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RESEARCH ARTICLE

First records of *Arctodiaptomus byzantinus* (Copepoda: Calanoida) from the East European Plain (Russia) and *A. similis* from Mongolia

Первые находки *Arctodiaptomus byzantinus* (Copepoda: Calanoida) на Восточно-Европейской равнине (Россия) и *A. similis* в Монголии

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Abstract. The calanoid copepod *Arctodiaptomus byzantinus* Mann, 1940 (Copepoda: Calanoida: Diaptomidae) is recorded for the first time from the East European Plain (Middle Volga Region, Russia), and *A. similis* (Baird, 1859) is found in Darkhat Hollow (Mongolia). Brief redescriptions and illustrations of both species are provided. Additionally, certain morphological characters are clarified, particularly those of the leg 5, antennulae and caudal rami.

Резюме. На Восточноевропейской равнине (Среднее Поволжье, Россия) и в Дархатской котловине (Монголия) впервые для этих регионов обнаружены виды каланоидных копепод *Arctodiaptomus byzantinus* Mann, 1940 и *A. similis* (Baird, 1859) (Copepoda: Calanoida: Diaptomidae), соответственно. Представлены краткие переописания видов и иллюстрации, уточнены некоторые особенности морфологии, в частности, пятой пары ног, антеннул и каудальных ветвей.

Key words: zooplankton, morphology, Middle Volga, Diaptomidae, new records

Ключевые слова: зоопланктон, морфология, Среднее Поволжье, Diaptomidae, новые находки

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Introduction

The genus *Arctodiaptomus* Kiefer, 1932, comprises an estimated 36 (Borutzky et al., 1991), 45 (Ranga Reddy, 1994), or 60 (Walter & Boxshall, 2023) species worldwide. In Europe, it is represented by three subgenera, which collectively encompass 21 species (Błędzki & Rybak, 2016), making it the most species-rich genus among calanoids in the region (Błędzki & Rybak, 2016). Some species, such as *A. dentifer* (Smirnov, 1928), *A. wierzejskii* (Richard, 1888), and *A. bacillifer* (Koelbel, 1885), are widely distributed across Europe, while others are rare and have restricted distributions, i.g. *A. acutulus* (Brian, 1927), *A. byzantinus* Mann, 1940, *A. dudichi* Kiefer, 1932, *A. fischeri* (Rylov, 1922), *A. osmanus*, Kiefer, 1974, *A. niethammeri* (Mann, 1940), and *A. similis* (Baird, 1859). The distribution ranges of certain taxa, such as *A. laticeps* (G.O. Sars, 1863), remain unknown. Within the East European Plain, the genus *Arctodiaptomus* is represented by *A. bacillifer*, *A. dentifer*, *A. laticeps* (Sars, 1863), *A. salinus* (Daday, 1885), and *A. wierzejskii* (Koshkina, 1953; Smirnova et al, 1981; Borutzky et al., 1991).

To date, the following species have been recorded from Mongolia: *A. wierzejskii*, *A. salinus*, *A. rectispinosus* Kikuchi K., 1940, *A. bacillifer*, *A. alpinus* (Imhof, 1885), *A. niethammeri*, *A. acutilobatus* (G.O. Sars, 1903), *A. dahuricus* Borutzky, 1959, and *A. anudarini* Borutzky, 1959 (Flößner et al., 2005; Dulmaa, 2009; Alonso, 2010; Itigilova et al., 2014). *Arctodiaptomus dahuricus* and *A. anudarini* are endemic to Mongolia (Borutzky et al., 1991).

The most recent revision of the genus *Arctodiaptomus* was conducted by Ranga Reddy (1994). In the present study, we redescribe and illustrate two species, *A. byzantinus* and *A. similis*, to clarify several poorly described morphological structures in these taxa. Additionally, we present the first records of *A. byzantinus* from the East European Plain (Middle Volga Region, Russia) and *A. similis* from Mongolia.

Material and methods

Specimens of *Arctodiaptomus byzantinus* were collected from shallow steppe reservoirs in the Sviyaga River basin, a right tributary of the Volga River located in the Middle Volga Region within the Prisurskiy State Nature Reserve in the Chuvash Republic, Russia, in May 2021 and 2023. Specimens of *A. similis* were collected from Lake Targan in Darkhat Hollow, Mongolia, in July 2022. The samples were collected by filtering 50 liters of water through an Apstein plankton net with a mesh size of 70 μm and were fixed using 40% formaldehyde, resulting in a final formaldehyde concentration of approximately 4%. Adult males and females of both species were selected from the samples for morphological study under a stereomicroscope. Images were taken using a Philips 525 M scanning electron microscope (SEM). For examination under the SEM, specimens were first transferred to pure methanol for one hour, then to hexamethyl disilasane for one day, and subsequently air-dried. The morphological terminology used follows Huys & Boxshall (1991).

In the Middle Volga locality, water surface temperature and acidity (pH) were measured using a Hanna HI-83141 pH meter equipped 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 ***Arctodiaptomus*** Kiefer, 1932

