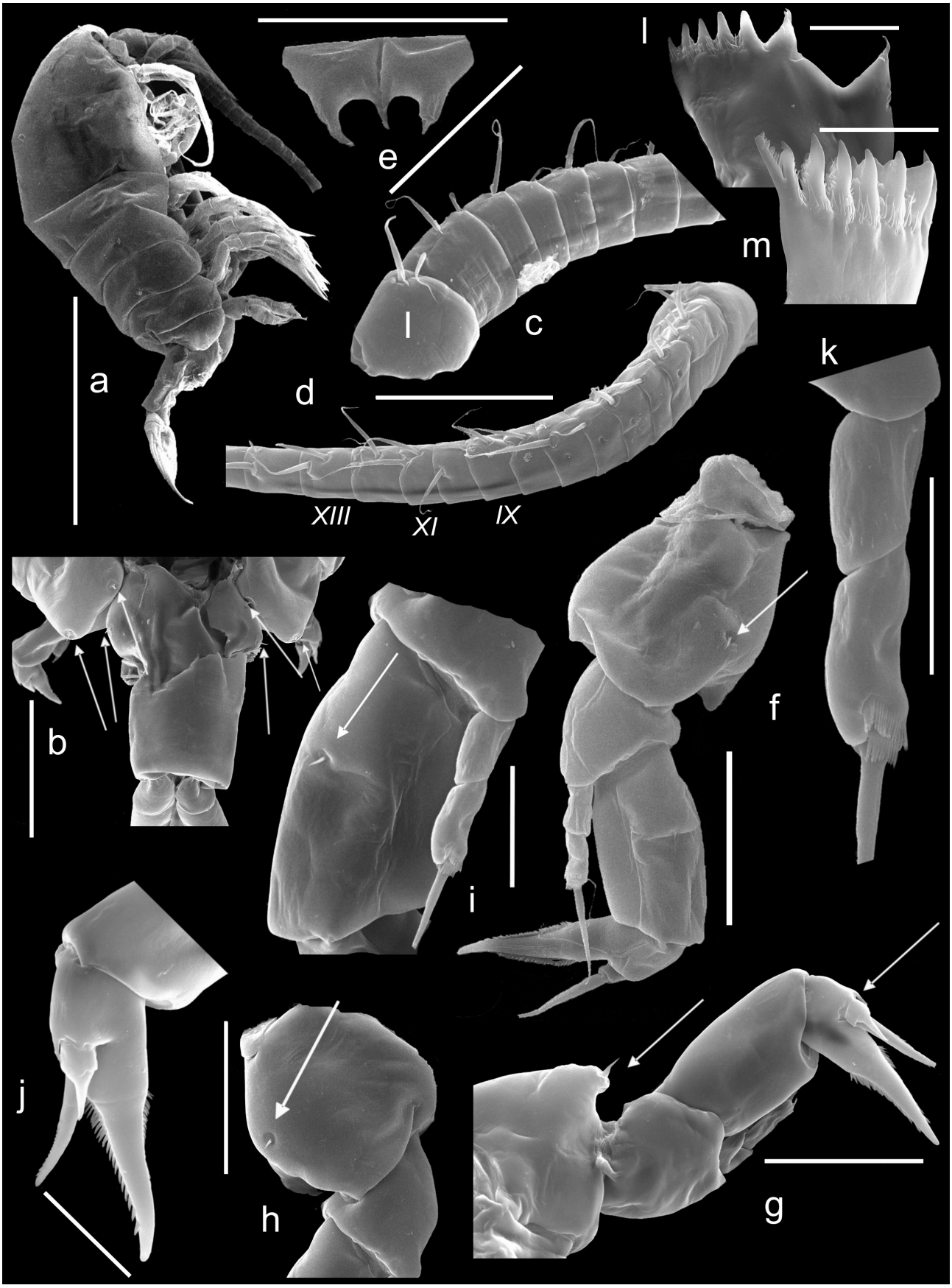
Diaptomus zografi Korchagin, 1887
(Figs 1–3)

Diaptomus kostromanus Kiefer, 1972: 238.

