

Unusual finding of chewing louse *Quadriceps* cf. *junceus* (Scopoli, 1763) (Phthiraptera: Ischnocera) on *Nathusius pipistrelle* *Pipistrellus nathusii* (Keyserling & Blasius, 1839) (Mammalia: Chiroptera) with review of findings of lice reported from bats


MARIA V. ORLOVA^{1,2,3,*}, ALEKSANDRA I. LARCHANKA⁴ & OLDŘICH SYCHRA⁵

¹ Department of Mobilization Training of Public Health and Disaster Medicine, Tyumen State Medical University, Tyumen, Russia;  <https://orcid.org/0000-0001-7811-4364>

² Research and Production Laboratory of Engineering Surveys and Environmental Management Technologies, National Research Tomsk State University, Tomsk, Russia.

³ Federal Scientific Research Institute of Viral Infections «Virome» of Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing, Ekaterinburg, Russia.

⁴ Laboratory of Population Ecology of Terrestrial Vertebrates and Bioresource Management, Scientific and Practical Center of the National Academy of Sciences of Belarus for Bioresources, Minsk, Belarus;

 <https://orcid.org/0000-0002-2332-6914>

⁵ Department of Biology and Wildlife Diseases, University of Veterinary Sciences, Brno, Czech Republic;

 <https://orcid.org/0000-0003-3481-5673>

* Corresponding author. E-mail: masha_orlova@mail.com

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Bats (Chiroptera) do not possess any specific louse species however, rare accidental registrations of this ectoparasites on chiropterans occur. Herein we report for the first time, identification of the lice *Quadriceps* cf. *junceus* (Ischnocera: Philopteridae) from vesper bat *Pipistrellus nathusii* (Keyserling & Blasius, 1839) (Chiroptera: Vespertilionidae) in Belarus. In addition, we provide and discuss previous findings about lice collected from bats.

Lice (Phthiraptera) are obligate ectoparasites of birds and mammals (Hopla et al. 1994; Price et al. 2003). Lice are traditionally divided into two groups: Anoplura, the sucking lice, and Mallophaga, the chewing lice (Hopla et al. 1994; Ritzi 2004).

Sucking lice (more than 540 described species) are obligate, permanent ectoparasites of eutherian mammals, parasitizing members of 12 of the 29 recognized mammalian orders and 840 mammalian species (approximately 20% of all species of the class). These host specific, blood-sucking insects are morphologically adapted for life on mammals: they are wingless, dorso-ventrally flattened, possess tibio-tarsal claws for clinging to host hair, and have piercing-sucking mouthparts for feeding (Durden & Musser 1994, Light et al. 2010).

In total, there are over 5000 species of chewing lice globally. It is a group of ectoparasites mainly of birds and to a lesser extent (only 12%) of mammals. The large diversity of avian lice of more than

4500 different species in more than 250 genera can be explained by the strict stenoxeny of most species and their presence in nearly all bird species. The body of the wingless insects is dorsoventrally compressed and clearly divided into caput, thorax, and abdomen. The diet of most chewing lice is dominated by keratin-rich dermal components such as feathers, skin, and hair. The chewing lice have been further separated into four suborders: Amblycera, Ischnocera, Rhyncophthirina, and Trichodectera (Price *et al.*, 2003, Moya *et al.* 2021).

Ischnocera is the largest suborder of lice, which contains about 2750 of the 4500 known species of chewing lice (Price *et al.* 2003). Representatives of Ischnocera with the single family Philopteridae are known from virtually all families of birds and representatives of Trichodectera with the single family Trichodectidae are reported from many orders of mammals.

The suborder Amblycera comprises six recognized families: three of them (Menoponidae, Laemobothriidae and Ricinidae) are present on a wide range of avian hosts, and three remaining (Boopidae, Gyropidae, Trimenoponidae) are restricted to a small section of mammals (Marshall 2003, Price *et al.* 2003).

