HELMINTHES OF MOUSE-LIKE RODENTS IN THE BELOGORYE STATE NATURE RESERVE (RUSSIA)

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The study was conducted in 2016–2017 on three sites in the Belogorye State Nature Reserve (Russia) located in the forest-steppe zone. These sites are 1) «Les na Vorskle», upland oak (*Quercus robur*) forest; 2) «Ostrasyevy Yary», ravine oak forest, grass-meadow steppe; 3) «Yamskaya Step'», Sury valley, shrublands and forb meadow steppe, Eremkin Log valley, upland oak forest, forb meadow steppe. The small mammals investigated in this present parasitological study were caught using snap traps. These traps were established in lines of 50 or 100 traps per line. In addition, single traps and cone-shape pitfall traps (average length of 30 m) were used. The caught rodents (118 specimens) concern five species: *Myodes glareolus*, *Microtus arvalis*, *Sylvaemus flavicollis*, *Sylvaemus uralensis*, and *Apodemus agrarius*. The total prevalence by helminthes was 72%. About 91% of the Muridae animals were infected, while the prevalence of infestation was 55.6% among the Cricetidae specimens. We registered 20 helminth taxa belonging to three classes, six orders, and 12 families. Among the trematodes only eurixenous species were found. Among the cestodes, eurixenous species predominated. Among the nematodes, eurixenous and stenoxenous species were present in almost equal proportion. Dominant species are characterised by maximal values of prevalence of infestation. There were *Hymenolepis* sp. (17%) among Plathelminthes, species of *Syphacia* (35.6%) and *Heligmosomoides* (27.1%) among Nematoda, including *Syphacia stroma* (17%) and *Heligmosomoides polygyrus* (14.4%). The other helminth species registered in the present study were either small in number (with prevalence of invasion from 2% to 14%) or rare (with prevalence of invasion less than 2%). *Platynosomum muris* (Trematoda, Dicrocoeliidae) and *Pterothominx sadovskoi* (Nematoda, Capillariidae) were reported for the first time in the Central Chernozem Region of Russia.

Key words: Belgorod region, Cestoda, field vole, helminthes, mice, micromammals, Nematoda, parasites, Trematoda

Introduction

The biodiversity studies of certain taxonomic groups are one of the most important issues of environmental research. Environmental monitoring of particular areas without the knowledge of its flora and fauna is almost impossible. In natural ecosystems, parasitism is considered as an ecological phenomenon, the form of interspecific relationships. So the parasites having various ecological connections are a significant factor in the regulation of the functioning of the entire ecosystem (Romashova, 2004; Hudson et al., 2006).

Mouse-like rodents are one of the leading vertebrate groups in regard to the abundance and species diversity in the forest and forest-steppe ecosystems (Poulin & Morand, 2000; Orlova & Orlov, 2019). Being the consumers of the first and second orders in the food chains, the rodents play a significant role in the helminthes' circulation as intermediate and definitive hosts. They participate in the maintenance of natural focal infections and invasions (Summers et al., 2003).

The study of the helminthes of mouse-like rodents is of particular interest in Protected Areas (PAs), where the zonal diversity of locally typical species and the conditions of their natural habitat are better preserved (Dobson et al., 2008; Sheykina & Zhigileva, 2018). The Belogorye State Nature Reserve is one of the main PAs in the Belgorod region (European Russia).

The paper aims to study the helminth species composition in mouse-like rodents in the Belogorye State Nature Reserve. As previously there were no helminthological studies of small mammals in the Belgorod region, it is relevant to obtain information on the helminthes species composition in the Belogorye State Nature Reserve as one of the inventory stages assessing the natural resources of the Belgorod region.

Material and Methods

To conduct the parasitological study, small mammals were caught using snap traps with treadle (Karaseva & Telitsina, 1996) during the spring – autumn of 2016–2017 on the sampling sites located in several clusters of the Belogorye State Nature Reserve. The first of them is «Les na Vorskle» (upland oak (*Quercus robur*

L.) forest, 50.612103°N, 35.994553°E). The second site is the «Ostrasyevy Yary» (ravine oak forest and forb meadow steppe, 50.553843°N, 36.054914°E). The third site is the «Yamskaya Step'» (Sury valley: shrublands and forb meadow steppe, 51.199722°N, 37.642222°E; Eremkin Log valley: upland oak forest, forb meadow steppe, 51.177222°N, 37.650556°E).

Snap traps were arranged in lines of 50 or 100 traps each. Additionally, single snap traps were used, too. We checked the traps every 24 h. On the site «Ostrasyevy Yary», we used an additional catching method using cone-shape pitfall traps (average length 30 m) (Karaseva & Telitsina, 1996). In total, 312 snap-trap-days and 30 pitfall-trap-days were performed.

