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RESEARCH ARTICLE

First record of *Sinodiaptomus sarsi* (Copepoda: Calanoida) from the East European Plain

Первая находка *Sinodiaptomus sarsi* (Copepoda: Calanoida) на Восточно-европейской равнине

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Abstract. The calanoid copepod species *Sinodiaptomus sarsi* (Rylov, 1923) is recorded from the East European Plain (the Sura River floodplain, Middle Volga Region, Russia) for the first time. A brief description and illustrations of the species are provided, and some differences between its European and Asian populations are revealed. The studied population of *S. sarsi* from the Sura River basin is mostly similar in morphological characters to populations from China and Japan.

Резюме. На Восточноевропейской равнине (пойма р. Сура, Среднее Поволжье, Россия) впервые обнаружен вид каланоидных копепод *Sinodiaptomus sarsi* (Rylov, 1923). Представлены его краткое описание и иллюстрации, выявлены некоторые отличия европейской от азиатских популяций. По морфологическим признакам популяция *S. sarsi* из Присурья наиболее схожа с популяциями из Китая и Японии.

Key words: zooplankton, morphology, Middle Volga Region, firs record, Copepoda, Calanoida, Diaptomidae, *Sinodiaptomus sarsi*

Ключевые слова: зоопланктон, морфология, Среднее Поволжье, новая находка, Copepoda, Calanoida, Diaptomidae, *Sinodiaptomus sarsi*

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Introduction

The genus *Sinodiaptomus* Kiefer, 1932 has a wide-range distribution in the waters of Central and East Asia (Ranga Raddy, 1994). It comprises eight species (Walter & Boxshall, 2018): *S. cavernicolax* (Shen et Tai, 1965) (China, Pearl River), *S. chaffanjoni* (Richard, 1897) (Mongolia), *S. ferus* (Shen et Tai, 1964) (China, Pearl River), *S. ganesa* Brehm, 1950 (India, Madras), *S. indicus* Kiefer, 1936 (India, Calcutta), *S. mahanandiensis* Ranga Reddy et Radhakrishna, 1980 (South India, Nagatjuna), *S. sarsi* (Rylov, 1923), and *S. valkanovi* Kiefer, 1938 (Japan). *Sinodiaptomus sarsi* is distributed from Japan (Ueda & Ohtsuka, 1998) and Bering Island (Novichkova & Chertoprud, 2015) to Iran (Löffler, 1961; Smagowicz, 1976) and the Carpathian Mountains (Mykitchak 2016). The species is recorded from the East European Plain for the first time. In the present study, the morphological characters of the *S. sarsi* population from the Sura River floodplain (Middle Volga Region) are described and illustrated.

Material and methods

Specimens of *Sinodiaptomus sarsi* were collected from a small reservoir formed in a sandpit (quarry pond) in 1983, and from a ravine pond formed in 2017. They were sampled from both the places in May 2018 and from the quarry pond in May–October 2019. These water bodies are located in the basin of Sura River (the right tributary of Volga River, Middle Volga Region) on the territory of the Prisurskiy State Nature Reserve, The Chuvash Republic of Russia.

The samples were obtained by filtering water through an Apstein plankton net (70 µm) and fixed in 40% formaldehyde. Adult males and females were selected from samples for morphological study under a stereoscopic microscope. Images were taken using a scanning electron microscope (SEM) Philips 525 M. For study under the SEM, specimens were transferred to pure methanol for an hour and then to hexamethyl disilazane for a day, and then dried in air.

Water transparency was measured by standard methods (Abakumov et al., 1992). Water surface temperature and dissolved oxygen concentration were measured using a HANNA HI-9147-04 dissolved oxygen meter; water acidity (pH), using a HANNA HI-83141 pH meter with electrode and temperature probe; and electrical conductivity (EC) and total dissolved solids (TDS), using a HANNA HI-98129 tester.