Bats are not specific hosts for lice, and findings of these ectoparasites on these mammals are so rare, but of a particular interest. In our article we describe the new finding of chewing louse ex bat in Belarus and discuss previous findings of lice (Phthiraptera) on bats (Chiroptera).

Medical significance

Heavy infestation of sucking lice can cause host hypersensitivity, dermatitis and even anemia. Anoplura are also important vectors of microorganisms that cause a variety of diseases, including tularemia, epidemic typhus, louse-borne relapsing fever, trench fever, and murine mycoplasmosis (Durden, Lloyd 2009).

Materials and methods

Animals were caught with mist nets and a mobile trap (Borisenko, 1999) in the territory of State Nature Protection Institution "Berezinsky Biosphere Reserve" (Vitebsk and Minsk regions, Republic of Belarus). Ectoparasites were collected with tweezers and fixed in 70% ethanol. The collected material was transferred for storage to the Department of Entomology of Moscow State University, after which it was returned to the authors of the article in 2022. All bats (20 specimens) were released after examination.

For morphological examination, louse specimen was mounted on a microscope slide, i.e. firstly cleared in KOH (20%), then sequentially immersed in acetic acid (10%), acid fuchsin (1%), ethanol (40%, 70% and 100%), pure clove oil and finally mounted in Canada balsam on slides (Palma 1978). Louse specimen was examined with a microscope AxioImager A2, Zeiss, Germany, equipped with equipped with phase-contrast and DIC objectives.

Characteristics of the material collection site

The Berezinsky Biosphere Reserve is the core of the ecological network of Belarus. The territory of the reserve is part of the International Network of Key Botanical Areas, as well as one of the leading republican centers for monitoring the state of natural ecosystems and individual species of flora and fauna, and a monitoring point for the National Environmental Monitoring System. Since 2010, the reserve has been included in the Ramsar List (the world's largest network of protected areas), and since 2016 in the Europe Emerald Network. According to the IUCN classification, the reserve corresponds to category 1a (a strictly protected natural reserve (Wildlife area)). Near the Berezinsky Reserve there are key ornithological territories of international and republican importance, constituting one of the largest complexes of floodplain meadows, forests and swamps in Europe, playing the role of a large biological reserve diversity of wetland plant and animal species are one of the most important ecological corridors of the emerging unified European environmental network.

The area of the reserve is 86,072.8 hectares. The dominant landscapes can be identified as lacustrine-marsh, occupying 54.1% of the reserve's territory; a smaller share is occupied by water-glacial landscapes (17.7%), landscapes of river valleys (14.3%) and kama-moraine (9.8%).

The territory of the reserve is located in the upper reaches of the Berezina River, the most important watercourse in the central part of Belarus and the main water artery of the region. The rivers and streams, lakes and oxbow lakes associated with the Berezina to a large extent form the uniqueness

of the reserve and play the role of an important landscape-forming component of its territory (Natarov, Lukashuk 2003).

According to the most recent faunistic list of the Berezinsky Reserve avifauna includes 237 species of birds from 18 orders, which is 76.7% of the total number of bird species in Belarus. Of these, 179 are nesting species, 36 are migratory, and 15 are vagrant (Bogutskaya 2018). The majority of the avian species belongs to the European, Siberian and Arctic types of faunas. The territory of the Berezinsky Biosphere Reserve is reliably inhabited by 10 species of bats of 6 genera: *Eptesicus serotinus* Schreber, 1774, *Eptesicus nilssonii* (Keyserling & Blasius, 1839), *Myotis dasycneme* (Boie, 1825), *Myotis daubentonii* (Kuhl, 1817), *Nyctalus noctula* (Schreber, 1774), *Nyctalus leisleri* (Kuhl, 1817), *Pipistrellus nathusii* (Keyserling & Blasius, 1839), *Pipistrellus pygmaeus* (Leach, 1825), *Plecotus auritus* Linnaeus, 1758, *Vespertilio murinus* Linnaeus, 1758 (Abstracts of reports... 2022).