Subgenus ***Arctodiaptomus*** Kiefer, 1932

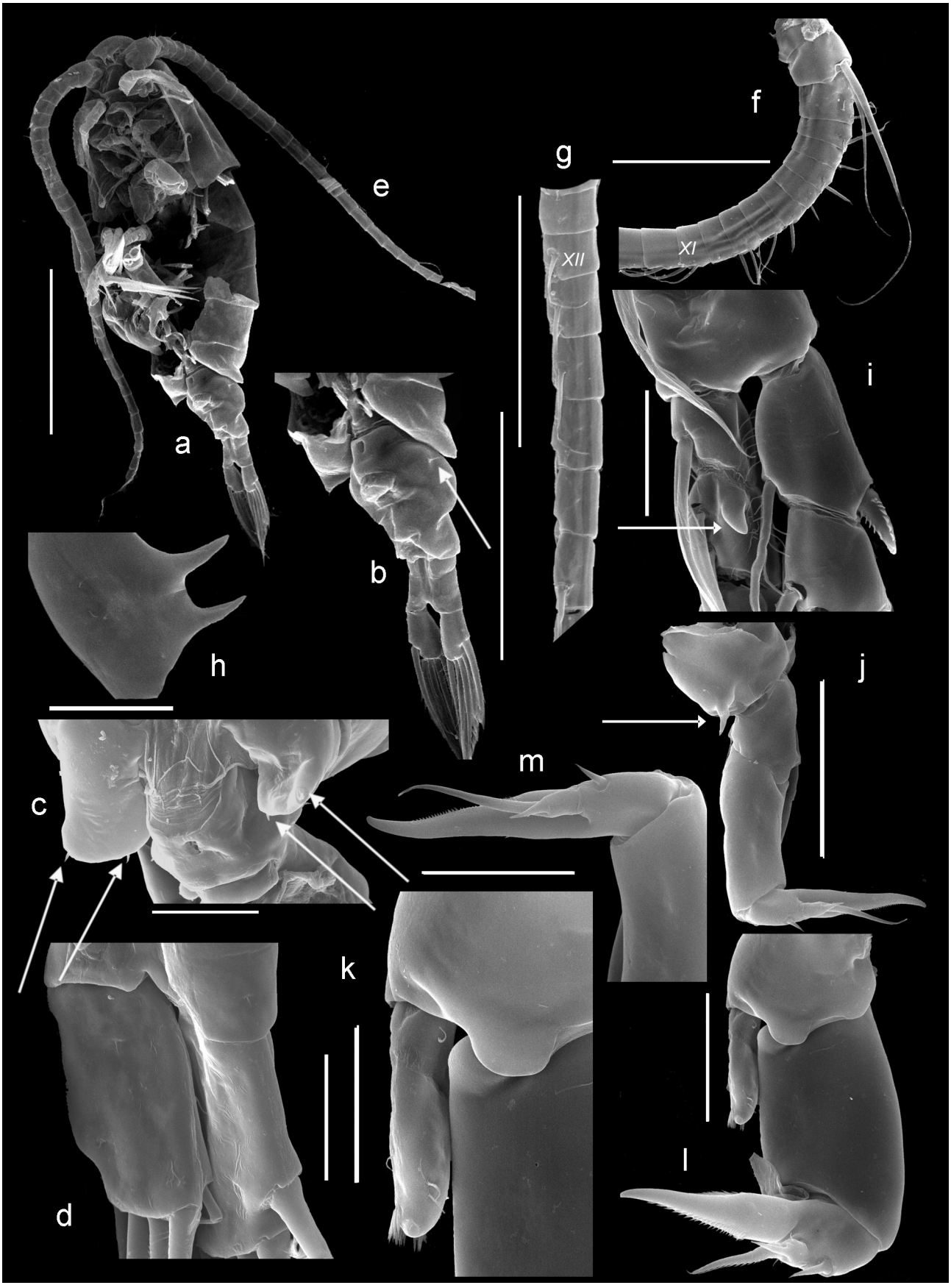
Arctodiaptomus byzantinus Mann, 1940
(Figs 1, 2)

Arctodiaptomus karadaghicus Ulomsky, 1941: 115

Material examined. **Russia**, *Chuvash Republic*, near Malye Shikhirdany Vill., shallow water bodies, 55.08644°N, 047.779382°E, 55.08673°N, 047.79307°E, 20 May 2021, 14 males, 5 females, 27 May 2022, 20 males, 20 females, E. Kuz'min leg.

Redscription. *Female* (Fig. 1a). Body length 1.45–1.75 mm (n = 25). Last thoracic segment dorsally not separayed from segment 4, with nearly rectangular wings extending to spines of genital compound somite (Fig. 1b) and with four small hyaline spines (Fig. 1b, arrowed). Urosome (Fig. 1b) two-segment. Genital compound somite elongated, weakly broadened in anterior part, slightly asymmetrical (more dilated at right side), with two thin, hyaline spines (Fig. 1c, arrowed). Caudal rami 1.9–2.0 times as long as wide, with shallow folds and six long, plumose setae (Fig. 1d). Four (second–fifth) setae located apically, sixth external seta located at two-thirds of outer margin, first (internal) seta slightly displaced on dorsal side of caudal ramus, thin, glabrous, as long as external seta. Rostrum with two long (ca. 25 μm, 3.5–4.0 times as long as wide), acute, curved processes (Fig. 1h). Antennule nearly reaching apices of caudal rami (Fig. 1a). Segment I of antennule with one long (ca. 360–380 μm) seta reaching segments IX–X; segment II with one long (ca. 200 μm) seta reaching segments VI–VII and with