Results

Order **Calanoida** Sars, 1903

Family **Diaptomidae** Baird, 1850

Genus ***Sinodiaptomus*** Kiefer, 1932

Sinodiaptomus sarsi (Rylov, 1923)

(Figs 1–3)

Material examined. **Russia**, *Chuvash Republic*, Atrat Settlm. environs, quarry pond, 54°58′08″N, 046°40′50″E, 24 May 2018, coll. A. Aleksandrov, May–October 2019, coll. E. Osmelkin, 14 males, 10 females; same locality, ravine pond, 55°01′18″N, 046°47′31″E, 24 May 2018, coll. A. Aleksandrov, 3 males.

Description. Female. Body (Fig. 1a) length 2.20–2.35 mm (n = 5) in specimens collected on 24 May 2018, and 19.00–19.50 (n=3) mm in specimens collected on 3 July 2019. Middorsal projection on pediger 5 (Fig. 2a) acute, triangular and directed posteriorly. Genital compound somite relatively asymmetrical, with weak dilation on left lateral surface (Fig. 2a). Caudal ramus 1.5 times as long as wide. Antennule extending almost to tip of apical caudal setae (Fig. 1a). Rostrum with two long curved processes (Fig. 1b). Cutting margin of mandible with plumose bristle and one ventral tooth (Fig. 1c). Ventral tooth separated from other teeth by deep diastema (Fig. 1c′). Central teeth rounded, bicuspidate, with wide base (Fig. 1c). Dorsal teeth unimucronate, acute, with narrow base bearing one spinule. Maxilla (Fig. 1d) and maxilliped (Fig. 1e) with long plumose setae raising capacity for filtration. In leg 5, coxa with distolateral projection nearly as large as endopod (Fig. 2b); exopod segment 1 square; exopod segment 2 with spine located close to base of segment 3 (Fig. 2b) and with terminal claw bearing a row of spinules in middle part of lateral and medial margins (Fig. 2c–d); exopod segment 3 with two apical spines, from which longer spine with spinules (Fig. 2c–d); endopod two-segmented, with terminal setulae (8–15) and one apical and one subapical spines (Fig. 2e–f).

Male. Body (Fig. 1b) length 2.10–2.25 mm (n=8) in specimens collected on 24 May, and 17.50–17.70 mm (n=4) in specimens collected on 3 July. Caudal ramus 1.8 times as long as wide. Left antennule extending to middle of caudal ramus. Right antennule with spiniform projections at segments 10, 11 and 13–16; segment 15 (Fig. 3a–b) with longer projection than that of segment 14; antepenultimate segment with comb-like process (Fig. 3c). In right leg 5 (Fig. 3d), basis with small plate-shaped hyaline process in distal part of medial margin and with wide-based triangular distal process (Fig. 3e–f, arrowed), apical end of which almost reaching exopod segment 2; exopod segment 2 about 1.4 times as long as wide, with lateral spine inserted at distal one-thirds of lateral margin (spine as long as one-thirds of segment width), and without sclerotised process between spine and distal end in population from the quarry pond (males from the ravine pond with such process); endopod one-segmented. In left