Material examined. **Russia**, *Chuvash Republic*, near Malye Shikhirdany Vill., shallow water body, 55.08673°N, 047.79307°E, 20 May 2021, E. Kuz'min leg., 14 males, 11 females.

Redescription. *Female* (Fig. 1a). Body length 2.35–2.55 mm (n = 11). Last thoracic segment with distinct triangular wings and four small hyaline spines (Fig. 1b, arrowed). Genital compound somite weakly broadened in anterior part, slightly asymmetrical (more dilated in right side), with two barely noticeable hyaline spines (Fig. 1b, arrowed). Caudal ramus with long plumose setae. Antennule symmetrical, 25-segmented, extending almost to posterior margin of cephalothorax, with one long (ca 150 μm) seta on segment I (Fig. 1c) and two setae on segments IX, XI and XIII (Fig. 1d). Setal formula (Roman numerals in parentheses refer to segment number): 1+ae (I), 3+ae (II), 1+ae (III), 1(IV), 1+ae (V), 1 (VI), 1+ae (VII), 1+ae (VIII), 2+ae (IX), 1 (X), 2 (XI), 1+ae+sp (XII), 2 (XIII), 1+ae (XIV), 1 (XV), 1+ae (XVI), 1 (XVII), 1+ae (XVIII), 1+ae (XIX), 1 (XX), 1 (XXI), 2 (XXII), 1 (XXIII), 2 (XXIV), 4+ae (XXV). Rostrum with two acutely curved processes (Fig. 1e). Margin of mandibular incision with seven single-vertex teeth (one ventral and six central) and one plumose dorsal seta. Ventral tooth with wide base separated from other teeth by a deep diastema (Fig. 1l). Central teeth acute, with wide base (Fig. 1m). Dorsal teeth acute, with fiber-like projections on proximal surface, with narrow base bearing a row of spinules (Fig. 1m). Maxilla and maxilliped with long plumose setae raising capacity for filtration. Maxilla (Fig. 3a, b) with two praecoxal (having six and three apical setae, respectively) and two coxal (each with three apical setae) endites. Allobasis with three setae. Endopod segments 1, 2 and 3 with two setae each. Maxilliped (Fig. 3c) with one praecoxal and three coxal endites, with 1, 2, 3, and 4 apical setae, respectively. Basis with three setae along median margin. Endopod segments 1–6 with 2, 3, 2, 2, 2, and 4 setae, respectively. In leg 2, endopod seg-