A total of 118 specimens of mouse-like rodents, belonging to five species, were captured: *Myodes glareolus* (Schreber, 1780) (53 specimens), *Microtus arvalis* (Pallas, 1778) (10 specimens), *Sylvaemus flavicollis* (Melchior, 1834) (38 specimens), *Sylvaemus uralensis* (Pallas, 1811) (15 specimens), and *Apodemus agrarius* (Pallas, 1771) (2 specimens). To determine the species of these small mammals, we used taxonomic keys according to Gromov & Erbaeva (1995). The rodent taxonomy was used in accordance to Pavlinov & Lissovsky (2012).

The helminthes detected during the autopsy were fixed, labeled, and delivered to the laboratory for subsequent staining and species determination (Anikanova et al., 2007). A total of 1813 helminthes were collected and analysed.

The helminth species were determined using taxonomic keys (Skryabin et al., 1961; Ryzhikov, 1978, 1979) and relevant publications (Romashova, 2004; Souza et al., 2009). The systematics of cestodes is used according to Caira et al. (2020).

Quantitative indicators of invasion and helminth occurrence in the hosts were evaluated. We used parasite prevalence (*PP*), invasion intensity amplitude (*IIA*), and abundance index (*AI*) (Anikanova et al., 2007).

Results and Discussion

As a result, 1507 helminth specimens were determined down to species level, 302 specimens to genus level, and four specimens to family level. The helminthes have been found in 85 specimens (72%) of mouse-like rodents belonging to five species. The *PP* of Muridae species was 91%, exceeding almost twofold the *PP* of Cricetidae (55.6%) (Table 1). We registered 20 helminth taxa belonging to three classes, six orders, and 12 families. Fourteen taxa have been identified to species level, four to genus level, and two taxa to family level. Seventeen species represent mature adults, three species larval stages (Table 2). The *PP*, *IIA*, and *AI* indices of the found helminth species and their affiliation to a particular group by the method of infection of the hosts are presented in Table 3.

There was no apparent dominance of a particular rodent species. The highest occurrence was found for *Myodes glareolus* (45%) and *Sylvaemus flavicollis* (32%). These species dominated in the forest-steppe zone together with *S. uralensis*, although the last species occurs non-frequently in the samples (13%). The occurrence frequency of these species gradually decreased at the boundary zones between forests and completely deforested areas (Vlasov, 1996). *Microtus arvalis* occurs relatively rarely (8%) only at the open (woodless) areas in the site «Ostrasyevy Yary». Non-numerous records of *Apodemus agrarius* within the present study are in accordance with data of the last seven years that this species has been rarely recorded in the Belogorye State Nature Reserve. It is caused by unfavourable habitat conditions of ravine oak forests for this species (Vlasov, 1996; Shchekalo, 2017).

Table 1. The species composition of the mouse-like rodents and data on their invasion by helminthes in the Belogorye State Nature Reserve (European Russia) in 2016–2017

Host species	Number of host specimens studied	*PP*, %	Number of helminth species				Number of helminth specimens
			Trematoda	Cestoda	Nematoda	Total	
Myodes glareolus	53	54.7	1	5	4	10	910
Microtus arvalis	10	60.0	–	1	2	3	30
Sylvaemus flavicollis	38	97.4	1	3	3	7	740
Sylvaemus uralensis	15	73.3	–	2	2	4	57
Apodemus agrarius	2	–	–	1	–	1	76
Total	118	72.0	2	12	11	25	1813

Table 2. The helminth species of mouse-like rodents in the Belogorye State Nature Reserve (European Russia) in 2016–2017

