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Lice (Anoplura) of small mammals in forest-steppe and sub-boreal subzones of the Southern Trans-Urals, Russia

Вши (Anoplura) мелких млекопитающих лесостепной и подтаежной подзон Южного Зауралья

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Ключевые слова: вши, мелкие млекопитающие, подтайга, лесостепь.

Abstract. 4211 lice of 9 species collected from 3063 small mammals belonging to 22 species were examined. The characteristics of species composition, abundance and occurence of insectivore and rodent lice are given. Multiple cases of lice found on uncharacteristic hosts were recorded, reflecting interspecies contacts of mammals. Specific aspects of biotopic allocation of the parasite are present.

Резюме. Исследовано 3063 особей мелких млекопитающих 22 видов, собрано 4211 вшей 9 видов. Дана характеристика видового состава, встречаемости и численности вшей насекомоядных и грызунов. Неоднократно отмечены случаи нахождения вшей на несвойственных им хозяевах, отражающие межвидовые контакты зверьков. Рассмотрены особенности биотопической приуроченности паразита.

Introduction

Kurganskaya Oblast in Southern Trans-Urals region ranges between 54–57° N and 61–69° E. The Oblast is situated on a forest-steppe border. According to the geobotanical subdivision plan of Western Siberia [Ilyina et al., 1976], four vegetation belts change from north to south of the Kurganskaya Oblast. In the sub-boreal subzone of boreal (taiga) zone, located in the north of the Oblast, microphyllous and pine forests with nearly complete absence of steppes and solonchaks. Swamp vegetation of the sub-boreal forest is represented by extensive lowland and upland (sphagnous) forest swamps. Most of the Kurganskaya Oblast is located in forest-steppe subzone of the steppe zone [Naumenko, 2019]. A prominent feature of forest-steppe is occurrence of two vegetation types, meadow steppes and outlier microphyllous forests. To the south of the latitude of Kurgan, dry coniferous forest are very common in forest-steppe and steppe Trans-Urals, covering up to 70 % of pine forests of the Pritobolye. Among the animals of the Kurganskaya Oblast in Southern Trans-Urals small mammals are particularly interesting as their role in biocenoses and human economic activity is quite significant. Particular importance of these animals (murine rodents and shrews) is due to the fact that they serve as the hosts of many blood-sucking parasitic arthropods, which are carriers of various natural focal infections.

Being permanent parasites and largely species-specific to the host, lice are not only unique models for studying biology and ecology, but also the evolution of parasites [Kittler et al., 2003; Light et al., 2010]. The research of persistent parasites (Anoplura) was not systemic though. Nevertheless, there are some papers by V.P. Starikov et al. [1988], where they established the species composition of rodent Anoplura in the Kurganskaya Oblast included *Hoplopleura edentula, H. acanthopus, H. longula, Polyplax ellobii* and *Neohaematopinus laeviusculus,* and considered the ecology of ectoparasites of the common mole vole, including Anoplura [Starikov, Vershinin, 2020].

Materials and methods

The research of lice-infested small mammals was conducted from the beginning of May until the end of August 2020–2021. We inspected 2072 animals in the forest-steppe subzone of the Kurganskaya Oblast in Pritobolny and Ketovsky districts in 2020. In 2021 records of small mammals were conducted in sub-boreal subzone in the north of Kurganskaya Oblast and in Shatrovsky district. Most of the research was conducted from May until August in the Samokhvalovo village (n = 804) and its vicinity. Small-scale collection of small mammals (n = 181) was conducted in July and August in the Mekhonskoye village and its vicinity, as well as one-time recording of ground squirrels (June) in the vicinity of Kamyshevka village (n = 2). The animals were collected using trapping grooves and trap lines [Naumov, 1955; Kucheruk, 1963], mole traps [Rakov, 1959] and steel traps. Russian and Latin names of small mammal species are given according to A.A. Lisovsky et al. [2019].

