REPUBLIC OF AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of doctor of philosophy

SPECIES DIVERSITY OF HELMINTHS OF MICE AND HAMSTERS (RODENTİA: MURİDAE, CRİCETİDAE) IN LANKARAN REGION, LANDSCAPE–ECOLOGICAL FEATURES OF THEIR SPREAD

Specialty: 2429.01 – "Parasitology"

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INTRODUCTION

Relevance and degree of completion of the topic. Lankaran region is located in a very favorable area for the economy of the republic. Part of the “Silk Road”, which is of great economic importance for our country, passes through this area and is considered the “South Gate” of the republic.

"Ghzil-Aghaj State Nature Reserve", "Hirkan National Park", "Zuvand Reserve" of international importance are located here. There are many species of plants and animals in Lankaran region, many of which are endemic, small, or endangered.

A large number of farms, a number of tourism and industrial enterprises engaged in animal husbandry, poultry, crop production, and other fields were established in the Lankaran region. Along with other groups of animals, various rodent species are widespread in this area.

Rodents are the most diverse group of mammals and are found all over the world except Antarctica, the southern part of South America, Australia, New Zealand, Indonesia (except Sumatra) and Madagascar. There are 2277 species of rodents in the world, which is 40% of modern mammals[1]. 37 species of rodents included in 8 families and 19 genera are distributed in the fauna of Azerbaijan[2].

Since rodents are mainly included in the diet of fur-bearing animals, and birds (mainly birds of prey and some chicken-like birds), the regulation of their number depends on the number of rodents. Thus, the reduction in the number of rodents in nature leads to a decrease in the number of animals, and birds that feed on them. Among rodents, there are also animals of industrial importance, such as marsh beavers, squirrels, etc. can be shown. Because rodents eat plants, they cause serious economic damage to agriculture, especially grain and horticulture.

Some species of rodents, especially Mice and Hamsters, can re-

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[1] Wilson, D.E. and Reeder, D.M. (eds.) - 3 rd.ed. –Johns Hopkins University Press, 16 november 2005. - Vol.2. - 2142 p.

[2] Azərbaycanın heyvanlar aləmi: / Baş redaktor: M.Ə Musayev. Bakı: Elm, cild 3. – 2004. - 620 s.

gularly pollute the environment by invading or entering human habitats. Rodents play an important role in the spread of dichroseliosis, mesocestoides, alveococcosis, hymenolepidosis, gastrodiscoides, coccidiosis, trichinella and other helminthic pathogens of serious epidemiological and epizootiological importance for humans and farm animals.

At a time when the world's attention is focused on protecting and improving the environment, the main challenge facing science is to clarify the interrelationships of individual components of biocenoses, all the subtleties of animal biocenotic relationships and, as a result, develop scientifically based measures to protect the environment from various invasive pathogens.

Mass deaths occur among animals during intensive infection with invasive pathogens. Therefore, it is very important to study the veterinary and sanitary situation on farms, livestock, furs, and hunting in the country, the presence of all factors that contribute to the proper development of animals, including the presence of invasive pathogens.

The study of the complex interaction between rodent helminths and their hosts as a component of the biocenosis, and their circulation, spread, and other bioecological features in the biocenosis allow the development of effective preventive measures against them.

With a few exceptions, rodent helminths have not been systematically studied in Azerbaijan. Some studies, covering different odent species in different areas, do not fully reflect the helminthological picture of the study area [3, 4, 5].

In Lankaran region, there is no information about rodent helminths. Taking into account all this and the role of rodents in the bio-

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[3] Садыхов, И.А. Гельминты промысловых зверей Азербайджана / И.А.Садыхов. -: Изд.-во НАНА, -1981. -168 с.

[4] Фаталиев, Г.Г. Гельминтофауна грызунов (Rodentia) Азербайджана и пути его формирования //-Махачкала: Юг России. Экология, развитие, -2009. №4, - с.118-122).

[5] Məmmədov, İ.M. Abşeron-Qobustanda ictimai çöl siçanının (*Microtus socialis*,Pall.) helmintlərinin növ tərkibiin öyrənilməsi // - Bakı: AMEA Zoologiya İnstitutunun əsərləri, -2006. Cild XXVIII, - s. 570-577.

cenosis, the species diversity of Mice and Hamsters helminths widespread in the Lankaran region, and the landscape-ecological features of their spread were studied in 2013-2018.

The object and subject of the research. The object of the research is rodent helminths spread in different landscapes of the Lankaran region. The subject of the research is the study of the bioecological characteristics of helminth pathogens parasitize in rodents in the region, and the development of preventive measures against them.

The purpose and tasks of the research. The main purpose of the research was to study the helminth fauna of rodents based on systematic groups in different landscapes of Lankaran region; analysis of helminth fauna of each rodent species studied; distribution of rodent helminths across horizontal and vertical landscape-ecological zones; their epidemiological and epizootiological characterization; to determine the role of rodents in the maintenanse of natural foci of helminthiasis in humans, domestic animals and birds and to develop measures to combat them.

To achieve the solution to the issues envisaged in the research work, the following main tasks have been set:

1. Determination of species composition of helminths of rodents in Lankaran region based on systematic groups;
2. Study of the helminth fauna of each rodent species separately.
3. Spread of rodent helminths in landscape-ecological zones, and their ecological analysis;
4. Determination of epidemiological and epizootiological significance of rodent helminths, the role of rodents in the preservation of natural foci of helminth pathogens in humans and domestic animals;
5. Development of scientifically based preventive measures against helminthic pathogens on the basis of scientific results.