№	Helminth taxa	Sites	Host	Localisation	Specificity of helminthes
Trematoda					
Family Dicrocoeliidae					
1	*Platynosomum muris* Stcherbakova, 1942	YS (Sv, ELv)	*Myodes glareolus*, *Sylvaemus flavicollis*	Liver	Euryxenous
2	Dicrocoeliidae spp. Odhner, 1911	YS (Sv, ELv)	*Myodes glareolus*, *Sylvaemus flavicollis*	Small intestine	Euryxenous
Cestoda					
Family Anoplocephalidae					
3	*Anoplocephaloides dentata* (Galli-Valerio, 1905) Rausch, 1976	OY	*Microtus arvalis*	Small intestine	Euryxenous
4	*Paranoplocephala omphalodes* (Hermann, 1783) Lühe, 1910	OY	*Myodes glareolus*	Small intestine	Oligoxenous
Family Catenotaeniidae					
5	*Catenotaenia henttoneni* Haukisalmi & Tenora, 1993	YS (Sv, ELv)	*Myodes glareolus*	Small intestine	Euryxenous
6	*Spasskijela lobata* (Baer, 1925) Tenora, 1959	OY, YS (ELv)	*Sylvaemus flavicollis*, *Sylvaemus uralensis*	Small intestine	Stenoxenous
Family Hymenolepididae					
7	*Hymenolepis* sp.	LnV, OY, YS (Sv)	*Myodes glareolus*, *Sylvaemus flavicollis*, *Sylvaemus uralensis*, *Apodemus agrarius*	Small intestine	Euryxenous
Family Taeniidae					
8	*Taenia* sp. L., 1758 larvae	OY, YS (Sv, ELv)	*Myodes glareolus*	Liver	Euryxenous
9	*Hydatigera taeniaeformis* (Batsch 1786) s.l. larvae	OY	*Sylvaemus flavicollis*	Liver	Euryxenous
Family Mesocestoididae					
10	*Mesocestoides* sp. Vaillant, 1863 larvae	YS (Sv)	*Myodes glareolus*	Abdominal cavity	Euryxenous
Nematoda					
Family Capillariidae					
11	*Pterothominx sadovskoi* Morozov, 1956	LnV	*Myodes glareolus*	Small intestine	Euryxenous
Family Trichuridae					
12	*Trichuris muris* (Schrank, 1788)	OY	*Sylvaemus flavicollis*	Cecum	Euryxenous
Family Metastrongylidae					
13	Metastrongylidae spp. Molin, 1861	OY	*Myodes glareolus*	Lungs	Euryxenous
Family Heligmosomidae					
14	*Heligmosomoides laevis* Dujardin, 1845	OY	*Microtus arvalis*	Small intestine	Stenoxenous
15	*Heligmosomoides polygyrus* Dujardin, 1845	LnV, OY, YS (Sv, ELv)	*Sylvaemus flavicollis*, *Sylvaemus uralensis*	Small intestine	Stenoxenous
Family Oxyuridae					
16	*Syphacia nigeriana* Baylis, 1928	OY	*Microtus arvalis*	Cecum	Stenoxenous
17	*Syphacia petrusewiczi* Bernard, 1966	LnV	*Myodes glareolus*	Cecum	Oioxenous
18	*Syphacia stroma* Linstow, 1884	LnV, OY, YS (Sv, ELv)	*Sylvaemus flavicollis*	Small intestine	Stenoxenous
19	*Syphacia* sp. Seurat, 1916	LnV, OY, YS (Sv, ELv)	*Myodes glareolus*, *Microtus arvalis*, *Sylvaemus flavicollis*, *Sylvaemus uralensis*	Cecum	–
Family Spirocercidae					
20	*Mastophorus muris* Gmelin, 1790	LnV, OY	*Myodes glareolus*	Stomach	Euryxenous

Note: Sites of the Belogorye State Nature Reserve: LnV – «Les na Vorskle», OY – «Ostrasyevy Yary», YS (Sv, ELv) – «Yamskaya Step'» (Sury valley, Eremkin Log valley). Specificity of helminthes: oioxenous parasite – highly specific to a host species; stenoxenous parasite – specific at the level of host genus; oligoxenous parasite – specific at the level of a host family; euryxenous parasite – infests a broad range of non-related hosts.

The fodder base of micromammals included the food of both plant (seeds, vegetative parts of plants) and animal (Molluska, Myriapoda, Insecta) origin. Cricetidae species fed mainly on herbaceous plants. Muridae preferred cereal crops, but their food spectra also included terrestrial invertebrates (Terekhovich, 1966). The differences in the feeding types and the main food types could affect the invasion of rodents by certain helminth species.

The helminthes were divided into eight groups according to the way of penetration into the host body (Tokobaev, 1976). On the examined sites in the Belogorye State Nature Reserve, there were three groups of helminthes (Table 3). First of them were invasive larvae in the eggs. Infection occurred when the eggs were swallowed (8 species). The second group was represented by invasive larvae living freely in terrestrial ecosystems. The infection occurred during ingestion of larvae (for example, together with plant leaves) (2 species). The third group includes invasive larvae localised in the body of terrestrial invertebrates (intermediate hosts). Infection of definitive hosts (small mammals) occurred, once the rodent consumed the intermediate hosts (9 species). We did not succeed in referring the representatives of the family Metastrongylidae to any group, because their biology has still not been studied sufficiently. Considering that the helminthes of the first, second (except *Myodes glareolus*), and the third group were found in all the studied hosts, we assumed that the diet of both Cricetidae and Muridae species included both plant and animal components and thus it was quite similar.