During the research period in 2020–2021 in the Southern Trans-Urals, we studied 3067 animals of 22 species, namely: the common shrew *Sorex araneus* Linnaeus, 1758, the tundra shrew *S. tundrensis* Merriam, 1900, Laxmann's shrew *S. caecutiens* Laxmann, 1788, the Eurasian pygmy shrew *S. minutus* Linnaeus, 1766, the Eurasian least shrew *S. minutissimus* Zimmermann, 1780, the Taiga Shrew *S. isodon* Turov, 1924, the Eura-

sian water shrew *N. fodiens* Pennant, 1771, the Russet Ground Squirrel *Spermophilus major* Pallas, 1779, the Siberian Chipmunk *Eutamias sibiricus* Laxmann, 1769, the northern Mole Vole *Ellobius talpinus* Pallas, 1770, the northern birch mouse *Sicista betulina* Pallas, 1779, the bank vole *Myodes glareolus* Schreber, 1780, the northern red-backed vole *M. rutilus* Pallas, 1779, the narrow-headed vole *Lasiopodomys gregalis* Pallas, 1779, the short-tailed vole *Agricola agrestis* Linnaeus, 1761, the root vole *Alexandromys oeconomus* Pallas, 1776, the common vole *Microtus arvalis* Pallas, 1778, the harvest mouse *Micromys minutus* Pallas, 1771, the striped field mouse *Apodemus agrarius* Pallas, 1771, the herb wood mouse *Sylvaemus uralensis* Pallas, 1811, the house mouse *Mus musculus* Linnaeus, 1758 and the brown rat *Rattus norvegicus* Berkenhout, 1769.

The Shannon index of species diversity was used in the analysis of the material [Shannon, Weaver, 1949]:

$H' = -\Sigma \cdot p_i \cdot \ln p_i$,

p_i – proportion of individuals of the i-th species.

Upon the Anoplura collection from small mammals, we followed the recommendations of E.F. Sosnina, M.V. Tikhvinskaya [1969]. The qualifiers of D.I. Blagoveshchensky [1964], J.C. Beaucurnu [1968] and V.N. Zarubina [1986] were used to determine the Anoplura species. Latin names of species are given according to L. Durden and G.G. Musser [1994].

There were 4211 lice of 9 species, namely: *Hoplopleura acanthopus* (Burmeister, 1839), *H. edentula* Fahrenholz, 1916, *H. longula* (Neumann, 1909), *H. affinis* (Burmeister, 1839), *Polyplax spinulosa* (Burmeister, 1839), *P. ellobii* (Sosnina, 1955), *P. serrata* (Burmeister, 1839), *Linognathoides laeviusculus* (Grube, 1851) and *Enderleinellus tamiasis* Fahrenholz, 1916.

In accordance with the norms adopted in faunistic studies, we divided the hosts of parasites into main, additional, and accidental [Balashov, 2000]. For the analysis, we used the indices generally accepted in parasitology: the occurrence index OI %, the abundance index AI, specimen; and the infestation intensity of animals with ectoparasites II, specimen [Beklemishev, 1961].

The present work is registered in ZooBank (www.zoobank.org) under LSID urn:lsid:zoobank.org:pub:9944AEAB-83CD-4E77-BABF-92C76A747039.

Results and discussion

By corresponding the population of small mammals in forest-steppe [Starikov et al., 2021] and sub-boreal forest we have discovered the following. Depending on inventory methods the small mammals' community of Southern Trans-Urals was both polydominant and monodominant. In sub-boreal forest during the entrapment using trapping grooves the dominant group was represented by 5 species: Laxmann's (24.41 %) and common shrews (15.86 %), root vole (14.36 %), Eurasian pygmy shrew (12.25 %) and common vole (11.72 %). Common shrew (44.65 %) was predominant in break-back traps inventory. The core of small mammals of the forest-steppe Trans-Urals (trapping grooves) was comprised of species, drawn to wooded and wetted habitats, common shrew (16.51 %) and field vole (10.38 %). The co-dominant species group consists of northern red-backed vole (9.97 %), herb wood mouse (9.14 %) and root vole (8.52 %). The small mammals' community registered by break-back traps also characterised as polydominant. Herb wood mouse (41.72 %) and common shrew (10.60 %) predominated, with northern red-backed (9.35 %) and narrow-headed voles (8.77 %) as co-dominants. The difference in identified species composition and dominance structure for the researched subzones is confirmed by Shannon's diversity index (sub-boreal forest H = 2.392, forest-steppe H = 3.396). For example, Eurasian least shrew, drawn to open and semi-open spaces in the Southern Trans-Urals [Nikiforov, 1955; Starikov, 1986], occurred only in forest-steppe. Tundra shrew and narrow-headed vole are open and semi-open space species, mainly registered in the forest-steppe subzone. Species occurring on the southern periphery of the range, Siberian chipmunk and taiga shrew, were registered in the sub-boreal forest.

