

The Genus *Hetercope* Sars 1863 (Copepoda, Calanoida) in Russia: Morphology and Distribution

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Abstract—The article presents a comparative description of previously unknown morphological features of species of the genus *Hetercope* Sars 1863 inhabiting the territory of Russia. Using the SEM capabilities, the genital plate, structure, and of the P5 armament for the *Hetercope soldatovi* Rylov 1922 female and male and the genital plate of *Hetercope saliens* (Lilljeborg 1863) were described in detail. For the first time, information on the oral appendages of these species is presented. A comparative analysis of the morphological and morphometric differences between females and males of different *Hetercope* species was carried out, and a general identification table was compiled. Based on modern data, the boundaries of species ranges were specified.

Keywords: Copepoda, Calanoida, *Hetercope*, morphology, distribution

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In Russia, the genus *Hetercope* includes five species: *Hetercope appendiculata* Sars 1863, *H. borealis* (Fischer 1851), *H. caspia* Sars 1897, *H. saliens* (Lilljeborg 1862), and *H. soldatovi* Rylov 1922. All of them are Palearctic, but the range of some of them is extremely narrow. For instance, *H. soldatovi* inhabits only the Amur River basin (Borutsky et al., 1991); *H. caspia*—the Sea of Azov, the Caspian and Black seas and their basins, including the reservoirs of the midstream and downstream Volga River, and the Kama River as well as the lower reaches of tributaries of the Sea of Azov and Black Sea (Borutsky et al., 1991). *H. appendiculata*, *H. borealis*, and *H. saliens* have a wider range but prefer the waterbodies of the northern Palaearctic. Nevertheless, the species of this genus are characterized by a natural tendency towards dispersal (Rivier and Dzyuban, 1978), which necessitates a clarification of the modern boundaries of their ranges. Modern

research methods reveal previously unknown structural features. The present paper seeks to provide a comparative morphological analysis of members of the genus *Hetercope* inhabiting the territory of Russia.

Samples collected from waterbodies in different parts of Russia from 2016 to 2018 served as the materials for studying the morphology of these crustaceans. The crustaceans were preserved in alcohol (96%) or formaldehyde (40%). We used an Olympus CX 41 optical microscope and a Philips 525M scanning electron microscope hosted by the Instrument Center for Collective Use of Physicochemical Ultramicroanalysis at Limnological Institute, Siberian Branch, Russian Academy of Sciences. To study morphology, sexually mature females and males were selected from the samples. The size of an individual was measured from the end of the rostrum to the end of the caudal branches. Descriptions are given for females. The

Table 1. Morphological characteristics of species of the genus *Heterocope* in Russian fauna

Characteristic	<i>H. appendiculata</i>	<i>H. soldatovi</i>	<i>H. borealis</i>	<i>H. saliens</i>	<i>H. caspia</i>
Female					
Body length, mm	2.00–2.63	1.55–1.63	2.37–3.13	2.15–2.18	1.50–1.73
Ceph. (L : W)	2.7–3.3	No data	2.3–2.8	2.5–2.8	3.0–3.2
Genitalsegment (L : W)	1.4–1.7	1.2–1.3	1.17–1.30	1.1–1.4	1.16–1.29
Appendages of the genital plate	Ribbon-like appendages in the center and one bivertex lateral tooth	Two lateral teeth on each side	Two rounded appendages	Appendages are absent	Two lateral teeth on each side
Caudal branches (L : W)	1.6–1.7	1.4–1.6	1.1–1.2	1.3–1.6	2.9–3.3
Setulae on the inner surface of caudal branches	Present on the distal ½ of the surface of caudal branches	Present on the distal ½–⅓ of the surface of caudal branches	Present on the distal ½ surface of caudal branches	Present on the distal ½ of the surface of caudal branches	Absent
Outer seta of caudal branches	Absent	Absent	Present	Present	Absent
s1:s2	0.50–0.70	n/a	0.80–0.82	0.82–0.86	0.84–0.94
Internal teeth P5exp2	Four single-vertex-dentate outgrowths	Four single-vertex-dentate outgrowths	Four dentate outgrowths, weakly bivertex	Four dentate outgrowths, clearly bivertex	Two to three dentate outgrowths
Male					
P5 right, exp2	One spine	Three spines	Three spines	Two spines	No spines

crustaceans were identified according to the morphological characteristics using well-known guidelines (Borutskiy, 1960; Borutskiy et al., 1991; Kiefer and Fryer, 1978; Dussart, 1967). The features of the geographical distribution are based on our unpublished data and literature data. Shading on the map indicates the continuous range of the species. The extreme points of the findings of the species mentioned in the text are marked with icons (circle or square).

Order Calanoida Sars 1903

Family Temoridae Sars 1903

Genus *Heterocope* Sars 1863

Heterocope appendiculata Sars 1863

Abbreviations: Ceph., cephalothorax; exp2, second segment of exopodite; P5, fifth pair of legs; P5exp2, second segment of exopodite of the fifth pair of legs; s1, internal apical seta of the furca; s2, central apical seta of the furca.

Material. The specimens of both sexes in a mass amount from the zooplankton sampled in the Bogu-

chany Reservoir (near-damzone: 52°46' N, 103°41' E); sampling depths of 5 to 10 m.

Description. Female. The cephalothorax is long, narrow. Its length is 3.3 times less than the maximum width. The thoracic somites have similar structures.

The female's genital somite is rectangular, longer than wide (Table 1). The genital plate bears ribbon-like appendages split at the ends, reaching the end of the posterior edge of the genital somite. Laterally from the ribbon-like appendages, there is one spine-like tooth-shaped appendage bifurcated at the end.

Caudal branches of the female are relatively long (1.6–1.7 times longer than width), pubescent by 1/3 of their length (from distal end) with sparse fine hairs, bearing four apical setae. Inner seta slightly displaced dorsally, transparent, very thin. Three apical setae thick; two outer ones almost equal in length; the longest one is in the middle, 1.5–1.7 times longer than the outer apical ones.

Antennules of the female are long, reaching the end of the genital somite.

The ventral tooth of the mandible is single-vertex, slightly curved, pointed, separated from the rest of the teeth by a deep diastema. The central teeth are

rounded at the end (Figs. 1a, 1b), bivertex, with a wide base; the dorsal ones are acute single-vertex, longer than the central ones, with a narrow base. Longitudinal, slightly curved rows of spines at the base of central teeth. Such mandibles are typical of crustaceans feeding on animals with fragile chitin (Monakov, 1998).

Maxilla and maxilliped have long pubescent setae (Figs. 1c, 1d), which probably indicates the ability to filter.

The P5 of the female consists of a basipodite and two segments of the exopodite (Figs. 2a, 2b). On the first segment of the exopodite, there is one spine on the outer side; on the second segment, there are two spines on the outer side and four dentate outgrowths on the inner side. The second segment of the exopodite terminates in a long spine serrated on the inner side (Fig. 2c).

Male. The left P5 of the male consists of a basipodite, a sickle-shaped endopodite (Fig. 2d), and a two-segmented exopodite (Figs. 2f, 2g). P5exp2 is relatively long, with a thickening in the first half of its length; the inner margin bears hairs proximally and a longitudinal row of spines distally (Figs. 2e, 2g). On the outer side of the second segment of the exopodite, there are three short, strong spines; the segment ends with one apical curved spine (Figs. 2e, 2g).

The right P5 of the male is shorter, curved, single-segmented (Fig. 2f), thickened in the middle part; on the inner surface of the distal part, there are two small spines; at the apical end — a curved spine (Fig. 2f).

Geographical distribution. According to Borutskiy et al. (1991), the distribution of *H. appendiculata* is confined to the northern part and north of the middle part of the European Palearctic and Western Siberia as well as to Eastern Siberia and the Far East (Fig. 3). Back in the middle of the 20th century, the distribution of this northern species to the south, downstream along the Volga to Kuibyshev Reservoir was recorded (Mordukhai-Boltovskoy and Dzyuban, 1976). At present, the species is also found downstream, in the Saratov (Popov, 2011) and Volgograd (Lazareva et al., 2018) reservoirs. The species was also found in the Sheksninskiy (Rivier and Litvinov, 2006) and Uvodskiy (Semenova et al., 2005) reservoirs, in the adjacent territories parallel to the Volga River (not connected with the Volga) at the latitude of the city of Kazan, in small lakes (low forest Transvolga (Bayanov, 2002; Podshivalina, 2006), Privolzhie region, city of Kazan (Gorshkova, 2012), and the west coast of the Rybinsk Reservoir (Lazareva, 2005) (Fig. 3). Most likely, the continuous part of the range in Europe can be characterized as limited by the Arctic and boreal latitudes; in Asia, it also includes temperate latitudes (up to 51° N, Baikal (the Maloye More Strait), the Zeya River, (data of N.G. Sheveleva)). Of special interest are the location points of the species in the Kiyv Reservoir on the Dnieper River (Semenova, 2009) and in the high-

mountain lakes of Kabardino-Balkaria (Pezheva et al., 2016) (Fig. 3).

Heterocope borealis (Fischer 1851)

Material. Specimens of both sexes from the samples collected in Lake Ilchir (the Eastern Sayan Mountains, 51°50' N, 101°00' E, July 2018).

Description. Female. The largest species of this family. The cephalothorax is wide (Table 1), with the greatest width in the middle part of the body, thoracic somites of the same structure.

The genital somite of the female is almost square, slightly longer than wide (Table 1). Genital plate with two outgrowths rounded at the posterior margin (Fig. 4d).

Antennula reaches the posterior edge of the cephalothorax.

The mandibular incisal edge (Fig. 4a) has a thin and long ventral tooth, with a clearly visible crown; it is separated from the rest by the diastema. The central teeth are large, bivertex; the dorsal teeth are single-vertex, long, sharp, with a narrow base; the last dorsal tooth is small, bivertex (Fig. 4a). At the base of the teeth, starting from the second central one, there are rows of long spines located at right angles.

Maxilla and maxilliped bear pubescent setae (Figs. 4b, 4c).

The caudal branches are short, trapezoidal. On the inner side, densely pubescent from the apical end to the middle. The caudal branches are armed with five apical setae. Apical outer seta spiny, glabrous, sharply narrowed towards the apical end, equal in length to caudal branches; inner apical seta, transparent, thin, displaced to the dorsal side, almost equal in length to the outer spiny seta (Table 1). Three central apical setae are thick, densely feathered, almost equal in length.

