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Structure of helminth fauna in *Apodemus uralensis* (Pallas, 1771) from natural and anthropized ecosystems of the Republic of Moldova

Oleg Chihai, Victoria Nistreanu, Alina Larion, Ștefan Rusu, Nina Tălămbuță, Maria Zamornea, Galina Melnic, and Oxana Kolodrevski

Abstract. The taxonomic structure consists of 3 classes, 10 families, 12 genera and 13 species, of which 6 parasitic species belong to the Cestoda class (*Skrjabinotaenia lobata*, *Catenotaenia cricetorum*, *Hydatigera taeniaeformis*, *Hydatigera taeniaeformis*, *Taenia pisiformis*, *Paranoplocephala omphaloides*, *Rodentolepis straminea*), with a share of 46.1% of the total species, 5 species - to the Secernentea class (*Syphacia obvelata*, *Syphacia stroma*, *Heligmosomoides polygyrus*, *Mastophorus muris*, *Strongyloides ratti*) with a share of 38.5%, and 2 species – to the Adenophorea class (*Trichuris muris*, *Capillaria hepatica*), constituting 15.4% of the total identified species.
Keywords: parasite fauna, *Apodemus uralensis*, biotopes, Republic of Moldova.

Structura helmintofaunei la *Apodemus uralensis* (Pallas, 1771) din ecosisteme naturale şi antropizate ale Republicii Moldova

Rezumat. Structura taxonomică este constituită din 3 clase, 10 familii, 12 genuri şi 13 specii, dintre care 6 specii parazitare sunt din clasa Cestoda (*Skrjabinotaenia lobata*, *Catenotaenia cricetorum*, *Hydatigera taeniaeformis*, *Hydatigera taeniaeformis*, *Taenia pisiformis*, *Paranoplocephala omphaloides*, *Rodentolepis straminea*), care constituie 46,1% din totalul de specii identificate, 5 specii – din clasa Secernentea (*Syphacia obvelata*, *Syphacia stroma*, *Heligmosomoides polygyrus*, *Mastophorus muris*, *Strongyloides ratti*) cu o pondere de 38,5% şi 2 specii – din clasa Adenophorea (*Trichuris muris*, *Capillaria hepatica*), alcătuind 15,4% din totalul de specii identificate.
Cuvinte cheie: parazitofauna, *Apodemus uralensis*, biotopuri, Republica Moldova.

1. Introduction

Small rodents occupy the dominant place among mammals, and from an ecological point of view they are one of the main components of the ecosystem. This group of animals has a beneficial effect on the structure of the soil and the layer of vegetation with grass and shrubs, also representing the main prey of many species of reptiles, prey birds and predatory mammals [10]. In addition to the beneficial effects on the environment,

rodents also have a negative role by being hosts (intermediate, definitive) for a variety of invasive forms of parasitic species characteristic to other animals and humans [1, 2, 3, 4, 6, 8, 17, 18, 28,].

The pygmy field mouse (*Apodemus uralensis*, Pallas, 1771) inhabits the forest edge and open type biotopes: meadows, grasslands, agrocenoses, fallow ground. It is a species of lower frequency and ecological significance compared to other small rodents [10, 11].

Parasitic organisms are an integral part of natural biocenoses. They are of particular importance in the biosphere, through direct involvement in the formation and regulation of biodiversity [5, 13]. Helminths, by interacting with different groups of animals through various ecological connections, form parasite-host systems with increased bioecological stability and represent models for studying the diversity and variability of parasite-host biosystems [23]. Quantitative and qualitative changes of parasite species, age and seasonal infection rates of hosts, characterize the specific changes of certain ecoparasitological situations in different types of ecosystems [7, 13, 14, 15].

The helminthological studies in rodents are of particular interest, because the global and local anthropogenic transformations have a considerable impact on the biodiversity of natural and anthropized ecosystems [21, 22].

The aim of the paper was the ecoparasitological study in order to establish the structure of the parasitic fauna of the host species *Apodemus uralensis* (Pallas, 1771) from different biotopes of the Republic of Moldova.

2. Materials and methods

The small rodents were collected during 2015–2020 years, from different natural and anthropogenic ecosystems of the Republic of Moldova. The capture of the specimens was carried out by placing 100 live traps at a distance of 5 m from each other. This methodology is recommended for biotopes with a well-developed shrub layer and abundant grass cover [12].

