New data on psammorheophilous Limoniidae (Diptera) of NE European Russia

Новые данные о псаммореофильных лимониидах (Diptera: Limoniidae) Северо-Востока европейской части России

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The new records of five species of Limoniidae (Diptera) are given: *Rhabdomastix beckeri* (Lackschewitz, 1935) and *Scleroprocta pentagonalis* (Loew, 1873) are recorded for the first time from Russia; the first reliable record of *Eloeophila mundata* (Loew, 1871) from Russia is given; *Hexatoma fuscipennis* (Curtis, 1836) and *H. nubeculosa nubeculosa* (Burmeister, 1829) are recorded for the first time from NE European Russia. It is found that the larvae of four species, *R. beckeri*, *S. pentagonalis*, *E. mundata* and *H. fuscipennis*, in NE European Russia (Perm Territory and Udmurtia) are aquatic psammorheophilous forms inhabiting sandy sediments at the bottom of rivers in sites with strong current. Previously the larvae in these genera and in three of these species have been considered mostly as semiaquatic forms that develop in substrata near the water margin. Larval habitats of the four species in the study area are characterized. The photographs of diagnostic characters of adult males of these species are given.

В статье приводятся новые находки для 5 видов комаров-лимониид (Diptera, Limoniidae): *Rhabdomastix beckeri* (Lackschewitz, 1935) и *Scleroprocta pentagonalis* (Loew, 1873) впервые отмечены для России, *Eloeophila mundata* (Loew, 1871) впервые достоверно отмечен для России, *Hexatoma fuscipennis* (Curtis, 1836) и *H. nubeculosa nubeculosa* (Burmeister, 1829) впервые отмечены для северо-востока европейской части России. Показано, что личинки 4 видов (*R. beckeri*, *S. pentagonalis*, *E. mundata* и *H. fuscipennis*) на северо-востоке европейской части России (Пермский край и Удмуртия) – это водные псаммореофильные формы, обитающие в песчаных грунтах на дне рек на участках с сильным течением. Ранее личинки из этих родов и трёх из этих видов рассматривались преимущественно как полуводные формы, проходящие развитие в субстратах вблизи уреза воды. Охарактеризованы биотопы развития личинок 4 видов. Приведены фотографии диагностических признаков имаго (самцов) этих видов.

Key words: short-palped crane flies, distribution, larval habitats, rearings, benthos, sand, psammon, psammorheophilous fauna, river, Perm Territory, Udmurtia, Diptera, Limoniidae, new records

Ключевые слова: лимонииды, распространение, биотопы развития личинок, выведения, бентос, песок, псаммон, псаммореофильная фауна, реки, Пермский край, Удмуртия, Diptera, Limoniidae, новые находки

INTRODUCTION

Sandy substrates occupy large areas of bottom in many rivers of European Russia, in particular, in the Volga Basin (Shadin, 1950). Moving sand in the sites with high water current is a peculiar extreme habitat, with a highly specialized but still poorly studied insect fauna, in which dipteran larvae usually predominate. A number of dipteran species is associated with this habitat, including the species whose larvae live only

in moving sand (psammorheobionts; represented mostly by members of Chironomidae) and the species whose larvae prefer this habitat but are able to live also in other ones (psammorheophiles).

The larvae of Limoniidae (Diptera) in several genera are often mentioned as a component of river benthos, in particular of sandy habitats, however, most identifications in hydrobiological works based on larvae are not reliable. The results presented in a few papers (Pozdeev, 2004, 2017; Pozdeev & Kotelnikova, 2014) demonstrate that the larvae of Limoniidae play an important role in the benthic communities of rivers in NE European Russia.

This paper provides the first reliable data from NE Russia on several limoniid species whose larvae live in moving sand on river bottom, based on the rearings of adults, together with the new data on larval habitats and the new regional records.