Research methods. The material was collected using Hero, and Sherman-live traps. Full Helminthological Autapsy method was used to study rodents. Trematodes, cestodes, and acanthocephalans, collected from helminths, were fixed in 70^0-ethyl alcohol, and nematodes in 3% formalin solution.

During the determination of detected helminths, permanent and temporary preparations were prepared on the basis of general methods

used in helminthological research. MBI-3, MBI-6, and Olympus light microscopes were used for biometric measurements during species identification.

The main provisions of the defense:

1. The species diversity of rodent helminths was studied and 47 species of helminths were found to be parasitic in the Lankaran region.

2. The spread of helminths found in rodents in different landscapes was studied, and the highest infection with helminths was recorded in dry-steppe semi-desert and temperate-humid subtropical landscapes with 38 species.

3. The helminth fauna complex of the studied rodent species was comparatively analyzed and the highest helminth infection was recorded in house mice with 29 species.

4. Helminth species found in rodents were characterized epidemiologically and epizootiologically, and 10 species were identified as potential threats to humans and domestic animals.

5. As a result of the research, the role of rodents in the preservation of natural foci of major helminthic pathogens was identified and preventive control measures were prepared against them.

Scientific novelty of the research. For the first time in Azerbaijan, the helminth fauna of rodents was completely studied in Lankaran region, and 47 species, including 7 species of trematodes, 14 species of cestodes, 1 species of acanthocephala, and 25 species of nematodes were determined as parasites. Of these, 12 (*Brachylaemus recurvus* (Dujardin, 1845), *Psilostomum arvicolae* Schulz et Dobrowa, 1933, *Andrya montana* (Kirschenblatt, 1941), *Paranoplocephala dentata* Galli-Valerio, 1905, *Rodentolepis straminea* (Goeze,1782), *Catenotaenia dendritica* (Goeze,1782), *Thominx gastrica* (Baylis,1926), *Trichocephalus carlieri* (Gedoelst,1916), *Heligmosomoides glareoli* (Baylis,1928), *H.yorkei* Schulz,1926, *Gongylonema problematicum* (Schulz,1924), *Physaloptera dogieli* (Schachnazarowa, 1949) were recorded for the first time in Lankaran region, Azerbaijan. *Catenotaenia dendritica* (Goeze,1782) Janicki, 1904, and *Heligmosomoides glareoli* (Baylis, 1928) were defined as specific for mountain-steppe landscape;

H.yorkei Schulz,1926, and *Thominx gastrica* (Baylis,1926) were defined as specific for the fauna of the Caucasus.

We registered for the first time house mouse, and ural field mouse as the definitive hosts for *Trichocephalus carlieri* species; Persian jird, and Tristram's jird as the intermediate hosts for *Taenia hydatigena, larvae* species.

Of the 47 species of helminths found in rodents, 10 species: *Gastrodiscoides hominis*, *Echinostoma mijagawai*, *Hymenolepis diminuta*, *Taenia pisiformis, larvae*, *T.hydatigena, larvae, Hydatigera taeniaeformis, larvae, Alveococcus multilocularis*, *larvae*, *Hepaticola hepatica*, *Syphacia obvelata,* and *Moniliformis moniliformis* are of epizootiological and epidemiological significance.

Theoretical and practical significance of the research. The results of the study of rodent helminths in different landscape-ecological zones in the Lankaran region will be important in determining the regularities of the geographical spread of helminths, the number and location of helminth species in systematics as part of the fauna, the spread within the helminth populations in different landscapes.

The results of the research can be used in the teaching of parasitological subjects in higher and secondary schools, in the writing of new works on the fauna of Azerbaijan, in the development of measures to improve the nature and livestock farms for helminthic pathogens, as well as the creation of animal reserves and sanctuaries.

Approbation and application of the research. The main provisions of the dissertation were heard and discussed at the annual report meetings of the Laboratory of Parasitology of the Institute of Zoology of ANAS, the Scientific Council, the scientific seminar of the Institute, as well as at the republican and international scientific-practical conferences listed below:

- XXI International Scientific Conference of Young Researchers "Biological Diversity of the Caucasus and Southern Russia" dedicated to the 25th anniversary of Ingush State University, and the 80th anniversary of the candidate of biological sciences, honored scientist of Russia, academician of the Russian Academy of Ecology, professor T.Y.Toychiyev (Magas, Ingushetia, 2019);

- International conference "Ecosystem services and management

of natural resources" held in Tyumen (Tyumen, 2019);

- International scientific-practical conference "Application of innovations in the development of veterinary science" dedicated to the 90th anniversary of the active member of ANAS, and Russian Academy of Agricultural Sciences, academician Y.H.Hajiyev, and correspondent member of both academies N.M.Shirinov (Baku, 2019);

- Scientific-practical conference "Fundamental and applied scientific research in zoology: current issues, achievements, and innovations" dedicated to the 85th anniversary of the Institute of Zoology of ANAS, and the 100th anniversary of the academician M.A. Musayev (Baku, 2021).

On the basis of research materials, 9 scientific articles (3 abroad) and 4 theses (2 abroad) reflecting the main content of the dissertation were published in the republic and abroad.