Four pairs of female swimming legs have the same structures. The basipodite of P5 in the female bears a seta on the outer side (Fig. 4e); the first segment of the exopodite is armed with one spine on the outer side; the second segment of the exopodite is armed with two sharp spines on the outer side, one of which is displaced to the apical end. On the inner side, this segment is armed with four thick bivertex dentate outgrowths (Fig. 4f). The apical end has a long, slightly curved spine, the inner surface of which has sparsely set teeth (Fig. 4g).

Male. The second to fourth pairs of the legs of the *H. borealis* male (Figs. 5a–5g) are asymmetric. Asymmetry manifests in the armament and length of the second and third segments of the exopodite of the right and left legs (Figs. 5a–5c). The left leg of the fifth pair of the male is basipodite with sickle-shaped endopodite (Fig. 5f). The first segment of the exopodite is short, with one spine in the distal part of the outer margin. The second segment of the exopodite is with two thin sharp spines on the outer margin (Fig. 5d).

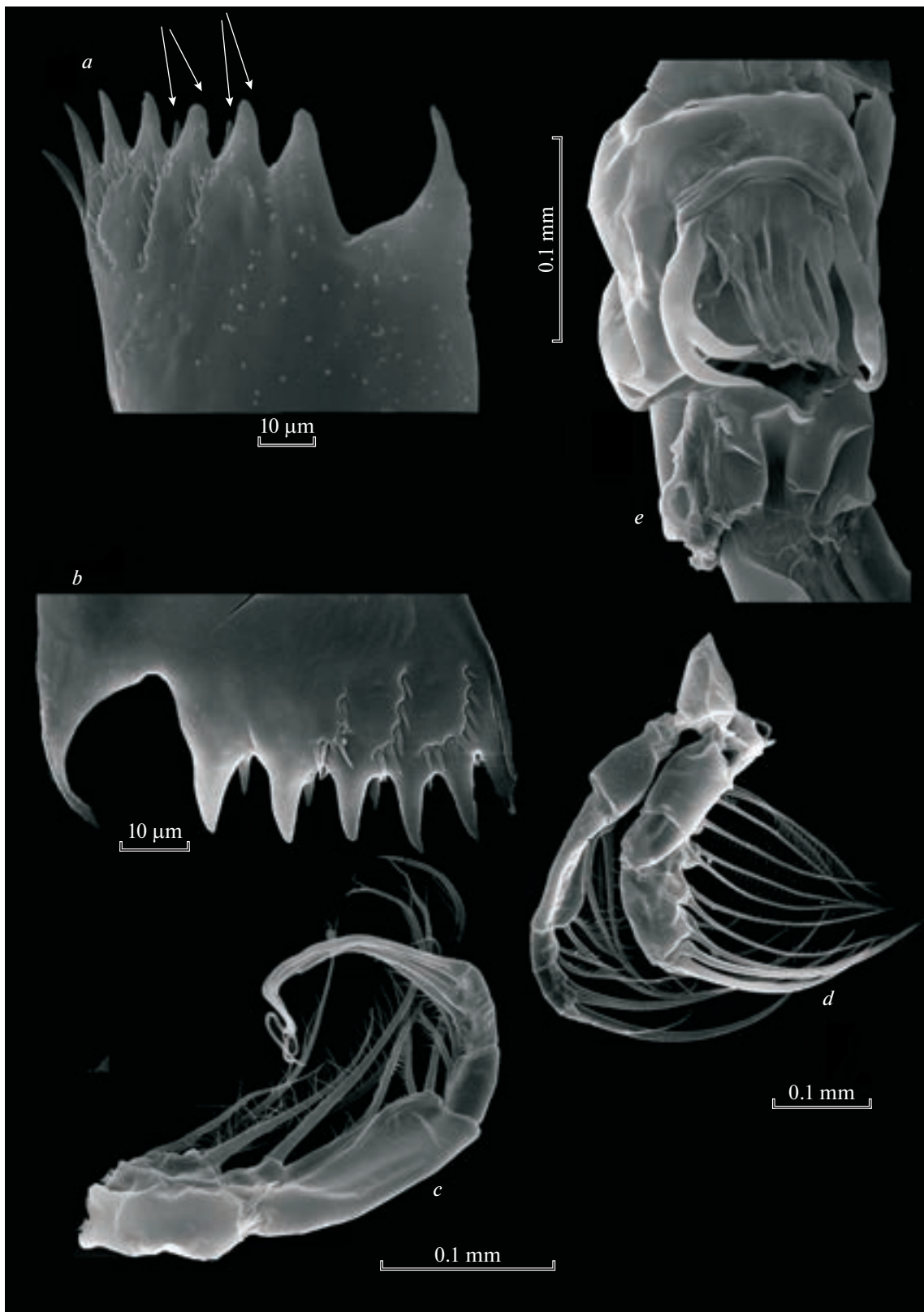


Fig. 1. *Heterocope appendiculata* Sars 1863: (a, b) chewing plate of the mandible; (c) maxilliped; (d) maxilliped and maxilla; (e) genital segment.

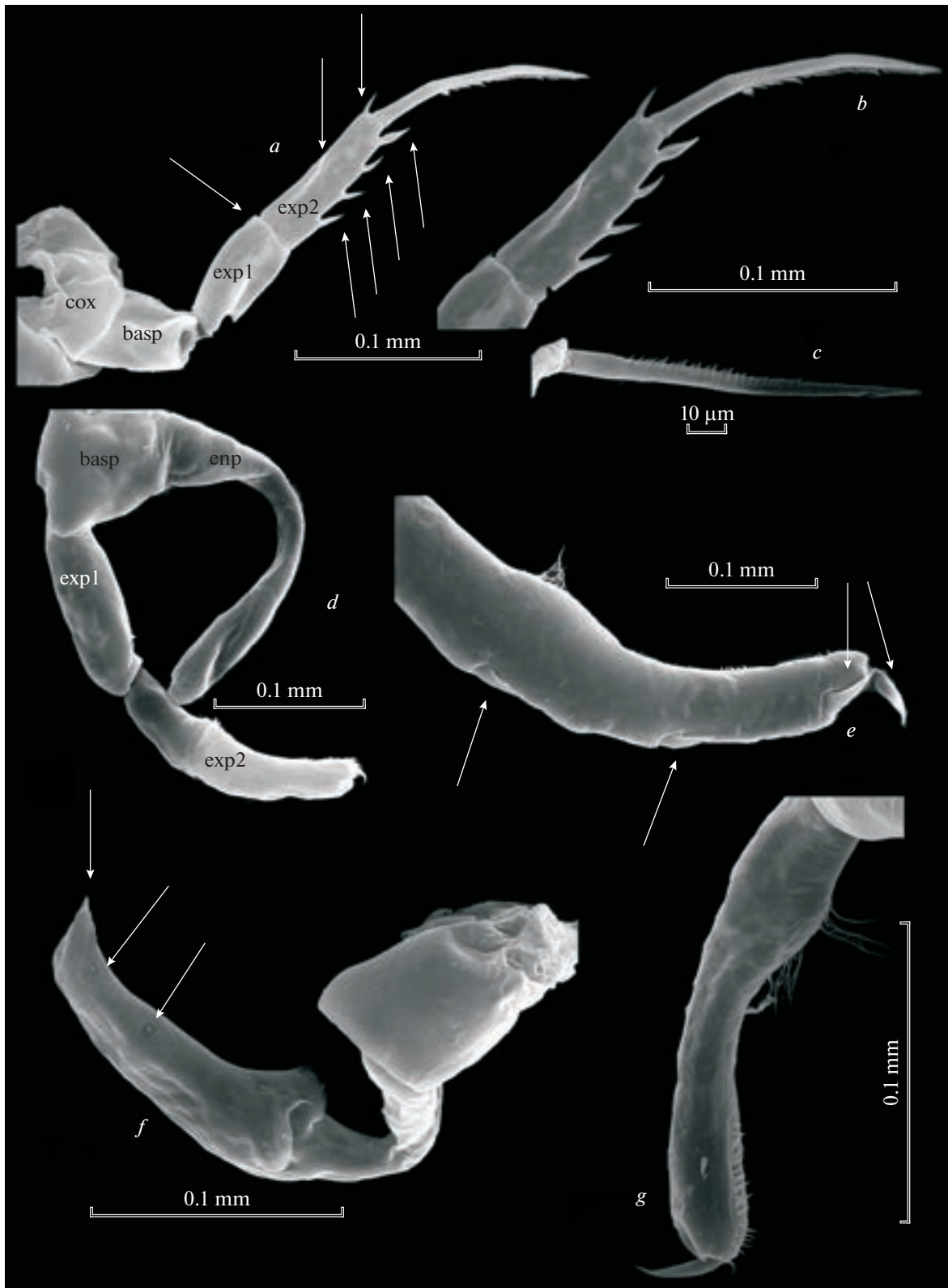


Fig. 2. *Hetercope appendiculata* Sars 1863: (a) P5 of female (arrows indicate spinelike outgrowths on exp1 and exp2); (b) P5exp2 of female; (c) P5exp2 apical spine of female; (d) left P5 of male; (e) exp2 of P5 in male (arrows indicate the spines); (f) right P5 of male; (g) exp2 of the left P5 in male, inner side.