MATERIAL AND METHODS

The material of larvae was collected from bottom sediments up to a ca. 10 cm depth with D-frame aquatic nets and with a modified grab-net Gruzov sampler (see Philippov et al., 2017). The aquatic habitats were sampled up to 2.5 m of water height. For extracting the larvae from sand, elutriation in a net or in a bucket with water and washing on sieves was mostly used. Additional material of adult Limoniidae was collected by net-sweeping near the larval habitats.

Current velocity was measured using a propeller flowmeter, water pH with a Hanna pHep+ pH meter, and water mineralization with a Hanna DIST2 conductometer.

The larvae and adults were collected in early September 2016, late May – early June 2017 and late July 2017, from ten different-sized running waters including streams, small, medium-sized and large rivers in Perm Territory and Udmurtia.

Most of larvae collected were kept alive in 50–250 ml plastic containers with partially watered sand taken from larval habitats. The containers were kept in the fridge at a temperature 5 to 15 °C depending on the season, at a dial light regime similar to the natural one at the sampling latitude.

The collected and reared specimens were kept in ca. 80% ethanol and deposited at the Zoological Institute, St Petersburg, Russia. The unreared larvae mentioned below were identified to generic level only.

The photos of morphological details were taken under a LOMO MSP-2 stereomicroscope with a Canon EOS 60D digital camera. The structures of the male terminalia were photographed after detachment, mostly after treatment in hot 10% KOH, washing in water and dissection in a drop of glycerol; the images were taken from temporary slides under a Leica DFC320 microscope with the above equipment or with a LOMO MC-6.3 digital camera with or without Nomarski contrast. In all the cases, the series of images were taken, then z-stacked using Helicon Focus 6 software and edited using Adobe Photoshop CS software.

STUDY LOCALITIES

Here, the conditions of three main sampling localities in Perm Territory (areas of moving sand on river bottom) are briefly characterized.

1. Vishera River is a large river, at sampling locality (near vill. Ryabinino, Cherdyn District, 60.32507°N 56.500827°E, 111 m; Fig. 19) ca. 300 m wide and no less than 4–5 m deep. The sampling sites were situated closer to the right bank, 50–100 m from the water margin; the water height at the sites in mean water periods was 1.5–2.5 m. The bottom substrate is fine sand with traces of detritus. The current velocity was 45–50 cm/s; water temperature reached 19 °C in summer; water pH was around 8.0, mineralization 0.19–0.26 ppt.

2. Yaiva River is a medium-sized river, (near vill. Romanovo, Usol'e District, 59.14951°N 56.78893°E, 105 m), ca. 100 m wide and 1–1.5 m deep. The sampling sites

were close to the right bank at river bend; the water height at the sites in mean water periods was 20–80 cm. The bottom substrate is coarse sand with small amount of detritus. The current velocity was 20–40 cm/s; water temperature reached 18–19 °C in summer; in September 2016, water pH was 8.3, mineralization 0.58 ppt.

3. Kemzelka River (about 1 km upstream of vill. Pokcha, Cherdyn District, 60.46665°N 56.44374°E, 118 m; Fig. 20) is a small river, 3–8 m wide and 20–70 m deep, situated in a 1–5 m deep valley in a mixed forest. Predominant bottom substrate is fine very clean sand, without traces of detritus, except for narrow lateral parts with muddy substrate. The sampling sites were situated along the medial zone of the riverbed; the water height at the sites was 20–60 cm in all periods of sampling. The current velocity varied between 10–60 cm/s, typically was 30–40 cm/s; water temperature was 5–10 °C in all sampling periods, never exceeding 10.5°C even in hot summer days; water pH was 7.4–8.5, mineralization 0.1–0.26 ppt.