Fig. 1. *Diaptomus zografi* Korchagin, 1887, female. **a**, habitus, lateral view; **b**, genital compound somite; **c**, **d**, antennule; **e**, rostrum; **f**, **g**, leg 5; **h**, coxa of leg 5; **i**, exopod 1 and endopod of leg 5; **j**, exopods 2 and 3 of leg 5; **k**, endopod of leg 5; **l**, **m**, mandible. Scale bars: 1 mm (a), 300 μm (b), 200 μm (c, d), 100 μm (e, f, g, h), 50 μm (i, j, l), and 40 μm (k, m).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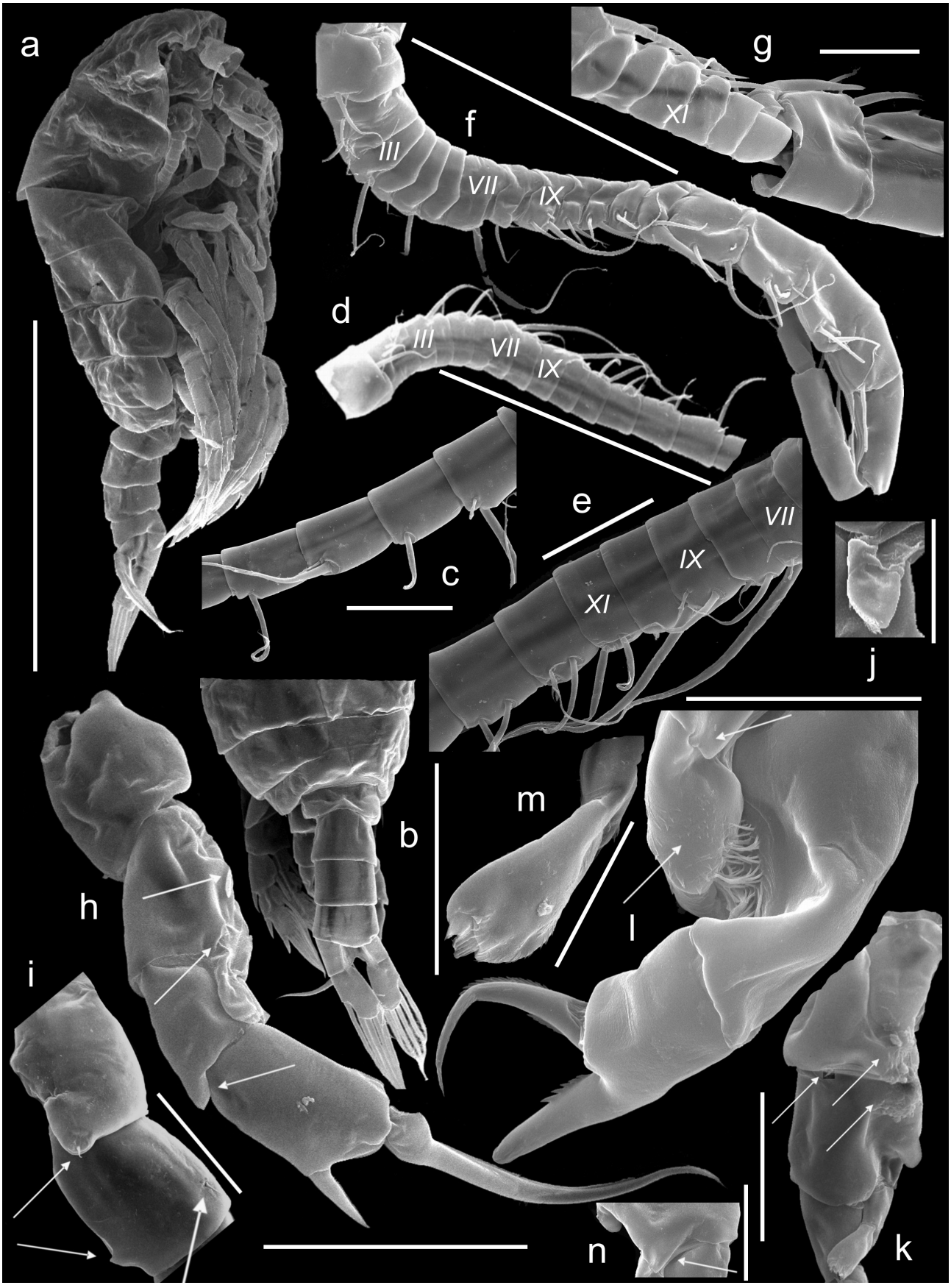
ment 2 without Schmeilsche lobus. In leg 5 (Fig. 3e), coxa with notable distolateral projection ending with long (about 15 μm) hyaline spine (Fig. 1f, g, arrowed) and having tiny spine in central part of medial margin (Fig. 1f, 1h, arrowed); basis triangular, with slightly extending distolateral inner angle; exopod segment 1 rectangular, about two times as long as wide, with thin little spine in centre of lateral outer surface (Fig. 1i, arrowed); exopod segment 2 with thin short spine near base of segment 3 (Fig. 1g, arrowed) and with terminal claw bearing a row of spinules on lateral and medial margins (Fig. 1j); exopod segment 3 with two apical spines, longer spine with three rows of spinules (Fig. 1j); endopod two-segmented, with parallel apical and subapical rows of setulae (with more than 15 setulae in each) (Fig. 1k) and one apical spine equal to endopod length (Fig. 1i).