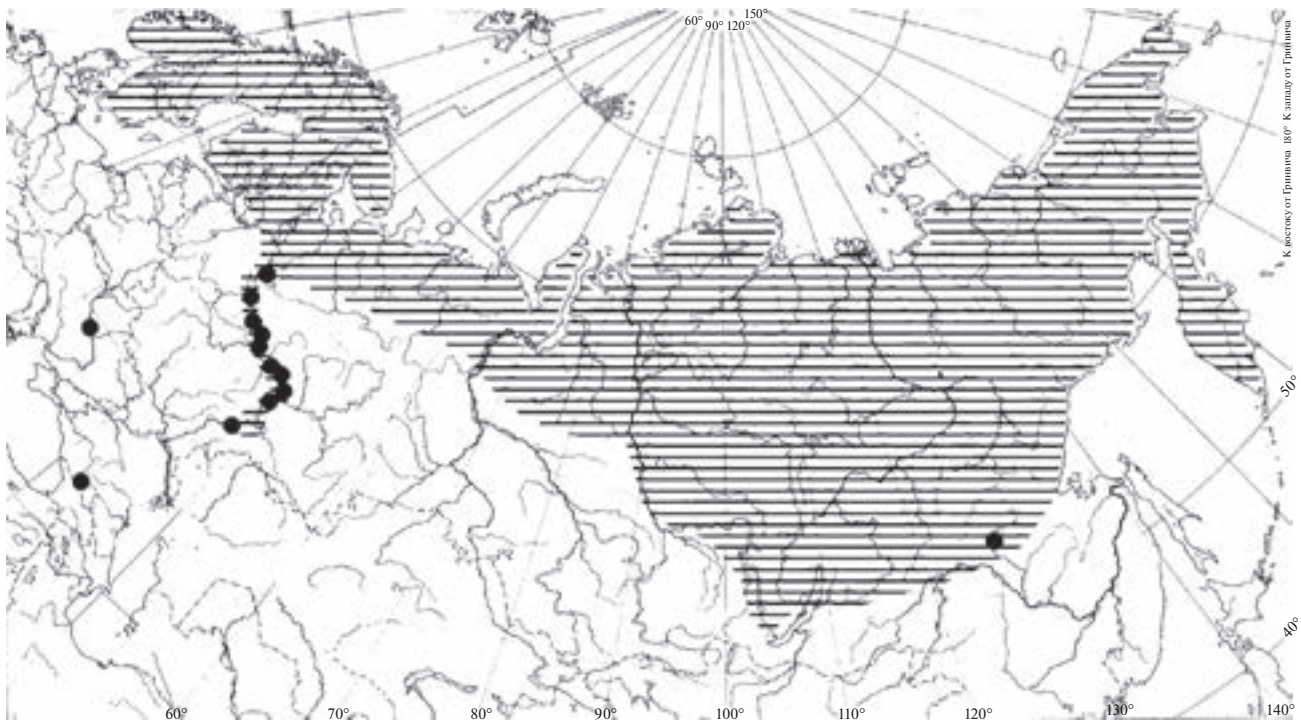


Fig. 3. Geographical distribution of *Heterocope appendiculata* Sars 1863 in the Palearctic.

Two spines at the apical end, of which the outer one is thin and short, and the inner one is long. The inner side of this segment has fine hairs. The right leg of the fifth pair with thick basipodite and two segments of exopodite, the first of which is longer than the second. The first segment of the exopodite has one small spine on the outer side, and the second segment of the exopodite has three spines, two of which are on the outer side, and one is located apically (Figs. 5f, 5g).

Geographical distribution. The main part of the *H. borealis* range is confined to the polar latitudes of the Palearctic where the species is rather common (Borutskiy et al., 1991). It is also found in the high-mountain waterbodies of East Siberia (Okinsk mountain range and the Eastern Sayan Mountains) (Sheveleva et al., 2009), Barguzin and Ikat ranges (Sheveleva et al., 2009), Stanovoy and Patom highlands (Sheveleva et al., 2009), as well as of the Far East (basin of the Anadyr River (Streletskaia, 2010) and waterbodies of Kamchatka (Kurenkov, 2005)). It is recorded in large deep waterbodies of Siberia (Khantaysk and Krasnoyarsk reservoirs) (Sheveleva, 1986; Priymachenko et al., 1993), as well as in the Yenisei River itself, downstream from the Krasnoyarsk hydroelectric power plant, up to Igarka (Priymachenko et al., 1993), lakes of the Todzhinsk Depression (Popkova, 2004; Zui-kova and Bochkarev, 2009) and Darkhad Valley (Dulmaa, 2009) (Fig. 6).

Previously (Borutskiy et al., 1991), findings of this species south of the Arctic Circle were explained by accidental introduction. Findings of the species in waterbodies of Ukraine are questionable, possibly resulting from confusion with *H. caspia* (Błędzki and Rybak, 2016). Most likely, in the European part of the range, the distribution is limited to polar latitudes; in the Asian part, in the conditions of a sharply continental climate, the species also inhabits more southern latitudes (up to 51° N, Okinsk lakes; data of N.G. Sheveleva) in the highlands and deep-water waterbodies. It is also possible that such a clearly disjunctive range of the species may indicate possible taxonomic differences between crustaceans in the northern and southern parts of the range, which requires additional detailed morphological studies.

Heterocope caspia Sars 1897

Materials. Specimens of both sexes from the Volga River down stream area (Volgograd Reservoir, 50°47' N, 45°59' N and an unregulated section of the Volga downstream the city of Volgograd, 47°01' N, 47°29' E, August 2018).

Description. Female. The body is elongated, slender; the chitin is very delicate. The cephalothorax is 3.0–3.2 times greater than its width.

The genital somite is 1.16–1.29 times longer than its width. The genital somite plate has two teeth on each side, of which the outer tooth is large with a long

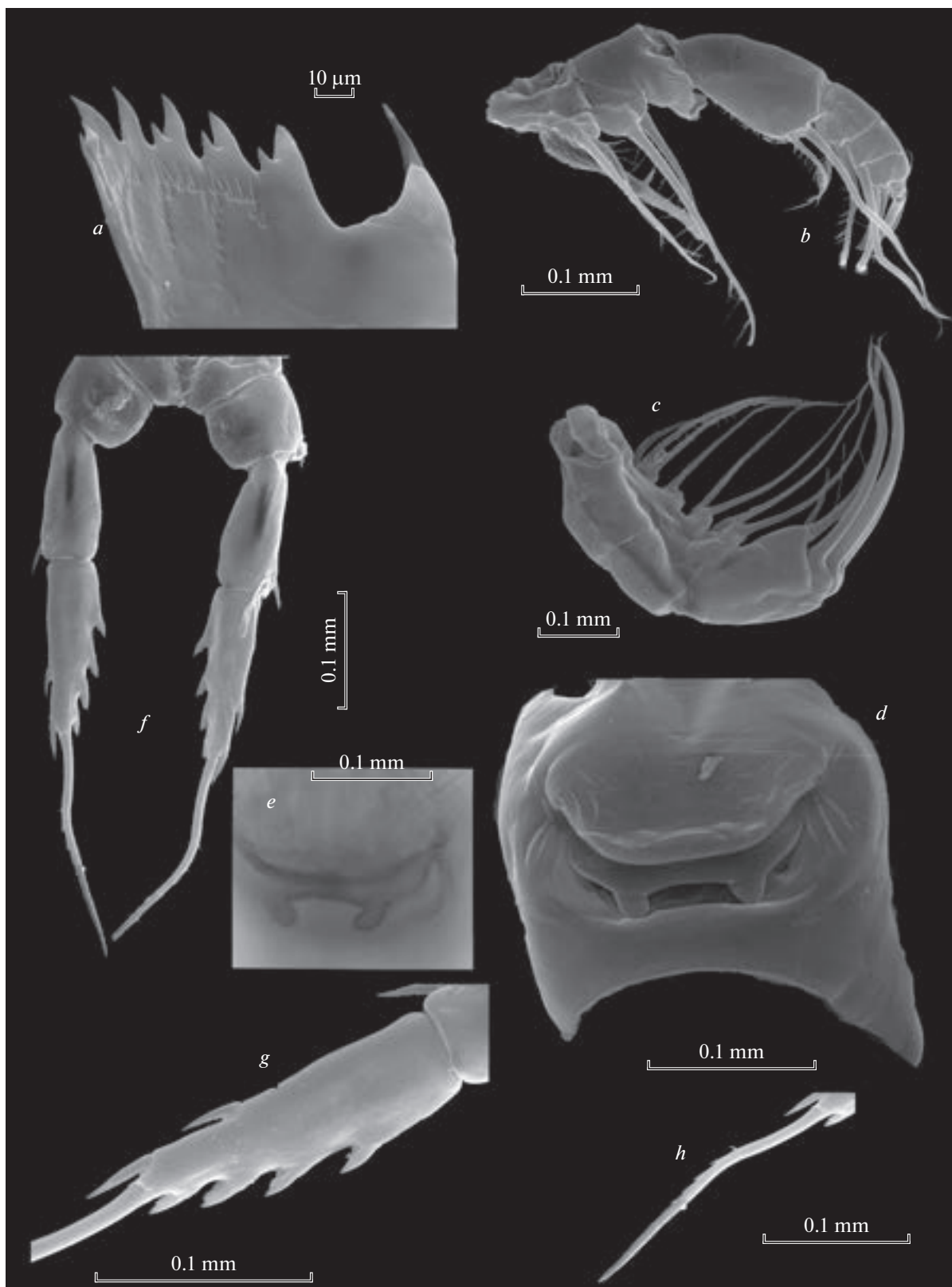


Fig. 4. *Hetercope borealis* (Fisher 1851), female: (a) incisal edge of the mandibular plate; (b) maxilliped; (c) maxilla; (d) genital plate; (e) P5; (f) P5exp2; (g) apical spine of P5exp2.