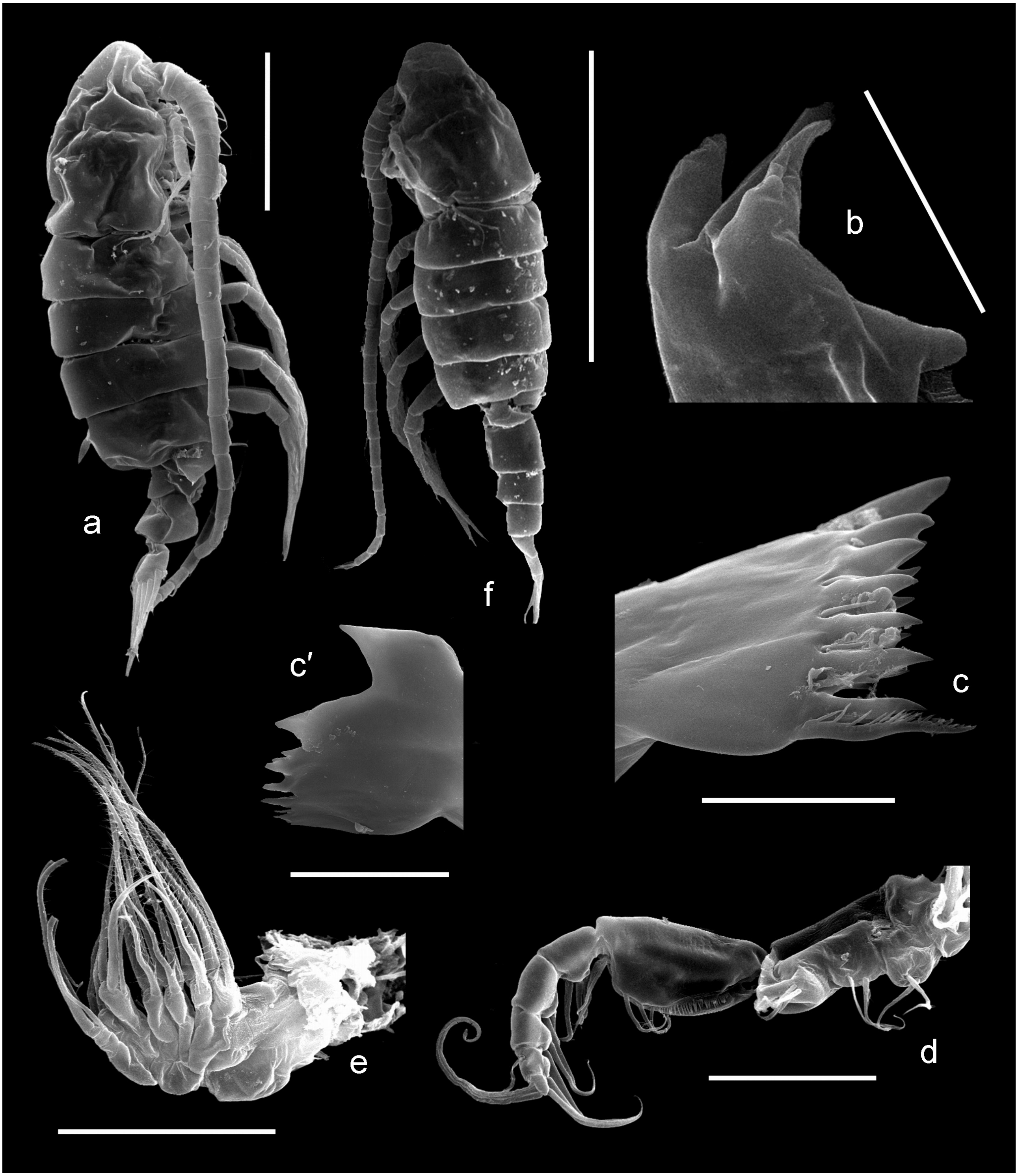

Fig. 1. *Sinodiaptomus sarsi*, female (a–e) and male (f). **a**, **f** – habitus, lateral view; **b** – rostrum; **c**, **c′** – mandible; **d** – maxilliped; **e** – maxilla. Scale bars: 0.5 mm (a), 20 µm (c), 50 µm (b, c′), 100 µm (d, e), 1 mm (f).