Results and discussion

The only specimen of the species belonging to genus *Quadraceps* was collected from the bat.

Quadraceps cf. *junceus* (Scopoli, 1763)

♀ ex *Nathusius' pipistrelle* bat *Pipistrellus nathusii* Keyserling & Blasius, 1839 (Chiroptera: Vespertilionidae) (adult ♀, collection lot №105) from State Nature Protection Institution "Berezinsky Biosphere Reserve" (54°45'36"N 28°20'24"E), 19 July 1996, leg. Sergei V. Kruskop, det. O. Sychra (Figure 1).

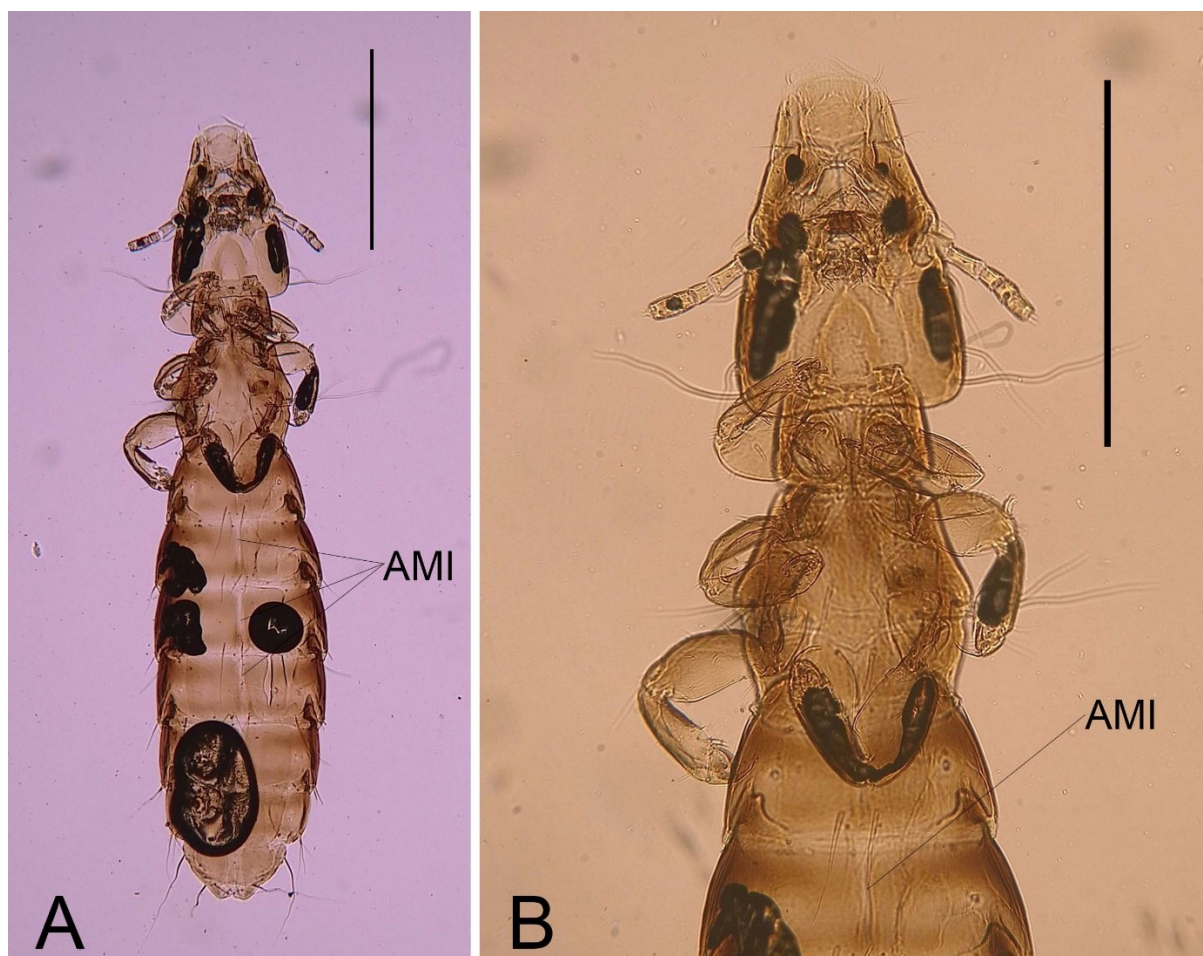


Figure 1. *Quadraceps* cf. *junceus*: A. Habitus. B. Detail of head, thorax and abdominal segments II–IV. Scale bar 500 μ m. Differential diagnosis (according to Gustafsson et al. 2018): pale and slender species; antero-medial indentations (AMI) of tergopleurites II–V slender, all longer than half of tergopleurite length.