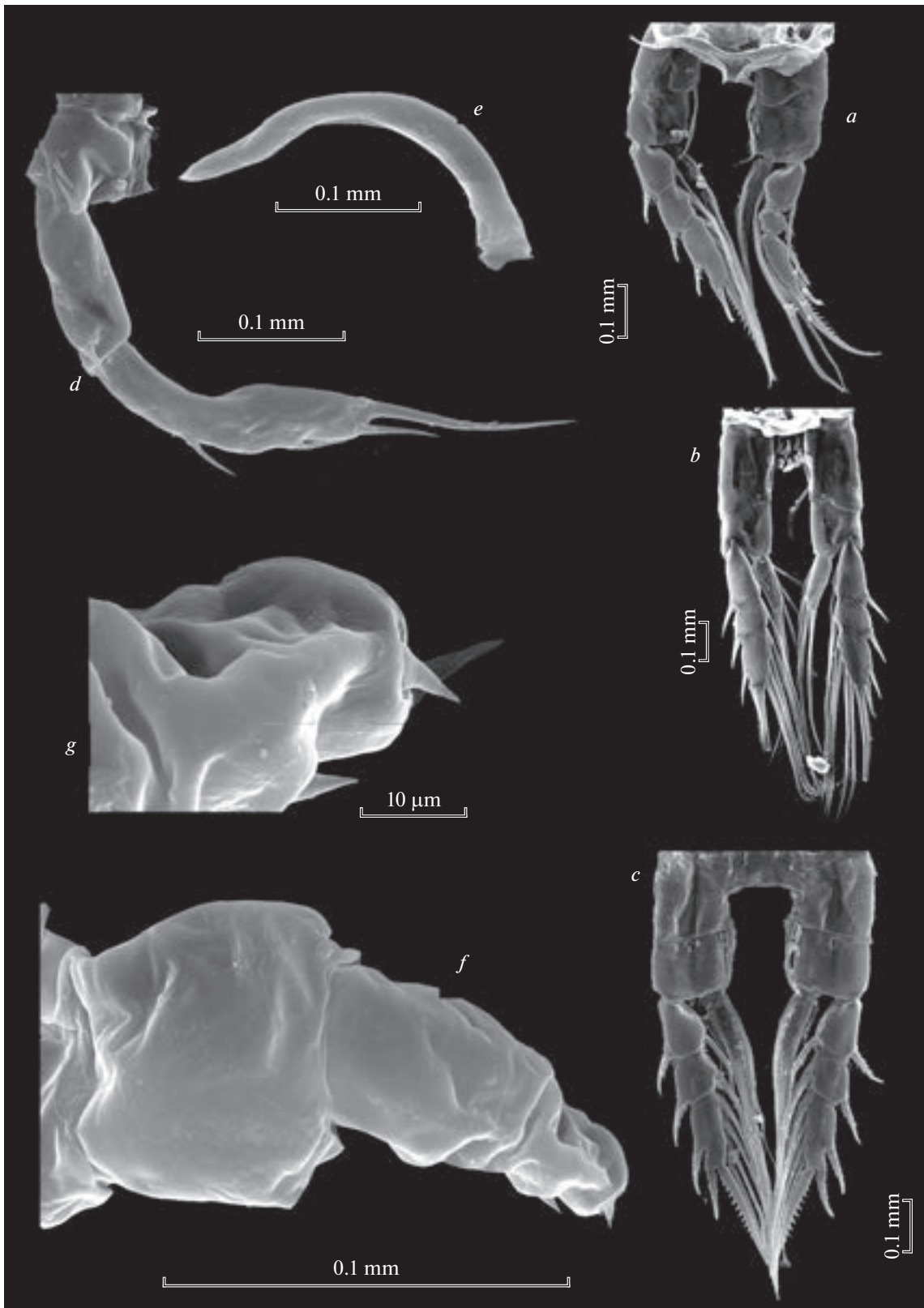


Fig. 5. *Heterocope borealis* (Fisher 1851), male: *a, b, c*, P2–P4 swimming legs; *d*, left P5; *e*, endopodite of left P5; *f*, right P5; *g*, apical part of exp2 of right P5.

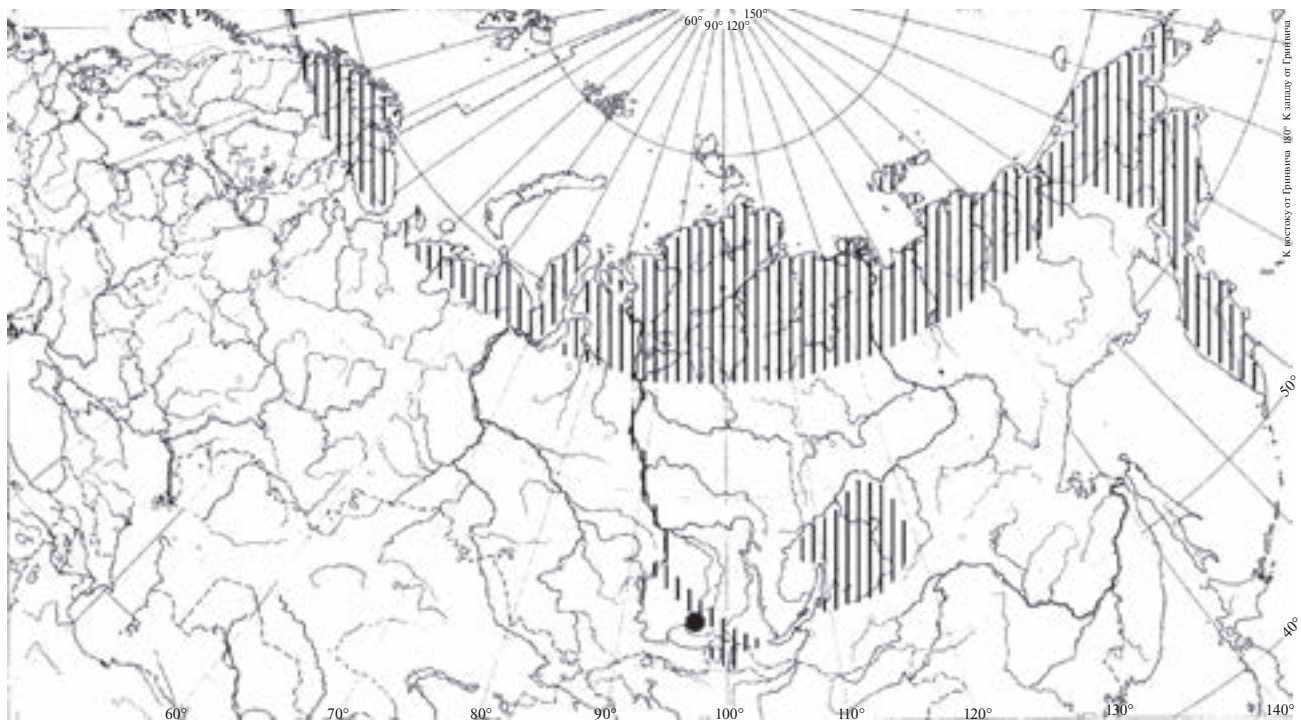


Fig. 6. Geographical distribution of *Heterocope borealis* (Fisher 1851) in the Palearctic.

process; the inner one is small (Fig. 8c). The lower surface of the genital somite, posterior to the genital opening, bears two rows of setules, and one row of spinules arranged in transverse rows (Fig. 8d).

Caudal branches are long (Fig. 7a); of the studied five species of the genus, in *H. caspia* these branches are the longest (Table 1), parallel, glabrous. They bear four apical setae: one inner is thin, which, like in all other species, is displaced to the dorsal side; it is the shortest among the species of the genus (Table 1). Three apical setae evenly tapering towards the end, armed with relatively short, sparse, slender setules. The external apical seta is short and has a spine-like shape.

Antennulae reach the posterior margin of the genital somite.

The mandibular incisal edge has six teeth (Fig. 7b). The ventral tooth is single-vertex, pointed, with a clearly visible crown; separated from the other teeth by a deep diastema. Three central teeth are bivertex, with a wide base, obtuse. The next two dorsal teeth have a narrower base, also bivertex, sharp; the dorsal-most tooth is spiny, long, and thin. Dorsal seta is long, thin, serrated. The transverse row of spines is situated at the base of teeth (except for the two most ventral ones).

Setae of maxillipeds pubescent with thick long hairs (Fig. 7a).

The fifth leg of the female is single-branched, four-segmented (Figs. 8b, 8e). On the outer side, exp1 has one spike. Exp2 has two to three short spines on the

outer side and one long apical spine. Three to four dentate outgrowths are situated on the inner side (Fig. 8g). Subapical outgrowth almost as long as the apical spine.

Male. The fifth right leg is single-branched, bisegmented; the inner side is smooth, the outer one is tuberos (Figs. 7d, 7e). The left legP5 is bisegmented with a sickle-curved endopodite (Fig. 7d) and bisegmented exopodite. The second segment of the exopodite is two times longer than the first, thickened in the middle, with a no btuse apical end having two small spines equal in length. On the outer side, there are small spines.

Geographical distribution. The range of *H. caspia*s confined to the Sea of Azov as well as to the Caspian and Black seas and their basins (Borutskiy et al., 1991). From this main part of the range, the crustacean spread upstream along the Volga River (up to the Kuibyshev Reservoir inclusive where it appeared back in 1967 (Mordukhai-Boltovskoy and Dzyuban, 1976), the Danube, Don, and Southern Bug rivers where it goes to her high upstream (Popov, 2007). The species was also recorded in the upper reaches of the Kama Reservoir in 2016 (Lazareva et al., 2018) as well as in lakes Abrau (Krasnodar Krai) (Stepanyants et al., 2015), Karakol (Kazakhstan) (Karapun et al., 2013), and Sapanca (Turkey) (Stepanyants et al., 2015).

