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Original paper

New geographical and host records of bat fleas (Siphonaptera: Ischnopsyllidae) in Russia

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ABSTRACT. To better understand the distribution and host-parasite relationships, we explored 12 large regions of Russia and recorded new bat fleas (Insecta: Siphonaptera: Ischnopsyllidae) for Dagestan, Bashkiria, Mordovia, Khakassia and Buryatia Republics. Also we curate previously known data and registered new host-parasite associations for species belonging to genus *Ischnopsyllus* (*Ischnopsyllus octactenus* and *I. variabilis* ex *Pipistrellus pygmaeus*, *I. intermedius* ex *Hypsugo savii*, *I. variabilis* ex *Myotis dasycneme, I. hexactenus* ex *Murina hilgendorfi*) and species *Myodopsylla trisellis*. One of the associations we recorded in Altai republic is particularly interesting (*Myodopsylla trisellis – Myotis blythii*). Further investigation is required to study vector role of bat fleas and the effects of flea parasitism on their natural hosts.

Keywords: bat flea, Ischnopsyllidae, *Myodopsylla trisellis*, *Myotis blythii*, Russia, parasite, biodiversity

Introduction

Territory of Russia is inhabited about 50 bat species mostly belonging to the family Vespertilionidae [1]. According to Lanza [2], 64 taxa of Siphonaptera has been reported as bat parasites in Europe. These species, mostly, belong to the family Ischnopsyllidae Wahlgren, 1907 and, to a lesser extent, to the Ceratophyllidae, Leptopsyllidae (accidental parasitism) and Pulicidae (accidental parasitism) families.

The cosmopolitan family Ischnopsyllidae Wahlgren, 1907 (Insecta: Siphonaptera) comprises specific bat fleas. It comprises 120 species belonging to 20 genera of two subfamilies: Ischnopsyllinae Wahlgren, 1907 and Thaumapsyllinae Jordan, 1947 [3]. Of these, Ischnopsyllinae includes 14 Russian species of 4 genera (*Myodopsylla*, *Ischnopsyllus*, *Nycteridopsylla* and *Rhinolophopsylla*) [4].

To date, ecology of fleas of Ischnopsyllidae is still poorly understood. Although *Ischnopsyllus octactenus* and *Nycteridopsylla pentactena* were regarded as vectors of bacterian pathogenes *Bartonella* sp. and *Rickettsia helvetica* [5], the number of infections related to bat flea-borne pathogens still remains unclear. This paper provides new geographical and host registrations of bat fleas from 12 regions of Russia.

Materials and Methods

Bat ectoparasites were collected from the eighteen localities of 12 regions in Russian Federation as follows (Fig. 1):

Figure 1. Map of collection localities (the numbers correspond to the list in the Material and Methods section)

1. Mordovia Republic: Mordovskiy State Natural Reserve 54°49'N; 43°20'E (region 1 in the map)
2. Penza Province: Penza 53°10'N; 45°05'E (region 2)
3. Rostov Province: Alexandrovskiy leskhoz 46°45'N; 39°08'E (region 3)
4. Rostov Province: Veshinskaya settlement 49°37'N; 41°43'E (region 3)
5. Krasnodar Province: Akhshtyrskaya Cave 43°31'N; 39°59'E (region 4)
6. Dagestan Republic: Terek River 43°31'N; 46°25'E (region 5)
7. Samara Province: State Nature Reserve "Samarskaya Luka" 53°18'N; 49°49'E (region 6)
8. Bashkiria Republic: Bol'shoy Kizil River 52°43'N; 58°54'E (region 7)
9. Bashkiria Republic: Maliy Kizil River 53°30'N; 59°00'E (region 7)
10. Bashkiria Republic: Yangel'ka River 53°30'N; 58°39'E (region 7)
11. Bashkiria Republic: Kapova Cave 53°03'N; 57°04'E (region 7)
12. Chelyabinsk Province: nearest of Kyshtym town 55°37'N; 60°39'E (region 8)
13. Chelyabinsk Province: Bol'shoy Kisegach Lake 55°02'N; 60°18'E (region 8)
14. Tyumen Province: biological station "Lukashino" 57°19'N; 64°59'E (region 9)
15. Altai Region: Ust'-Pustynka Cave 51°28'N; 83°11'E (region 10)
16. Khakassia Republic: Arkheologicheskaya Cave 54°24'N; 89°25'E (region 11)
17. Buryatia Republic: nearest of Bayan settlement 50°32'N; 105°16'E (region 12)
18. Buryatia Republic: Dolganskaya Yama Cave 54°28'N; 113°47'E (region 12)
19. Buryatia Republic: Natural Park "Tunkinskiy" 51°40'N; 102°15'E (region 12)