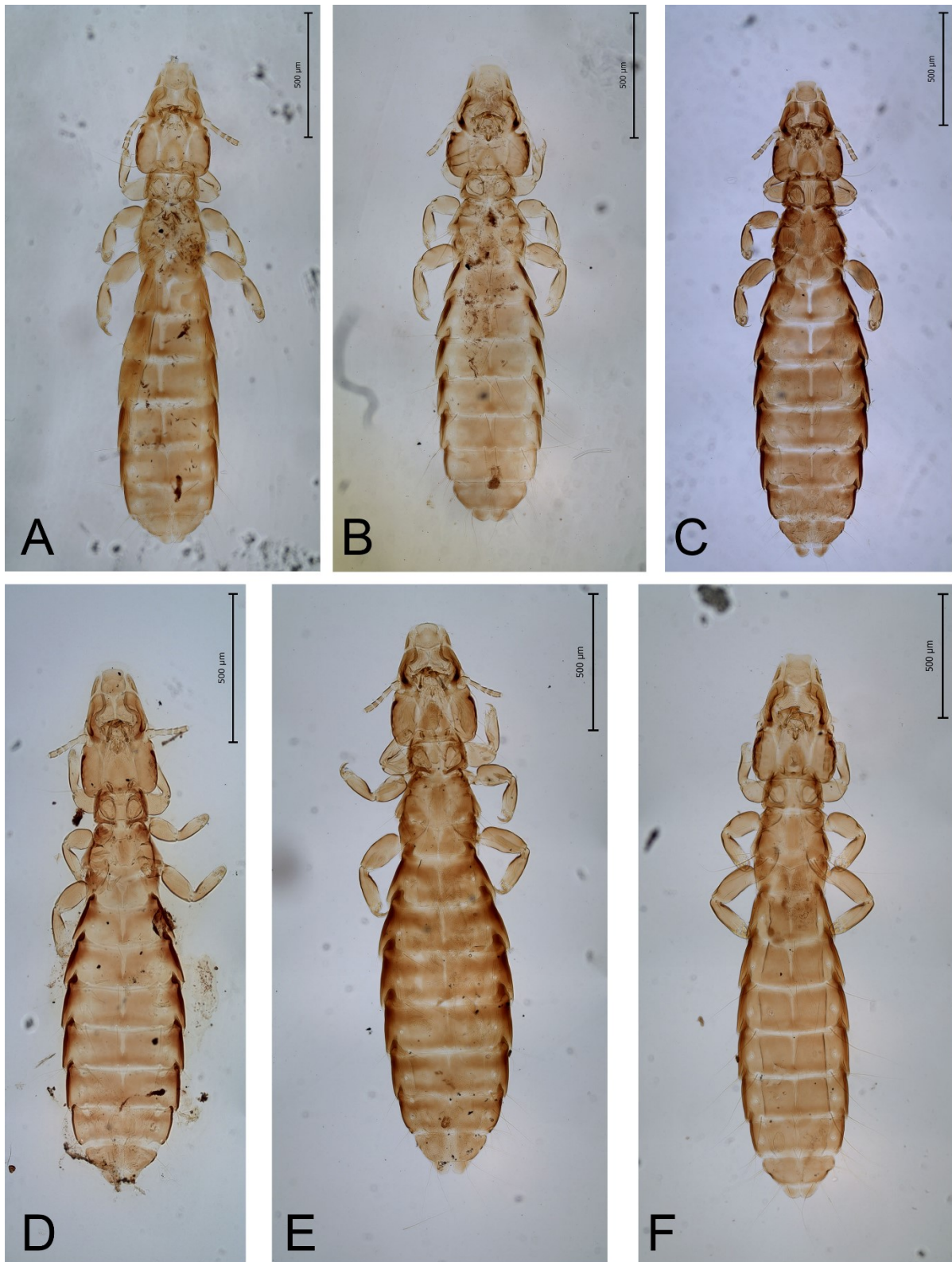


Figure 2. Lice of genus *Quadriceps* parasitizing birds of the genus *Tringa*: A. *Q. furvus*; B. *Q. junceus*; C. *Q. obscurus*; D. *Q. obtusus*; E. *Q. ochropi*; F. *Q. similis* (Sychra, own data).

Quadriceps represents one of morphologically very variable genus. Gustafsson (2012) suggested that this genus should be split into smaller, morphologically and genetically distinct genera. There is about 127 species described from about 236 species of birds from the order Charadriiformes all

around the world (Price et al. 2003). There is a total of 23 species of *Quadriceps* known from those 38 species of charadriid birds reported in Republic of Belarus (Table 1).

According to the key by Gustafsson et al. (2018) the collected female was identified as *Quadriceps* cf. *junceus*, a louse species occurring on *Vanellus vanellus* (Linnaeus, 1758). However, the determination of females of this genus to species level can be problematic, because some important characteristics are on male genitalia and without male it was impossible to identify our female for sure. It is not possible to completely exclude also other morphologically very similar species, *Quadriceps furvus* (Burmeister, 1838), *Quadriceps obscurus* (Burmeister, 1838), *Quadriceps obtusus* (Kellogg & Kuwana, 1902), *Quadriceps ochropi* (Denny, 1842), and *Quadriceps similis* (Giebel, 1866) occurring on birds of the genus *Tringa* (Linnaeus, 