Fig. 1. *Arctodiaptomus byzantinus* Mann, 1940, female. **a**, habitus, ventral view; **b**, genital compound somite; **c**, last thoracic segment; **d**, caudal rami; **e**–**g**, antennule; **h**, rostrum; **i**, leg 2; **j**, **l**, leg 5; **k**, endopod of leg 5; **m**, exopods 2 and 3 of leg 5. Scale bars: 500 μm (a), 400 μm (b), 200 μm (e, f, g), 100 μm (c), 50 μm (d, h, i, j, l, m), 30 μm (k).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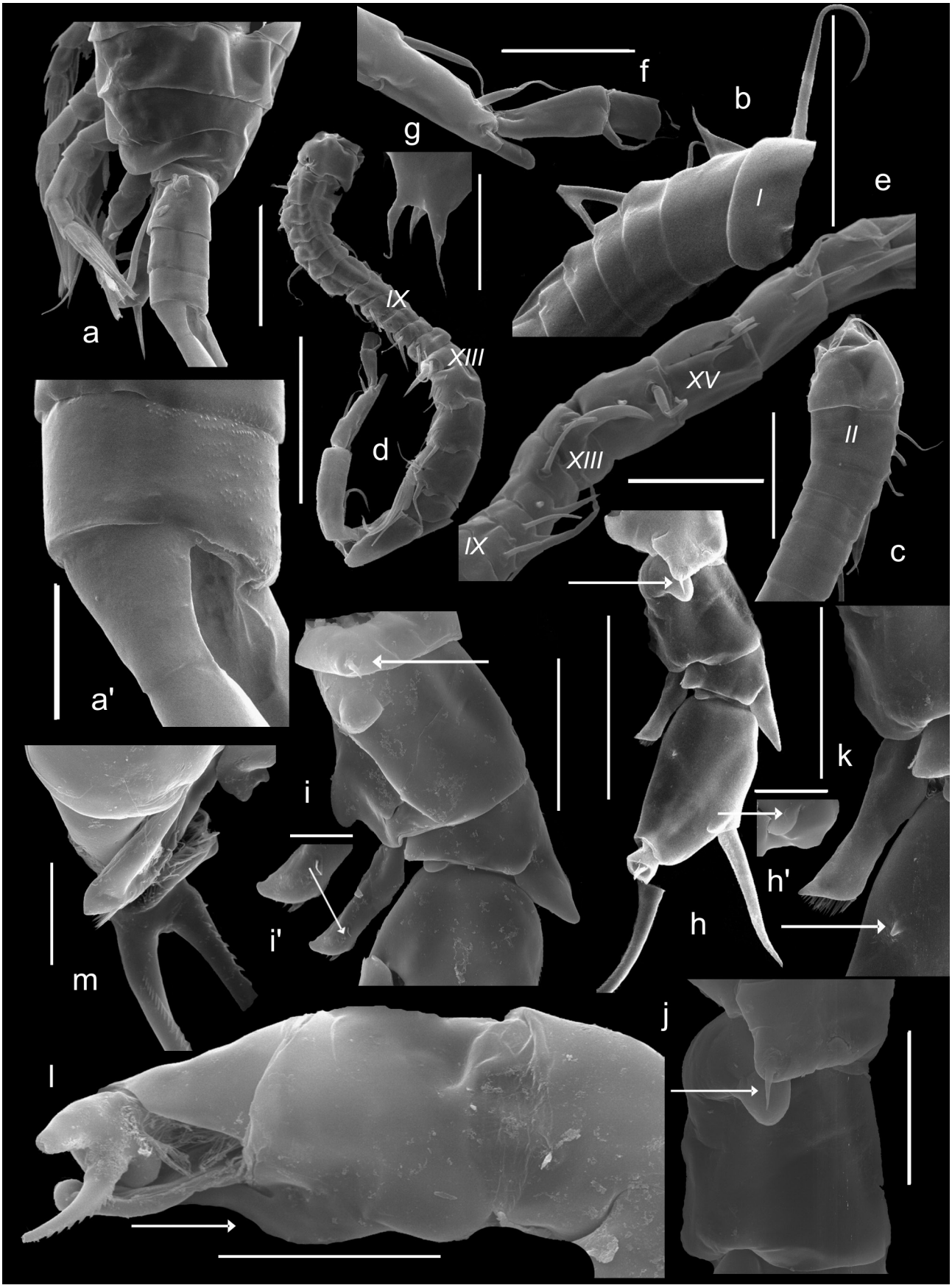
two short (ca. 0.33 times as long as aforementioned one) setae; segment XI with two setae (Fig. 1e, f, g); each segment XII–XVII with one seta (Fig. 1g). Maxilla and maxilliped with long, plumose setae raising filtration capacity. In leg 2, endopod segment 2 with elongated, triangular Schmeilsche lobus located centrally (Fig. 1i, arrowed). In leg 5, coxa almost quadrangular, with notable distolateral projection ending with a hyaline spine (ca. 15 μm length) (Fig. 1j, arrowed); basis triangular (Fig. 1j), with slightly projecting, rounded distolateral inner angle (Fig. 1k) and one long lateral seta located near distal margin. Exopod segment 1 rectangular, about twice as long as wide, with one thin, short spine in centre of lateral outer surface (Fig. 1l). Exopod segment 2 with one well-developed, short (ca. 15 μm) spine near base of segment 3 (Fig. 1l) and with a terminal claw bearing a row of spinules on lateral and medial margins (Fig. 1m). Exopod segment 3 almost separated, ca. 12 μm in length, with one apical spine and one seta, both positioned crosswise at base; seta reaching five-sixths of terminal claw, 3.5–4.0 times as long as spine, curved distally, bearing a row of spinules (Fig. 1m). Endopod two-segmented (dividing suture not distinct, second endopod segment twice as long as first segment), reaching half length of exopod segment 1, with a subapical semicircular row of setulae and several setulae located irregularly (Fig. 1k).

Male. Body length 1.22–1.55 mm (n = 34). Last thoracic segment with slightly asymmetrical wings and four small, hyaline spines. Urosome (Fig. 2a) five-segmented, asymmetrical. Last abdominal segment asymmetrical, extended posterolaterally on right side, irregularly covered with groups of numerous tiny spinules (Fig. 2a′) compared to other abdominal segments (Fig. 2a). Caudal rami 2.5–3.0 times as long as wide (Fig. 2a′), with six long, plumose setae. Four (second–fifth) setae located apically, sixth external seta located at two-thirds of outer margin, first (internal) seta slightly displaced on dorsal side of caudal ramus, thin, glabrous, as long as external seta. Rostrum with two long (ca. 30 μm, five times as long as wide), acute, curved processes (Fig. 2g). Antennulae nearly reaching apex of abdomen. Left antennule with one long (110–150 μm) seta at segment I (Fig. 2b), three almost equal setae (ca. 45 μm) at segment II (Fig. 2c), one long (ca. 130 μm) seta at segment VII. Right antennule with spiniform projections on segments X–XV (Fig. 2d, e), with one short (ca. 75 μm) seta on segment I and one long (ca. 100 μm) seta on segment IX. Projection of segment XIII (ca. 50 μm) slightly curved (Fig. 2e), almost perpendicular; antepenultimate segment with one long, finger-shaped process (Fig. 2f). In right leg 5 (Fig. 2h), coxa with slightly dilated, rounded distolateral angle bearing one small (ca. 10 μm) spine (Fig. 2h, j, arrowed); basis nearly rectangular, with rounded projection located in proximal part of medial margin (ca. 20 μm), with hyaline, hook-shaped process (ca. 20–25 μm) located in central part of medial margin, and with a sclerotised fold located in distal part (Fig. 2h, i, arrowed). Exopod segment 1 two times as wide as long, with dilated (up to 30 μm), triangular distolateral outer angle and one semicircular process located on distal margin close to inner angle (Fig. 2h–i). Exopod segment 2 about 1.7 times as long as wide, with a claw slightly curved distally, one lateral spine being as long as segment, inserted in distal part of lateral margin (Fig. 2h), with one small semicircular process resembling fold, located proximal to lateral spine (Fig. 2h, arrowed), and with one small triangular process looking like peg, located in central part close to medial margin (Fig. 2k, arrowed). Endopod indistinctly two-segmented, half as long as exopod segment 2, thickened at base, beveled and with a row of setulae apically, with one seta located at distal one-third (Fig. 2i, i′, arrowed). In left leg 5 (Fig. 2l), coxa with one small spine located on lateral inner surface and one small seta located on distal margin; basis nearly rectangular, slightly narrowing distally, with weakly elongated (ca. 20–25 μm) process located in central part of medial margin (Fig. 2l, arrowed), directed distally, reaching