Bats were captured by mist nets and identified using morphological measurements following [6]. All captured bats of the *Myotis daubentonii* species-complex from eastern areas of the Ob' river within the Khanty-Mansiysk Autonomous Region and eastern areas of the Ob-Irtysh interfluve were identified as *Myotis petax* Hollister, 1912 [7,8]. Small mouse-eared bats belonging to the *Myotis brandtii*-group and *Plecotus* cf. *auritus* (Linnaeus, 1758) from West Altai and the Ob' river were identified as *Myotis sibiricus* Kastschenko, 1905 and *Plecotus ognevi* Kishida, 1927, respectively [8]. *M. mystacinus* (Kuhl, 1817) from Central Asia and *M. aurascens* Kuzyakin, 1935 was considered as junior synonyms of *Myotis davidii* (Peters, 1869) [9]. Natterer's bats, *M. nattereri* (*sensu lato*), from the Baikal region and eastern Russia were regarded as *M. bombinus* Thomas, 1906 [10]; *M. capaccini* (*sensu lato*) from the Far East region were reclassified as *M. macrodactylus* (Temminck, 1840) [11,12]. All individuals of *Murina leucogaster* (*sensu lato*) from Russia were identified as *Murina hilgendorfi* Gray, 1842; and individuals of *Miniopterus schreibersi* (*sensu lato*) from Eastern Russia were identified as

Table 1. Our findings of bat fleas in Russia

Host species	Bat flea species					Total
	Myodopsylla trisellis	*Ischnopsyllus* (*I.*) *octactenus*	*Ischnopsyllus* (*I.*) *intermedius*	*Ischnopsyllus* (*I.*) *variabilis*	*Ischnopsyllus* (*H.*) *hexactenus*	
Myotis blythii	2	–	–	–	–	2
M. nattereri	–	–	–	3	–	3
M. dasycneme	384	–	–	22	–	406
M. daubentonii	7	–	–	1	–	8
M. mystacinus	1	–	–	–	–	1
M. davidii	2	–	–	–	–	2
Vespertilio murinus	1	–	–	2	–	3
Nyctalus noctula	–	1	–	–	–	1
Pipistrellus nathusii	–	–	–	39	–	39
P. pipistrellus	–	–	–	5	–	5
P. pygmaeus	–	5	–	4	–	9
Hypsugo savii	–	–	2	–	–	2
Eptesicus nilssonii	–	–	–	1	–	1
Plecotus auritus	–	–	–	–	3	3
Pl. ognevi	–	–	–	–	30	30
Murina hilgendorfi	–	–	–	–	98	98
Total	397	6	2	77	131	613

Miniopterus fuliginosus (Hodgson, 1835) [8,13–15].

The body parts (face, back, tail, wings, ears, uropatagium) of all captured bats were visually examined for ectoparasites using an LED headlamp. All ectoparasites from each bat were removed with forceps and placed into a single vial filled with 95% ethanol (for each host individual). They were then transferred into a new vial containing 70% ethanol and delivered to the lab for mounting and identification. Flea specimens were cleared in 5% KOH for 24 hours, washed in distilled water, and mounted on permanent microscopic slides in Faure-Berlese's mounting medium [16]. Morphological identification was done by MO using the following Hopkins and Rothschild [17] and Medvedev [4]. Every bat was released after collecting ectoparasites and identified morphologically [6].

Non-chiropteran hosts are indicated in square brackets in the relevant sections of the text.

Results

We investigated 269 bat specimens belonging to 16 species and collected 613 flea individuals belonging to five species and two genera: *Myodopsylla trisellis* Jordan, 1929, *Ischnopsyllus* (*I.*) *octactenus* (Kolenati, 1856), *Ischnopsyllus* (*I.*) *intermedius* (Rothschild, 1898), *Ischnopsyllus* (*I.*) *variabilis* (Wagner, 1898) and *Ischnopsyllus* (*H.*) *hexactenus* (Kolenati, 1856) (Tab. 1).