1758) and *Vanellus* Brisson, 1760 (Table 1). The findings of *Q. junceus* are known from Russia (Lower Don region – Malysheva et al. 2020), Azerbaijan (Blagoveshtchensky 1940) and Tajikistan (Blagoveshtchensky 1951); specimens of *Q. obtusus* were collected from Azerbaijan (Blagoveshtchensky 1940) and Tajikistan (Blagoveshtchensky 1951); and species *Q. ochropi* was obtained from Azerbaijan (Blagoveshtchensky 1940).

Nevertheless all these species have short tergoventral setae on tergoventrites III–VI, that do not reach posterior margin of following segment, while our female has these setae long and reaching beyond posterior margin of following segment (Figure 2).

The Charadriiformes order includes 38 species in the reserve (Table 1). The representative of the Charadriiformes (*Tringa ochropus*), unlike most waders, usually makes a nest in trees, using old buildings of thrushes, jays, crows, squirrels, on spruce branches near the trunk, on old fallen trees, stumps, in hollows, less often on the ground, hummocks (Fedyushin, Dolbik 1967; Nikiforov, Yaminsky 1989). Thus, it is possible that the same roosts can be used by forest pipistrelle and representatives of Charadriiformes. Also, owls (eagle owls) could bring the captured sandpiper into a hollow, which the bat could use in the future.

Table 1. List of bird species of the Charadriiformes family of the Berezinsky Biosphere Reserve and their lice from the genus *Quadriceps*.