The investigations were carried out in the laboratory of Parasitology and Helminthology of the Institute of Zoology, on 20 specimens of *A. uralensis* (5 – ♂, 15 – ♀) collected from various biotopes of the Republic of Moldova. Laboratory parasitological investigations were performed by total dissection of previously euthanized rodents, with microscopic examination of the muscles (masseter muscles, arms, diaphragm) and internal organs (trachea, lungs, heart, tongue, esophagus, stomach, small intestine, large intestine, liver, spleen, kidneys, urinary bladder) in order to establish the structure of the helminth fauna and determine the parasitological indices [20, 25]. The identification of helminth species was carried out on morphological criteria according to standard methods [26, 27].

3. Results and discussions

The pygmy field mouse (*A. uralensis*) was identified on the territory of Moldova in the 80s of the 20th century from the polytypic species *A. sylvaticus* (Linnaeus, 1758). It is slightly larger than the house mouse (*Mus musculus*, Linnaeus, 1758) and smaller than the wood mouse [24]. *A. uralensis* usually prefers different natural (grasslands, forest shelter belts, perennial grass) and artificial (agrocenoses with cereal grasses, annual and perennial agricultural crops) biotopes. It avoids forests, wet meadows and wetlands. It is more frequently found in unprocessed biotopes, such as pastures, landslides with shrubs, thickets. Other types of biotopes are unevenly populated during the year. In autumn and winter, it usually inhabits the forest belts, in summer it can be met in wheat fields, perennial crops – vineyards, orchards. The animal has a predominantly nocturnal activity, it moves at different hours of the night, but sometimes also during the day. They can migrate to neighboring stations at a distance of several hundreds of meters. They live in underground galleries and feed on the seeds of spontaneous plants and agricultural crops, sometimes they consume insects, fruits, berries [9, 10, 16].

The ecological study regarding the preferences and distribution in various biotopes of the host *A. uralensis* compared to other species of small rodents, confirms the character of a spread throughout the whole territory between the Prut and the Dniester rivers. Thus, the higher biotope preference was found in weeding crops with a frequency of 52.6%, followed by unprocessed lands and autumn cereal grasses with 44.3% for each, then forest belts with 34.8%, perennial forage crops – 26.1% and perennial plantations – 17.3%.

The results of the parasitological investigations (tab. 1) carried out on the investigated host species (*A. uralensis*), show a prevalence with *Paranoplocephala omphaloides* of 10.0%, and the mean intensityis of 1.5 sp., respectively with *Rodentolipis straminea* – 5.0%, 2.0 sp., *Hydatigera taeniaeformis* – 10.0%, 1.0, *Catenotaenia cricetorum* – 5.0%,2.0, *Skrjabinotaenia lobata* – 10.0%, 1.5, *Taenia pisiformis* – 10.0%, 1.5, *Capillaria hepatica* – 15.0%, intensitate mică (+), *Syphacia stroma* – 5.0%, 82.0, *Syphacia obvelata* – 20.0%, 83.5, *Heligmosomoides polygirus* – 5.0%, 9.0, *Strongyloides ratti* – 15.0%, 19.7, *Mastophorus muris* – 20.0%, 5.0, and with *Trichocephalus muris* – 15.0%,2.3. Thus, from the total (20 specimens) of hosts examined, 70.0% (14 sp.) were infested with an average intensity of 37.6 specimen/animal.

The highest degree of spread was found with parasitic species *R. straminea*, *S. obvelata*, *M. muris*, *C. hepatica*, *S. lobata* (19.3 – 22.3%), a level of frequent spread was identified in *H. taeniaeformis*, *P. omphaloides*, *S. ratti*, *T. muris* (12,9 – 16,1%), a level of relative

Table 1. Structure of parasite fauna in *Apodemus uralensis* (Pallas, 1771)

Class	Family	Species	Prevalence, %	Intensity, sp.
Cestoda (6 species)	*Catenotaeniidae*	*Skrjabinotaenia lobata* (Baer, 1925)	10.0	1.5
		Catenotaenia cricetorum (Kirshenblatt, 1949)	5.0	2.0
	Taeniidae	*Hydatigera taeniaeformis* (Batsch, 1786)	10.0	1.0
	Mesocestoididae	*Taenia pisiformis* (Bloch, 1780)	10.0	1.5
	Anoplocephalidae	*Paranoplocephala omphaloides* (Herman, 1783)	10.0	1.5
	Hymenolepididae	*Rodentolepis straminea* (Goeze, 1782)	5.0	2.0
Secernentea (5 species)	*Oxyuridae*	*Syphacia obvelata* (Rudolphi, 1802)	20.0	83.5
		Syphacia stroma (Linstow, 1884)	5.0	82.0
	Heligmosomidae	*Heligmosomoides polygyrus* (Dujardin, 1845)	5.0	9.0
	Spirocercidae	*Mastophorus muris* (Gmelin, 1790)	20.0	5.0
	Strongyloididae	*Strongyloides ratti* (Sandground, 1925)	15.0	19.7
Adenophorea (2 species)	*Trichuridae*	*Trichuris muris* (Scrank, 1788)	15.0	2.3
	Capilariidae	*Capillaria hepatica* (Bancroft, 1893)	15.0	+

spread was identified *T. pisiformis* (10,0 %), and in species *S. stroma*, *H. polygyrus*, *C. cricetorum* a rarer spread has been recorded (5,0 – 6,5%).