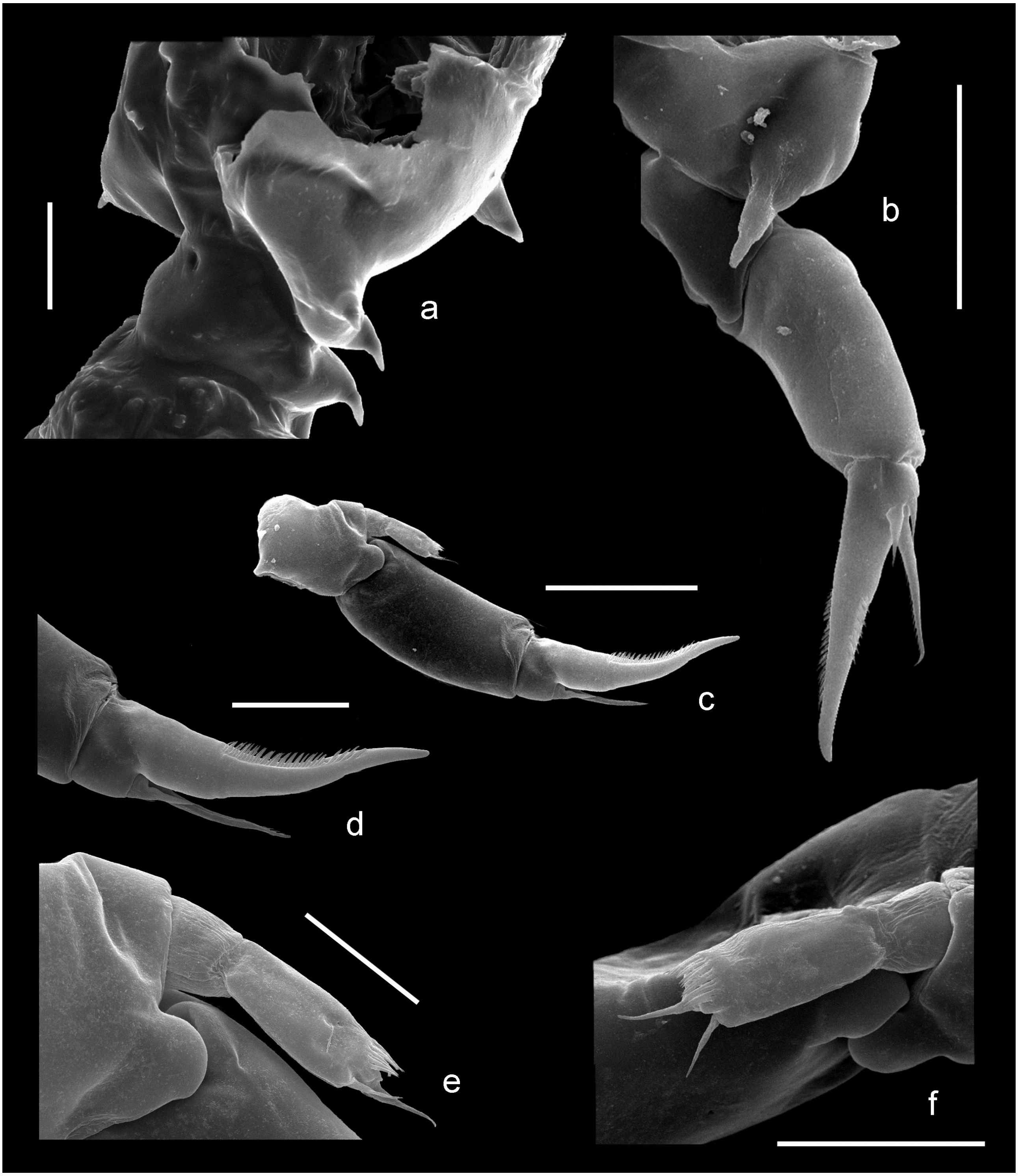

Fig. 2. *Sinodiaptomus sarsi*, female. **a** – pediger 5 and genital compound somite, ventral view; **b** – leg 5, posterior view; **c** – leg 5, anterior view, **d** – leg 5 exopod 2 and 3; **e–f** – leg 5 endopod. Scale bars: 0.1 mm (a), 100 μm (b, c), 50 μm (d), 30 μm (e), 40 μm (f).