Fig. 2. *Arctodiaptomus byzantinus* Mann, 1940, male. **a**, last thoracic segments and abdomen; **a′**, last abdomenal segment; **b**, **c**, left antennule; **d–f**, right antennule; **g**, rostrum; **h, i**, right leg 5; **h′**, fragment of segment 3 of right leg 5 exopod; **i′**, **k**, endopod of right leg 5; **j**, coxa and basis of right leg 5; **l**, left leg 5; **m**, exopod and endopod of left leg 5. Scale bars: 200 μm (a, d), 100 μm (b, c, e, h), 50 μm (a′, f, g, i, l), 40 μm (j, k), 20 μm (h′, i′, m).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distal margin of exopod segment 1. Exopod two-segmented, with long capillaceous setulae located on segment 1 and in proximal part of segment 2 (Fig. 2l); proximal part of exopod segment 1 two times as wide as its distal part; exopod segment 2 half as long as segment 1, with one serrate spine being longer than apex of exopod segment 2, crescent-shaped, curved subapically, with a row of setae apically directed (Fig. 2l–m); endopod two-segmented, protruding beyond spine of exopod segment 2, subapically with setulae arranged in semicircle (Fig. 2m).

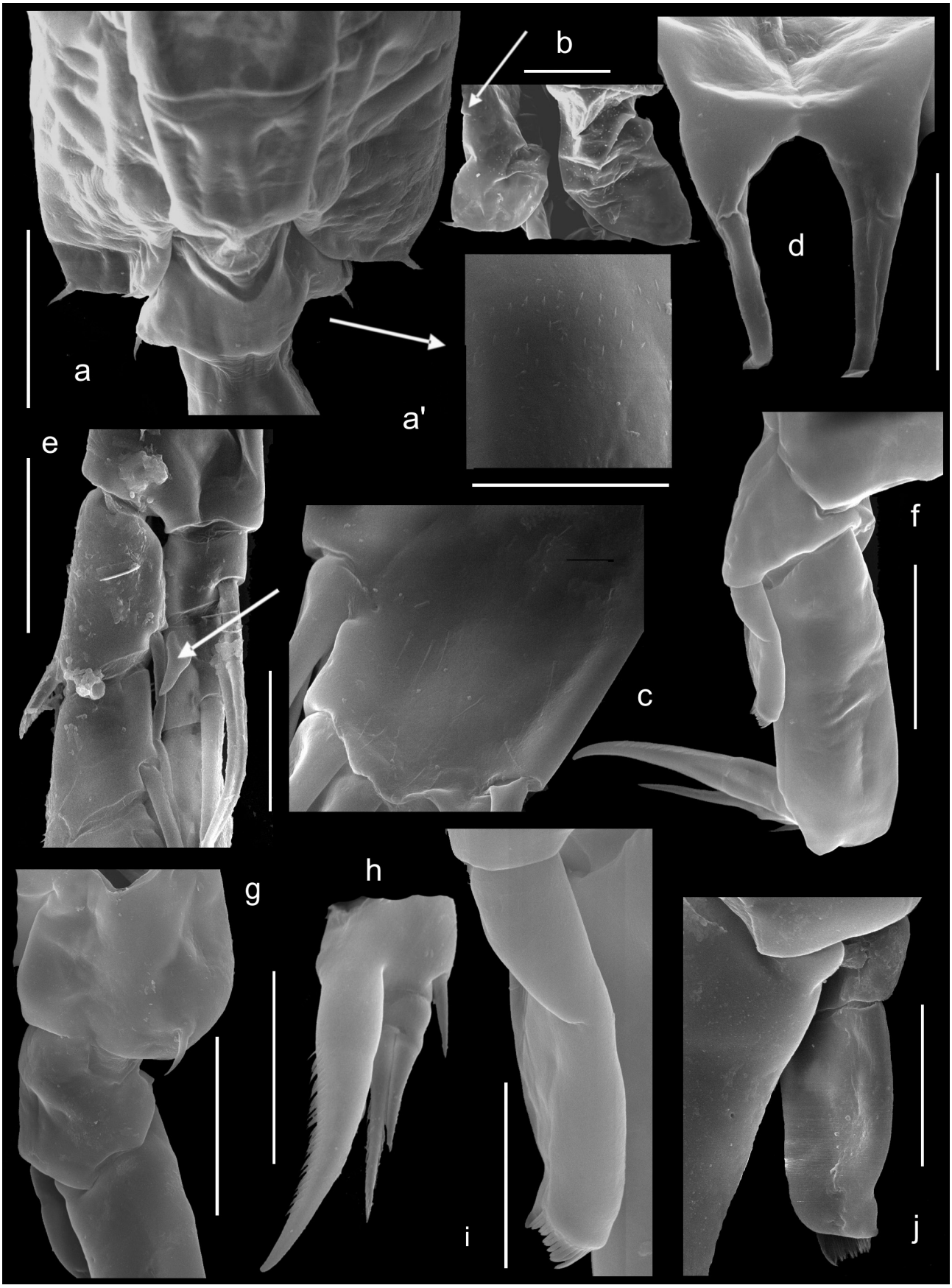
Distribution. *Arctodiaptomus byzantinus* was described based on male specimens collected from the vicinity of Istanbul, Turkey (Mann, 1940). This species is distributed in Crimea (Ulomsky, 1941; Anufrieva et al., 2014), Turkey (Bozkurt & Yusuf, 2008), and Bulgaria (Borutzky et al., 1991; Naidenow, 1994) (Fig. 5). *Arctodiaptomus karadaghicus* Ulomsky, 1941 described from the Crimean Peninsula was later synonymised with *A. byzantinus* by Kiefer (1974). Here *A. byzantinus* is recorded from the East European Plain for the first time. We found the species in the centre of the East European Plain (Middle Volga Region), specifically within the steppe cluster of the Prisurskiy State Nature Reserve. This finding represents the northernmost and easternmost occurrence of this species.