Order Charadriiformes	<i>Quadriceps</i> lice
Family Haematopodidae	
1 <i>Haematopus ostralegus</i> Linnaeus, 1758	<i>Quadriceps auratus</i> (De Haan, 1829)
Family Charadriidae	
2 <i>Pluvialis apricaria</i> (Linnaeus, 1758)	<i>Quadriceps charadrii</i> (Linnaeus, 1758)
3 <i>Vanellus vanellus</i> (Linnaeus, 1758)	<i>Quadriceps junceus</i> (Scopoli, 1763)
4 <i>Charadrius dubius</i> Scopoli, 1786	<i>Quadriceps bicuspis</i> (Nitzsch, 1874)
5 <i>Charadrius hiaticula</i> Linnaeus, 1758	<i>Quadriceps fissus</i> (Burmeister, 1838)
	<i>Quadriceps hiaticulae</i> (Fabricius, O., 1780)
Family Scolopacidae	
6 <i>Numenius phaeopus</i> (Linnaeus, 1758)	–
7 <i>Numenius arquata</i> (Linnaeus, 1758)	–
8 <i>Limosa limosa</i> (Linnaeus, 1758)	–
9 <i>Calidris pugnax</i> (Linnaeus, 1758)	<i>Quadriceps lahorensis</i> Ansari, 1955
10 <i>Calidris ferruginea</i> (Pontoppidan, 1763)	–
11 <i>Calidris temminckii</i> (Leisler, 1812)	–
12 <i>Calidris alpina</i> (Linnaeus, 1758)	–
13 <i>Calidris minuta</i> (Leisler, 1812)	–
14 <i>Phalaropus lobatus</i> (Linnaeus, 1758)	<i>Quadriceps connexus</i> (Kellogg & Mann, 1912)

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Table 1

15	<i>Actitis hypoleucos</i> (Linnaeus, 1758)	<i>Quadriceps ravus</i> (Kellogg, 1899)
16	<i>Tringa ochropus</i> Linnaeus, 1758	<i>Quadriceps ochropi</i> (Denny, 1842)
17	<i>Tringa nebularia</i> (Gunnerus, 1767)	<i>Quadriceps similis</i> (Giebel, 1866)
18	<i>Tringa glareola</i> Linnaeus, 1758	<i>Quadriceps obscurus</i> (Burmeister, 1838)
19	<i>Tringa totanus</i> (Linnaeus, 1758)	<i>Quadriceps obtusus</i> (Kellogg & Kuwana, 1902)
20	<i>Tringa erythropus</i> (Pallas, 1764)	<i>Quadriceps furvus</i> (Burmeister, 1838)
21	<i>Lymnocyrtus minimus</i> (Brunnich, 1764)	–
22	<i>Scolopax rusticola</i> Linnaeus, 1758	–
23	<i>Gallinago gallinago</i> (Linnaeus, 1758)	–
24	<i>Gallinago media</i> (Latham, 1787)	–
Family Stercorariidae		
25	<i>Stercorarius parasiticus</i> (Linnaeus, 1758)	<i>Quadriceps normifer</i> (Grube, 1851)
Family Laridae		
26	<i>Sternula albifrons</i> (Pallas, 1764)	<i>Quadriceps anagrapsus</i> (Nitzsch [in Giebel], 1866) <i>Quadriceps nycthemerus</i> (Burmeister, 1838)
27	<i>Hydroprogne caspia</i> (Pallas, 1770)	<i>Quadriceps caspius</i> (Giebel, 1874) <i>Quadriceps punctatus regressus</i> Timmermann, 1952
28	<i>Chlidonias hybrida</i> (Pallas, 1811)	<i>Quadriceps anagrapsus</i> (Nitzsch [in Giebel], 1866)
29	<i>Chlidonias niger</i> (Linnaeus, 1758)	<i>Quadriceps phaeonotus</i> (Nitzsch [in Giebel], 1866)
30	<i>Chlidonias leucopterus</i> (Temminck, 1815)	<i>Quadriceps anagrapsus</i> (Nitzsch [in Giebel], 1866)
31	<i>Sterna hirundo</i> Linnaeus, 1758	<i>Quadriceps sellatus</i> (Burmeister, 1838)
32	<i>Hydrocoloeus minutus</i> (Pallas, 1776)	<i>Quadriceps eugrammicus</i> (Burmeister, 1838)
33	<i>Chroicocephalus genei</i> (Breme, 1840)	<i>Quadriceps punctatus pallidus</i> Timmermann, 1952
34	<i>Chroicocephalus ridibundus</i> (Linnaeus, 1766)	<i>Quadriceps punctatus punctatus</i> (Burmeister, 1838)
35	<i>Larus canus</i> Linnaeus, 1758	<i>Quadriceps ornatus ornatus</i> (Grube, 1851) <i>Quadriceps punctatus regressus</i> Timmermann, 1952
36	<i>Larus fuscus</i> Linnaeus, 1758	<i>Quadriceps punctatus regressus</i> Timmermann, 1952
37	<i>Larus argentatus</i> Pontoppidan, 1763	<i>Quadriceps ornatus striolatus</i> (Nitzsch [in Giebel], 1866) <i>Quadriceps punctatus regressus</i> Timmermann, 1952
38	<i>Larus marinus</i> Linnaeus, 1758	<i>Quadriceps ornatus striolatus</i> (Nitzsch [in Giebel], 1866)