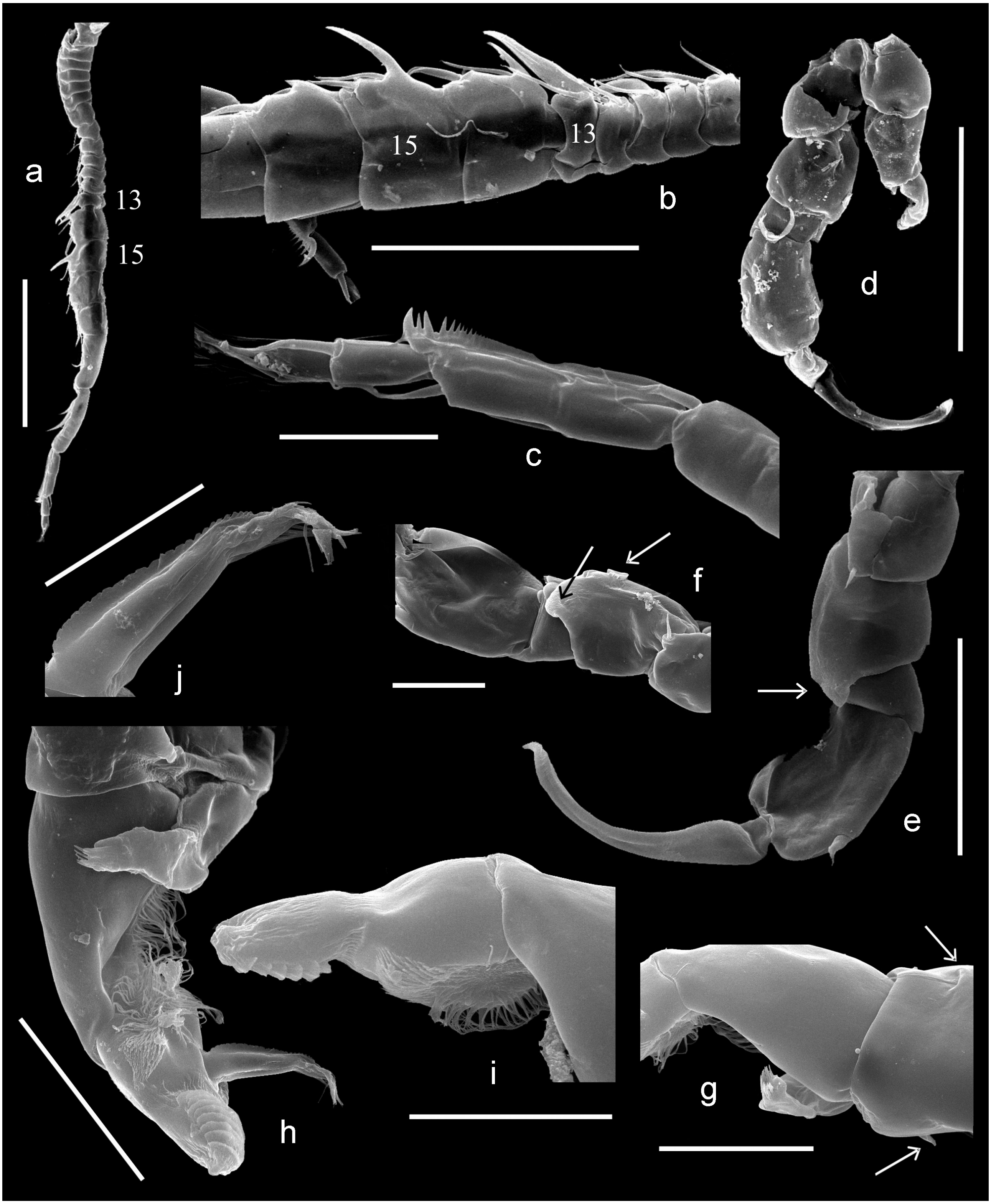

Fig. 3. *Sinodiaptomus sarsi*, male. **a** – right antennule; **b** – right antennule, segments 9–16; **c** – right antennule, segments 20–22; **d** – leg 5, posterior view; **e** – right leg 5; **f** – right leg 5 exopod; **g** – left leg 5; **h** – left leg 5 exopod and endopod; **i** – left leg 5 exopod 2; **j** – left leg 5 exopod 2 spine. Scale bars: 500 μm (a), 300 μm (b, d), 100 μm (c, f), 200 μm (e), 50 μm (g, h), 40 μm (i), 20 μm (j).