The organization where the dissertation work was performed. The research was performed in the Parasitology Laboratory of the Institute of Zoology of the Azerbaijan National Academy of Sciences.

The structure and volume of the dissertation. The dissertation consists of 208574 characters, and contains an introduction (11575 characters), 7 chapters (I chapter-21586, II chapter-7955, III chapter-12804, IV chapter-73312, V chapter-28013, VI chapter-25234, VII chapter-22834), results (2761 characters), preventive measures (2500 characters), literature review, 50 tables, 10 figures, and 6 graphs. The list of references includes 182 sources (58 Azerbaijani, 97 Russian, and 27 other foreign literature).

CHAPTER I. LITERATURE REVIEW

In this chapter of the dissertation, the helminth fauna of rodents in Azerbaijan and different countries of the world, landscape-ecological features of their spread, epizootiological and epidemiological significance, the role of rodents in the preservation of natural, and synanthropic foci of major helminth pathogens were studied, and a brief summary of the important scientific works dedicated to these studies was given.

It was noted that during helminthological research carried out in

Azerbaijan and surrounding regions since 1918, along with other animal species, some rodent species were also studied. However, some data on rodent helminths do not fully reflect the landscape of the modern age, as they date back to 50-100 years ago. It was found that the species diversity of rodent helminths in Azerbaijan, especially in the Lankaran region, has not been comprehensively studied.

CHAPTER II. MATERIALS AND METHODS

The materials were prepared in the Parasitology Laboratory of the Institute of Zoology of the Azerbaijan National Academy of Sciences.

The research was conducted in 2013-2018.

Helminthological materials were collected from different landscapes of the Lankaran region (dry steppe semi-desert, temperate-humid subtropical, humid-subtropical, temperate-warm broad-leaved mountain-forest, mountain-steppe, forest-steppe) (Figure 1).

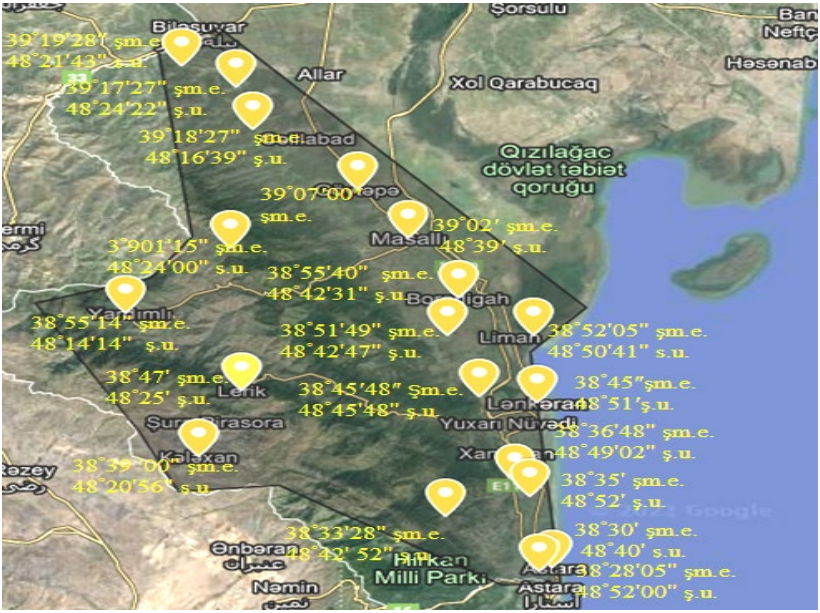

Figure 1. Districts and villages where rodents were collected (with geographical coordinates).

Lankaran region - 38 ° 45″N.lat. 48 ° 51′N.long., Separadi village - 38 ° 51′49″ N.lat. 48 ° 42′47″ N.long; Narimanabad village - 38 ° 52′05″ N.lat. 48 ° 50′41″ N.long.; Haftoni village - 38 ° 45′48″ N.lat. 48 ° 45′48″ N.long.; Astara region - 38 ° 30′N.lat. 48 ° 40′ N.long.; Pensar village - 38 ° 36′48″ N.lat. 48 ° 49′02″ N.long.; Suparibagh village - 38 ° 28′05″ N.lat. 48 ° 52′00″ N.long.; Shiyakaran village - 38 ° 35′ N.lat. 48 ° 52′ N.long.; Ovala village - 38 ° 33′28″ N.lat. 48 ° 42′ 52″ N.long.; Masalli region - 39 ° 02′ N.lat. 48 ° 39′ N.long., Boradigah village - 38 ° 55′40″ N.lat. 48 ° 42′31″ N.long.; Goytapa village - 39 ° 07′00″ N.lat.; Jalilabad region - 39 ° 18′27″ N.lat. 48 ° 16′39″ N.long., Gulmammadli village - 39 ° 19′28″ N.lat. 48 ° 21′43″ N.long.; Adnali village - 39 ° 17′27″ N.lat. 48 ° 24′22″ N.long., Yardimli district - 38 ° 55′14″ N.lat. 48 ° 14′14″ N.long., Barjan village - 3 ° 901′15″ N.lat. 48 ° 24′00″ N.long., Lerik district - 38 ° 47′ N.lat. 48 ° 25′ N.long., Kalakhan village - 38 ° 39 ′00″ N.lat. 48 ° 20′56″ N.long.