Table 3. Quantitative indicators and characteristics of helminthes in mouse-like rodents captured in the Belogorye State Nature Reserve (European Russia) in 2016–2017

№	Helminth taxa	Host	*PP* for certain species of hosts, %	*PP* total, %	*IIA*	*AI*	Way of penetration into the host body
Trematoda							
1	*Platynosomum muris*	*Myodes glareolus* *Sylvaemus flavicollis*	1.89 ± 1.87 5.26 ± 3.60	2.55 ± 1.45	1–6 1–5	0.11 0.16	LiI*
2	Dicrocoeliidae spp.	*Myodes glareolus* *Sylvaemus flavicollis*	1.87 ± 1.86 2.63 ± 2.59	1.70 ± 1.19	0–1 1–3	0.02 0.08	LiI*
Cestoda							
3	*Anoplocephaloides dentata*	*Microtus arvalis*	10.00 ± 9.50	1.58 ± 1.15	0–2	0.20	LiI
4	*Paranoplocephala omphalodes*	*Myodes glareolus*	5.67 ± 3.18	4.76 ± 1.96	1–2	0.09	LiI
5	*Catenotaenia henttoneni*	*Myodes glareolus*	3.78 ± 2.62	1.70 ± 1.19	0–2	0.08	LiI
6	*Spasskijela lobata*	*Sylvaemus flavicollis* *Sylvaemus uralensis*	7.90 ± 4.37 6.70 ± 6.45	3.40 ± 1.67	2–5 0–2	0.30 0.13	LiI
7	*Hymenolepis* sp.	*Myodes glareolus* *Sylvaemus flavicollis* *Sylvaemus uralensis* *Apodemus agrarius*	3.77 ± 2.61 36.80 ± 7.80 6.70 ± 6.45 100.00	17.00 ± 3.46	1–3 3–129 1–2 20–47	0.06 7.26 0.20 33.50	LiI*
8	*Taenia* sp. larvae	*Myodes glareolus*	7.50 ± 3.62	3.40 ± 1.67	1–4	0.24	E
9	*Hydatigera taeniaeformis* s.l. larvae	*Microtus arvalis* *Sylvaemus flavicollis*	10.00 ± 9.50 1.90 ± 2.21	0.85 ± 0.84	0–1 0–1	0.10 0.03	E
10	*Mesocestoides* sp. larvae	*Microtus arvalis* *Myodes glareolus* *Apodemus agrarius*	20.00 ± 12.65 1.90 ± 1.80 –	0.85 ± 0.84	2–3 0–1 0–1	0.50 0.02 0.50	LiI
Nematoda							
11	*Pterothominx sadovskoi*	*Myodes glareolus*	11.32 ± 4.35	5.09 ± 2.02	1–60	3.92	E
12	*Trichuris muris*	*Sylvaemus flavicollis*	13.16 ± 5.48	4.24 ± 1.86	2–9	0.60	E
13	Metastrongylidae spp.	*Myodes glareolus*	1.89 ± 1.87	0.85 ± 0.84	0–12	0.23	?
14	*Heligmosomoides laevis*	*Microtus arvalis*	20.00 ± 12.65	6.80 ± 2.32	1–6	0.7	FLL
15	*Heligmosomoides polygyrus*	*Sylvaemus flavicollis* *Sylvaemus uralensis*	55.26 ± 8.07 46.67 ± 12.89	14.4 ± 3.23	1–12 1–6	3.44 0.8	FLL
16	*Syphacia nigeriana*	*Microtus arvalis*	30.00 ± 14.50	4.70 ± 1.95	1–4	0.70	E
17	*Syphacia petrusewiczi*	*Myodes glareolus*	1.90 ± 1.80	1.89 ± 1.25	0–1	0.02	E
18	*Syphacia stroma*	*Sylvaemus flavicollis*	23.70 ± 6.90	17.00 ± 11.96	2–43	3.90	E
19	*Syphacia* sp.	*Microtus arvalis* *Myodes glareolus* *Sylvaemus flavicollis* *Sylvaemus uralensis*	10.00 ± 9.50 16.98 ± 5.15 34.21 ± 7.70 26.70 ± 11.40	22.04 ± 3.85	0–12 1–300 2–17 1–20	1.20 10.63 3.13 2.67	E
20	*Mastophorus muris*	*Myodes glareolus*	15.09 ± 4.90	6.78 ± 2.30	1–8	0.49	LiI*

Note: E – invasive larvae were in the eggs, infection occurred when the eggs were swallowed; FLL – invasive larvae live freely in terrestrial ecosystems, the infection occurred during ingestion of larvae; LiI – invasive larvae were localised in the body of terrestrial invertebrates (intermediate hosts), invasion of definitive hosts (small mammals) occurred when the rodent consumed the intermediate host; asterisk (*) indicates the helminthes that infect the rodents through prey (invertebrates) as a result of active hunting.

Single trematodes occurred only in the studied mouse-like rodents sampled on the site «Yamskaya Step'». *Platynosomum muris* Stcherbakova, 1942 was found with low abundance (*PP* = 2.55%) only in four host specimens. Other species of the family Dicrocoeliidae (1.7%) were also recorded in low number. However, they have not been identified at species level. These helminthes were polyhostal. Their life cycle probably included terrestrial mollusks or insects as intermediate hosts, since there were no large water bodies on the sampling site.