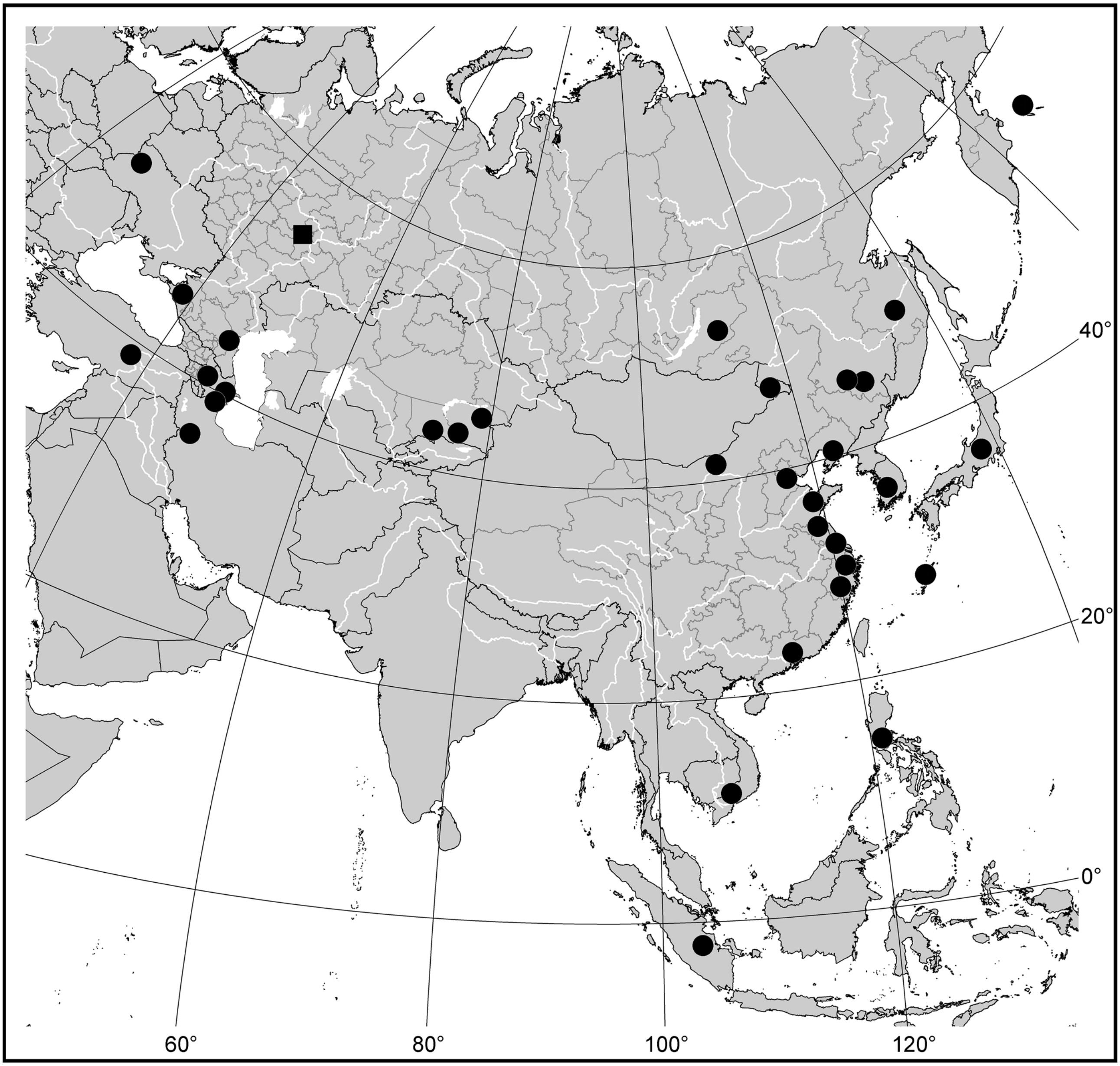

Fig. 4. Distribution of *Sinodiaptomus sarsi*. Previous findings (circles) and the new record (square).

leg 5 (Fig. 3d), basis with small lateral spine and small medial process near distal margin (Fig. 3g, arrowed); exopod two-segmented, with setulae in middle of segment 1 and in proximal part of segment 2, and with setae in proximal part of segment 2 (Fig. 3h–i); proximal part of exopod segment 1 wider than its distal part; exopod segment 2 with long spine being slightly curved subapically and transverse terminally, with tiny hairs on anterior surface, with setae at extreme apex (Fig. 3j), and with overlapping membranous folds in amount of six to nine on distomedial surface (Fig. 3h–i); endopod two-segmented, apically with setulae located in semicircle (Fig. 3 g–h).