During the research years, 572 rodents belonging to 1 class, 1 order, 2 families, seven genera, and nine species were studied by the method of Full Helminthological Autopsy[6]. The materials collected during the expedition were fixed in 70^0- ethyl alcohol and placed in glass vials, labeled with the place and date of collection. The assignment of the materials was carried out in the Laboratory of Parasitology of the Institute of Zoology of ANAS.

In the ecological analysis of the collected helminthological materials, special attention was paid to the extensiveness (E) and intensiveness (I) of the invasion.

The following indicators were used to assess the infection:

1. Extensiveness of infection (EI) - the number of infected individuals among the studied animals,

2. Intensiveness of infection (II) - the number of helminths of the same species detected in an individual rodent.

[6] Скрябин, К.И. Методы полных гельминтологических вскрытий позвоночных, включая человека / К.И.Скрябин. - Москва: Изд-во МГУ, - 1928, - 45 с.

The following formula was used to determine the intensiveness of infection:

$$II = \frac{m}{n}$$

Here m - is the number of helminths detected, n- is the number of infected rodents.

The following formula was used to determine the extensiveness of infection:

$$\mathrm{EI} = \frac{\mathrm{n}}{\mathrm{N}} \times 100\%$$

n - The number of rodents infected with a particular type of helminth,

N - The total number of studied rodents.

According to the accepted practice in parasitology, in cases when less than 10 rodents are studied, the extensiveness of infection is not calculated; the number of infected rodents is indicated.

The animals were caught using Hero, and Sherman live traps. From the collected helminths, trematodes, cestodes, and acanthocephalans were fixed in 70^0- ethyl alcohol, and nematodes in 3% formalin solution. During the determination of detected helminths, permanent and temporary preparations were prepared on the basis of general methods used in helminthological research.[7]

The determination of the detected helminths was carried out based on relevant designation books[8].

During the determination of helminths, biometric measurements were performed under the microscopes MBI-3, MBI-6, and x20 and x40 magnified Olympus microscopes.

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[7] Боев, С.Н., Соколова, И.В., Панин, В.Я. Гельминты копытных животных Казахстана, т.1, Алма-ата: АН Казахской ССР, 1962, с.30-100

[8] Рыжиков, К.М., Гвоздев, Е.В., Токобаев, М.М. и др. Определитель гельминтов грызунов фауны СССР. I, II часть, М.: Наука, 1978, 1979, 173 с., 273 с.

CHAPTER III. PHYSICAL AND GEOGRAPHICAL FEATURES OF THE LANKARAN REGION

This chapter describes in detail the geographical position, relief, physical and geographical features in terms of horizontal and vertical zones, land cover, plant communities, and fauna of the Lankaran region.

Lankaran region includes six landscape-ecological zones on horizontal and vertical zones identified by geographers, soil scientists, botanists, and zoologists: I. Dry-steppe and semi-desert landscape included in the sloping plain zone (-28-100-200 m); II. Temperate-humid subtropical landscape included in the sloping plain zone (28-100-200 m); III. Humid-subtropical landscape included in the foothills forest (partially lowland) (200-500-700 m); IV. Temperate-warm broad-leaved mountain-forest landscape included in the middle mountain zone (700-1800-2000 m); V. Forest-steppe landscape included in the foothills zone (400-600 m); VI. Mountain-steppes landscapes included in the highland-steppe zone (2000-2500 m).[9]

Lankaran region is located in the southeastern part of the Republic of Azerbaijan and is 125 km long from north to south, and 96 km wide (from east to west). The total area is 5,330 km^2 (636,338 hectares), which is 7.3% of the country's territory. It is bordered by the Caspian Sea from the east, by Iran from the south, southwest and northwest. The relief is divided into 2 areas, depending on the geomorphological and geological structure of the area: Lankaran lowland, and Talish mountains. About 55% of the area is mountainous, and the rest is the Lankaran lowland. The majority of the population lives in the lowlands. In mountainous areas, the population is sparse[10].

Lankaran region includes six administrative districts: Lankaran, Astara, Masalli, Jalilabad, Lerik, and Yardimli.

Lankaran region is characterized by a peculiar humid-subtropical climate.

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[9] Əliyev, A.Ə., Həsənov, N.K. Talışın landşaftı. Bakı: Elm, 1972, 60 s.

[10] Məmmədov, R.M. Azərbaycan Respublikasının coğrafiyası. Fiziki coğrafiya. Bakı: Avropa, 2014, s.459-506.

The region differs from the other regions of Azerbaijan due to the vegetation richness. Thus, endemic and relict plant species are widespread in the foothills and lowlands. Here you can find all types of plants except cornel, and conifers. Except for the northeastern and northwestern ends of the area, forest cover has developed in the remaining areas.

The modern fauna of the region is characterized by relict endemic animals depending on the geological history of the area. The territory of the "Gizil-agaj State Nature Reserve" located in the eastern part of the Lankaran lowland, is rich in swamp animals. Reptiles and rodents live in the areas of the foothills zone is bordered by the plain zone. The mountain terrain is poor compared to the fauna. There are mostly rodents and reptiles.