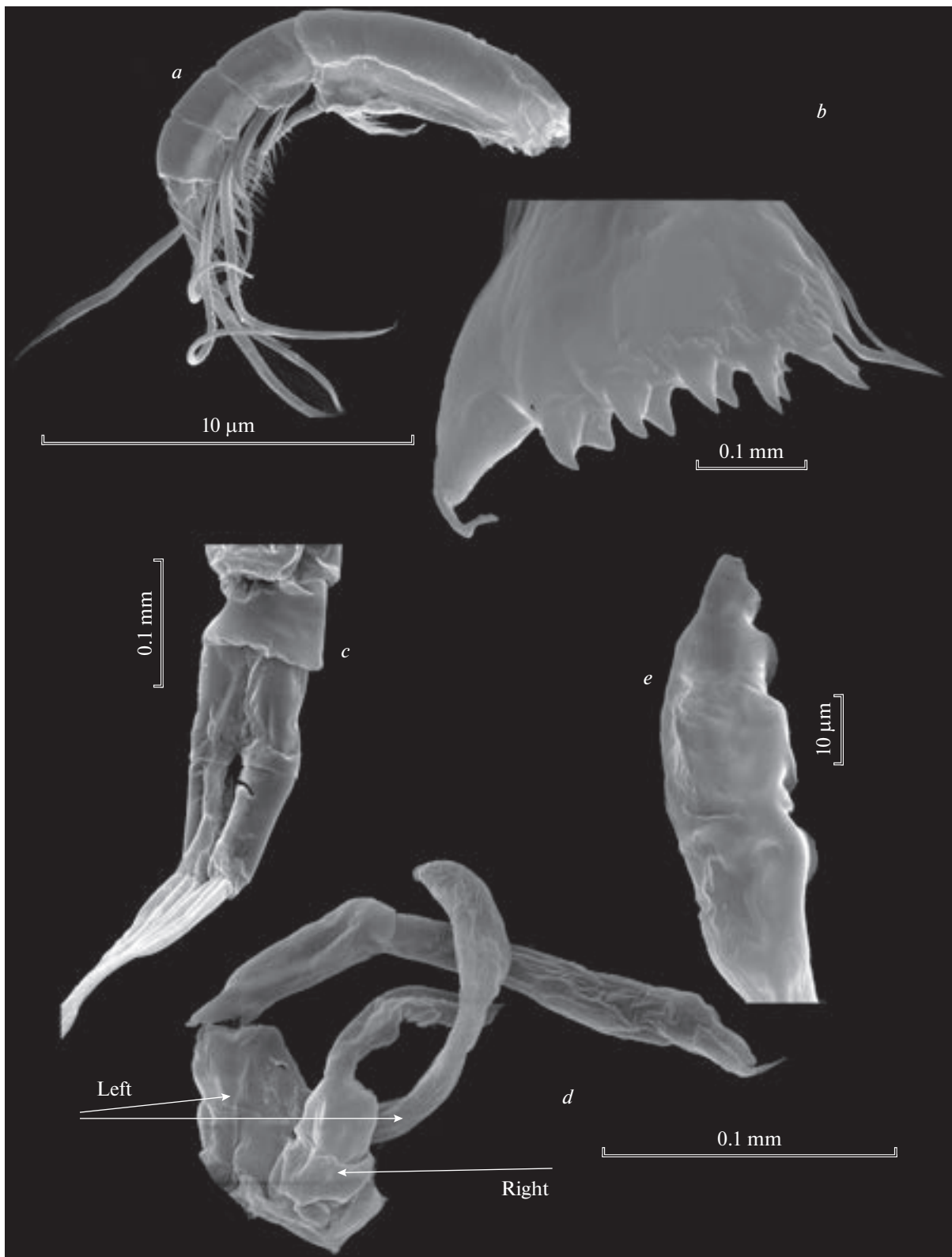


Fig. 7. *Hetercope caspia* Sars 1897: *a*, maxilliped of female; *b*, incisal edge of the mandibular plate in female; *c*, caudal branches in male; *d*, P5 of male; *e*, right P5 of male.

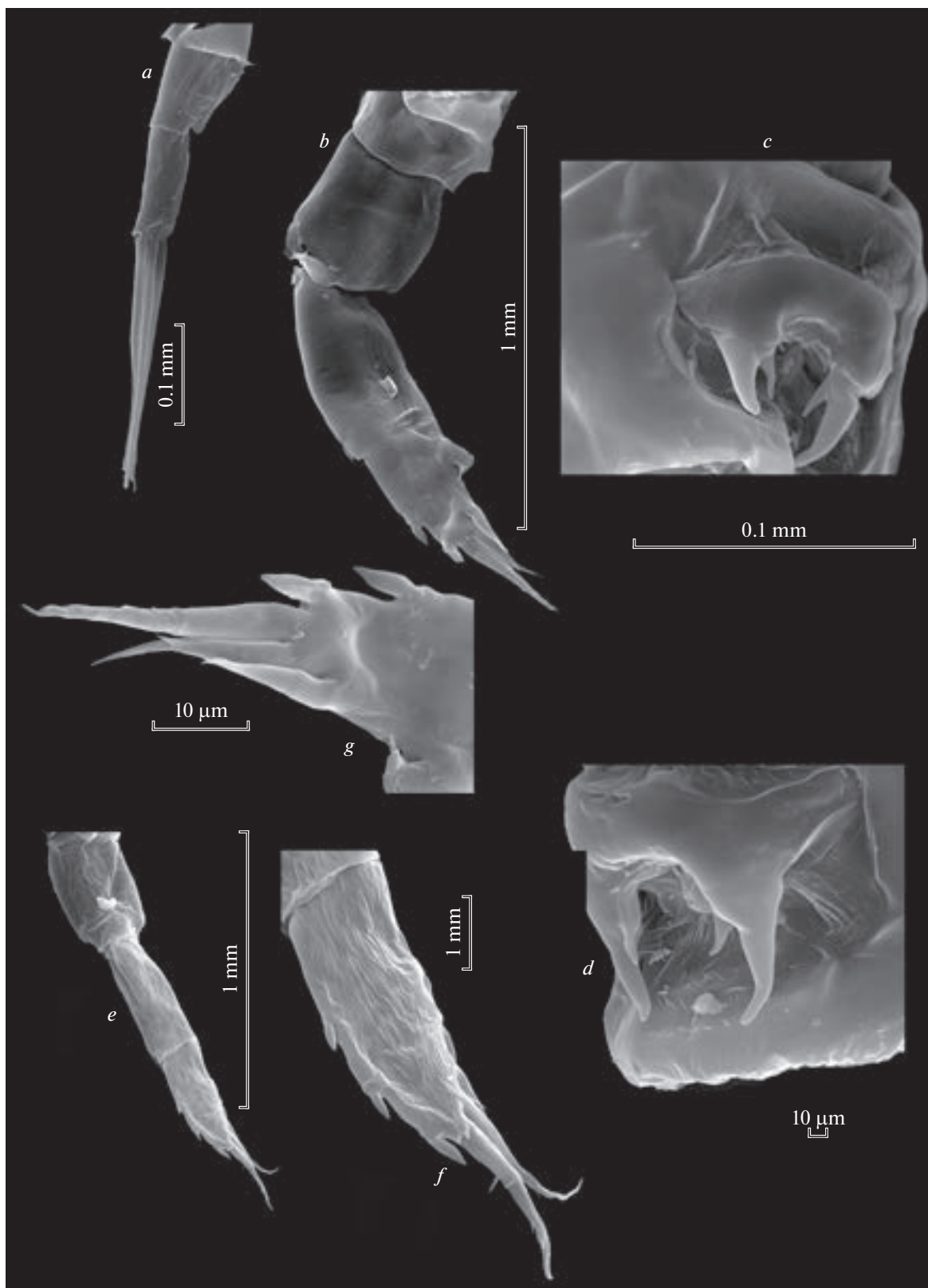


Fig. 8. *Hetercope caspia* Sars 1897, female: *a*, caudal branches; *b*, *e*, P5 of female; *c*, *d*, genital plate; *f*, P5exp2; *g*, apical part of P5exp2.

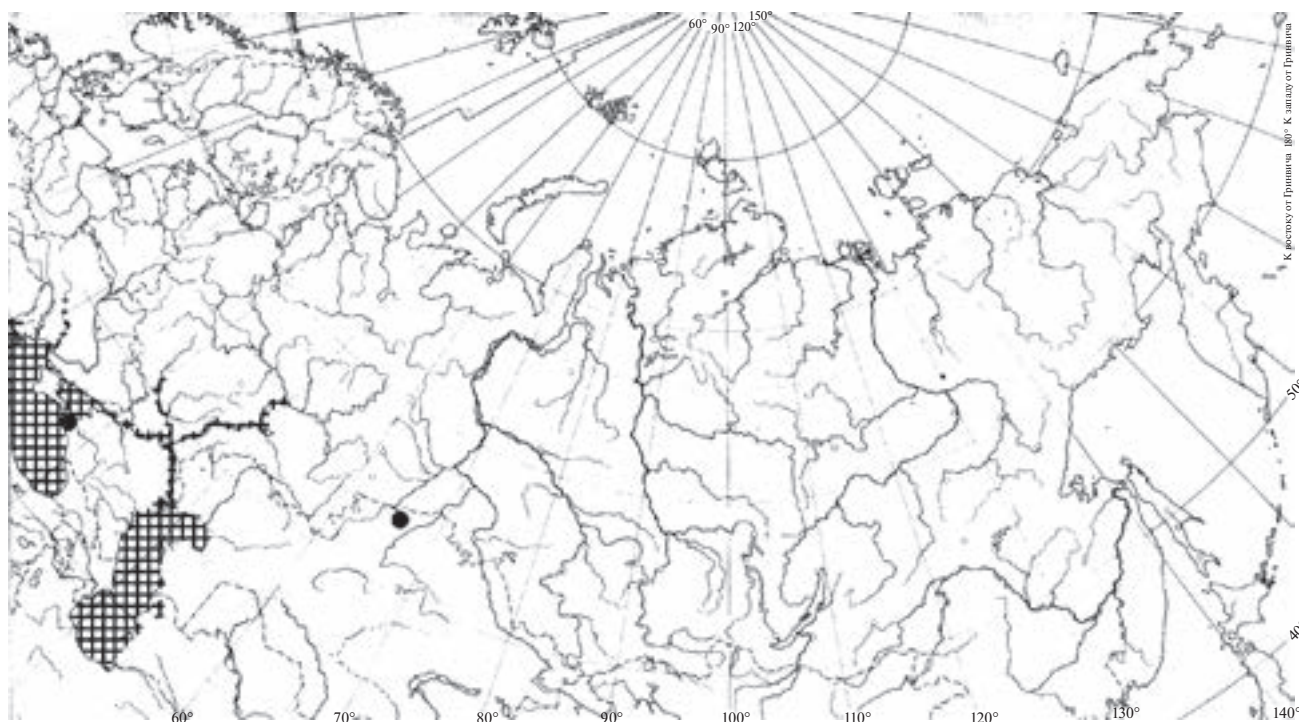


Fig. 9. Geographical distribution of *Heterocope caspia* Sars 1897 in the Palearctic.

Heterocope saliens (Lilljeborg 1862)

Materials. The specimens of both sexes from the zooplankton samples of Lake Pustoye (Pustynnoye) (Nizhny Novgorod Oblast, 56°28' N, 45°18' E, August 2018).

Description. Female. The body is elongated, slender, cephalothorax 2.5–2.8 times longer than wide.

The length of the genital somite slightly exceeds its width (Table 1); its plate in the proximal part has a shallow notch in the center and wide rather low lateral lobes (Fig. 10d).

The caudal branches are relatively short, 1.3–1.6 times longer than wide (Table 1), slightly widened towards the apical end, pubescent on the inner side with coarse, thick hairs, from the apical end to the middle. The caudal branches bear three feathery relatively long setae, one outer spine-like seta and one thin inner seta. The outer apical glabrous spine-shaped seta is two times shorter than in *H. borealis* (Table 1), the thin apical inner seta, as in all species of this genus, is displaced to the dorsal side. It is also shorter than in *H. borealis*.