Among Cestoda species, we found mature adults (55%), for which rodents were the final hosts, as well as larva individuals (45%), which used rodents as intermediate hosts. *Hymenolepis* sp. (*PP* = 17%) dominated amongst mature adults, followed by *Paranoplocephala omphalodes* (Hermann, 1783) Lühe, 1910 (4.8%), *Spasskijela lobata* (Baer, 1925) Tenora, 1959 (3.4%) (subdominant species), *Catenotaenia henttoneni* Haukisalmi & Tenora, 1993 (1.7%), and *Anoplocephaloides dentata* (Galli-Valerio, 1905), Rausch, 1976 (1.6%) (secondary species).

Paranoplocephala omphalodes was found in *Myodes glareolus*, while *Microtus arvalis* was the main definitive host of this parasite in the neighbouring regions (Kursk region and Voronezh region) (Romashova & Romashov, 1996; Vlasov et al., 2015). We determined this species according to morphological characters. However, *P. omphalodes* is morphologically similar to some other species. In this case, it is preferable to analyse the nucleotide sequences, since there is no molecular genetic evidence that this parasite infects *Myodes glareolus* in the Central Russian Upland, nor in the whole of Russia (Vlasenko et al., 2019).

Taenia sp. (3.4%) was the dominant cestode species at the larval stages of development. *PP* of *Hydatigera taeniaeformis* (Batsch 1786) larvae and *Mesocestoides* sp. larvae were only 0.85%. As domestic cats (*Felis catus* Linnaeus, 1758) play a considerable role in the *H. taeniaeformis* distribution, this parasite species can occur much more frequently on territories adjacent to Protected Areas.

According to the degree of specificity, euryxenous species prevailed among the registered cestodes (six species, including three at the larval ontogenetic stages). One species was oligoxenous (found in Cricetidae species). Finally, one species was stenoxenous (found only in *Sylvaemus uralensis* and *Apodemus agrarius*) (Table 2).

*Heligmosomoide*s (*PP* = 27.1%) and *Syphacia* (*PP* = 35.6%) were the dominant Nematoda genera, in particular, presented by *Heligmosomoide*s *polygyrus* Dujardin, 1845 (14.4%) and *Syphacia stroma* Linstow, 1884 (17%). Subdominant species were presented by *Mastophorus muris* Gmelin, 1790 (6.8%), *Pterothominx sadovskoi* Morozov, 1956 (5.1%), and *Trichuris muris* (Schrank, 1788) (4.2%). *Syphacia petrusewiczi* Bernard, 1966 (1.9%) was a rare species (Table 3).

According to the host specificity, the found nematodes were presented nearly equally by polyhostal (euryxenous) parasites (4 species) with a wide range of potential hosts and genus-specific (stenoxenous) parasites (4 species). One species, *Syphacia petrusewiczi*, was highly specific for *Myodes glareolus* (Table 3).

Part of the specimens, designated as *Syphacia* sp. and similar to *Sylvaemus flavicollis*, was not identified to the species level, because the helminth specimens were damaged. These species were localised in the upper parts of the small intestine. It is not typical for most *Syphacia* species, while it is typical for *Syphacia stroma*. In addition, some morphological traits (e.g., the shape of the cephalic apex, distribution and number of papillae) indicated that these nematodes could belong to *S. stroma*. However, additional genetic analysis is necessary for confident species identification.

Long-term studies of the helminth fauna of mouse-like rodents have been also carried out in regions, adjacent to the Belgorod region (Kursk region (Vlasov et al., 2015; Vlasov, 2016), Voronezh region (Romashov & Shulyak, 1995; Romashova & Romashov, 1996; Romashov, 1997; Romashov et al., 2003). However, these investigations concerned only Protected Areas. The comparison of these studies and our results demonstrates that in the Central Chernozem Region of Russia, the helminth fauna comprises in total over 60 species at the mature adult and larval ontogenetic stages of the five species of mouse-like rodents. Amongst them there are Trematoda (at least eight and one species in mature adult and larval stages, respectively), Cestoda (at least 11 and nine species in mature adult and larval stages, respectively), Nematoda (at least 26 and two species in mature adult and larval stages, respectively), and Acanthocephala (only one species in the larval ontogenetic stage).

Now, nine species have been recorded for all three mentioned regions, including *Anoplocephaloides dentata* (Galli-Valerio, 1905), Rausch, 1976, *Paranoplocephala omphalodes*, *Spasskijela lobata*, *Hydatigera taeniaeformis* s.l. (larvae), *Trichuris muris*, *Heligmosomoides polygyrus*, *Syphacia nigeriana* Baylis, 1928, *S. petrusewiczi*, and *S. stroma*. Four species (*Plagiorchis elegans* (Rudolphi, 1802), *Catenotaenia matovi* Genov, 1971, *Heligmosomum costellatum* (Dujardin, 1845), and *Syphacia agrarian* Sharpilo, 1973) were reported in Kursk region and Voronezh region, while they are still not registered in rodents of the Belgorod region. The first of those four species was recorded at the stage of cercaria in mollusks in the Belgorod region. Most likely, the remaining three species may also be found in the Belgorod region in future.