The soil cover consists of yellow mountain-forest, yellow podzolic, podzolic cleyic acrisols, brown, meadow-brown, gray-brown, brown earth, mountain-chestnut, mountain-meadow steppe, marsh meadow, coastal sands, etc. soil types.[11]

CHAPTER IV. SYSTEMATIC REVIEW OF RODENT HELMINTHS IN LANKARAN REGION

This chapter shows the definitive, and intermediate hosts, localization, and places of the spread of helminth species in rodents in Lankaran region. The hosts of the species found based on personal material, the spread in the regions and landscape-ecological zones by indicating the extensiveness and intensitveness of the invasion were described.

The composition of helminth fauna was analyzed according to the numerical indicators based on the systematic groups. The helminth fauna of rodents in the Lankaran region consists of 47 species included in 7 orders, 9 suborders, 20 families, and 31 genera united in 4 classes.

Of these, 7 species belong to the class of trematodes, 14 species

[11] Azərbaycan Respublikasının coğrafiyası. Regional coğrafiya / AMEA, akad. H.Ə.Əliyev adına Coğrafiya İnstitutu. – Bakı: “Avropa” nəşriyyatı, - c. 3. -2015. -400 s.

to cestodes, 25 species to nematodes, and 1 species to acanthocephalans (Table 1).

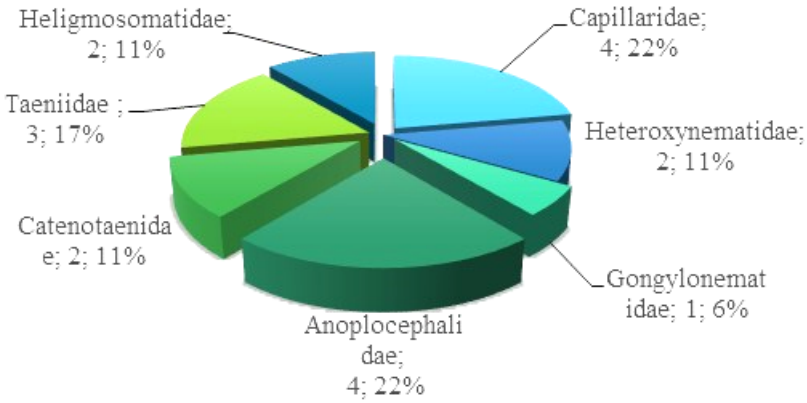
Table 1

Numerical indicators of rodent helminths on systematic groups in the Lankaran region

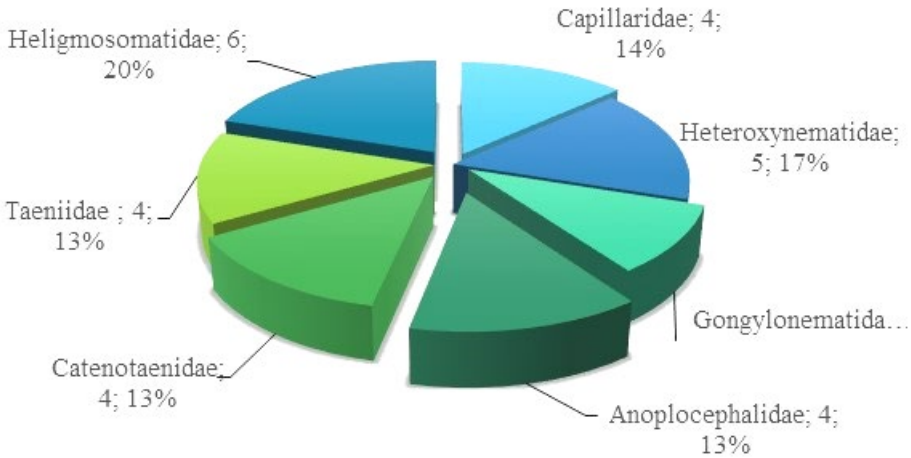
Classes	Orders	Suborders	Families	Numberof genera	Numberof species
Trematode	Fasciolida	Fasciolata	Brachylaemidae	1	1
			Plagiorchidae	1	1
			Psilostomatidae	1	1
		Paramphistomata	Gastrodiscidae	1	1
		Pronocephalata	Notocotylidae	2	2
		Echinostomatata	Echinostomatidae	1	1
Total	1	4	6	7	7
Sestoda	Cyclophyllidea	Anoplocephalata	Anoplocephalidae	4	4
			Catenotaeniidae	2	4
		Hymenolepidata	Hymenolepididae	2	2
			Taeniidae	3	4
Total:	1	2	4	9	14
Nematoda	Trichocephalida	Trichocephalata	Capillariidae	4	4
			Trichocephalidae	1	3
	Rhabditida	Rhabditata	Heligmosomatidae	2	6
	Ascaridida	Oxyurata	Heterakidae	1	1
			Heteroxynematidae	2	5
	Spirurida	Spirurata	Gongylonematidae	1	3
			Physalopteridae	1	1
			Rictulariidae	1	1
			Spiruridae	1	1
Total:	4	4	9	14	25
Archicanthocephala	Oligacanthoriiynchida		Moniliformidae	1	1
Total:	1		1	1	1
Grand total:	7	10	20	31	47

Capillariidae (4 genera, 4 species), Anoplocephalidae (4 genera, 4 species), Taeniidae (3 genera, 4 species), Heligmosomatidae (2 genera, 6 species), Heteroxynematidae (2 genera, 5 species), Catenotaeniidae (2 genera, 4 species) and Gongylonematidae (1 genus, 3 species) families predominate due to the number of genera and species in

the composition of helminth fauna. Each of the other 13 families is represented by 1-2 species (Graphic 1; Graphic 2).