The antennulae reach the posterior end of the cephalothorax.

The incisal edge of the mandibular plate has sharp teeth characteristic for feeding on animal food. The ventral tooth is acute, single-vertex, separated from the other teeth (Fig. 10a). Three central teeth are bivertex, with a wide base; three more dorsal teeth are

single-vertex, with a narrow base; dorsal seta sharp and fine. There are three longitudinal rows of spines at the base of the four central teeth (Fig. 10a).

Setae of maxilla and maxilliped are covered with long hairs; maxillipede are large (Figs. 10b, 10c).

The fifth leg exhibits similar features to *H. borealis* (Fig. 10f), except that P5exp2 is shorter and thicker in the basal part (Fig. 4e). There are four dentate outgrowths of the inner margin of this segment, which are clearly bifurcated at the apex (Fig. 10g). A long spine is situated at the apical end of the segment (Fig. 10h).

Male. Swimming legs P1–P4 are symmetrical. The basipodite of the right leg P5 of the fifth pair is large, with a spine on the outer margin (Fig. 11b). Its bisegmented exopodite is clearly separated. Two segments of the exopodite are almost equal in length, and on its second segment, there are two small spines and transverse folds on the outer side (Fig. 11d). The left leg P5 of the fifth pair has a thin sickle-shaped endopodite, that is clearly separated from the basipodite and two exopodites, the first of which is shorter than the second (Fig. 11c). The second segment of the exopodite has a convex outer edge and bears two lateral spines. Two spines are located apically, of which a short spine is the middle length of the second spine (Fig. 11e). A long spine is serrated at the end (Fig. 11f).

Geographical distribution. *H. saliens* inhabits waterbodies of different types in various landscapes, in polar, boreal, and, partially, temperate latitudes of the European Palearctic (Borutskiy et al., 1991; Błędzki

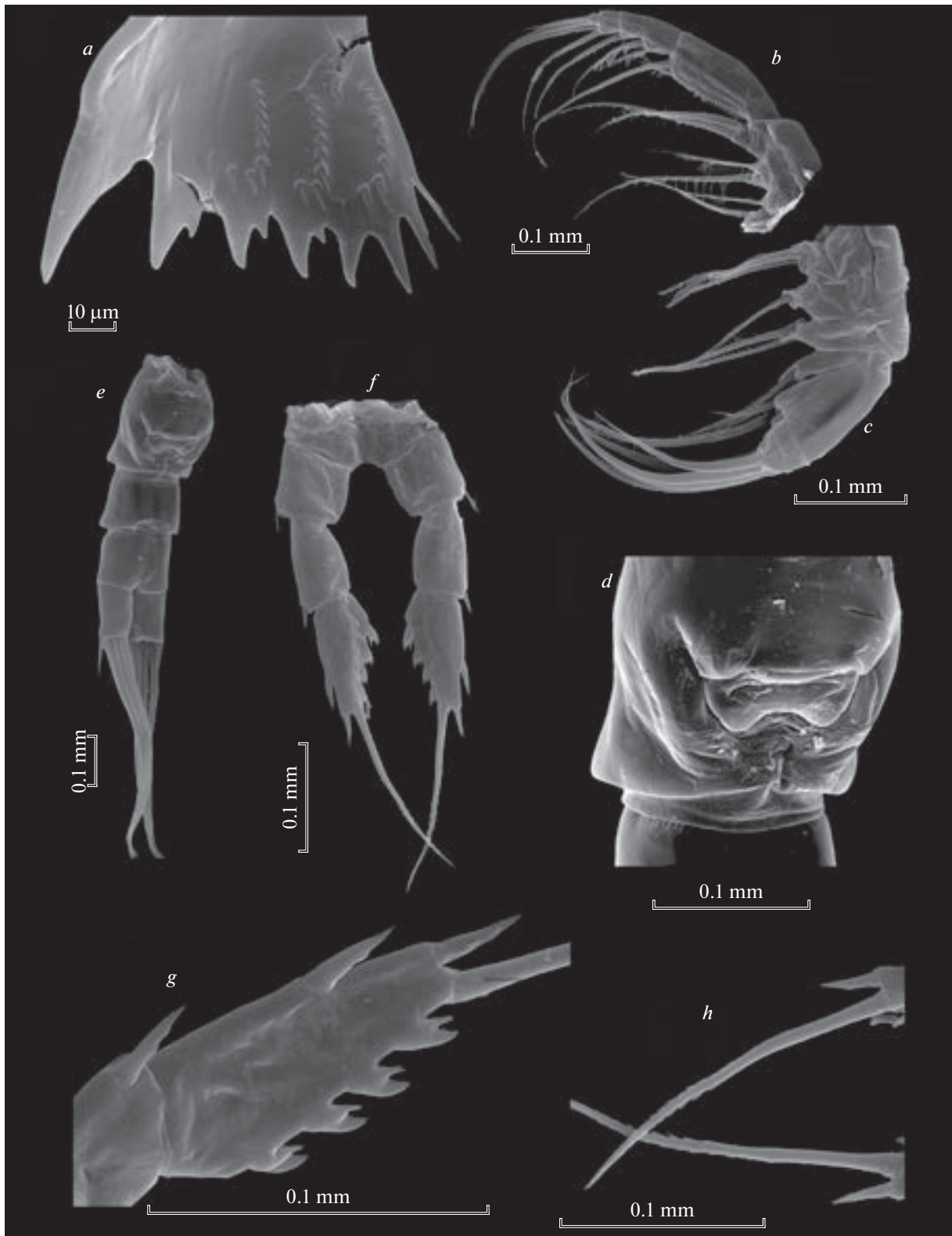


Fig. 10. *Heterocope saliens* (Lilljeborg 1862), female: *a*, incisal edge of the mandibular plate; *b*, maxilliped; *c*, maxilla; *d*, genital segment; *e*, genital segment and abdomen; *f*, P5; *g*, P5exp2; *h*, apical spine of P5exp2.

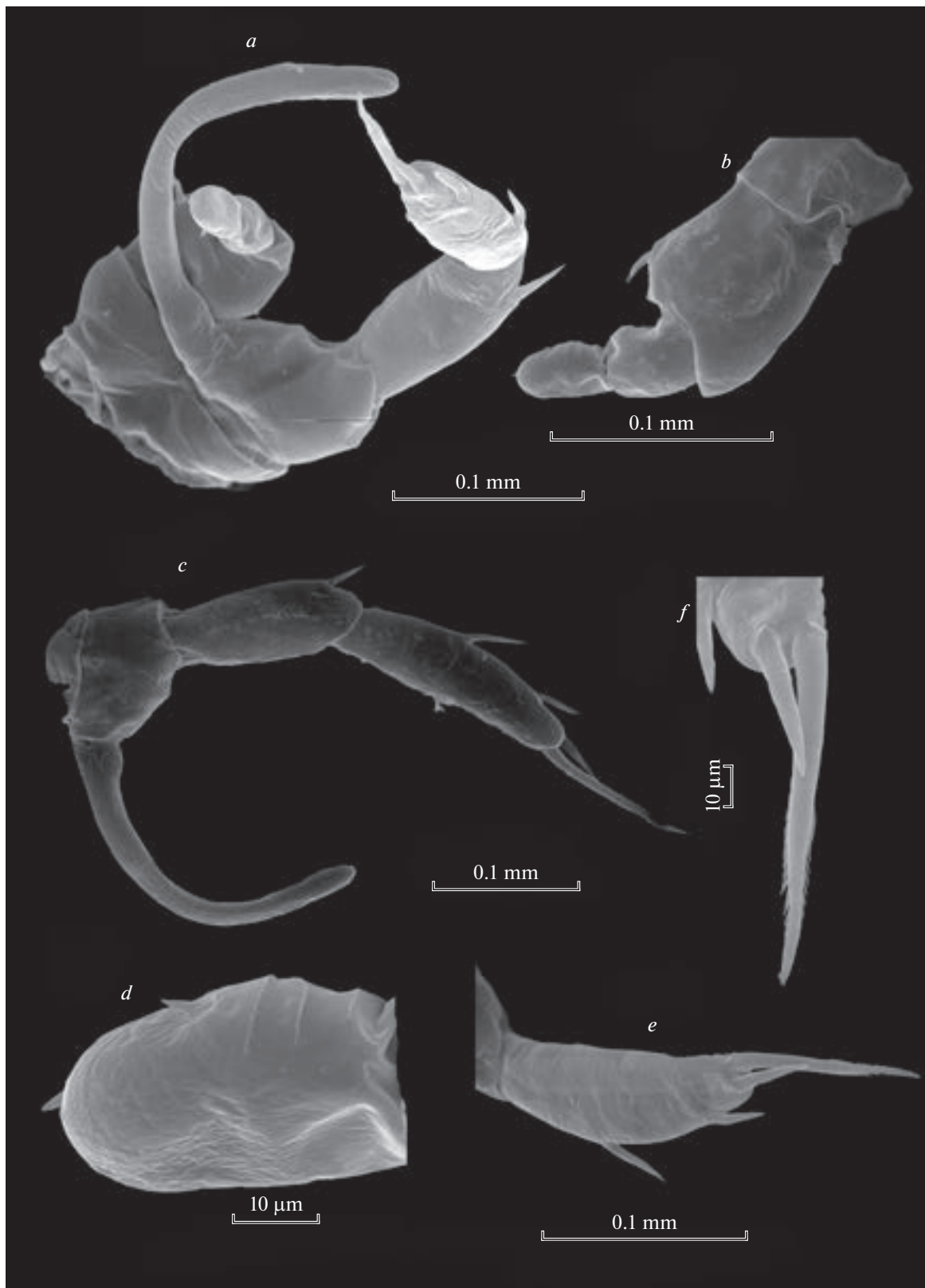


Fig. 11. *Hetercope saliens* (Lilljeborg 1862), male: *a*, P5; *b*, right P5; *c*, left P5; *d*, apical part of exp2 of right P5; *e*, exp2 of left P5; *f*, apical part of exp2 of left P5.