Arctodiaptomus similis (Baird, 1859)
(Figs 3, 4)

Material examined. **Mongolia**, *Khövsgöl Prov.*, Tsagaannuur Distr., Dood Tsagaan Lake, 51.362222°N, 99.357222°E, 5 July 2022, N. Sheveleva leg., 10 males, 10 females.

Redescription. *Female.* Body length 1.35–1.38 mm (n = 10). Last thoracic segment dorsally fused with segment 4 (Fig. 3a), partly separated only with notch laterally (Fig. 3b, arrowed), with well-developed, slightly asymmetrical, rounded wings (right one slightly elongated; Fig. 3b) reaching genital compound somite spines (Fig. 3a), and with four small hyaline spines, of which outer ones directed posterolaterally (Fig. 3a). Urosome two-segment. Genital compound somite elongated, broadened in anterior part, slightly asymmetrical (more dilated on right side), with two thin, hyaline spines directed posterolaterally (Fig. 3a) and numerous short, acute setulae (Fig. 3a′). Caudal rami 1.1–1.2 times as long as wide, with fine, long, acute setulae being sparsely scattered on dorsal surface (Fig. 3c) and with six setae. Four (second–fifth) setae located apically, sixth external seta located in middle of outer margin, first (internal) seta slightly displaced on dorsal side of caudal ramus, thin, glabrous, as long as external seta. Rostrum with two elongated (ca. 40–50 μm, ca. five to seven times as long as wide), sharply curved, pointed processes (Fig. 3d). Antennule nearly reaching half length of genital compound somite or, at most, its distal margin; segment 1 with one short (ca. 80 μm) seta reaching, at most, segment 3; segment 2 with three short, almost equal setae; segments 13, 15 and 17 each with two setae; segments 12, 14 and 16 each with one seta. Maxilla and maxilliped with long, plumose setae raising filtration capacity. In leg 2, endopod segment 2 with Schmeilsche lobus of elongated triangular shape, located posterolaterally (Fig. 3e, arrowed). In leg 5 (Fig. 3f), coxa almost quadrangular, with one long (ca. 15 μm) distolateral hyaline spine (Fig. 3g); basis almost triangular (Fig. 3f), with one long lateral seta located near distal margin. Exopod segment 1 rectangular, about 2.5–3.0 times as long as wide (Fig. 3f). Exopod segment 2 slightly curved distally, bearing a row of spinules along both lateral and medial margins, one well-developed (ca. 18 μm) spine located near base of segment 3 (Fig. 3h), and a terminal claw looking like two-segmented (Fig. 3h). Exopod segment 3 well separated, 8–9 μm long, with one apical spine and one seta reaching four-fifth length of terminal claw, being 1.6 times as long as spine, looking relatively strong, bearing a row of spinules on lateral and medial margins (Fig. 3h). Endopod subconical, two-segmented, reaching half length

Fig. 3. *Arctodiaptomus similis* (Baird, 1859), female. **a, b**, last thoracic segments and genital compound somite (part); **a′**, magnified surface of genital compound somite; **c**, caudal ramus; **d**, rostrum; **e**, leg 2; **f**, leg 5; **g**, coxa and base of leg 5; **h**, exopod of leg 5; **i**, **j**, endopod of leg 5. Scale bars: 100 μm (a, b), 50 μm (c, f, g), 40 μm (d, h), and 20 μm (a′, c, i, j).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of exopod segment 1. Second endopod segment 2.5 times as long as first segment, with subapical semicircular row of spinules gradually decreasing in length (Fig. 3i, j).

Male. Body length 1.26–1.28 mm (n = 10). Last thoracic segment (Fig. 4a) with slightly asymmetrical wings being round on left and more angular on right side, and with four small hyaline spines. Urosome (Fig. 4a) five-segmented, asymmetrical. Genital somite asymmetrical, slightly dilated posterolaterally on right side, with one small spine at right distal outer corner. Each urosome segment 2 and 3 with one small spine in centre of lateral margin (Fig. 4a). Urosome segment 4 extended posterolaterally on right side (Fig. 4a). Caudal rami twice as long as wide (Fig. 4a), with six long, plumose setae. Four (second–fifth) setae located apically, sixth external seta located in middle of outer margin, first (internal) seta slightly displaced on dorsal side of caudal ramus, thin, glabrous, as long as external seta. Rostrum with two pointed, sharply curved processes being shorter than in females. Antennulae nearly reaching apices of caudal rami. Left antennule with one seta on each segment 13, 15 and 17 (75, 160–163 and 125–130 μm long, respectively). Right antennule with spiniform projections on segments 13 and 14 (Fig. 4b); projection of segment 13 curved to middle of segment 14 (Fig. 3e); projection of segment 14 short, curved, located proximally, with two setae (37 and 112–115 μm long, respectively); antepenultimate segment with one long (37.5 μm, nearly as long as segment) finger-shaped process being slightly curved distally, tuberous along inner margin and equipped with hyaline membrane along outer lateral margin (Fig. 4c). In right leg 5, coxa with a slightly dilated, rounded distolateral inner corner bearing one small (ca. 10 μm) spine (Fig. 4d); basis almost rectangular, with rounded projection located in proximal part of medial margin (Fig. 4d, e) and with hyaline rectangular process having uneven margin (two-thirds of basis length, ca. 40–45 μm, 0.67 times as long as basis), located in centre of medial margin (Fig. 4e, f, f′, arrowed). Exopod segment 1 three times as wide as long, with slightly dilated, rounded inner angle, dilated (up to 20 μm), triangular distolateral outer angle and one semicircular process on distal margin close to it (Fig. 4d, e). Exopod segment 2 about twice as long as wide, narrowing distally, with a claw being curved proximally, one lateral spine (nearly as long as segment) inserted in middle part of lateral margin (Fig. 4h), dorsally with one small, semicircular process (looking like fold) located proximal to lateral spine (Fig. 4g, arrowed), and with one small, semicircular process in central part (Fig. 4g, arrowed). Endopod indistinctly two-segmented, half as long as exopod segment 2, thickened at base, apically beveled, with a subapical row of setulae (Fig. 4i). In left leg 5 (Fig. 4j), coxa with one small spine on lateral inner surface and with one small seta on distal margin; basis almost rectangular, slightly narrowing distally, with one weakly elongated (ca. 50 μm), distally directed process located in central part of medial margin, reaching middle of exopod segment 1 (Fig. 4j, k, l, arrowed). Exopod two-segmented, with long setulae on segment 1 and in proximal part of segment 2 (Fig. 4k, l). Exopod segment 1 twice as long as segment 2, narrowing distally. Exopod segment 2 with one serrate spine located close to segment apex, being slightly crescent-shaped, curved subapically, bearing a row of apically directed setae, and with one elongated inner process of cylindrical shape, being as long as spine (Fig. 4l). Endopod two-segmented, reaching spine of exopod segment 2, with tiny setulae in proximal part of segment 1 and on segment 2, subapically with longer setulae located in semicircle (Fig. 4k, l).