Graphic 1. Distribution of genera included in the helminth fauna of rodents on families in the Lankaran region



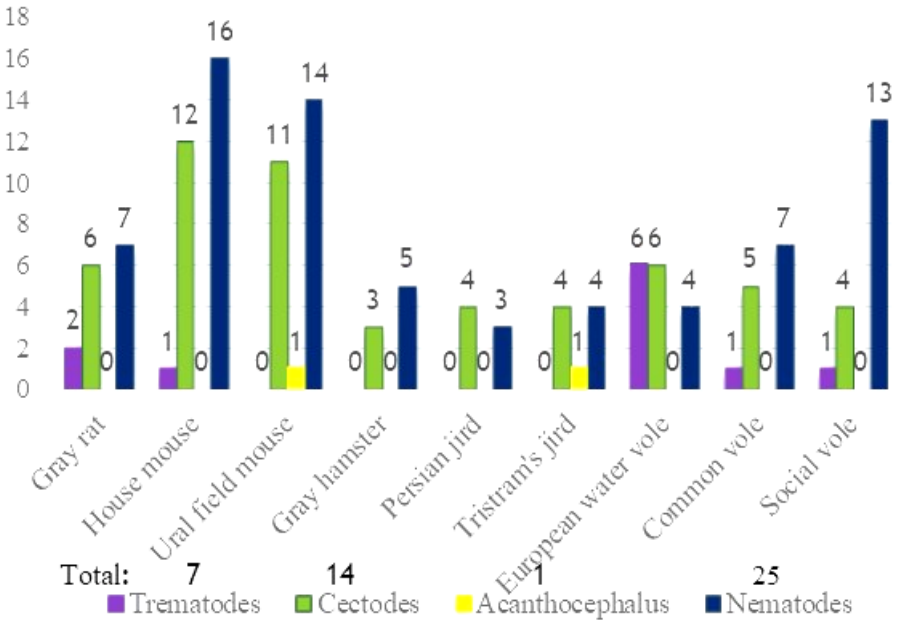
Graphic 2. Distribution of species included in the helminth fauna of rodents on families in the Lankaran region

When analyzing the distribution of genera based on families, it was found that nematodes predominate, both due to the number of orders and families, and the number of genera and species, which indicates that they are in a biological progression. The vast majority of the species found in rodents are adapted to living in different landscape-ecological zones and are ecologically plastic species. The vast majority of the species included in the mentioned families have wide geographical zoning and senotic relation to the soil and water animals living in land in the development cycle. Of these species, 26 are biohelminths with a complex development cycle, and 21 species are geohelminths.

CHAPTER V. FAUNISTICAL REVIEW OF RODENTS HELMINTHS IN THE LANKARAN REGION

This chapter provides brief information on the characteristics of rodent species, their spread, number, diet, lifestyle, reproductive capacity based on taxonomic categories. Based on the individual material, the spread of helminth species found in each rodent species in horizontal and vertical landscape-ecological zones is analyzed. During the helminthological research conducted in the Lankaran region, 3 species included in the 3 genera from the family of mice: 44 gray rat, 134 house mouse, 97 ural field mouse; 6 species included in the 4 genera from the family of Hamsters: 76 gray hamster, 26 Persian jird, 55 Tristram's jird, 63 social vole, 15 common vole, and 62 water vole were studied.

As a result of the research, 15 species in gray rat (trematode-2, cectode-6, nematode-7), 29 species in house mice (trematode-1, cectode-12, nematode-16), 26 species in Ural field mice (cectode-11, nematode-14 və acanthocephala-1), 8 species in gray hamster (cectode -3, nematode-5), 13 species in common vole (trematode-1, cectode -5, nematode-7), 7 species in Persian jird (cectode -4, nematode-3), 9 species in Tristram's jird (cectode -4, nematode-4, acanthocephala -1), 18 species in social vole (trematode-1, cectode -4, nematode-13), and 16 species in Water vole (trematode-6, cectode -6, və nematode-4) helminths were detected (Graphic 3).



Graphic 3. Structural indicators of helminth species found in rodents

The spread of helminth species among rodents is different, and there are significant differences in numbers. The helminths of house mice are dominant in terms of both species diversity, and the number of individuals. Most helminth species were found in house mice-29, and to a lesser extent in ural field mice-26 species.

As it is known, small rodents do not move far from their burrows due to their small areal, they move within a limited areal and feed on those areas. Therefore, they are less likely to feed on food contaminated with eggs released by predators. For this reason, the species diversity of helminths was low in small rodents such as a gray hamster, Persian jird, common vole, etc.

Here, the factor of attachment to the burrow-habitat also has an impact. Thus, small rodents are attached to their habitat and do not go far. However, relatively large rodents do not have a factor of an attachment to the habitat, and they have a wide range of feeding grounds, so

they are more likely to come across invasive pathogens, and become infected.