Male (Fig. 2a). Body length 2.00–2.15 mm (n = 14). Last thoracic segment with small wings (Fig. 2b) and four tiny hyaline spines. Caudal ramus 1.8 times as long as wide (Fig. 2b). Antennule extending almost to posterior margin of cephalothorax. Left antennule with one seta on segments XV and XVII (Fig. 2c), like in female. Both left and right antennulae with long (ca 250μm) setae on segments III, VII, and IX (Fig. 2d, 2e, 2f). Right antennule with spiniform projections at segments X, XI, XIII, XVI, and XVII and short spine at segment XV (Fig. 2g); projection of segment XIII recurved, extending length of segment XIV; antepenultimate segment with hyaline membrane along it. Right antennule setal formula: 1+ae (I), 3+ae (II), 1+ae (III), 1 (IV), 1+ae (V), 1 (VI), 1+ae (VII), 1+ae (VIII), 2+ae (IX), 1+sp (X), 1+sp (XI), 1+ ae (XII), 1+ae+sp (XIII), 2+ae (XIV), 1+ae+sp (XV), 1+ae+sp (XVI), 1+sp (XVII), 1 (XVIII), 2+ae (XIX), 1 (XX), 2+ae (XXI), 2 (XXII), 4+ae (XXIII). In right leg 5 (Fig. 2h, 3d), coxa with convex fold in central part of medial margin (Fig. 2i, arrowed) and with small rounded distolateral projection ending with small spine (Fig. 2i, arrowed); basis more long than wide, with hyaline process (ca 25 μm) in central part of medial margin (Fig. 2h, i, arrowed), with sclerotised folds in distal part (Fig. 2h, arrowed) and small spine in distal part of lateral surface (Fig. 2i, arrowed); exopod segment 1 almost square, with an elongated outer distolateral angle extending onto segment 2 by 25 μm; exopod segment two times as long as segment 1 and about two times as long as wide, with claw being strong, slightly curved in distal end [the structure is given according to classical concepts according to Dussart & Defaye, 2001 and Borutzky et al., 1991], covered with row of spinules, and lateral spine inserted at distal part of lateral margin (spine as long as two-thirds of segment width, covered with a row of spinules) (Fig. 2h); endopod two-segmented, as long as exopod segment 1, apically with short setulae (Fig. 2j; the thin white curved line is the border between the segments). In left leg 5 (Fig. 3a), coxa with small (ca 8–10 μm) spine at distal margin (Fig. 2k, arrowed), thin seta on lateral outer surface, and tuberous area at distal part (Fig. 2k, arrowed); basis almost rectangular, slightly narrowing distally, with large medial hook-shaped process located in its central part near medial margin, directed distally (Fig. 2k), triangular dilated ventral part of distal margin (Fig. 2l, 2n, arrowed), and tuberous area in proximal part (Fig. 2k, arrowed); exopod two-segmented, with setulae in middle of segment 1 and in proximal part of segment 2 (Fig. 2l), and tiny triangular projections ("thorns") in central part of segment 1 (Fig. 2l, arrowed); proximal part of exopod segment 1 two times as wide as its distal part; exopod segment 2 half as long as segment 1, with long dentate spine being crescent-shaped, curved subapically, with rows of setae directed apically (Fig. 2l); endopod two-segmented (boundary between segments passing approximately in proximal third of endopodite at point of inflection), extending to middle of exopod segment 2 (Fig. 2k), apically and subapically with setulae located in circle, and bearing numerous irregular spinules on posterior surface (Fig. 2m).