One way of colonization of new host used by ischnoceran lice is phoresis (Price et al. 2003). Up to date there is no report of phoresis for *Quadriceps* (Kerans 1975, Bartlow et al. 2016). On the other hand two hippoboscoid flies, *Ornithomya avicularia* (Linnaeus, 1758) and *Ornithomya chloropus* Bergroth, 1901 commonly associated with phoresis of lice, are regularly reported also from charadriid hosts (Maa, 1969). Nevertheless, no flies from the family Hippoboscidae have been reported from bats yet (Maa 1969).

It should be noted that previous findings of lice on bats are extremely limited (Table 2). All of them were removed from bats belonging to three families (Vespertilionidae, Rhinolophidae, Phyllostomidae), which are by far the most studied. Most of the findings are likely also related to the sharing of roosts (caves and other).

Table 2. Previous findings of lice Phthiraptera on bats*.

Lice species	Number	Sex	Bat species	Locality	Date	Reference	Natural host	Note
Parvorder Anoplura								
Family Polyplacidae								
<i>Polyplax serrata</i> (Burmeister, 1839)	1	-	<i>Rhinolophus hipposideros</i> (Borkhausen, 1797) (fam. Rhinolophidae)	Trémont-sur-Saulx (Meuse area, France)	1925-1926	Rémy 1948	Mostly forest and field mice <i>Apodemus</i> spp. (Kristofik, Lysy 1992)	
<i>Polyplax</i> sp.	104	-	<i>Rhinolophus mehelyi</i> Matschie, 1901 (fam. Rhinolophidae)	Azykhskaya and Marallygskaya caves (Nagorno-Karabakh Republic and Nakhichivan Autonomous Republic respectively, Azerbaijan)	1964 (all seasons)	Gadzhiev, Dubovchenko 1976	Rodents, mostly from the Muridae, but also Abrocomidae, Sciuridae; occasionally also on insectivorans from the family Soricidae (Durden & Musser, 1994)	
<i>Polyplax spinigera</i> (Burmeister, 1839)	4	-	<i>Myotis daubentonii</i> Kuhl, 1817 (fam. Vespertilionidae)	Udmurtia Republic (European Russia)	1992-1998 (spring- summer seasons)	Orlova et al. 2011	<i>Arvicola terrestris</i> Linnaeus, 1758 (Durden & Musser, 1994)	
Family Hoplopleuridae								
<i>Hoplopleura</i> sp.	1	-	<i>Rhinolophus mehelyi</i> Matschie, 1901 (fam. Rhinolophidae)	Azykhskaya and Marallygskaya caves (Nagorno-Karabakh Republic and Nakhichivan Autonomous Republic respectively, Azerbaijan)	1964 (all seasons)	Gadzhiev, Dubovchenko 1976	Murid rodents (Durden & Musser, 1994)	