Mesocestoides sp. (larvae), *Heligmosomoides laevis* Dujardin, 1845 and *Mastophorus muris* are known in the Belgorod region and Voronezh region. Parasites of the genus *Hymenolepis* were reported for the Belgorod region (*Hymenolepis* sp.) and Kursk region (*Hymenolepis apodemi* Makarikov & Tkach, 2013, *Hymenolepis* sp.).

The larvae of trematodes *Posterocirrus clethrionomi* Andreiko & Khotenovsky, 1964, *Skrjabinoplagiorchis vigisi* Petrov & Merkuscheva, 1963, *Psilotrema simillimum* (Muhling, 1898), *Notocotylus noyeri* Joyeux, 1922, *Echinostoma miyagawai* Ishii, 1932, *Echinostoma revolutum* (Fröhlich, 1802), and *Alaria alata* (Goeze, 1782) were recorded only in the Voronezh region. This may be explained by the lack of large water bodies which is necessary to complete the life cycle of trematodes in the Kursk region and Belgorod region.

Platynosomum muris has currently only been recorded in the Belgorod region, being reported for the first time in the Central Chernozem Region of Russia. Cestodes of genus *Catenotaenia* are found in all three regions. Of them, *C. henttoneni* is known in Belgorod region and Kursk region, while *C. cricetorium* Kirschenblatt, 1949 is noted in the Belgorod region.

Among cestodes, the mature adults of *Paranoplocephala gracilis* Tenora & Murai, 1980 and larvae of *Paruterina candelabraria* (Goeze, 1782), *Taenia crassiceps* (Zeder, 1800), *T. martis* (Zeder, 1803), *T. polyacantha* Leuckart, 1856, and *Versteria mustelae* (Gmelin, 1790) are known only in the Voronezh region. Only in the Kursk region, *Rodentolepis straminea* (Goeze, 1782) and unidentified taxa of families Anoplocephalidae and Paruterinidae are noted.

Nematodes of the genus *Heligmosomoides* are known in a large number from all three regions. However, *H. polygyrus* is predominated among them. *Heligmosomoides laevis* is a specific parasite of the genus *Microtus*. It less commonly occurrs and is known only in the Voronezh region and Belgorod region. Noteworthy, *H. glareoli* Baylis, 1928, a widespread parasite of *Myodes glareolus*, has not been found in the Belogorye State Nature Reserve, although this species is the dominant species in the Voronezh region. Finally, *H. mixtum* is reported only in the Voronezh region.

The nematodes *Capillaria hepatica* Bancroft, 1893, *C. murissylvatici* Dieseng, 1851, *Eucoleus bacillatus* (Eberth, 1863), *Trichinella native* Britov & Boev, 1972, *Strongyloides papillosus* (Wedl, 1856), *Ganguleterakis spumosa* (Schneider, 1866), *Aspiculuris dinniki* Schulz, 1927, *A. tetraptera* (Nitzsch, 1821), *Syphacia obvelata* (Rudolphi, 1802), *Rictularia proni* Seurat, 1915, *Boreostrongvlus minutus* , *Syngamus* sp., *Physocephalus sexalatus* (Molin, 1860) (larvae), and *Spirocerca lupi* (Rudolphi, 1809) (larvae) are known only in the Voronezh region. *Trichocephalus arvicolae* and *Syphacia frederici* Roman, 1945 were reported only in the Kuresk region.

The nematode *Pterothominx sadovskoi* is known only from the Belgorod region. In the present study, this species is noted for the first time in the Central Chernozem Region of Russia. Only one species of Acanthocephala, *Macracanthorhynchus catulinus* Kostylew, 1927 (larvae), was registered in mouse-like rodents in the Voronezh region. Its presence is associated with a specific intermediate host, the beetle *Elenephorus* sp.

Conclusions

In the present study, five species of mouse-like rodents (*Myodes glareolus*, *Microtus arvalis*, *Sylvaemus flavicollis*, *Sylvaemus uralensis*, and *A. agrarius*) were registered in 2016–2017 at three clusters in the Belogorye State Nature Reserve («Les na Vorskle», «Ostrasyevy Yary», and «Yamskaya Step'»). Twenty helminth species were found. Of them, ten species belong to Nematoda, and ten species to Plathelminthes, including eight Cestoda species and two Trematoda species. In Cestoda, we found both mature adults (for which the rodents were definitive hosts) and larvae (for which the rodents were intermediate hosts). In the examined mammals, the parasite prevalence was 72%. We recorded parasites in 91% of the Muridae specimens and only in 55.6% of the Cricetidae specimens.

According to the host specificity, euryxenous species prevailed in flatworms. The nematodes were represented by polyhostal and host-specific species in almost equal proportions. *Syphacia petrusewiczi*, a highly specific parasite for *Myodes glareolus*, was also found.