Family Ischnopsyllidae Wahlgren, 1907

Genus *Myodopsylla* Jordan et Rothschild, 1911

***Myodopsylla trisellis* Jordan, 1929 (Fig. 2)**

Material. ♂ ex *Myotis mystacinus* 25 XI 2001, from "Samarskaya Luka", leg. D.G. Smirnov; 9 ♀♀, 4 ♂♂ ex *M. dasycneme* 13 VII 2010 from nearest of Kyshtym town, leg. O.L. Orlov, M.V. Orlova; 10 ♀♀, ♂ ex *M. dasycneme* 1 VI 2013, from nearest of Kyshtym town, leg. O.L. Orlov, M.V. Orlova; 222 ♀♀, 93 ♂♂ ex *M. dasycneme* 2 VII 2013, from

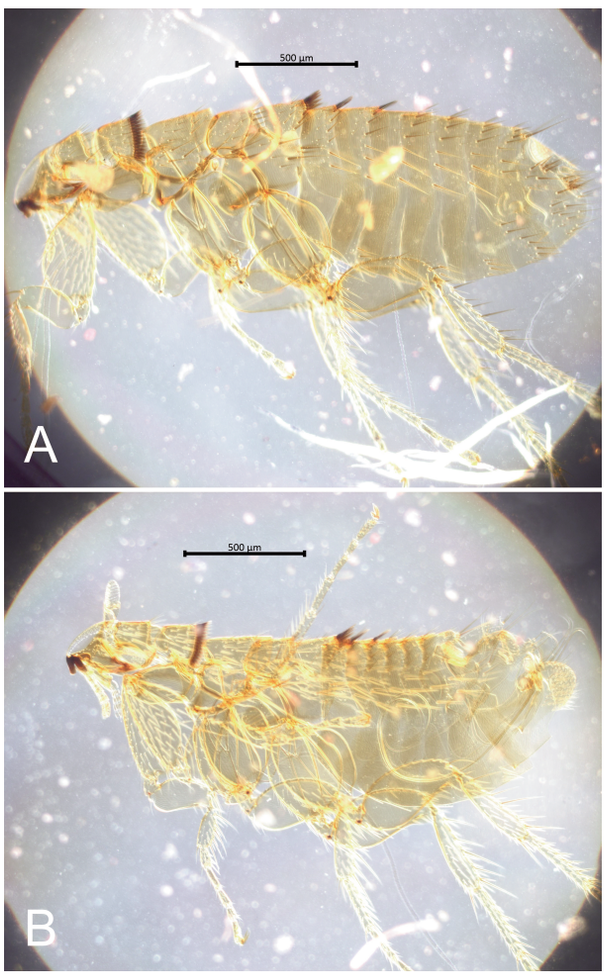

Figure 2. *Myodopsylla trisellis* ex *Myotis blythii*: A. female, B. male

nearest of Kyshtym town, leg. O.L. Orlov, M.V. Orlova; 23 ♀♀, 14 ♂♂ ex *M. dasycneme*, 2 ♀♀ ex *M. daubentonii*, ♀ ex *Vespertilio murinus* 26 VII 2013, from nearest of Kyshtym town, leg. O.L. Orlov, M.V. Orlova; ♀, ♂ ex *M. davidii* 6 VII 2016, from nearest of Bayan settlement, leg. D.V. Kazakov; ♀ ex *M. dasycneme* 11 VII 2018 from biological station "Lukashino", leg. O.L. Orlov, M.V. Orlova; 2 ♀♀ ex *M. daubentonii* 19 VIII 2014, from Bol'shoy Kizil River, leg. A.V. Zhigalin; ♀, ♂ ex *M. daubentonii* 24 VIII 2014, from Maliy Kizil River, leg. A.V. Zhigalin; ♂ ex *M. daubentonii*, 4 ♀♀, 3 ♂♂ ex *M. dasycneme* 21 VIII 2014, from Yangel'ka River, leg. A.V. Zhigalin; ♀, ♂ ex *M. blythii* 15 VIII 2019, from Ust'-Pustynka Cave, leg. J. Pikula, O.L. Orlov.

New geographical records. Results from the present study include the first records from three provinces, namely Chelyabinsk Province, Tyumen Province, Altai republic..