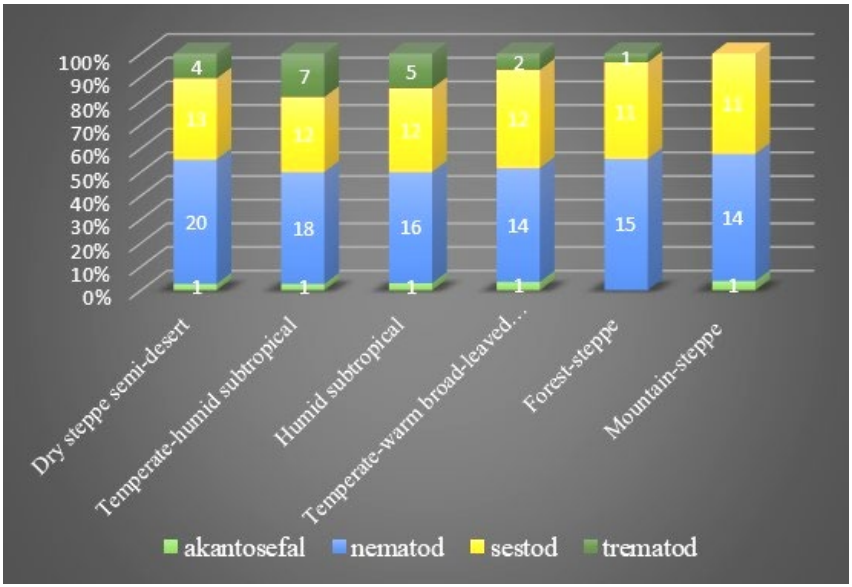
The lifestyle, geographical spread, density in nature, nutritional characteristics, food composition, and other bioecological characteristics of rodents are the main factors influencing the species diversity of their helminths.

CHAPTER VI. LANDSCAPE AND ECOLOGICAL FEATURES OF THE SPREAD OF RODENT HELMINTHS IN THE LANKARAN REGION

This chapter analyzes the degree of spread, and grouping of rodent helminths in horizontal and vertical zones in different landscape-ecological zones of the Lankaran region. It was found that the species diversity of helminths in different landscapes is different depending on the influence of biotic and abiotic factors present there. Anthropogenic factors also have a significant impact on landscapes. Thus, as a result of anthropogenic factors, landscapes have changed, and the lifestyle of animals, the number of intermediate hosts have changed significantly. Such changes have had a significant impact on the spread of helminths. The most common helminth infections were recorded in the dry steppe semi-desert (38 species: 4-trematodes, 13-cestodes, 20-nematodes, 1-acanthocephala), and in temperate-humid subtropical landscapes (38 species: 6-trematodes, 12-cestodes, 18-nematodes, 1-acanthocephala), relatively less infection in humid-subtropical (34 species: 5-trematodes, 12-cestodes, 16-nematodes, 1-acanthocephala), temperate-warm broad-leaved mountain-forest (29 species: 2-trematodes, 12-cestodes, 14-nematodes, 1-acanthocephala) landscapes, while the lowest infection was recorded in forest-steppe (27 species: 1-trematode, 11-cestodes, 15-nematodes), and mountain-steppe (26 species: 11-cestodes, 15-nematodes, 1-acanthocephala) landscapes (Graphic 4).

As can be seen, the spread of detected helminth species in landscapes varies depending on the characteristics of the studied landscapes. Thus, each landscape has its own components that form the climate, as well as soil types, plant communities, and animal species. The high species composition of helminths in the dry-steppe semi-desert,

and temperate-humid subtropical landscapes of the plain zone is due to the fact that there are all the necessary conditions for the development of helminths.



Graphic 4. The spread of species included in the helminth fauna of rodents in landscapes

Of the 7 species of trematodes found in different landscapes of the Lankaran region, 4 were found in dry-steppe semi-desert landscape, 7 in the temperate-humid subtropical landscape, 5 in humid-subtropical landscape, 2 in the temperate-warm broad-leaved mountain-forest landscape, and 1 in the forest-steppe landscape.

The high species composition of trematodes in temperate-humid subtropical, and humid-subtropical landscapes is due to the natural climatic conditions of these landscape types, food abundance, favorable conditions- drainage marsh basins for the development and reproduction of freshwater snails, which are intermediate hosts of trematodes. In contrast, forest-steppe, and mountain-steppe landscapes have a dry

climate in summer, and cold in winter, here plant communities, and fauna are poorly developed, and intermediate hosts are poorly developed.

During the research, 14 species of cestodes were found in rodents, of which 13 species in the dry-steppe semi-desert landscape, 12 species in each of the temperate-humid subtropical, humid-subtropical, and temperate-warm broad-leaved mountain-forest landscapes, 11 species in each of the forest-steppe and mountain-steppe landscapes were recorded. It is known that all species of cestodes are biohelminths, and the completion of the development cycle takes place with the participation of various species of invertebrates and vertebrates. In all landscape types, *Paranoplocephala dentata, Catenotaenia pusilla, C.cricetorum, Aprostatandrya caucasica, Andrya montana, and Hymenolepis dimunuta* species are widespread in rodents in the adult stage.

The relative predominance of cestodes in dry steppe semi-desert, and humid subtropical landscapes is due to the favorable conditions for the development and reproduction of their intermediate hosts, oribatid ticks, insects, and other arthropods. *Taenia pisiformis, T.hydatigena, Hydatigera taeniaeformis,* and *Alveococcus multilocularis* species of cestodes were found in the larval stage in rodents. The development of these species is characterized by the richness of the species composition of intermediate, and definitive hosts and these species are very plastic against the effects of both biotic and abiotic factors. Thus, when they are fed, they absorb the invasive eggs of these species together with the feed, and infection occurs. Rodents play an intermediate host role in completing the development cycle of these species. The reason for the infection of rodents with these species is that they live in the same landscape as wild, and carnivorous animals.