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Table 2

Parvorder Ischnocera							
Family Philopteridae							
<i>Physconelloides</i> sp.	1	-	<i>Carollia perspicillatum aztecum</i> (Saussure, 1860) (fam. Phyllostomidae)	Summit, Canal Zone (USA),	19.11.1930	Gerberg, Goble 1941	Pigeons and doves (Price et al. 2003) Host as <i>Hemiderma perspicillatum aztecum</i>
<i>Brueelia straminea</i> (Denny, 1842)	2	♀ and ♂	<i>Pipistrellus kuhlii</i> Kuhl, 1817 (fam. Vespertilionidae)	Beyugdash near Gobustan (at present Azerbaijan)	19.06.1982	Černý, Scholz 1983	<i>Dendrocopus major</i> (Linnaeus, 1758) (Price et al. 2003)
<i>Columbicola columbae</i> (Linnaeus, 1758)	2	-	<i>Desmodus rotundus</i> (Geoffroy, 1810) (fam. Phyllostomidae)	San Bartolomé district (Huarochirí Province, Lima, Peru)	09.2016	Minaya et al. 2021	Pigeons (Price et al. 2003)
<i>Campanulotes compar</i> (Burmeister, 1838)	2	-	<i>Desmodus rotundus</i> (Geoffroy, 1810) (fam. Phyllostomidae)	San Bartolomé district (Huarochirí Province, Lima, Peru)	09.2016	Minaya et al. 2021	<i>Columba livia</i> Gmelin, 1789 (Price et al. 2003)
<i>Quadraceps</i> cf. <i>junceus</i> (Scopoli, 1763)	1	♀	<i>Pipistrellus nathusii</i> Keyserling & Blasius, 1839 (fam. Vespertilionidae)	State Nature Protection Institution "Berezinsky Biosphere Reserve"	19 July 1996	Present study	<i>Vanellus vanellus</i> (Linnaeus, 1758)
Parvorder Trichodectera							
Family Trichodectidae							
<i>Geomydoecus geomydis</i> (Osborn, 1891)	1	-	<i>Leptonycteris nivalis</i> (Saussure, 1860) (fam. Phyllostomidae)	Nuevo Leon (Mexico)	18 VIII 1938	Gerberg, Goble 1941	<i>Geomys bursarius</i> (Shaw, 1800) (Price et al. 2003)

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Table 2

Parvorder Amblycera							
Family Menoponidae							
<i>Colpocephalum</i> sp.	1	-	<i>Desmodus rotundus</i> (Geoffroy, 1810) (fam. Phyllostomidae)	San Bartolomé district (Huarochirí Province, Lima, Peru)	IX 2016	Minaya et al. 2021	Birds from about 11 orders (Price et al. 2003)

* This table doesn't contain the information about finding of chewing lice (without concretization) ex *Nycticeius humeralis* (Rafinesque, 1818) (Chiroptera: Vespertilionidae) from Ellis County (Kansas, USA), leg. E. Schumann, because according to the photo in this dissertation it is in fact demonstrates not chewing louse, but bark louse (Schumann 2019).

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Ethical statement

All applicable institutional, national and international guidelines for the care and use of animals were followed. Fieldwork was conducted in accordance with the Law of the Republic of the Belarus, dated July 10, 2007 No. 257-Z About the animal world, Section 30.

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