Previous records in Russia. Leningrad Province [18,19], Moscow Province [19], Voronezh Province [19,20], Saratov Province [20], Udmurtia Republic [21], Perm Region [22], Sverdlovsk Province [22], Chelyabinsk Province (present paper, new record), Tyumen Province (present paper, new record), Khanty-Mansi Autonomous Region [23,24], Novosibirsk Province [20,26], Altai republic (present paper, new record), Khakassia republic [28], Tuva Republic [27], Kemerovo Province [26], Krasnoyarsk Region [20], Irkutsk Province [19,20,29,30], Buryatia Republic [28], Zabaykal'skiy region [20], Yakutia Republic [28], Khabarovsk Region [20], Magadan Region [20,31], Primorskiy Region [31], Kamchatka Region [20,31], Povolzhie [19,29,30].

Distribution outside Russia. Finland [32], Latvia [33], Estonia [34], Kazakhstan [35], China [36], Japan [37].

Hosts. *Myotis blythii* (present study, new record), *M. dasycneme* [22], *M. davidii* (present paper, new record), *M. daubentonii* [22], present paper], *M. brandtii* [22,24], *M. mystacinus* [20], *M. ikonnikovi* [31], *M. nattereri* [20], *M. sibiricus* [28; as *M. gracilis* – 37], *M. petax* [25; as *M. daubentonii* 31], *Pipistrellus nathusii* [20], *Eptesicus nilssonii* [18], *Vespertilio murinus* [20; present study], *Plecotus ognevi* [*as P. auritus* – 31], *Murina hilgendorfi* (present study, new record).

***Ischnopsyllus* (*I.*) *octactenus* (Kolenati, 1856)**

Material. ♂ ex *Nyctalus noctula* 21 VI 2016, from Mordovskiy State Natural Reserve, leg. D.G. Smirnov; 2 ♀♀ ex *Pipistrellus pygmaeus* 9 VII 2017, from Alexandrovskiy leskhoz, leg. A.V. Zabashta; ♂ ex *Pipistrellus pygmaeus* 28 VI 2017, from Alexandrovskiy leskhoz, leg. A.V. Zabashta; ♀ and ♂ ex *Pipistrellus pygmaeus* 2 VII 2017, from Alexandrovskiy leskhoz, leg. A.V. Zabashta.

Distribution in Russia. Crimea Republic [38–40), Rostov Province [41; present paper], Krasnodar Region [42,43], Severnaya Osetia [43], Dagestan [41], Mordovia Republic (present paper, new record).

Distribution outside Russia. Europe [17]. Asia: Turkey [44], Lebanon [45], Kyrgyzstan [35], Kazakhstan [35]. Africa: Morocco [17], Algeria [46].

Hosts. *Pipistrellus pipistrellus* [43; as *Vespertilio pipistrellus*, as *Scotophilus pipistrellus* – 17], *P. kuhlii* [as *Vespertilio kuhlii* – 17], *P. pygmaeus* (present study, new record), *Myotis mystacinus* [as *Vespertilio mystacinus* – 17], *M. nattereri* [as *Vespertilio nattereri* – 17], *M. daubentonii* [47], *M.*

emarginatus [47], *M. myotis* [47], *Nyctalus noctula* [as *Vesperugo noctula* – 17; present study], *Nyctalus leisleri* [as *Vesperugo leisleri*, as *Scotophilus leisleri,* as *Pterygistes leisleri* – 17], *Eptesicus serotinus* [47], *Eptesicus nilssonii* [47], *Plecotus auritus* [47], *Barbastella barbastellus* [47], *Vespertilio murinus* [47], *Hypsugo savii* [as *Vespertilio savii*, as *Pipistrellus savii* – 17], *Rhinolophus hipposideros* [47], *Miniopterus schreibersii* [48], [*Mus musculus*] [17].

Ischnopsyllus (I.) intermedius (Rothschild, 1898)

Material. 2 ♀♀ ex *Hypsugo savii* 1–31 VIII 2001, from Akhshtyrskaya Cave, leg. D.G. Smirnov.

Distribution in Russia. Crimea Republic [38], Rostov Province [43], Stavropol' Region [43], Krasnodar Region [43; present study], Severnaya Osetia [43].

Distribution outside Russia. Europe: Baltic states [34], Belorussia [49]. Caucasus: Georgia [50]. Asia: Kazakhstan [35], Iran [51], Africa: Algeria [46].