Louse infestation rates in small mammals of Southern Trans-Urals are moderate. Even in the most infested (II) species no more than 30 % of individuals had lice, with abundance index (AI) being 6.00, frequency index (FI) – 20 insects per one infested animal. That is why this species of louse is characterised by high rates of infestation in various types of biotopes. Only northern mole vole, specialised subterranean social rodent, had highest possible infestation indexes. For the majority of inspected animals louse infestation indexes were significantly lower than indicated. At the same time, we have found more than 50 lice on single individuals. In forest-steppe their maximum number on northern mole vole is 123, on common rat 80 lice, on root vole 73 lice, herb wood mouse 67 and 68 lice. In the sub-boreal forest the highest number of Anoplura was also registered on herb wood mouse is 179 lice, northern mole vole 144 lice and northern red-backed vole 79 lice. Overall lice infection rate of small mammals is higher in sub-boreal forest, than in forest-steppe.

On abundantly inspected shrews, lice were rarely found. All the shrews, procured in the sub-boreal forest, the common 201 specimens, the Laxmann's 190 specimens, the Eurasian pygmy 91 specimens, the tundra 5 specimens and the taiga 2 specimens, had no lice. In the forest-steppe subzone, specific lice, typical for *Sylvaemus* and *Apodemus* genera, were occasionally found on shrews. Of 340 investigated common shrews two individuals had two specimens of *H. affinis*; of 55 tundra shrews only one had one louse, and of 91 Eurasian pygmy shrews two had two lice. Northern Birch Mice are also characterised by low infection rate. In the forest-steppe, only two of 89 individuals had lice, one *H. affinis* and one *H. acanthopus*. This situation is distinctive for other territories. For example, E.F. Sosnina et al. [1981] pointed out low infestation of insectivores and northern birch mouse in Volzhsko-Kamskii Nature Reserve.

Parasitological research data on hibernating rodents are rare. According to the taxonomic checklist by L.A. Durden and G.G. Musser [1994], the only species occurring on russet ground squirrel is *L. laeviusculus*. Our data also suggests that it is the only louse species parasitizing on *S. major*. According to E.F. Sosnina and Yu.T. Artemyev [1968] in Volzhsko-Kamskii Krai the russet ground squirrel was also infested by *Enderleinellus propinquus* Blagoveshtchensky, 1965. Within our research area, *S. major* infestation indexes in forest-steppe are 5 to 8.3 times higher, than in sub-boreal forest.

Three parasite species were registered on individuals of Muridae family in Southern Trans-Urals. *H. affinis* with principal hosts being herb wood and striped field mice, as described by I.T. Arzamasov [1968] for Gomel Region Republic of Belarus, G.D. Sergienko [1974] for northern regions of Ukraine, Yu.S. Balashov [2004] for Novgorodskaya Oblast of Russia and E.F. Sosnina [1981] for Volzhsko-Kamskii Nature Reserve; *H. longula* is specific parasite of the harvest mouse [Durden, Musser; 1994] and *P. spinulosa* is parasite of the genus *Rattus* [Durden, Musser; 1994]. Overall infestation indexes for individuals of Muridae family are higher in the forest-steppe subzone. Only in herb wood mouse infestation is higher in the sub-boreal forest, FI — 2.4 times and AI — 4.9 times.

Common vole, abundant in sub-boreal forests of Southern Trans-Urals, is infested by *H. acanthopus* in this biotope approximately five times more often (20.90 % of 124 animals) than in forest-steppe (4.40 % of 91 animals), the abundance index is 8.8 times higher. According to our data, lice infestation of field vole in Kurganskaya Oblast occurs very rarely. Of 167 investigated in forest-steppe animals, none had lice infestations; in the sub-boreal forest the single recorded field vole had 21 lice. These measures are significantly higher in Volzhsko-Kamskii Nature Reserve, where 7.2 % of population are infested, II is 5.2 and AI is 0.38 [Sosnina et al., 1981]. Infestation indexes of the root vole are approximately 3 times higher in forest-steppe. Narrow-headed vole is belonging to common species of forest-steppe subzone was infested by *H. acanthopus* approximately two times less 5.26 of 114 animals than in forest-steppe 10.00 of 10 animals, frequency index being two times higher in forest-steppe. That is why lice abundant index for this host is almost identical, namely: 0.11 in forest-steppe subzone, 0.10 in sub-boreal forest.