We found dominant species characterised by maximum parasite prevalence, invasion intensity amplitude, and abundance index. There were *Hymenolepis* sp. (PP = 17%, $1 < IIA < 129$) amongst Plathelminthes, the species of *Syphacia* (PP = 35.6%) and *Heligmosomoides* (PP = 27.1%) amongst Nematoda, in particular, *S. stroma* (17%) and *H. polygyrus* (14.4%). The other helminth species registered within the present study were either secondary ($2\% < PP < 14\%$) or rare ($PP < 2\%$).

Two species, *Platynosomum muris* (Trematoda, Dicrocoeliidae) and *Pterothominx sadovskoi* (Nematoda, Capillariidae), were reported for the first time for the helminth fauna of the Central Chernozem Region of Russia.

References

Anikanova V.S., Bugmyrin S.V., Ieshko E.P. 2007. *Methods for collecting and studying helminthes of small mammals*. Petrozavodsk: Karelian Research Center of RAS. 145 p. [In Russian]

Caira J.N., Jensen K., Barbeau E. (Eds). 2020. *Global Cestode Database*. Available from www.tapewormdb.uconn.edu

Dobson A., Lafferty K.D., Kuris A.M., Hechinger R.F., Jetz W. 2008. Homage to Linnaeus: how many parasites? How many hosts? *Proceedings of the National Academy of Sciences of the United States of America* 105(Suppl. 1): 11482–11489. DOI: 10.1073/pnas.0803232105

Gromov I.M., Erbaeva M.A. 1995. *Mammals of the fauna of Russia and adjacent territories. Lagomorphsand rodents*. Saint-Petersburg: Zoological Institute RAS. 522 p. [In Russian]

Hudson P.J., Dobson A.P., Lafferty K.D. 2006. Is a healthy ecosystem one that is rich in parasites? *Trends in Ecology and Evolution* 21(7): 381–385. DOI: 10.1016/j.tree.2006.04.007

Karaseva E.V., Telitsina A.Yu. 1996. *Methods for the study of rodents in the field: counts and tagging*. Moscow: Nauka. 227 p. [In Russian]

Orlova M.V., Orlov O.L. 2019. Conservation of animals' parasite species: problems and prospects. *Nature Conservation Research* 4(1): 1–21. DOI: 10.24189/ncr.2019.011 [In Russian]

Pavlinov I.Ya., Lissovsky A.A. (Eds). 2012. *The Mammals of Russia: A Taxonomic and Geographic Reference*. Moscow: KMK Scientific Press Ltd. 604 p. [In Russian]

Poulin R., Morand S. 2000. The diversity of parasites. *Quarterly Review of Biology* 75(3): 277–293. DOI: 10.1086/393500

Romashov B.V. 1997. Helminthes of mouse-like rodents in the Usmansky pine forest. *Proceedings of Voronezh State Nature Biosphere Reserve*. 23: 186–206. [In Russian]

Romashov B.V., Shulyak A.V. 1995. *Helminthes of rodents at the biological station of the Voronezh State University*. *Proceedings of the biological educational-scientific centre of the Voronezh State University «Venevitinovo»* 6: 101–106. [In Russian]

Romashov B.V., Khitsova L.N., Trufanova E.I., Romashova N.B. 2003. *Methodics of helminthological studies of vertebrates*. Voronezh: Voronezh State University. 35 p. [In Russian]

Romashova N.B. 2004. *Ecology and biodiversity of helminthes of mouse-like rodents in the conditions of island forests of the Central Chernozem Region*. PhD Thesis. Voronezh. 113 p. [In Russian]

Romashova N.B., Romashov B.V. 1996. Helminthes of mouse-like rodents of the Voronezh State Nature Reserve. In: *Fauna of the Central Chernozem Region and the formation of ecological culture*. Lipetsk. P. 51–52. [In Russian]

Ryzhikov K.M. (Eds). 1978. *Determinant of the helminthes in rodents of the USSR fauna. Cestodes and trematodes*. Moscow: Nauka. 232 p. [In Russian]

Ryzhikov K.M. (Eds). 1979. *Determinant of the helminthes in rodents of the USSR fauna. Nematodes and Acanthocephala*. Moscow: Nauka. 272 p. [In Russian]

Shchekalo M.V. 2017. Population and abundance of small mammals in ravine oak forests of the upper Pososkolye region. In: *Nature of Belgorod region and its protection*. Gubkin. P. 5. [In Russian]

Sheykina Z.V., Zhigileva O.N. 2018. Helminthes of shrews (Soricidae) in the «Malaya Sosva» Nature Reserve (Russia). *Nature Conservation Research* 3(3): 28–36. DOI: 10.24189/ncr.2018.019 [In Russian]

Skryabin K.I., Shikhobalova N.P., Ladogovskaya E.A. 1961. *Oxyurates of animals and humans*. Vol. 10(2). Moscow: AS USSR. 497 p. [In Russian]