The highest level of invasion intensity was found with *S. stroma* and *S. obvelata* (83,5 – 82,0 sp./animal), medium level – in *S. ratti* (19,7 sp./animal), and inferior level – in *S. lobata*, *C. cricetorum*, *H. taeniaeformis*, *Taenia pisiformis*, *P. omphaloides*, *R. straminea*, *T. muris*, *M. muris*, *H. polygirus* (1,0 – 2,3 sp./animal).

The taxonomic structure (tab. 1) is divided into 3 classes, 10 families, 12 genera and 13 species, of which 6 parasitic species belong to the Cestoda class, with a share of 46.1%

of the total species, 5 species - to Secernentea class with a share of 38.5%, and 2 species – to Adenophorea class constituting 15.4% of the total species identified.

The evolutionary characteristic (tab. 2) is represented by 6 species that develop according to the monoxenous model (*S. stroma*, *S. obvelata*, *C. hepatica*, *T. muris*, *H. polygirus*, *S. ratti*) and 7 species with polyxenous evolution, including 6 species with development according to the dixenous model with the presence of exogenous forms (*H. taeniaeformis*, *T. pisiformis M. muris*, *S. lobata*, *C. cricetorum*, *P. omphaloides*, *R. straminea*).

Table 2. Evolutive characteristics of the parasites

Model	Class			Total
	Cestoda	Secernentea	Adenophorea	
Monoxenous	-	S. obvelata S. stroma S. ratti H. polygirus	C. hepatica T. muris	6 species
Dixenous	H.taeniaeformis T. pisiformis S. lobata C. cricetorum P. omphaloides R. straminea	M. muris	-	7 species

Analyzing the bioevolutionary characteristic of the parasitic species of the class Cestoda, we find that endoparasitism is represented by 3 species with obligate stationary larval parasitism (*H. taeniaeformis* , *T. pisiformis*) and 3 species (*C. cricetorum*, *P. omphaloides*, *R. straminea, S. lobata*) with imaginal stationary obligate parasitism. While most species of nematodes are geohelminths (*H. polygyrus*, *M. muris*, *S. stercoralis*, *S. ratti*, *A. caninum*, *T. canis*, *T. leonina*, *T. vulpis*, *T. muris*, *C. hepaticum*), which develops freely without intermediate hosts. In the respective species, the embryogenesis and postembryonic evolution take place in the environment, where the free invasive forms keep the infesting property for a long period of time. Some species are geohelminths (*Syphacia stroma, S. obvelata*), they are located in the small and large intestine of rodents and humans, and females can lay fertilized eggs in the perianal region of the host, omitting the stage of development in the environment. Infestation takes place by autoinvasion, individual contact between hosts or by trophic way in carnivores.

Previously, on the territory of the Republic of Moldova, parasitological research was carried out between the 1960s and 1970s, and during this period the species *A. uralensis* was considered *A. sylvaticus*. Later, thanks to research in the field, *A. uralensis* was confirmed as a separate species [24]. Therefore, parasitological investigations from that period in *A. sylvaticus* highlighted an infestation with *Catenotaenia pusilla* – 3,74%, respectively, with *Skrjabinotaenia lobata* – 2,67%, *Rodentolepis straminea* – 3,03%, *Paruterina candeabraria* – 0,72%, *Taenia hydatigena – 0,54%, Hydatigera taeniaeformis* – 1,62%, *Trichinela spiralis* – 1,08%, *Trichocephalus muris* – 1,62%, *Heligmosomum aberrans* – 20,3%, *H. azerbaidjani* – 52,9%, *H. polygyrum* – 11,37%, *H. skrjabini* – 1,6%, *Aspiculurus dinniki* – 0,54%, *A. tetraptera* – 3,74% and *Syphacia stroma* – 8,02% [19].