Distribution. Korchagin (1887) described *Diaptomus zografi* based on material from the vicinity of Moscow (Russia) (Fig. 3). The species was

Fig. 2. *Diaptomus zografi* Korchagin, 1887, male. **a**, habitus, lateral view; **b**, last thoracic segments and genital compound somite; **c**, **d**, **e**, left antennule; **f**, **g**, right antennule; **h**, right leg 5; **i**, coxa and basis of right leg 5; **j**, endopod of right leg 5; **k**, left leg 5; **l**, exopod of left leg 5; **m**, endopod of left leg 5; **n**, distal part of basis of left leg 5. Scale bars: 1 mm (a), 500 μm (d), 400 μm (f), 300 μm (b), 200 μm (h), 100 μm (c, e, g, i), 50 μm (j, k, l, n), and 40 μm (m).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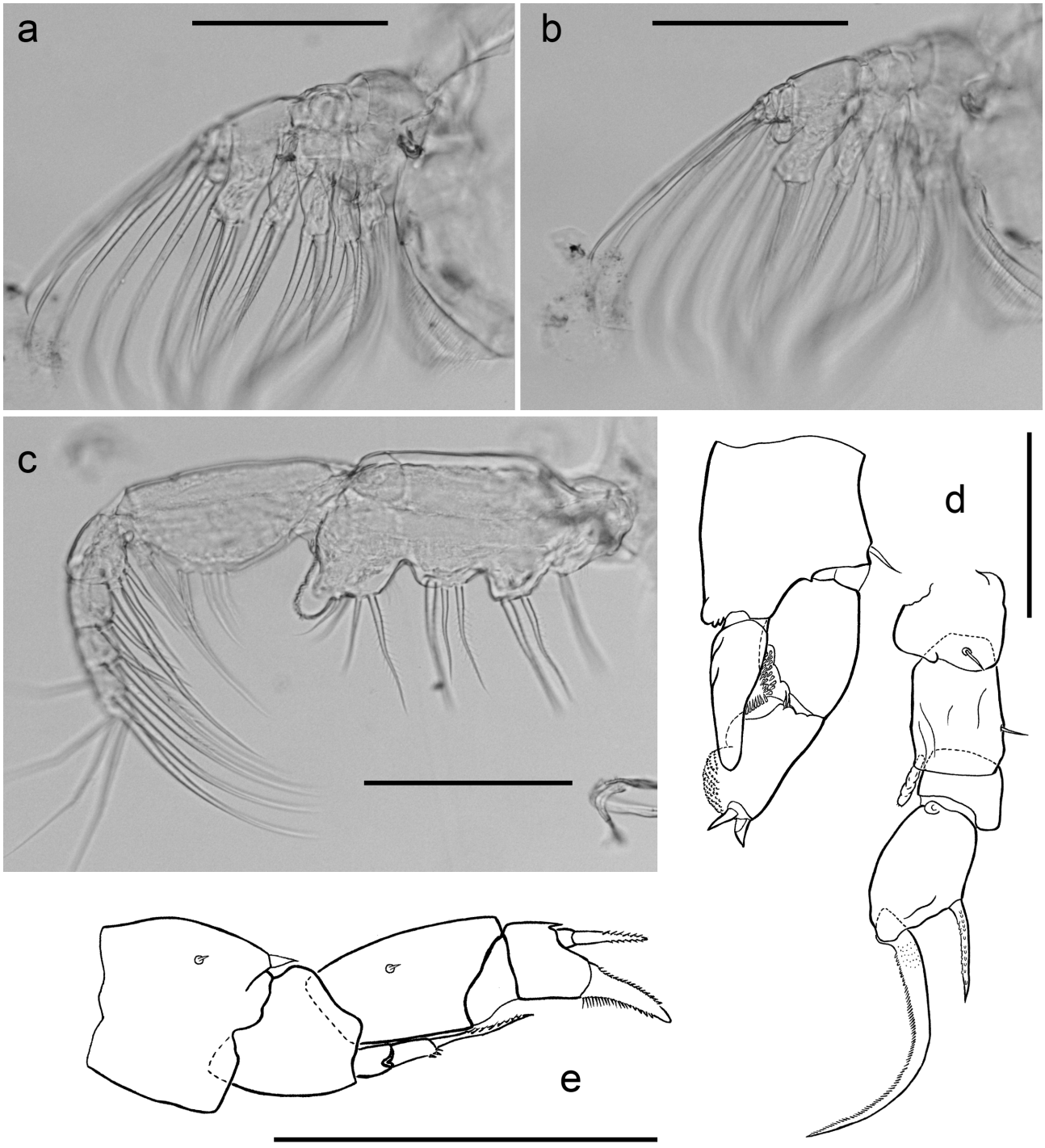