Distribution. Rylov (1923) described *Sinodiaptomus sarsi* based on the material from the vicinity of Harbin, and recorded it from other parts of China, from Khabarovsk Territory and Mongolia. In China and Mongolia, this species was also found by Kiefer (1928), Shen (1956), and Borutzky (1959). Later, it was recorded from Bering Island (Novichkova & Chertoprud, 2015),

Fig. 5. Quarry pond, the habitat of *Sinodiaptomus sarsi* in the Sura River basin.

Vietnam (Hai et al., 2008), the Korean Peninsula (Chang & Kim, 1986; Chang, 2014), Indonesia (Sari et al., 2014), Philippines (Lagbas et al., 2017) and Transbaikalia (Afonina, 2018). A wide disjunction separates the eastern populations of *S. sarsi* from a group of populations in Kazakhstan (Krupa et al., 2016), Iran (Löffler, 1961; Smagowicz, 1976), Azerbaijan (Weisig, 1931; Ali-Zade, 1939; Kasymov et al., 1972), Eastern Anatolia (Gündüz, 1998), Ciscaucasia (Rylov, 1923), and the Carpathian Mountains in Ukraine (Mykitchak 2016) (Fig. 4). It is doubtful that this disjunction is natural; most likely it is the result of unevenness in the study of different territories within the continuous range of the species. Also, the western group of populations may be a separate species and deserves additional research with a genetic analysis (Li et al., 2014). When considering the distribution of Diaptomidae in the Western Palearctic, Marrone et al. (2017) concluded that there was no reliable data on the identity of the *Sinodiaptomus* species occurring in Turkey and Ukraine, and had opted for its exclusion from the analysis. There may be some reasons for finding a new species outside of East and Central Asia, but according to the morphological characters described above and literature data, it can be concluded that the studied population from the Sura River basin is mostly similar to those from the eastern part of *S. sarsi* range (in China and Japan).

Bionomics. The population from the Sura River basin inhabits shallow water bodies (Fig. 5,) as well as populations from Manchuria (Rylov, 1923) and Japan (Ueda & Ohtsuka, 1998). These crustaceans prefer warm waters with pH close to neutral and with low salinity (Table 1). The quarry pond is totally overgrown with macrophytes, and its surface changes substantially during the summer.

Population features. Individuals of *S. sarsi* appeared from late May to August, at water temperatures of 19–23°C. In early May (water temperature was about 10°C) they were not found. The population consisted of adult and juvenile specimens. Ovigerous females occurred from May to August. Males prevailed over females in May (50 and 36% of the total abundance, respectively) and August–October (31–100 and 11–33% of the total abundance, respectively) (Fig. 6). Juvenile specimens were abundant in August (57% of the total abundance). The highest population density was observed in August (Fig. 6). The largest specimens occurred in May, similarly to the population from Japan (Ueda & Ohtsuka, 1998), and in October.

Ovigerous females were observed during the main part (May–July) of the vegetation period, and in the population from Manchuria (Rylov, 1923), they occurred in late July only. The population abundance dynamics was similar to that in the cooler pond of the Kharanorskaya hydroelectric power station in Transbaikalia (Afonina, 2018).

The most abundant zooplankton species found together with *S. sarsi* were *Mesocyclops leuckarti* (Claus, 1857), *Chydorus sphaericus* (O.F. Müller, 1776), *Diaphanosoma mongolianum* Ueno, 1938 (in summer), *Polyphemus pediculus* (Linnaeus, 1761), and *Euchlanis dilatata* Ehrenberg, 1832. Frequently encountered zooplankton species are acidophilic rotifers of the genus *Lecane* Nitzsch, 1827: *L. ungulata* (Gosse, 1887), *L. bulla* (Gosse, 1851), *L. luna* (Müller, 1776), *L. ligona* (Dunlop, 1901), and *L. crenata* (Harring, 1913). The quarry pond is inhabited by the crucian carp *Carassius carassius* (Linnaeus, 1758).