The parasitological research carried out on samples of *A. uralensis*(*Sylvaemus uralensis*) collected from the National Park "Samarskaya luka" located in the Samara Region, Russian Federation, revealed 19 species of parasites belonging to different taxa: Trematoda - 3 species (*Plagiorchis elegans*, *Dicrocoelium lanceatum*, *Corrigia vitta*), Cestoda – 7 (*Aprostatandrya macrocephala*, *Skrjabinotaenia lobata*, *Catenotaenia cricetorum*, *Hymenolepis diminuta*, *Taenia hydatigena*, *Cladotaenia globifera* , *Hydatigera taeniaeformis*), Nematoda – 8 (*Heligmosomum mixtum*, *Heligmosomoides polygyrus*, Trichocephalus muris, *Syphacia montana*, *S. obvelata*, *Gongylonema neoplasticum*, *Rictularia proni*, *Capillaria annulosa*), Acanthocephala – 1 species (*Moniliformis moniliformis*). Among them, 6 species have a zoonotic and epizootic impact: the trematodes *Dicrocoelium lanceatum*, cestode *Hymenolepis diminuta, Rodentolepis straminea, Hydatigera taeniaeformis* larvae, *Taenia hydatigena larvae* and the nematode *Syphacia obvelata* [21, 22]. A similar study carried out in the Voronezh Region, Russia, shows that the helminth fauna of *A. uralensis* consists of *Syphacia stroma*with a prevalenceof 42,4%, *Syphacia obvelata* – 30,6%, *Heligmosomoides polygyrus* – 29,3% *Syphacia obvelata* – 15,7%, *Heligmosomoides polygyrus* – 25,2%, *Capillaria hepatica* – 8,2%, *Pseudocatenotaenia matovi* – 2,4%, *Trichocephalus muris* – 0,82%, *Ganguloterakis spumosa*–2,3%, *Rictularia proni* – 2,0%, *Mesocestoides lineatus* – 1,2%, *Skrjabinotaenia lobata* – 1,2%, *Plagiorchis elegans* – 1,2%, *Aspiculus tetraptera* – 1,2%, *Alaria alata* – 1,2%, *Hydatigera taeniaeformis* – 0,75%, *Hymenolepis diminuta*–0,42%, *Trichinela nativa* – 0,26% [25].

In this context, the parasitic organisms are an integral part of natural biocenoses, having a particular importance in the biosphere through direct impact on natural biodiversity. This is explained by the fact that helminths interacting with different groups of animals through various ecological connections, form host-parasite systems with increased bioecological

stability, and finally are considered factors regulating the diversity and variability of natural and anthropogenic ecosystems.

4. Conclusions

(1) The taxonomic structure of helminths is divided into 3 classes, 10 families, 12 genera and 13 species, of which 6 parasitic species belong to the class Cestoda (*Skrjabinotaenia lobata*, *Catenotaenia cricetorum*, *Hydatigera taeniaeformis*, *Hydatigera taeniaeformis*, *Taenia pisiformis*, *Paranoplocephala omphaloides*, *Rodentolepis straminea*), with a share of 46,1% from the total species, 5 species – to class Secernentea (*Syphacia obvelata*, *Syphacia stroma*, *Heligmosomoides polygyrus*, *Mastophorus muris*, *Strongyloides ratti*) with a share of 38,5%, and 2 species – to class Adenophorea (*Trichuris muris*, *Capillaria hepatica*) constituting 15,4% from the total species identified.

(2) Parasitological research on the host species *Apodemus uralensis* (Pallas, 1771) highlighted a prevalence with *Paranoplocephala omphaloides* de 10,0%, respectively, with*Rodentolipis straminea* – 5,0%, *Hydatigera taeniaeformis* – 10,0%, *Catenotaenia cricetorum* – 5,0%, *Skrjabinotaenia lobata* – 10,0%, *Taenia pisiformis* – 10,0%, *Capillaria hepatica* – 15,0%, low intensity (+), *Syphacia stroma* – 5,0%, *Syphacia obvelata* – 20,0%, *Heligmosomoides polygirus* – 5,0%, *Strongyloides ratti* – 15,0%, *Mastophorus muris* – 20,0%, and with *Trichocephalus muris* – 15,0%.

(3) The evolutionary characteristic of the helminth fauna is represented by 6 species that develop according to the monoxenous model (*S. stroma*, *S. obvelata*, *C. hepatica*, *T. muris*, *H. polygirus*, *S. ratti*) and 7 species with polyxenous development, including 6 species with development according to the dixenous model with the presence of exogenous forms (*H. taeniaeformis*, *T. pisiformis*, *M. muris*, *S. lobata*, *C. cricetorum*, *P. omphaloides*, *R. straminea*).

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(Chihai Oleg, Nistreanu Victoria, Larion Alina, Rusu Ștefan, Zamornea Maria, Melnic Galina) Institute of Zoology
E-mail address: olegchihai@yahoo.com

(Tălămbuță Nina) Free International University from Moldova

(Kolodrevski Oxana) Theoretical High School Public Institution „Alecu Russo", Orhei, Republic of Moldova