Common species of forest-steppe subzone, the red-backed vole was infested with its distinctive species *H. edentula,* infested with lice approximately two times less (11.2 of 241 animals), than in sub-boreal forest (25.0 of 32 animals), infestation and abundance indexes significantly lower (3 and 4.8 times respectively). In sub-boreal forest 111 individuals of *H. edentula* were found on 6 northern red-backed voles, but alien parasites were also registered. For example, we found ten *P. serrata* lice on one vole. This species parasitizes on *Mus musculus*, mice of genera *Sylvaemus* and *Apodemus* [Durden, Musser; 1994]. Accidental hosts during collection included bank and common vole [Kristofik, Lysy, 1992]. Our collections are also recorded co-parasitizing of one *H. acanthopus* louse with three *H. edentula* on a single red-backed vole.

For a rare species, bank vole, only one case of infestation by *H. edentula* was registered in sub-boreal forest, with one louse collected from one vole. In 2020 this louse species has not been observed. In the work by Yu.S. Balashov and co-authors [Balashov, 2004; Balashov et al., 2007] is also pointed out the parasitizing of this obligatory hematophages on the bank vole.

21 specimen of lice *E. tamiasis* are typical of *E. sibiricus*, were picked from the three Siberian chipmunks, and caught in the sub-boreal forest. Prior to that this species was found on Siberian chipmunks in the second half of XX century in Komi Republic, Amurskaya and Sakhalinskaya Oblasts according to Zoological Institute of RAS.

Occurrence index is the number of individuals infected expressed as a percentage of the examined ones. Infestation index is the intensity of ectoparasitic infestation of mammals. Abundance index is the average number of the parasites per one mammal examined.

Relatively close biotopes, overall we examined 29 in forest-steppe subzone; 21 in sub-boreal forest, were joined into types. The largest abundance and species diversity of hosts in the Southern Trans-Urals was found in near-water riverine and lacustrine and afforestated biotopes, where the highest number of lice species was recorded. *P. spinulosa* — specific louse of the common rat, a synanthropic rodent, and thus only accounted in «structures». *H. acanthopus*, due to high flexibility, occurs on a wide variety of hosts. Principal hosts: common, reed, Eurasian water voles and the root vole [Sosnina, 1970; Volkov et al., 1977; Savitsky, Kulnazarov, 1998; Starikov, Kravchenko, 2020]. In our research, *H. acanthopus* parasitized on root, common and narrow-headed voles. That is why this species of louse is characterised by high indexes of infestation in various types of biotopes. Figure 2 shows the connection between the parasite and the host. Since this group of obligatory hematophages are permanent parasites of certain species or genus of animals, the parasite's frequency is tied to their allocation to a certain type of biotope.

Conclusion

In summary, the fauna of lice of small mammals in forest-steppe and sub-boreal subzones of Southern Trans-Urals comprises of 9 species, four of which, *P. ellobii, H. affinis, H. acanthopus* and *H. edentula,* are dominant. Lice infestation was abundantly registered in rodents and partially in shrews. The host range of certain louse species is uneven: some parasitize on a number of host species *E. tamiasis, H. edentula, H. longula, L. laevisculus, P. ellobii,* and *P. spinulosa*, others on several species like *H. acanthopus, H. affinis*. Louse species *H. acanthopus* parasitizes on a wide range of hosts, but its principal host in forest-steppe is root vole, accessory host - narrow-headed vole; principal host in sub-boreal forest is common vole, accessory — root

Table 1. Anoplura of small mammals in the South Trans-Urals (2020–2021)
Таблица 1. Вши мелких млекопитающих Южного Зауралья (2020–2021 гг.)