Distribution. *Arctodiaptomus similis* has a limited distribution in southeastern Europe (Błędzki & Rybak, 2016) and southwestern Asia (Borutzky et al., 1991). It is found in southeastern Bulgaria (Naidenow, 1994), western Anatolia (Mann, 1940), the western coast of the Caspian Sea in Russia (Smirnov, 1928), Syria (Marsh, 1926), Iran (Brehm, 1959), Lebanon, Jordan (Dimentman & Por, 1985), and Bangladesh (Ranga Reddy, 1994) (Fig. 5). This species is the most common calanoid copepod in the inland waters of Israel (Marrone et al., 2014). The presence of *A. similis* in Sardinia (Italy) and India remains uncertain (Ranga Reddy, 1994; Marrone et al., 2014). This represents the first record of the species from Mongolia and Central Asia. We found *A. similis* in the water bodies of Darkhat Hollow, located at the easternmost point of the range of this species.

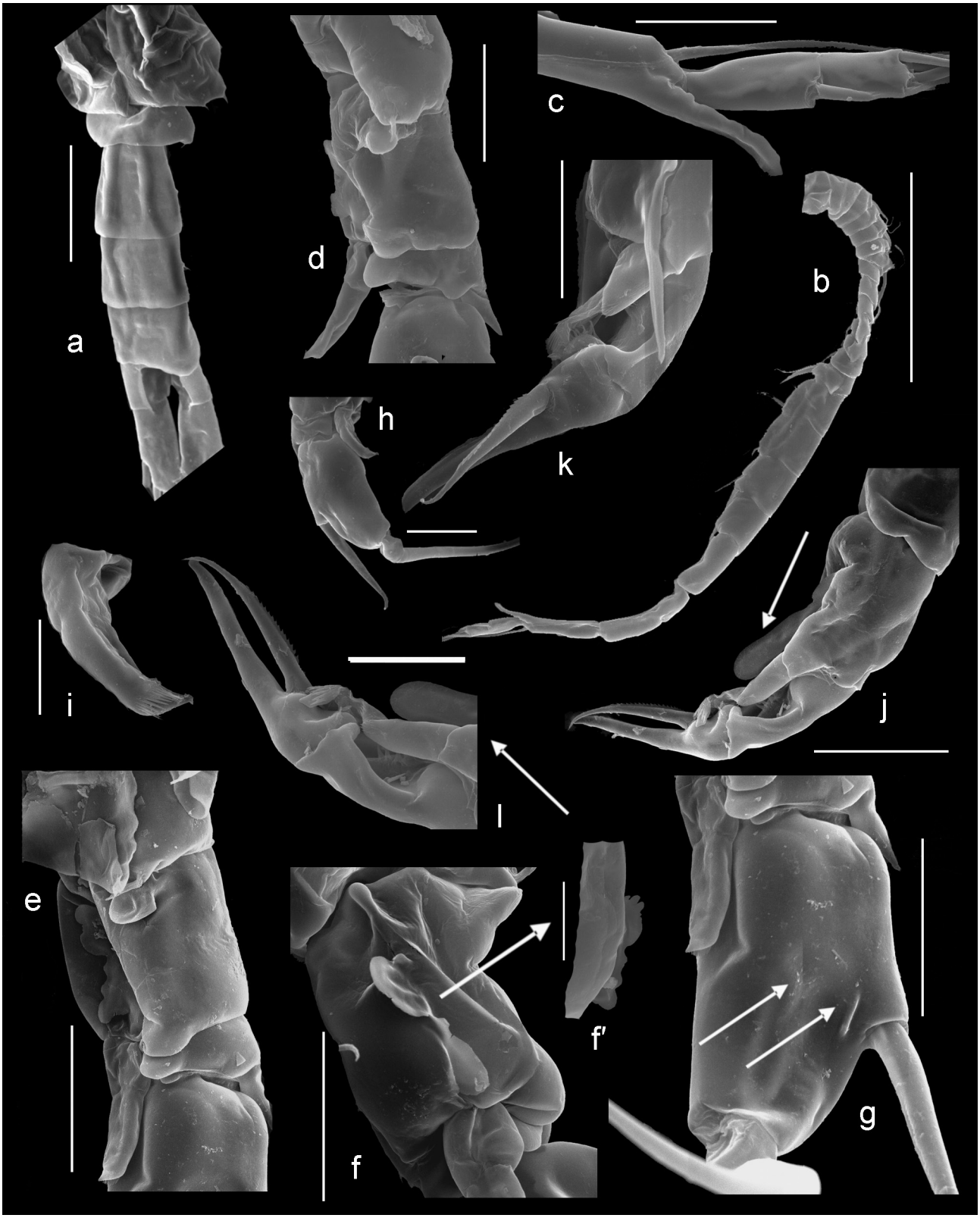

Fig. 4. *Arctodiaptomus similis* (Baird, 1859), male. **a**, thoracic segments and urosome; **b**, right antennule; **c**, antepenultimate segment of right antennule; **d**, **e**, coxa, basis and exopod segment 1 of right leg 5; **f**, **f′**, basis of right leg 5 with a process; **g**, **h**, right leg 5 exopod; **i**, endopod of right leg 5; **j**, left leg 5; **k**, **l**, exopod of left leg 5. Scale bars: 300 μm (b), 100 μm (a, j), 50 μm (c, d, e, g, h), 40 μm (f, f′), 30 μm (k, l), and 20 μm (i).