Hosts. *Eptesicus serotinus* [43], *Pipistrellus pipistrellus* [43], *Myotis dasycneme* [35], *My. blythii* [47], *Nyctalus noctula* [43], *Ny. azoreum* [17], *N. leisleri* [17], *Hypsugo savii* (present study, new record), *Plecotus auritus* [47], *Eptesicus nilssonii* [47], *Barbastella barbastellus* [47], *Rhinolophus hipposideros* [47].

***Ischnopsyllus* (*I.*) *variabilis* (Wagner, 1898)**

Material. ♂ ex *Vespertilio murinus*, ♂ ex *Myotis dasycneme* 13 VII 2010, from Kyshtym, leg. O.L. Orlov, M.V. Orlova; 5 ♀♀, 6 ♂♂ ex *M. dasycneme* 1 VI 2013, from Kyshtym, leg. O.L. Orlov, M.V. Orlova; ♀ ex *V. murinus* 26 VII 2013, from Kyshtym, leg. O.L. Orlov, M.V. Orlova; ♀ ex *Pipistrellus nathusii* 18 VII 2014, from Bolshoy Kisegach Lake, leg. O.L. Orlov; 2 ♀♀ ex *P. nathusii* 20 VIII 2014, from Elimbetovo village, leg. A.V. Zhigalin; 4 ♀♀ ex *P. pipistrellus*, 27 ♀♀, 3 ♂♂ ex *P. nathusii* 1 VI 2015, from Veshinskaya settlement, leg. M.V. Orlova, A.P. Golovanova; 2 ♀♀, ♂ ex *P. pygmaeus* 3 VII 2016, from Alexandrovskiy leskhoz, leg. A.V. Zabashta; ♀ ex *Eptesicus nilssonii* 1-31 VII 1994, from Samarskaya Luka, leg. D.G. Smirnov; 3 ♀♀ ex *Myotis nattereri* 25 XI 2001, from Samarskaya Luka, leg. D.G. Smirnov; ♀ ex *P. pygmaeus*, ♀ ex *P. nathusii* 1-31 VII 2006, from Samarskaya Luka, leg. D.G. Smirnov; 2 ♀♀ ex *P. nathusii* 1-31 V 2006, from Penza, leg. D.G. Smirnov; 7 ♀♀, 3 ♂♂ ex *M. dasycneme*, ♀ ex *M. daubentonii,* 3 ♀♀ ex *P. nathusii* 21-23 VI 2016, from Mordovskiy State Natural Reserve, leg. D.G. Smirnov; ♀ ex *P. pipistrellus* 22 V 2019, from Terek River, leg. D.G. Smirnov.

Distribution in Russia. Pskov Province [52], Leningrad Province [53], Novgorod Province [49], Tver' Province [49], Voronezh Province [17], Penza Province [20], Stavropol' Region [43], Karachaevo-Cherkessia Republic [43], Dagestan Republic (present paper, new record), Ulyanovsk Province [41], Mordovia Republic (present paper, new record), Kirov Province [21], Udmurtia Republic [21], Bashkiria Republic (present paper, new record), Chelyabinsk Province (present study, new record).

Distribution outside Russia. Europe [17].

Hosts. *Pipistrellus nathusii* [17,52], *P. pipistrellus* [17], *P. kuhlii* [17,41], *P. pygmaeus* (present study, new record), *Nyctalus noctula* [as *Vesperugo noctula* – 17], *Nyctalus leisleri* [17], *Myotis dasycneme* (present study, present paper), *My. daubentonii* [54], *M. mystacinus* [54], *Vespertilio murinus* [54], *Eptesicus serotinus* [as *Vespertilio serotinus* – 17], *Ep. nilssonii* [54], *Plecotus auritus* [54], *Barbastella barbastellus* [54].

Ischnopsyllus (H.) hexactenus (Kolenati, 1856)