Fig. 3. *Diaptomus zografi* Korchagin, 1887, male. **a**, **b**, maxilla; **c**, maxilliped; **d**, male right and left legs 5; **e**, female leg 5. Scale bars: 200 μm.

also found by Smirnov (1929) in snow pools in the vicinity of Kostroma (Russia) (Fig. 4). Later, it was not recorded anywhere until now. We found the species ca 700–750 km to the east from the type locality. So, the species has a limited distribution in the centre of the East European Plain. Such sporadic findings do not allow us to outline the boundaries of the range of this species. Taking into account our finding, we believe that *D. zografi* can be found in other parts of the East Eu-

ropean Plain and Europe as a whole. Careful study of small bodies of water (such as snow puddles), which are usually not well surveyed by collectors, is necessary in order to detect this rare species.

Bionomics. Populations from the vicinity of Moscow and Kostroma were found in snow puddles (Korchagin, 1887; Smirnov, 1929). The population from the Middle Volga region (Prisurskiy State Nature Reserve) inhabits an artificially deepened steppe shallow water reservoir whose surface area reduces substantially during the summer. Sometimes the water body shallows so much that it becomes a mud puddle or disappears. The reservoir has been studied since 2011, and the species was registered in 2021 only.

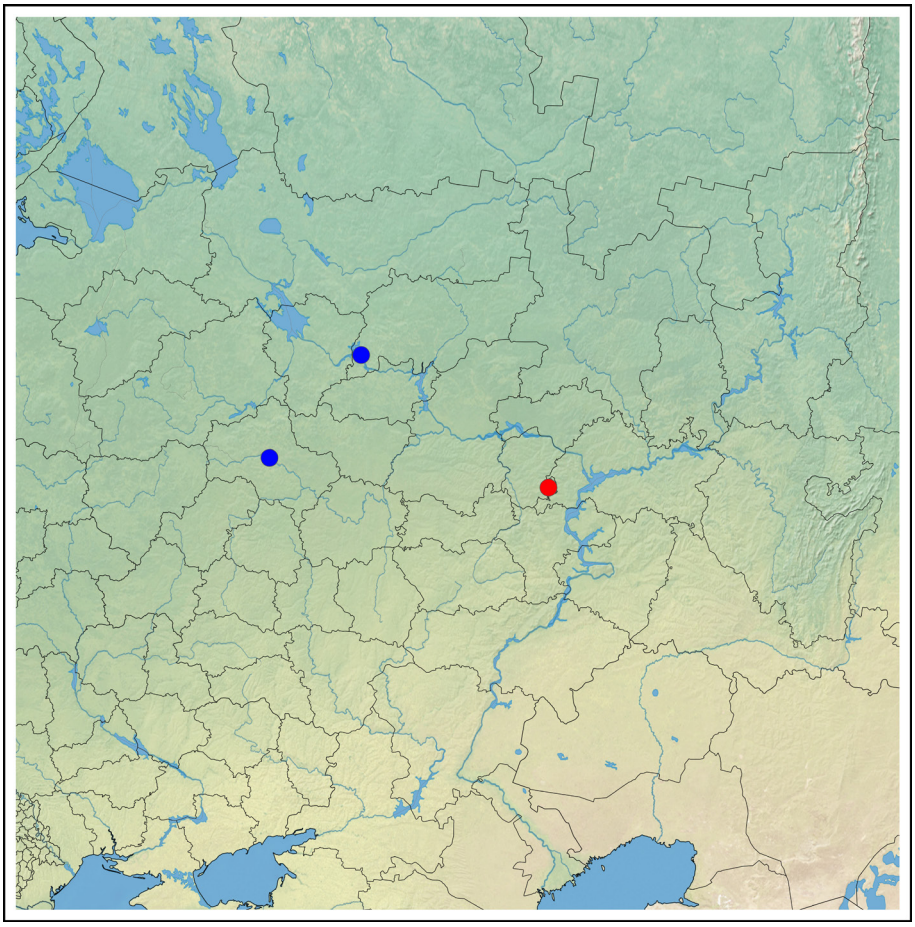

Fig. 4. Distribution of *Diaptomus zografi* Korchagin, 1887. Previous findings in the vicinities of Moscow and Kostroma (blue circles), and the new record in the Middle Volga Region (red circle).

Individuals of *D. zografi* were registered by us in late May, at water temperatures of 23.6–23.8 °C. In the middle of April (the water temperature was about 14.4 °C) they were not found. The population consisted of adult specimens. Males prevailed over females (73 and 27% of the total abundance, respectively). The main ecological parameters of the habitat of the studied population are given below. Water surface area (min–max): 1650–500 m^2; mean depth (min–max): 0.3–0.8 m; maximum depth: 1.5 m; total dissolved solids (TDS): 521–530 ppm; pH: 6.67–7.75.