RESULTS

Family **LIMONIIDAE**

Subfamily **CHIONEINAE**

Rhabdomastix* (s. str.) *beckeri (Lackschewitz, 1935) (Figs 1–7)

Material. Perm Terr., Cherdyn Distr., Vishera River, left bank opposite to vill. Ryabinino, 60.32507°N 56.500827°E, 111 m, sand at river bottom, water height ca. 2 m, pupa with pharate male obtained 25.VIII.2017 from larva collected 6.IX.2016 (Przhiboro leg.); same locality, sandy shore, net-sweeping, 5.IX.2016, 3 males (Pozdeev & Przhiboro leg.); same locality, 25.VII.2017, 1 male (Przhiboro leg.). *Perm Terr.*, right bank of Kama River at Gainy Town, 60.32243°N 54.32874°E, 183 m, low sandy shore 50 m from water margin, net-sweeping, 2 males, 28.VII.2017 (Przhiboro leg.).

Notes. New record for Russia. *Rhabdomastix beckeri* is a rare distinctive species, which was described from SW Romania (Orsova at the Danube River) and later recorded only from a single locality in Slovakia (Starý, 2004). Possibly the species has a broad European distribution.

The only pharate male was obtained from a larva collected from the bottom of the Vishera River; the terminalia of this specimen fit to those in the adult males swept in two localities, one of which is the same as for the larva (see Material). Our specimens fit well to the redescription by Starý (2004) but the darker coloration along wing veins is not pronounced (see Figs 1, 3).

The habitat in NE European Russia is illustrated in Fig. 19. The sampling habitat in Slovakia is a sandy bank of the Tisa River similar to those in Perm Territory (Starý, pers. comm.). Nothing was known about the larval habitats of *R. beckeri*. *Rhabdomastix* larvae of different size groups were common in moving sand areas on the bottom of Kama and Vishera rivers at the study sites (see Material) but were not found in similar habitats of smaller running waters. According to these data *R. beckeri* seems to be a true aquatic psammorheophilous or even psammorheobiontic species living in large rivers.

Scleroprocta pentagonalis (Loew, 1873) (Figs 8–13)

Material. Perm Terr., Cherdyn Distr., Kemzelka River about 1 km upstream of vill. Pokcha, 60.46665°N 56.44374°E, 118 m, fine sand at river bottom, water height 0.3–0.6 m, 5 males and 7 females reared 19.VI–14.VII.2017 from larvae collected 30.V.2017 (Przhiboro leg.).

Notes. New record for Russia. The species was known from many European countries, mostly in middle Europe, and also from E Kazakhstan; the nearest record is from Finland (Savchenko, 1989; Savchenko et al., 1992; Starý, 2008; Oosterbroek, 2017).

Some external characters proposed by Savchenko (1982) for distinguishing *S. pentagonalis* and *S. sororcula* (Zetterstedt, 1851) seem to be not reliable: in several specimens in my material, the vein *m-cu* is at *M*-fork and the pterostigma is well distinct (Fig. 9).

The habitat in NE European Russia is illustrated in Fig. 20. In this area, I found *Scleroprocta* larvae in moving sand in three different small cold rivers in forests, but no records were from larger rivers. As distinct from larvae in three other genera, the early instar larvae of *Scleroprocta* were almost absent in moving sand in the medial zone of rivers. The larvae, mostly of later instars, were found in this habitat in spring and in autumn, but no larvae were found during summer, after the emergence of adults (Pozdeev and Przhiboro, pers. obs.). It is possible that the early instars of *Scleroprocta* are confined mostly to lateral parts of the riverbed.

In western and central Europe, the species is associated with various small running waters, mostly different-type springs and streams, but mostly was reared from semi-aquatic habitats (Oosterbroek, 2017 and references therein). However, Podeniene (2009) indicated that the larvae of this species can be found underwater.

Subfamily **LIMNOPHILINAE**

Eloeophila mundata (Loew, 1871)
(Figs 14–16)

Material. Perm Terr., Cherdyn Distr., Kemzelka River about 1 km upstream of vill. Pokcha, 60.46665°N 56.44374°E, 118 m, fine sand at river bottom, water height 0.3–0.6 m, 5 males and 2 females reared 22.vi.2017 from larvae collected 30.V.2017 (Przhiboro leg.).