Host type	Species of Anoplura	Forest steppe, 2020 infestation indices			Species of Anoplura	Subtaiga subzone, 2021 infestation indices		
		OI, %	II, sp.	AI, sp.		OI, %	II, sp.	AI, sp.
S. araneus	*H. affinis*	0.59	1.00	0.02	–	–	–	–
S. tundrensis	*H. affinis*	1.82	1.00	0.02	–	–	–	–
S. caecutiens	–	–	–	–	–	–	–	–
S. minutus	*H. affinis*	2.20	1.00	0.02	–	–	–	–
S. minutissimus	–	–	–	–	–	–	–	–
S. isodon	–	–	–	–	–	–	–	–
N. fodiens	–	–	–	–	–	–	–	–
S. major	*L. laeviusculus*	60.00	74.33	44.60	*L. laevisculus*	100.0	9.00	9.00
S. betulina	*H. affinis* *H. acanthopus*	1.12 1.12	1.00 1.00	0.011 0.011	–	–	–	–
M. glareolus	–	–	–	–	*H. edentula*	3.10	10.00	0.03
M. rutilus	*H. edentula*	11.62	6.21	0.72	*P. serrata* *H. edentula* *H. acanthopus*	3.10 18.70 3.10	10.00 18.50 1.00	0.31 3.47 0.03
E. sibiricus	–	–	–	–	*E. tamiasis*	100.0	7.00	7.00
E. talpinus	*P. ellobii*	96.88	57.29	55.50	*P. ellobii*	100.0	81.67	81.67
L. gregalis	*H. acanthopus*	5.26	2.00	0.11	*H. acanthopus*	10.00	1.00	0.10
A. agrestis	–	–	–	–	*H. acanthopus*	0.02	21.00	0.37
A. oeconomus	*H. acanthopus*	6.32	10.17	0.64	*H. acanthopus*	6.20	3.40	0.21
M. arvalis	*H. acanthopus*	4.40	3.50	0.15	*H. acanthopus*	20.90	6.42	1.35
M. minutus	*H. longula*	9.76	9.50	0.93	*H. longula*	12.50	1.00	0.13
A. agrarius	*H. affinis*	20.00	30.00	6.00	*H. affinis*	15.00	16.88	2.55
S. uralensis	*H. affinis*	6.86	14.54	1.00	*H. affinis*	16.60	29.38	4.90
M. musculus	–	–	–	–	–	–	–	–
R. norvegicus	*P. spinulosa*	66.67	40.00	26.67	–	–	–	–

OI — Occurrence index, %, II — Infestation index, speciments, AI — Abundance index, speciments

Table 2. The distribution of Anoplura of small mammals in different type biotopes in the Southern Trans-Urals (2020–2021)
Таблица 2. Распределение вшей мелких млекопитающих в разных типах биотопов Южного Зауралья (2020–2021 гг.)

Type of biotope	Species of Anoplura	Forest steppe, 2020 infestation indices			Species of Anoplura	Subtaiga subzone, 2021 infestation indices		
		OI, %	II, spn.	AI, spn.		OI, %	II, spn.	AI, spn.
Near-water (lakeside and riverside)	*H. edentula* *H. acanthopus* *H. longula* *H. affinis*	1.55 0.78 0.87 2.13	7.00 10.75 2.33 18.59	0.109 0.083 0.020 0.396	*E. tamiasis* *H. acanthopus* *H. longula* *H. affinis*	8.00 11.33 1.00 6.90	0.33 1.00 0.66 3.65	0.027 0.112 0.007 0.252
Forested (microphyllous forests and pinewood/ forest outliers)	*H. edentula* *H. acanthopus* *H. affinis*	1.54 0.19 1.54	6.88 1.00 6.00	0.106 0.002 0.092	*H. edentula* *H. acanthopus* *H. affinis* *E. tamiasis* *P. serrata*	1.50 5.40 0.40 0.40 0.20	17.29 5.28 5.50 6.50 10.00	0.262 0.286 0.023 0.028 0.021
Ecotone	*H. edentula* *H. acanthopus* *H. longula* *H. affinis*	0.26 3.59 0.77 0.77	1.00 4.43 19.67 14.00	0.003 0.159 0.151 0.108	*H. acanthopus* *H. affinis*	9.50 96.50	7.14 3.57	0.679 3.446
Swamps	–	–	–	–	*H. acanthopus*	1.50	1.34	0.020
Settlements, buildings	*H. edentula* *P. spinulosa*	3.23 2.15	2.00 37.00	0.065 0.796	*H. affinis*	59.00	9.09	5.363

OI — Occurrence index, %, II — Infestation index, speciments, AI — Abundance index, speciments

vole. Simultaneous parasitizing of different louse species on a single host species is recorded sporadically. Landscape-wise, distribution of lice is uneven and depends mainly on biotopic distribution and population of hosts on given area. Larger lice abundance indexes are characteristic for «humid overgrowth» and «ecotones», and may be due to the climatic conditions of years 2020 and 2021, marked by high temperatures and low amounts of precipitation.

At the moment, the results of the two-year research in the Southern Trans-Urals give an idea about the fauna and abundance of lice in common species of small mammals and can be used to characterise the parasitophauna of rodents and insectivores. The research allows us to complement the faunistic composition of lice of small mammals in the Southern Trans-Urals by two species, *H. affinis* and *P. spinulosa*, in 2020 [Starikov, Kravchenko, 2020], and *P. serrata* and *E. tamiasis* in 2021.

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