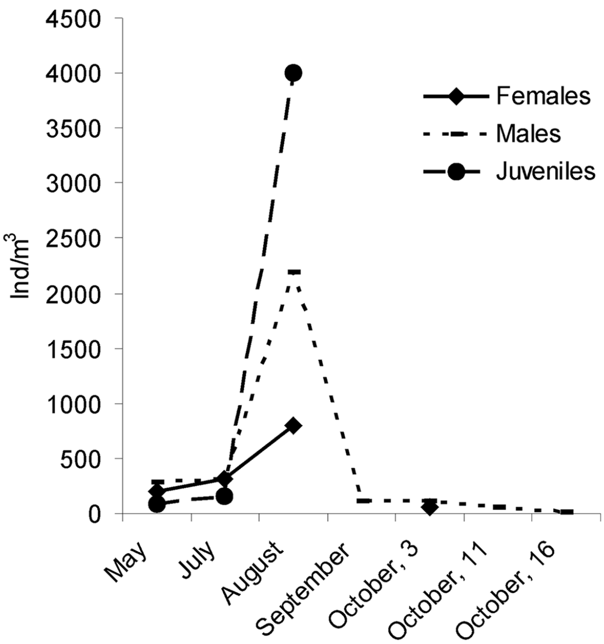

Fig. 6. *Sinodiaptomus sarsi* population abundance in the quarry pond.

Table 1. Environmental parameters of habitats of *Sinodiaptomus sarsi* in the Sura River basin.

Parameters	Quarry pond	Ravine pond
Water surface area, ha	0.3–0.6	0.1
Mean depth, m	0.6	0.8
Transparency, m	0.5	1.5
Water temperature, °C:		
in May (litoral / pelagial)	22.1 / 19.1	no data
in July–August (pelagial)	23.0–23.5	22.5
in October (pelagial)	10.5	10.2
Oxygen concentration, mg/l, %	2.7; 29%	no data
pH	6.6–7.4	6.8–7.5
Conductivity, μS/sm	83	132
TDS, ppm	43	165

Discussion

We did not find any significant morphological differences of the studied population from the Asian populations described in the literature (Rylov, 1923; Kiefer, 1978; Gündüz, 1998; Borutzky et al., 1991; Ueda & Ohtsuka, 1998; Krupa et al., 2016). At the same time, there are some morphological variations in the leg 5 of males and females. The endopod of leg 5 in the females from the Sura River basin is two-segmented, as in most of the described populations, except that from Turkey (Gündüz, 1998). The females have the special appendage complex located terminally on the endopod of leg 5, which is rather similar to the same of females from the Eastern Anatolia (Gündüz, 1998), but the females from the Sura River basin differ from those in Kazakhstan (Krupa et al., 2016) and Japan (Ueda & Ohtsuka, 1998) by the presence of two spines.

The basis of left leg 5 in males lacks a medial process near the distal margin in the population from the Sura River basin. Males in populations from Kazakhstan (Krupa et al., 2016) and Transbaikalia (Afonina, 2018) have a relatively larger spine on the exopod segment 2 of the left leg 5 than in other populations including that from the Sura River basin. The endopod of left leg 5 in males from the latter place is two-segmented as in populations from Japan (Ueda & Ishida, 1997; Ueda & Ohtsuka, 1998) and Korea (Chang, 2014), but in males from Vietnam, Kazakhstan (Krupa et al., 2016), Transbaikalia (Afonina, 2018) and Turkey (Gündüz, 1998) this endopod is one-segmented.

Mosaic findings do not allow to precisely outline the boundaries of the range of *S. sarsi*, especially in its western part. One of the causes for this is that small and shallow waterbodies (pools and ponds) are usually not sufficiently studied. So, additional examinations of the distribution of this species are necessary.

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