Notes. The first reliable record from Russia. Previously, Chuzhekova (2015) identified as this species the larvae from springs in Samara Prov. and Oosterbroek (2017) mentioned this species from Bashkortostan referring to a personal communication by D.I. Gavryushin.

The species was known from many European countries, mostly in middle and southern Europe; the nearest record is from southern Finland (Savchenko, 1989; Savchenko et al., 1992; Oosterbroek, 2017).

The habitat in NE European Russia is illustrated in Fig. 20. In western and central Europe, the species occurs mostly at small running waters, e.g. springs, springbrooks and streams (Oosterbroek, 2017 and references therein). It was supposed to develop or, more rarely, recorded as developing, in substrata at the margins of these running waters (e.g., Pokorny, 1978; Reusch & Hohmann, 2009).

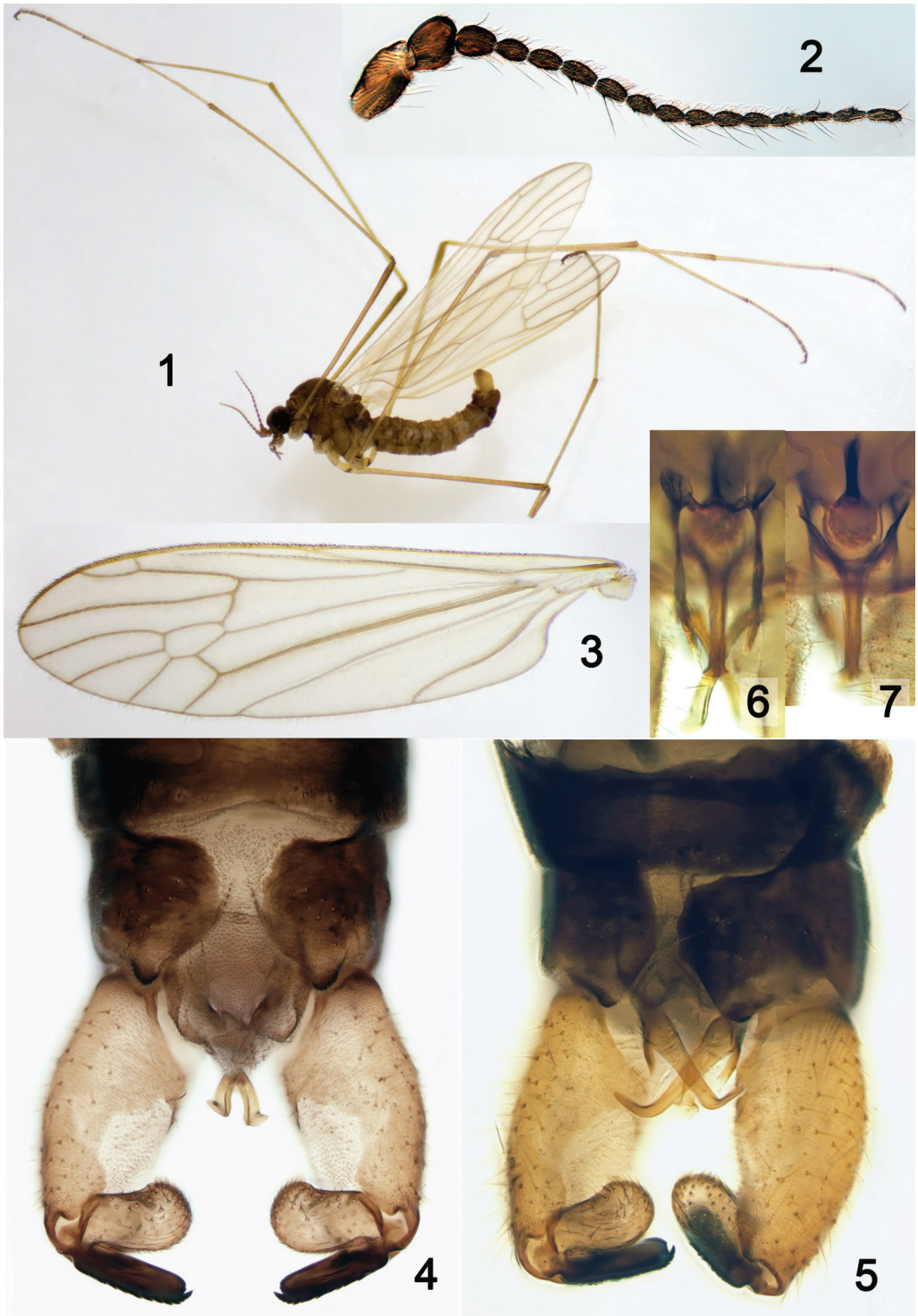
Hexatoma* (s. str.) *fuscipennis
(Curtis, 1836)
(Figs 17–18)