Discussion

Morphology. We did not find any significant morphological differences between the examined population of *Arctodiaptomus byzantinus* and those described previously (Mann, 1940; Kiefer, 1974; Borutzky et al., 1991; Ranga Reddy, 1994). Studying the specimens from the Middle Volga Region allowed us to clarify specific morphological characters in the caudal rami (surface folds) and the exopod of leg 5 (spinules on the surface of the terminal claw and lateral spine) in females, as well as in the antennulae (appendages), the right leg 5 endopod (appendages), and both the exopod and endopod of the left leg 5 in males. We found that segments 3, 7, and 9 of the antennule in the studied females possess setae that are 0.33 to 0.40 times as long as those in males. Consequently, the left antennule in males differs from that in females, which contradicts the assertions made by Kiefer (1974) and Borutzky et al. (1991). Additionally, the left antennule in the studied males has one long seta on segment 1, similar to that of females, rather than the short setae present in both the left and right antennules of males, as some authors have claimed (Borutzky et al., 1991; Ranga Reddy, 1994; Błędzki & Rybak, 2016). According to our data, the antennule can be used for the identification and differentiation of females of *A. byzantinus* from closely related species, namely *A. stephanidesi* (Pesta, 1935) [with subspecies *A. stephanidesi stephanidesi* (Pesta, 1935) and *A. stephanidesi bulgaricus* Kiefer, 1971] and *A. dudichi* Kiefer, 1932. All three species are characterised by a very long seta on segment 1 of the antennule, which reaches segments 8–10 (Borutzky et al., 1991; Ranga Reddy, 1994). However, in females of *A. byzantinus*, the antennule reaches the apices of the caudal rami, whereas in *A. stephanidesi* and *A. dudichi*, it only extends to the genital compound somite and the last thoracic segment, respectively. The females of *A. byzantinus* examined in our study differ from those of *A. stephanidesi* and *A. dudichi* in having relatively long first setae on segment 2 of the antennule, which reach segments 6–7 compared to segment 3 in the latter two species.

The males from the Middle Volga Region population exhibit a similar shape of exopod segment 2 (which is approximately 1.7 times as long as it is wide) of the right leg 5 when compared to the males from Bulgaria (Kiefer, 1974). In contrast, this segment was more elongated in males from Turkey (Mann, 1940) and the Crimea Peninsula (Ulomsky, 1941), in which exopod segment 2 was approximately 1.4 to 1.5 times as long as it is wide. Additionally, the endopod of the right leg 5 in the studied males is relatively short, measuring about half the length of exopod segment 2, whereas it was more elongated (nearly equal to the length of exopod segment 2) in males from other described populations (Mann, 1940; Ulomsky, 1941; Kiefer, 1974; Borutzky et al., 1991). The studied males exhibit relatively long endopods on the left leg 5, extending beyond a spine of the exopod segment 2, similar to specimens from the Crimea (Ulomsky, 1941) and Turkey (Mann, 1940) populations. In contrast, males from Bulgaria displayed shorter endopods that did not reach the spine (Kiefer, 1974).

Also we did not find any significant morphological differences between the examined specimens of *A. similis* and previously published descriptions (Baird, 1859; Kiefer, 1974, 1978; Borutzky et al., 1991; Marrone et al., 2014). The studied males possess a single seta on each segment 13, 15, and 17 of the left antennule, while the antepenultimate segment bears a finger-shaped process that is slightly curved distally in the right antennule. This morphology is consistent with the typical characteristics of *A. similis* (Kiefer, 1974, 1978; Marrone et al., 2014). The examination of specimens from Mongolia enabled us to clarify several structural details of *A. similis*, namely the diagnostic characters of the exopod (spinules on the surface of the terminal claw and lateral spine) and endopod (appendage) of the leg 5 and the caudal rami (setules) in the females, as well as the basis (the shape of the process) and endopod (appendages) of the right leg 5, and the exopod and endopod of the left leg 5 (appendages) in the males. Furthermore, we observed differences in leg 5 of both sexes. The endopod of leg 5 in both the females and males from the Mongolian population is two-segmented, whereas in other populations it is uni-segmented (Baird, 1859; Kiefer, 1974, 1978; Borutzky et al., 1991; Marrone et al., 2014). In the females, the antennulae possess a short seta on segment 1, which extends only up to segment 3, similar to the left antennule in males. In contrast,