Remarks. Although the description of *D. zografi* by Korchagin (1887) is brief, it is accurate and sufficient to compare it with Kiefer's (1972, 1978) descriptions of *D. kostromanus*. This comparison we made confirms the synonymy of *D. kostromanus* with *D. zografi*, established by Borutzky et al. (1991). At the same time, the description and illustration of the characters of *D. mirus* in the work of Smirnov (1929) do not correspond to the description of Kiefer and the main characters of *D. zografi* (Borutzky et al., 1991). Smirnov (1929) listed two (instead of one) apical spines on the endopod in females and a large (instead of small) distolateral projection on the coxa of the right leg in males. A species with these characters (*D. mirus* ?) is not conspecific with *D. zografi*.

We did not find any significant morphological differences between the examined population of *D. zografi* and those described in the literature (Korchagin, 1887; Kiefer, 1972, 1978). The studied specimens have the same dimensions as specimens collected in 1925. The study of specimens from the Middle Volga region made it possible to clarify some structural details of *D. zografi*, namely the features of the P5 exopod (spinules on the

surface of the terminal claw and lateral spine) in the females, the antennulae (appendages), the right P5 endopod (appendages), and the left P5 exopod and endopod in the males. It was found that the segments 3, 7, and 9 of the antennule in the males studied have setae 2.5–3.0 times longer than those in females. The left antennule in males is not the same as in females, as noted by Kiefer (1972).

In Korchagin's article (1887), his last name is written only in Russian. Guerne & Richard (1889) transliterated it into French as "Kortschaguine". This spelling has been adopted by Borutzky et al. (1991). The "World of Copepods Database" (Walter & Boxshall, 2023) uses the spelling "Korchagin", which we adhere to in this article.

Acknowledgements

We thank E.V. Osmelkin and E.M. Kuz'min (Prisurskiy State Nature Reserve) for their valuable logistic support in collecting this material and T.M. Alekseeva (Limnological Institute, Siberian Branch of the Russian Academy of Sciences, Irkutsk) for making drawings. The work was made using the equipment of the Electronic Microscopy Centre of the Limnological Institute (Irkutsk). This work was carried out as part of State Task No. 122072100053-1 from the Ministry of Natural Resources and Ecology of the Russian Federation.

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Received 31 August 2022 / Accepted 30 September 2023. Editorial responsibility: D.A. Gapon