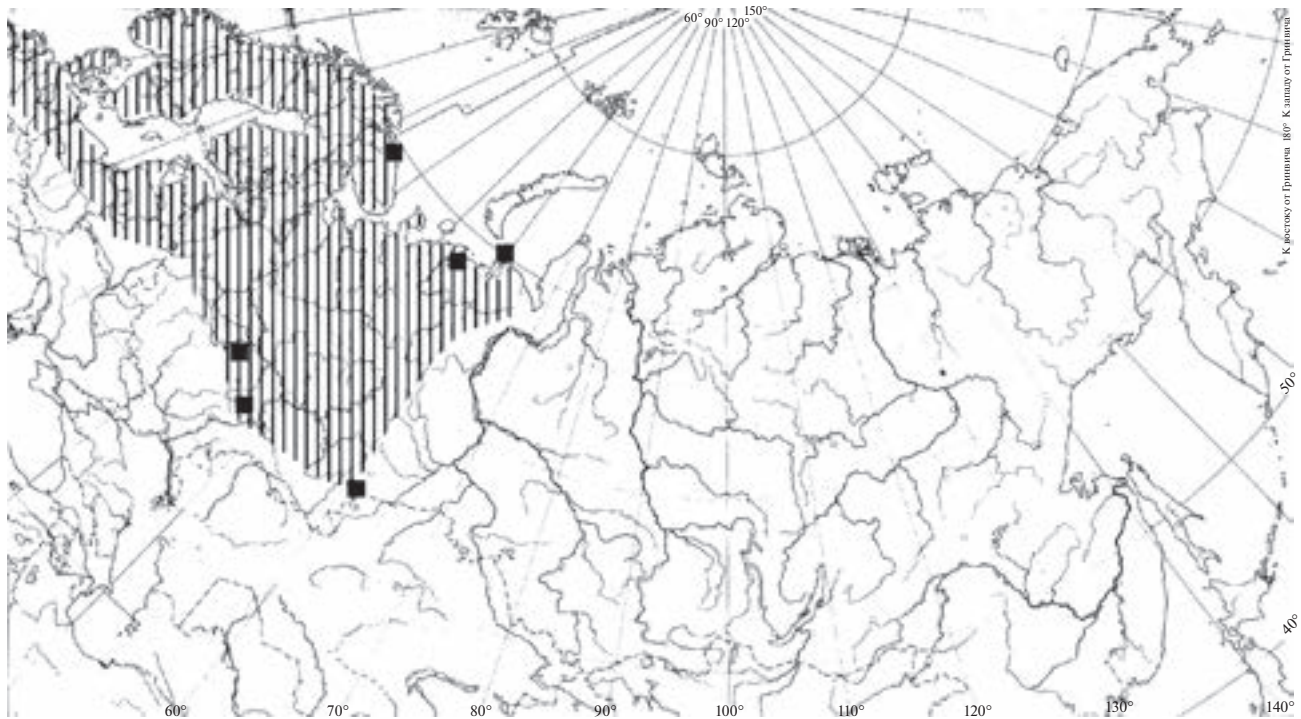


Fig. 12. Geographical distribution of *Heterocope saliens* (Lilljeborg 1862) in the Palearctic.

and Rybak, 2016) (from polar latitudes to 56° N, Lake Pustoye (Pustynnoye), Nizhny Novgorod Oblast) (Fig. 13). Unlike *H. appendiculata* and *H. borealis*, it is often found in Europe (Błędzki and Rybak, 2016).

Heterocope soldatovi Rylov 1922

Materials. The specimens of both sexes from the zooplankton samples of Lake Bolon (Khabarovsk Krai, 49°84' N, 36°27' E).

Description. Female. The body is elongated, tapering evenly posteriorly.

The genital somite is almost square, slightly widened in the basal part. The inner surface of the genital somite is covered with four rows of transverse spines (Fig. 14b). The genital opening has a genital plate with two teeth on each side (Fig. 14b).

Caudal branches elongated, slightly widened toward the apical end, pubescent with setulae by 1/2 to 1/3 of their length. The thin apical inner seta is displaced to the dorsal side.

Antennulae are long, reaching the last abdominal somite.

The incisal edge of the mandibular plate is represented by seven teeth, six of which are single-vertex (Fig. 13a).

The setae of the maxilla are long, feathered (Figs. 13b, 14a).

The fifth leg of the female: basipodite is wide, with a rounded inner margin (Figs. 13c, 14d). The first segment of the exopodite is elongated, with a small spine on the outer side. P5exp2 is almost of the same length as P5exp1. On its outer side, there are two small spines, one of which is near the apical spine; on the inner side, there are four elongated, thin and pointed dentate outgrowths, of which the dentate outgrowth near the apical spine is longer than the other three; this segment ends with a long strong spine curved inward serrated by 1/2 of its length (Figs. 1c, 1d).

Male. The basipodite of the right leg P5 of the male is thick; the exopodite is irregularly shaped, single-segmented, wide, and rounded at the end (Fig. 14i), and has three small spines on the inner side. The endopodite of the left leg P5 is sickle-shaped, rounded at the end, thickened in the basal and distal parts (Fig. 1e). The first segment of the exopodite is short, widened in the distal part. The second segment of the exopodite is elongated, armed with a long thick sharp spine at its apical end (Fig. 1f). Near the apical spine, a relatively short sharp spine curved inward is attached (Fig. 14h). On the inner edge of the second segment of the exopodite, there are six to eight conical spines, the first of which is located approximately in the middle of the margin, and the last one is at the base of the apical spine. These spines extend to the surface of the segment (Fig. 14g).

Geographical distribution. The species is characterized by an extremely limited distribution: the down-

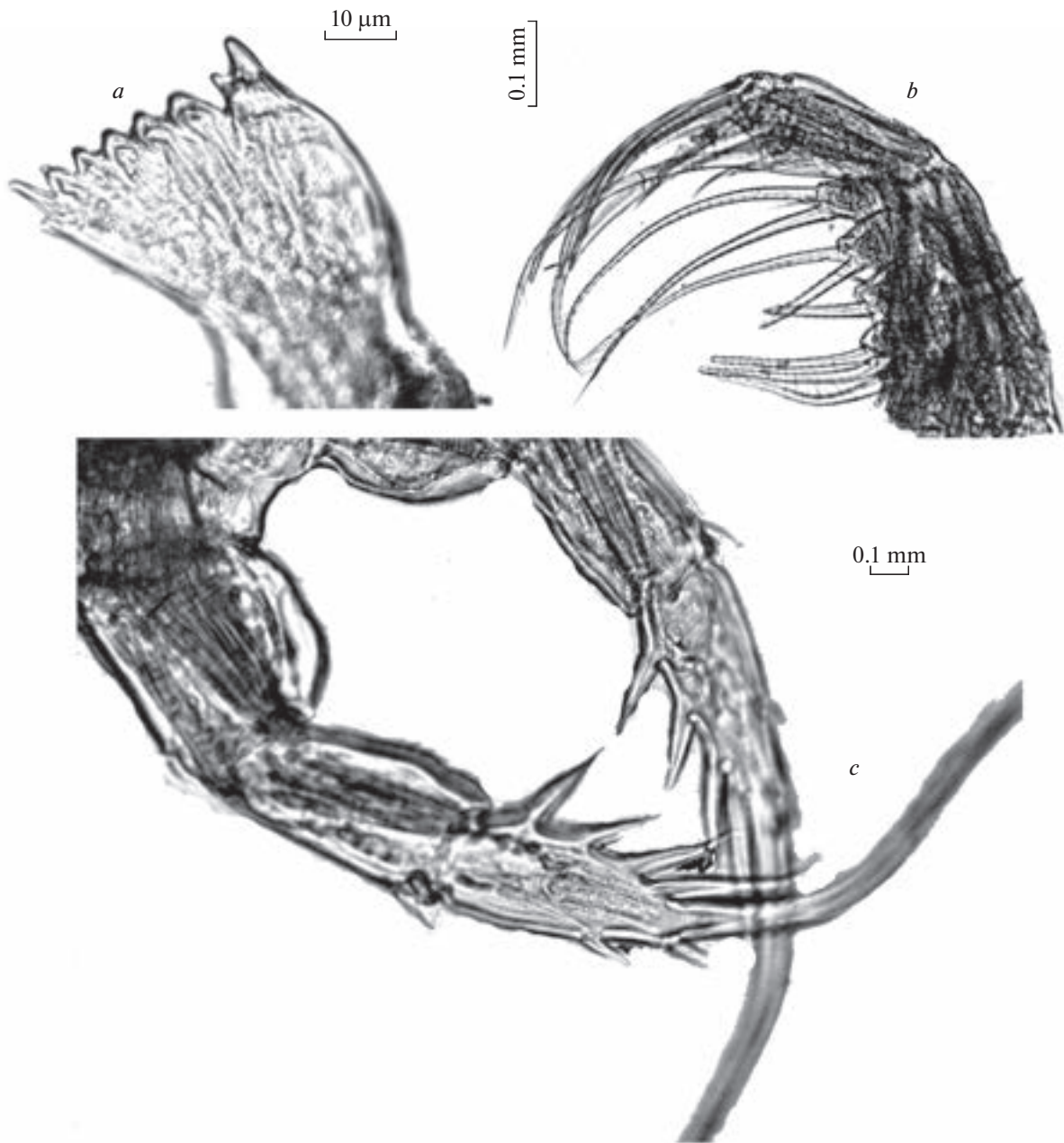


Fig. 13. *Hetercope soldatovi* Rylov 1922, female: a, chewing plate of mandible; b, maxilliped; c, P5.

stream reaches of the Amur River, as well as the Ussuri (Rylov, 1922; 1932) and Sungacha (Barabanshchikov, 2001) rivers, and lakes Khasan (data of N.G. Shevelova.), Bolon, Lebekhe, Khanka, Petropavlovskoye, Kabar, and Gassi (Borutsky, 1952), of its basin (Fig. 15). The finding of this species in the European part of the Palearctic, in one of the waterbodies of the city of Kazan (Mingazova et al., 2008), is questionable. Possibly, *H. caspia* (inhabiting the Kuibyshev Reservoir, with which the waterbodies of Kazan are connected) was mistaken for *H. soldatovi*.