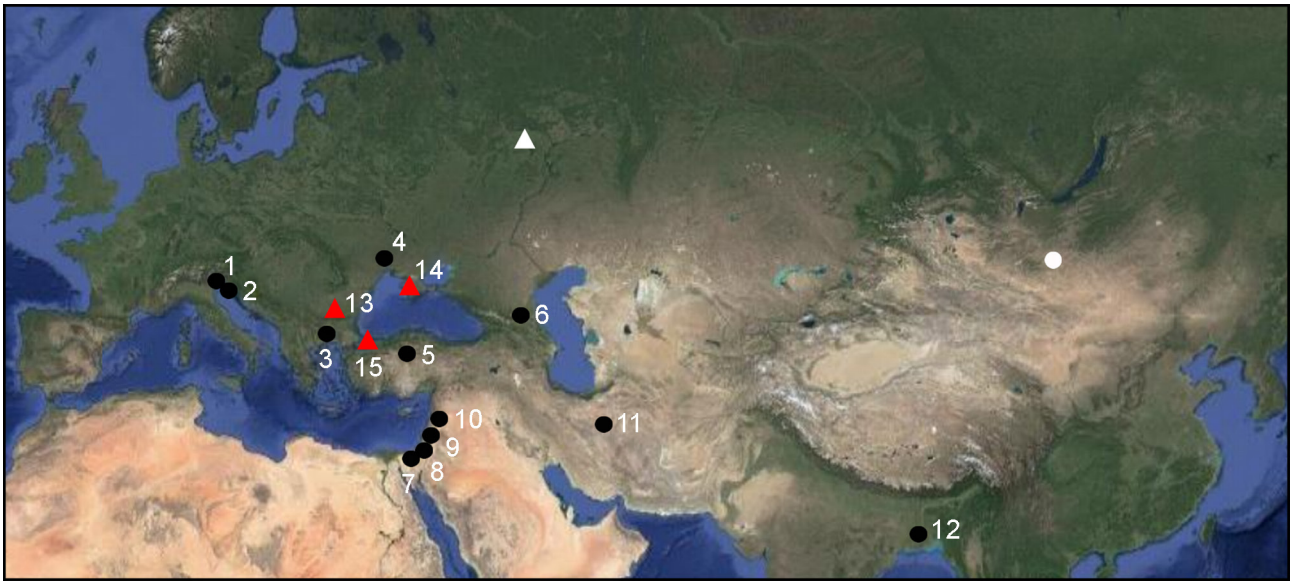

Fig. 5. Distribution of *Arctodiaptomus byzantinus* Mann, 1940 (triangles) and *A. similis* (Baird, 1859) (circles): previous findings (red and black, respectively) [according to Baird, 1859 (7); Marsh, 1926 (10); Smirnov, 1928 (6); Mann, 1940 (4, 5); Ulomsky, 1941 (14); Brehm, 1959 (11); Kiefer, 1974 (8, 9); Naidenow, 1994 (1, 2, 3, 13); Ranga Reddy, 1994 (12); Bozkurt & Yusuf, 2008 (15)] and the new records (white).

females from other populations exhibit a long seta that extends up to segment 5 (Kiefer, 1974, 1978; Borutzky et al., 1991).

Ecology and distribution. The studied population of *Arctodiaptomus byzantinus* from the Middle Volga Region (Prisurskiy State Nature Reserve) inhabits temporary water bodies (such as snowmelt pools and floodplains) as well as perennial shallow water bodies with variable depths and volumes. These bodies of water may disappear in years with normal rainfall or transform into bogs during years of heavy rainfall. The species was found in all five nearby studied reservoirs of different types, which exhibit variable physicochemical conditions. Research on these reservoirs has been ongoing since 2011, but the species was only recorded in 2021. Populations from Turkey, Bulgaria, and the Crimean Peninsula have also been found in shallow temporary and small perennial water bodies, including rain pools, puddles, and roadside ditches (Mann, 1940; Ulomsky, 1941; Naidenow, 1994; Anufrieva et al., 2014). Additionally, it has been recorded in the deep waters of Birecik Dam Lake in Turkey (Bozkurt & Yusuf, 2008).

In mid-April, when water temperatures ranged from 13.0 to 14.4 °C, and at the end of the month, with temperatures between 14.9 and 19.6 °C, individuals of *A. byzantinus* were not observed. They were first registered in early to mid-May, at water temperatures of 13.4 to 23.8 °C, approximately three weeks after the snow cover had melted. The population primarily consisted of adult specimens, with males outnumbering females (approximately 59% and 41% of the total adult population, respectively). Females with attached spermatophores and ovigerous females were present from early to late May. The population persisted until early June in typical years or until mid-June in humid years, depending on the presence of water bodies. These reservoirs typically form in this area after being replenished by spring meltwater and runoff from the Bula River flood.

The total abundance of *A. byzantinus* varied significantly, ranging from 300 to 22,800 individuals per cubic meter (ind/m³), depending on the size of the reservoir and the climatic conditions (humidity and thermal regime) of the year. The population was more abundant, approximately 2 to 8 times greater, in larger water bodies. In the relatively more humid year of 2022, the population was about twice as numerous as in 2021 and 2023 across all study sites. The main ecological parameters of the habitat for the studied population are outlined below: water surface area

(minimum–maximum): 500–1,650 m²; mean depth (minimum–maximum): 0.3–0.8 m; maximum depth: 1.5 m; total dissolved solids (TDS): 181–1,328 ppm in dry years (2021, 2023) and 138–469 ppm in the humid year (2022); pH: 6.7–8.2 in dry years (2021, 2023) and 7.3–8.2 in the humid year (2022).

We can assume that the crustaceans from the studied population emerge in May, represented by adult and late juvenile individuals. They mature in a short period, produce a new generation, and encyst from early to mid-June. These crustaceans survive dry and cold periods in a state of diapause until the next spring flood.

In the rain pools of the Crimea Peninsula, *A. byzantinus* appears in October as the last copepodite stage, coinciding with the pools being filled with rainwater. The individuals mature during November and December. Both adult and juvenile crustaceans survive until May. They encyst and endure dry period as the last copepodite stage or as not fully mature individuals (Ulomsky, 1941; Borutzky et al., 1991). In small water bodies in Bulgaria, *A. byzantinus* specimens have been recorded from December to May (Naidenow, 1994). In the deep-water Birecik Dam Lake in Turkey, the species was observed in July (at depths of 10–15 m and 20–30 m) and August (at depths of 0–5 m and 10–40 m), but it was not found in March and December (Bozkurt & Yusuf, 2008).

Thus, the life cycle of *A. byzantinus* is highly adaptable and can be influenced by the hydrological regime of the water body and the prevailing climate.

Arctodiaptomus similis was found in the shallow, fishless water body of Lake Targan, the only location in the Darkhat Hollow. In June, the lake was partially covered with ice. The species was observed at a depth of 0.70 to 1.0 metres. The water exhibited a slightly greenish hue, while the bottom of the lake comprised muddy and stony-sandy sediments. In other localities, this species has been found in various freshwater bodies, including temporary habitats such as snow puddles and rain pools (Dimentman & Por, 1985), as well as permanent reservoirs (Marrone et al., 2014), where it typically appears following winter floods (Mann, 1940).

Arctodiaptomus byzantinus has a limited distribution in Europe, and this study represents its first recorded presence in the East European Plain (Middle Volga Region, Russia). We found this species over 1,500 kilometers northeast of its nearest known locality, the Crimea Peninsula, in a northern steppe landscape that serves as a migratory pathway for birds. *Arctodiaptomus similis* is recorded from Mongolia, approximately 2,000 kilometres northeast of its closest known locality in Bangladesh, also for the first time. Consequently, the distribution ranges of *A. byzantinus* and *A. similis* are broader than previously understood. Small and shallow water bodies, which are preferred habitats for both species, are often inadequately studied. Therefore, further investigations into the distribution of these species are essential, particularly along migratory routes of birds.

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