Material. ♀ ex *Plecotus auritus* 1-30 XI 2005, from Samarskaya Luka, leg. D.G. Smirnov; 2 ♀♀ ex *Pl. auritus* 1 XI 2012, from Kapova Cave, leg. O.L. Orlov; 4 ♀♀, 2 ♂♂ ex *Pl. ognevi* 14 XI 2012, from Arkheologicheskaya Cave, leg. L.B. Kravchenko; 3 ♀♀ ex *Pl. ognevi* 3-4 IX 2015, from Okhotnichiya Cave, leg. D.V. Kazakov; 4 ♀♀, 5 ♂♂ ex *Pl. ognevi* 18-19 IX 2015, from Argaley-3 Cave, leg. D.V. Kazakov; ♂ ex *Pl. ognevi* 8 VIII 2016, from Natural Park "Tunkinskiy", leg. D.V. Kazakov; 3 ♀♀, 6 ♂♂ ex *Pl. ognevi* 20 VIII 2016, from Dolganskaya Yama Cave, leg. D.V. Kazakov; ♀, ♂ ex *Pl. ognevi* 27-28 VI 2016, from Zeyskiy Natural Reserve, leg. D.V. Kazakov; 47 ♀♀, 20 ♂♂ ex *Murina hilgendorfi* 18-20 VIII 2016, 23 ♀♀, 8 ♂♂ ex *Mu. hilgendorfi* 11 IX 2017, from Dolganskaya Yama Cave, leg. D.V. Kazakov.

Distribution in Russia. Saint-Petersburg [30,49,53], Moscow [53], Saratov Province [53], Northern Osetia Republic [43], Sverdlovsk Province [22], Bashkiria republic (present study, new record), Khakassia republic (present study, new record), Krasnoyarsk Region [53], Irkutsk Province [53; present study], Buryatia republic (present paper, new record), Zabaykal'skiy Region [53], Primorskiy Region [53], Urals, Trans-Urals, Trans-Caucasus [30,53].

Distribution outside Russia. Europe [17]. Asia: Kazakhstan [30], Mongolia [56].

Hosts. *Plecotus auritus* [17: present study], *Pl. ognevi* [as *Plecotus auritus* – 31; present paper], *Myotis mystacinus* [as *Vespertilio mystacinus* – 17], *M. nattereri* [as *Vespertilio nattereri* – 17], *M. sibiricus* [as *Myotis brandtii* – 31], *M. petax* [as *Myotis daubentonii* – 31], *M. ikonnikovi* [31], *Nyctalus noctula* [55], *Barbastella barbastellus* [as *Synotus barbastellus* – 17], *Vespertilio murinus* [17], *Eptesicus serotinus* [as *Vespertilio serotinus* – 17], *Hypsugo alashanicus* [as *Pipistrellus savii* – 31], *Murina hilgendorfi* (present paper, new record), *Miniopterus fuliginosus* [as *Miniopterus schreibersii* – 31], [*Homo sapiens*] [17].

Discussion

We recorded 8 new host-parasite associations: *Myodopsylla trisellis – Myotis blythii*, *Myodopsylla trisellis – Myotis davidii*, *Myodopsylla trisellis – Murina hilgendorfi*, *Ischnopsyllus octactenus – Pipistrellus pygmaeus*, *Ischnopsyllus intermedius – Hypsugo savii*, *Ischnopsyllus variabilis – P. pygmaeus, Ischnopsyllus variabilis – Myotis dasycneme*, *Ischnopsyllus hexactenus – M. hilgendorfi*.

Myodopsylla trisellis is the only species of *Myodopsylla* – genus which includes 12 recognized species [37] – represented in Old World, presumably distributed from Northern America through the territory of Northern Eurasia by Beringia. The areal of this species described in 1929 (based on specimens observed in *Pipistrellus* sp. in July 1928 in Nenjiang in north-eastern chinese province of Heilongjiang) reaches Baltic states in the west [57]. Our study confirms its wide distribution in Russia. We first discovered it in two large regions: the southern Urals (Bashkiria Republic and Chelyabinsk Province) and southern Western Siberia (Tyumen Province and Altai republic).

The findings of *M. trisellis* on *M. blythii* is particularly interesting. The host species, Mediterranean-Central-Southern-Asian species, is phylogenetically distant from most species of *Myotis* in the Russian Federation [58], and has only three marginal habitat entries in Russia: Crimean peninsula, the Caucasus, and the Altai. Thus, the Altai Territory is the only territory where the ranges of these species intersect.

Ischnopsyllus (*H.*) *hexactenus* is newly recorded in Bashkiria Republic and two regions of Siberia (Khakassia Republic and Buryatia Republic) for the first time. *Ischnopsyllus* (*I.*) *variabilis* is newly reported from 3 regions of Russia and other parts of Europe: Dagestan Republic (the Caucasus), Mordovia Republic and Bashkiria Republic. *Ischnopsyllus* (*I.*) *octactenus* is also recorded from Mordovia Republic for the first time.

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