An identification key table for females based on general and distinctive morphological characteristics has been compiled for practical purposes (Table 2). Previously, similar but different tables were proposed by Rylov (1930) and Borutskiy et al. (1991). The most similar morphological features (for example, the presence of an external spiny seta on the caudal branches) are characteristic of *H. borealis* and *H. saliens*. However, these species are easily distinguished by the females. In *H. borealis*, there are (1) relatively short caudal branches that have a trapezoidal shape and (2) long spine like setae, where as (3) the genital plate has

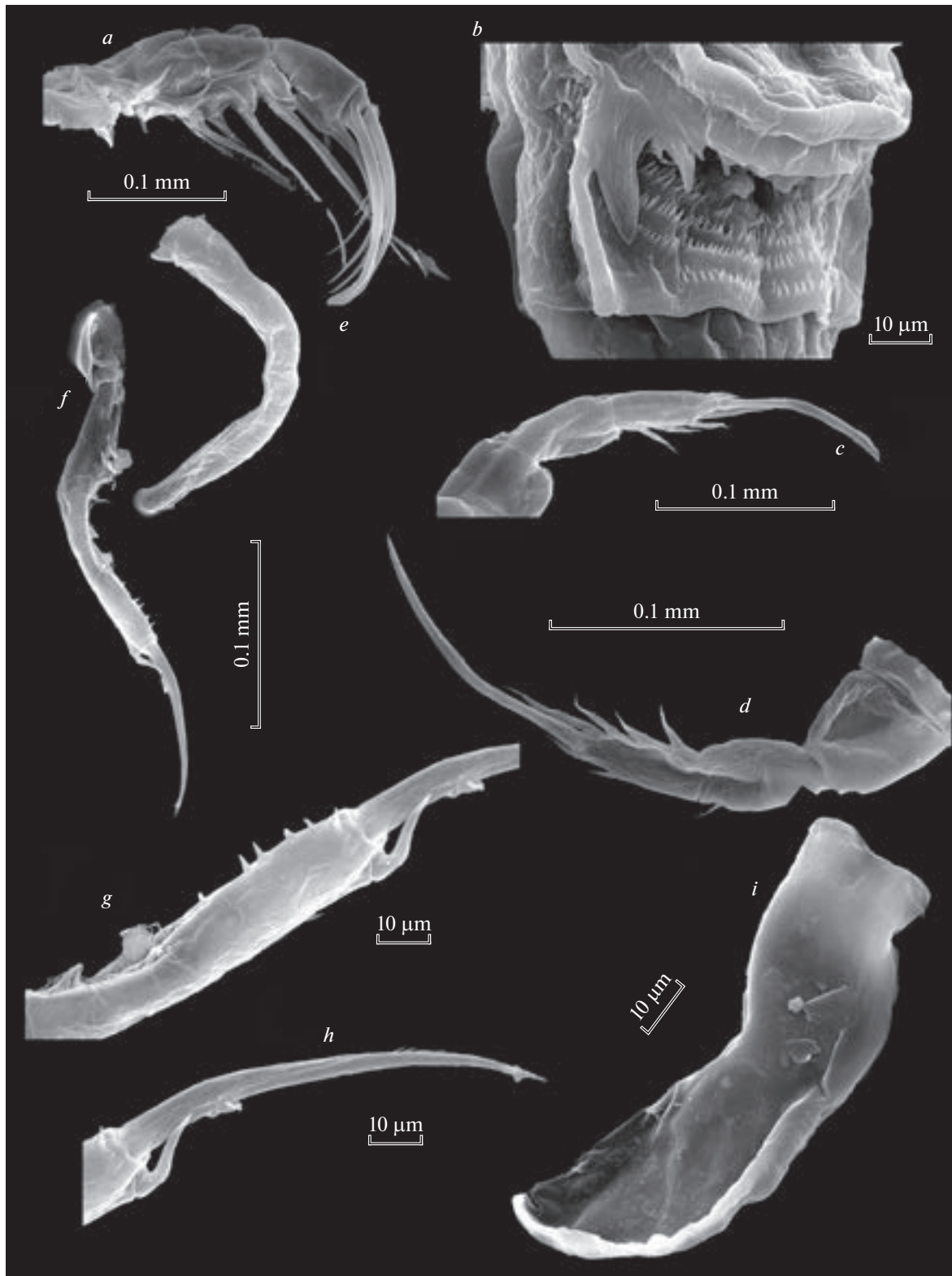


Fig. 14. *Heterocope soldatovi* Rylov 1922: *a*, maxilla of female; *b*, genital segment; *c*, *d*, P5 of female; *e*, endopodite of left P5 in male; *f*, left P5 of male; *g*, exp2 of left P5 in male; *h*, apical spines of exp2 of left P5 in male; *i*, right P5 of male.

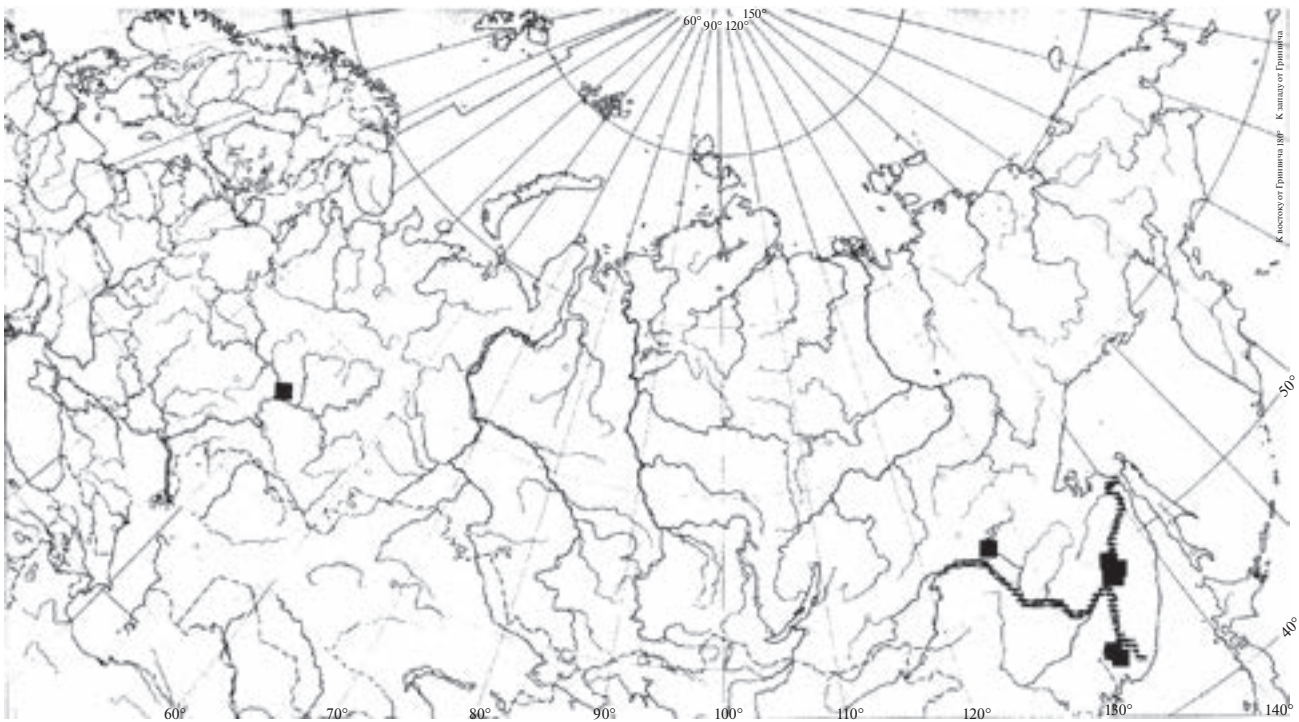


Fig. 15. Geographical distribution of *Heterocope soldatovi* Rylov 1922 in the Palearctic.

one short rounded outgrowth on each side, and (4) there are four weakly bivertex dentate outgrowths in P5exp2 on the inner side. In the male, the arms of the P2–P4 swimming legs are asymmetric. In *H. saliens*, the male has symmetrical armament of the swimming legs. The female has a genital plate without appendages, and the P5exp2 internal dentate outgrowths are clearly bivertex. Live and preserved individuals of different sexes of *H. borealis* are of blue color.

The females of *H. appendiculata* have a ribbon-like genital plate; the male of this species, on the left leg of P5, has two small spines on the outer side of the second exopodite and two spines of different lengths at its apical end. The right leg of P5 in the male is implicitly dissected, thickened in the middle part, and ends with a small spine.

The females of *H. caspia* and *H. soldatovi* have a genital plate with two lateral teeth on each side, but the genital surface of *H. caspia* is covered with thin setules inside, whereas in *H. soldatovi*, these setules are larger and clearly visible. In the *H. caspia* female, the second segment of the P5 exopodite is armed on the inner side with two to three single-vertex dentate outgrowths; one relatively long spine is located apically. The P5 left leg of the *H. caspia* male has very small spines both on the outer side on the second segment of the exopodite and at the apical end; the right leg has no armament and has a wavy surface. The females and males of *H. soldatovi* have very characteristic morphological features that are unique to this species. In this species, the P5 exopodite of the right leg is wide, flat, and rounded with small spines along the inner edge. The

Table 2. Identification key to all species of the genus *Heterocope* in Russian fauna

1	L: W caudal branches over 2.5; their inner surfaces are glabrous.....	<i>H. caspia</i>
–	L: W caudal branches less than 2.0; their inner surfaces bear hairs.....	2
2	The outer seta of the caudal branches is present.....	3
–	The outer seta of the caudal branches is absent	4
3	Genital plate with two rounded outgrowths	<i>H. borealis</i>
–	Genital plate without outgrowths and with two lowwide lobes.....	<i>H. saliens</i>
4	The genital plate bears ribbon-like appendages in the center and one double-apical lateral tooth on each side	<i>H. appendiculata</i>
–	The genital plate bears two lateral teeth on each side.....	<i>H. soldatovi</i>

second segment of the exopodite of the left leg is rectangular, elongated, with almost parallel anterior and posterior sides; at the end, it bears two spines, one of which is long, and the other is short and curved. The inner side of the exopodite contains six to eight conical chitinous outgrowths.

The present study shows that both females and males of all five *Heterocope* species inhabiting Russian territory clearly differ from each other. A detailed comparative analysis of morphological differences and the identification table of species compiled on its basis will ensure the unambiguous identification of members of the genus. This is especially important for the analysis of the fauna in the regions where different *Heterocope* species live together, which is typical of the northern Palaearctic.

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