Material. Perm Terr., Usol'e Distr., left bank of Yaiva River opposite to vill. Romanovo, 59.14951°N 56.78893°E, 105 m, coarse sand at river bottom, water height ca. 0.5 m, pupa with pharate male reared 15.V.2017 from larva collected 3.IX.2016 (Przhiboro leg.). *Perm Terr.*, Cherdyn Distr., Vishera River, left bank opposite to vill. Ryabinino, 60.32507°N 56.500827°E, 111 m, sandy shore, net-sweeping, 25–26. VII.2017, 1 male, 1 female (Pozdeev & Przhiboro leg.). *Udmurtia*, Debesy Distr., right bank of Cheptsa River near (upstream of) vill. Chepyk, 57.72123°N, 53.64775°E, 211 m, net-sweeping of shoreline vegetation, 2.VI.2017, 9 males, 4 females (Pozdeev & Przhiboro leg.).

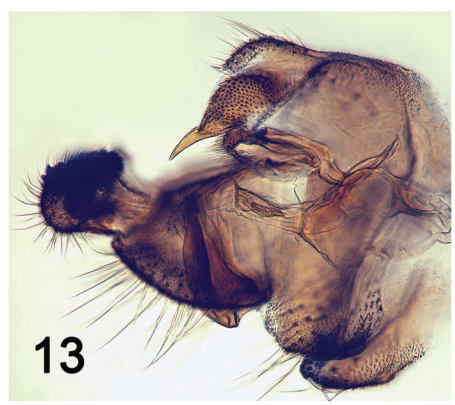
Notes. The first record from NE European Russia. Widely distributed European species known also from the Caucasus (Georgia, according to personal communication by V.I. Lantsov) and in the Near East (Savchenko, 1989; Savchenko et al., 1992; Oosterbroek, 2017). In Russia, it was recorded from Leningrad Prov. (Stackelberg, 1951), Crimea (Savchenko, 1986), Orenburg Prov. (Savchenko, 1989) and Marii El Republic (Paramonov, 2011); Oosterbroek (2017) also mentioned it from Murmansk Prov. referring to a personal communication by D.I. Gavryushin.

The species is associated with rivers; at least in the Great Britain, it is mostly recorded from sandy banks (Oosterbroek, 2017 and references therein).