Souza J.G., Simoes R.O., Thiengo S.A., Lima W.S., Mota E.M., Rodrigues-Sylva R., Lanfredi R.M., Maldonado A.Jr. 2009. A New Metastrongilid Species (Nematoda: Metastrongylidae): A Lungworm From Akodon Montensis (Rodentia: Sigmodontinae) in Brazil. *Journal of Parasitology* 95(6): 1507–1511. DOI: 10.1645/GE-2013.1

Summers K., McKeon S., Sellars J., Keusenkothen M., Morris J., Gloeckner D., Pressley C., Price B., Snow H. 2003. Parasitic exploitation as an engine of diversity. *Biological Reviews* 78(4): 639–675. DOI: 10.1017/S146479310300616X

Terekhovich V.F. 1966. *Ecology of the Bank vole and Yellow-necked field mouse*. PhD Thesis Abstract. Minsk. 22 p. [In Russian]

Tokobaev M.M. 1976. *Helminthes of wild mammals in Central Asia. The experience of ecological-geographical analysis*. Frunze: Ilim. 177 p. [In Russian]

Vlasenko P., Abramov S., Bugmyrin S., Dupal T., Fomenko N., Gromov A., Zakharov E., Ilyashenko V., Kabdolov Zh., Tikunov A., Vlasov E., Krivopalov A. 2019. Geographical distribution and hosts of the cestode *Paranoplocephala omphalodes* (Hermann, 1783) Lühe, 1910 in Russia and adjacent territories. *Parasitology Research* 118(12): 3543–3548. DOI: 10.1007/s00436-019-06462-z

Vlasov A.A. 1996. *Population of small mammals of Protected Areas in the central forest-steppe zone*. PhD Thesis Abstract. Ekaterinburg. 19 p. [In Russian]

Vlasov E.A. 2016. *Helminthes of wild mammals in the Central Chernozem State Nature Reserve (fauna, ecology, pathogenic value)*. PhD Thesis. Kursk. 167 p. [In Russian]

Vlasov E.A., Malisheva N.S., Krivopalov A.V. 2015. Helminth fauna of myomorph rodents (Rodentia, Myomorpha) in the Central Chernozem State Nature Reserve. *Russian Parasitological Journal* 4: 24–33. DOI: 10.737/16656

ПАРАЗИТИЧЕСКИЕ ЧЕРВИ МЫШЕОБРАЗНЫХ ГРЫЗУНОВ ГОСУДАРСТВЕННОГО ПРИРОДНОГО ЗАПОВЕДНИКА «БЕЛОГОРЬЕ» (РОССИЯ)

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Исследования проводились в 2016–2017 гг. на трех участках Белогорского государственного природного заповедника (Россия), расположенных в пределах лесостепной зоны: 1) «Лес на Ворскле» (нагорная дубрава); 2) «Острасьевы яры» (байрачная дубрава, разнотравно-луговая степь); 3) «Ямская степь» (балка Суры – кустарниковые заросли, разнотравно-луговая степь; Еремкин лог – нагорная дубрава, разнотравно-луговая степь). Мелкие млекопитающие отлавливались с помощью ловушек-давилок, выставлявшихся в линии по 50 шт. или 100 шт. Дополнительно использовались одиночные давилки и ловчие канавки с конусами (средняя длина 30 м). Среди пойманных грызунов (118 особей) было зарегистрировало пять видов: *Myodes glareolus*, *Microtus arvalis*, *Sylvaemus flavicollis*, *Sylvaemus uralensis*, *Apodemus agrarius*. Общая экстенсивность инвазии грызунов составила 72%. При этом среди мышей зараженными оказались 91%, а зараженность полевок была почти в два раза меньше (55.6%). Отмечено 20 видов гельминтов, относящихся к трем классам, шести отрядам и 12 семействам. Среди трематод были обнаружены только эвриксенные виды. Среди цестод преобладали эвриксенные виды. Среди нематод эвриксенные и стеноксенные виды присутствовали в равном соотношении. В качестве доминирующих видов, характеризующихся максимальными значениями экстенсивности инвазии (ЭИ) среди плоских червей были отмечены *Hymenolepis* sp. (17%), среди нематод – представители родов *Syphacia* (35.6%) и *Heligmosomoides* (27.1%), в частности *S. stroma* (17%) и *H. polygyrus* (14.4%). Остальные виды обнаруженных гельминтов отнесены к малочисленным (2% < ЭИ < 14%) либо к редким (ЭИ < 2%). Впервые для территории Центрально-Черноземного региона приводятся два вида гельминтов: *Platynosomum muris* (Trematoda, Dicrocoeliidae), *Pterothominx sadovskoi* (Nematoda, Capillariidae).

Ключевые слова: Белгородская область, гельминты, микромаммалии, мыши, нематоды, паразиты, полевки, трематоды, цестоды