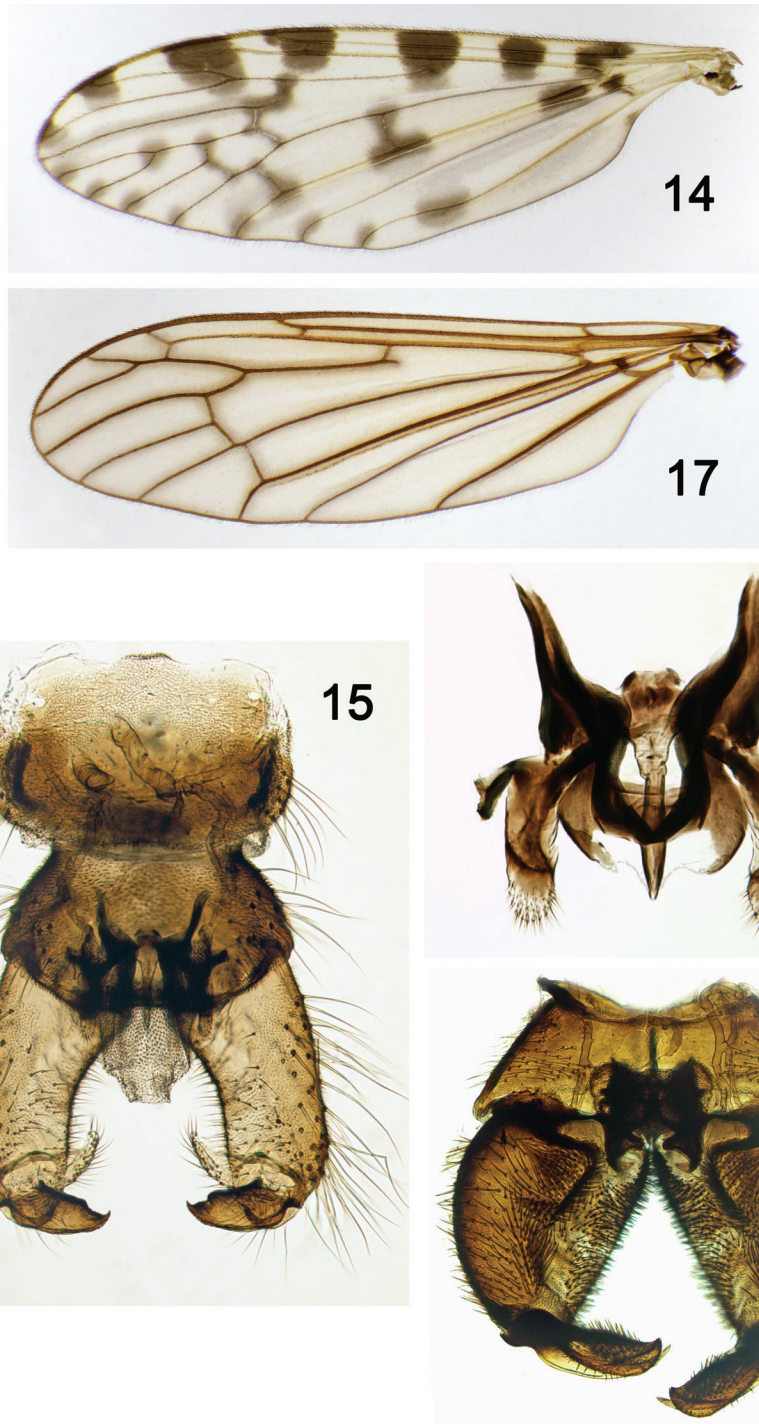
In the study area, the larvae of *Hexatoma* were common on sandy and gravel substrata in rivers, medium-sized to large, on sites with water height 0.3 to 2 m, but they were not found in cold small rivers like Kem-



Figs 1–7. *Rhabdomastix beckeri*, adult male (1, Gaino, Perm Terr.; 2–7, Ryabinino, Perm Terr.). **1**, total view; **2**, antenna; **3**, wing; **4–5**, hypopygium, in dorsal view (4, cleared; 5, uncleared); **6–7**, aedeagal complex (in two different layers).



Figs 8–13. *Scleroprocta pentagonalis*, adult male (Pokcha, Perm Terr.). **8**, antenna; **9**, wing; **10–13**, hypopygium, cleared (10, dorsal view; 11, inner structures including aedeagal complex; 12, ventral view; 13, right lateral view, with aedeagal complex shown).



Figs 14–18. Limoniidae, adult males. **14–16**, *Eloeophila mundata* (Pokcha, Perm Terr.); **17–18**, *Hexatoma fuscipennis* (Chepyk, Udmurtia). 14, 17, wing; 15, 18, hypopygium (dorsal view, cleared); 16, aedeagal complex.

Figs 19–20. Aquatic larval habitats of psammorheophilous Limoniidae in Perm Territory. **19**, Vishera River at vill. Ryabinino, an example of large river with large areas of sandy bottom and high current velocity; a habitat of *Rhabdomastix beckeri*; **20**, Kemzelka River near vill. Pokcha, an example of small river with sandy bottom and high current velocity; a habitat of *Scleroprocta pentagonalis* and *Eloeophila mundata*. Photos were taken on October 5, 2016. Arrows indicate typical collecting sites of mature larvae.

zelka. It is probable that other species of *Hexatoma* inhabit river bottom in the same region as well, considering that *Hexatoma nubeculosa* (Burmeister, 1829) occurred as adults at the banks of the same rivers (see below). Hence, more larvae associated with adults are necessary.

Hexatoma* (s. str.) *nubeculosa nubeculosa (Burmeister, 1829)

Material. Perm Terr., Cherdyn Distr., Vishera River, left bank opposite to vill. Ryabinino, 60.32507°N 56.500827°E, 111 m, sandy shore, net-sweeping, 25.VII.2017, 1 female (Pozdeev leg.). *Perm Terr.*, right bank of Kama River at Gainy Town, 60.32243°N 54.32874°E, 183 m, low sandy shore 50 m from water margin, net-sweeping, 4 males, 2 females, 28.VII.2017 (Przhiboro leg.).

Notes. The first record from NE European Russia. The subspecies is known from middle Europe, the central and southeastern parts of European Russia: Moscow and Orenburg provinces and the Republic of Tatarstan (Savchenko, 1989; Savchenko et al., 1992; Paramonov, 2014; Oosterbroek, 2017).

The data on the larval habitat of this species were found only in Podeniene & Gelhaus (2015), who collected the larvae of *H. nubeculosa* from sand or gravel on the bottom of large and medium-sized rivers in Mongolia and reared them to adults. [Podeniene & Gelhaus (2015) did not specify subspecies; probably they had *H. nubeculosa longivena* Savchenko, 1972, which was described from Krasnoyarsk Territory of Russia and from Mongolia (Savchenko, 1972)]. It is probable that the larvae of *H. nubeculosa* in NE European Russia develop on sandy bottom of large rivers as well, considering that the larvae of *Hexatoma* were common in this habitat at the sites where the adults of *H. nubeculosa* were collected.

DISCUSSION

The above new records indicate not only the poor knowledge of the regional crane fly fauna in NE European Russia but also an importance of the hydrobiological approaches and rearing techniques in studying the diversity of this group. It is probable that many species are mostly confined to sandy areas of rivers so they hardly can be collected at a distance of such places.

It is evident that the larvae of species considered in the paper are truly aquatic at least in the habitats and rivers of the study region. According to the author's laboratory observations, they can live for weeks underwater without aeration at 5–12 °C. A low number of 'underwater' records of these species in Western Europe either indicates a lack of attention to rearing aquatic larvae (which is almost always necessary to get precise identifications) or points to a difference in the habitat conditions of lowland running waters, first of all, in the oxygenic regime.

The recently published data on the larvae of different species in *Hexatoma* from different parts of the Palaearctic testify that these larvae are truly aquatic, confined to running waters and develop mostly or only on the bottom of streams and rivers rather than in the water margin zone (Przhiboro et al., 2009; Lantsov, 2012; Podeniene & Gelhaus, 2015). Additional data on running waters in different regions (the North Caucasus, the Kuril Islands, Kamchatka, etc.) confirm this conclusion (Przhiboro, unpublished).

Apparently the four recorded limoniid species are psammorheophilous. They are probably confined to sandy sites in rivers but display habitat selectivity, probably depending mostly on the river size, water temperature and trophic conditions. More detailed sampling from different habitats and rearings of adults is necessary to clarify these assumptions.

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