Among the detected helminths, nematodes are dominant and are represented by 25 species. Of these, 20 species in the dry-steppe semi-desert landscape, 18 in the temperate-humid subtropical landscape, 16 in the humid-subtropical landscape, 14 in the temperate-warm broad-

leaved mountain-forest landscape, 15 in the forest-steppe landscape, and 14 in the mountain-steppe landscape were recorded.

4 species of nematodes: *Armocapillaria sadovskajae, Gongylonema neoplasticum, G.problematicum, Physaloptera dogieli* are biohelminths, in which insects are intermediate hosts, and rodents are definitive hosts in completing the development cycle. 21 species are geohelminths, the development and spread of which depend on the influence of abiotic factors. Thus, nematode eggs released into the environment can remain in the soil for several months and maintain their vital functions. Because there is enough moisture and humidity in the soil for helminth eggs to grow, they can grow to the infective stage and stay there for a long time, and infection occurs when such eggs are ingested by the definitive hosts.

One species of acanthocephala found during the research was detected in some rodent species in all landscape types, except for the forest-steppe landscape.

In order to analyze the collected helminthological materials, we group them according to the ecological-helminthological vertical landscapes proposed by S.M Asadov[12] (Table 2).

Thus, S.M. Asadov suggested that species detected with high extensiveness and intensity of invasion compose characteristic elements of the complex (core), species found with relatively low extensiveness and intensity compose non-characteristic elements (facultative) of the complex, as well as unspecified, newly described species, conflicting or suspicious species compose a potential element of helminth fauna. Here, the core of helminth fauna, and facultative species compose the main complex, and together with potential species form a whole complex of helminth fauna.

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[12]Асадов, С.М. Гельминтофауна жвачных животных СССР и ее эколого-географический анализ. Баку: АН Азерб.ССР, 1960, 511 с., с.337-365.

Table 2

The spread of rodent helminths in horizontal and vertical landscape-ecological zones in the Lankaran region

The composition of the complex of rodents' helminth fauna	Landscapes					
	Dry steppe semi-desert	Temperate-humid subtropical	Humid subtropical	Temperate-warm broad-leaved mountain-forest	Forest-steppe	Mountain-steppe
	38	38	34	29	27	26
Specific (the core of the complex)	31(81.6%)	35(92.1%)	23(67.6%)	18(62.1%)	16(59.2%)	19(73.0%)
Trematode	-	6(17.6%)	3(13.0%)	1(5.5%)	-	-
Cestode	12(38.7%)	10(28.5%)	8(34.7%)	8(44.4%)	8(50.0%)	9(47.3%)
Acanthocephala	1(3.2%)	1(2.8%)	1(4.3%)	1(5.5%)	-	1(5.2%)
Nematode	18(58.1%)	17(48.6%)	11(47.8%)	8(44.4%)	8(50.0%)	9(47.3%)
Facultative	7(22.5%)	3(7.8%)	11(32.3%)	11(37.9%)	11(40.7%)	7(26.9%)
Trematode	4(57.1%)	1(33.3%)	2(18.1%)	1(9.0%)	1(9.1%)	-
Cestode	2(28.5%)	2(5.5%)	4(40.0%)	2(28.5%)	2(22.2%)	1(20.0%)
Acanthocephala	-	-	-	-	-	-
Nematode	2(28.6%)	1(33.3%)	5(45.5%)	6(54.5%)	7(63.6%)	5(71.4%)
Complete complex	38(100%)	38(100%)	34(100%)	29(100%)	27(100%)	26(100%)
Number of species specific to landscape	5(13.1%)	6(15.7%)	1(2.9%)	-	-	2(7.6%)
Number of species specific to the Caucasus	1(2.6%)	-	1(2.9%)	-	2(7.4%)	-
Number of species with broad zoning	20(52.6%)	21(55.2%)	20(58.8%)	-	19(70.3%)	17(65.3%)
Number of species in common with other landscapes	11(28.9%)	-	10(29.4%)	-	10(37.0%)	4(15.3%)
Number of biohelminths	22(57.8%)	24(63.1%)	18(52.9%)	15(51.7%)	16(59.2%)	12(46.1%)
Number of geohelminths	16(42.1%)	14(36.8%)	16(47.0%)	14(48.2%)	13(48.3%)	14(53.8%)

Note: the first number is the number of helminths found in rodents; in parentheses — indicates the extensiveness of the invasion.

As can be seen from the table, the temperate subtropical landscape (35 species, 92.1%) predominates due to the number of characteristic species. The next are dry steppe semi-desert landscapes (31 species, 81.6%). The humid-subtropical landscape forms a transition zone between plains and mountain zones. In these areas, rodents are more likely to migrate due to the lack of permanent habitat. For this reason, the number indicators- extensiveness of specific species in the landscape (23 species, 67.6%) is slightly lower compared to the other landscapes. The temperate-subtropical landscape dominates other landscapes in terms of the number of trematodes (6 species, 17.6%), which is due to the presence of favorable conditions for the reproduction of freshwater snails, which are intermediate hosts of trematodes in the area. The infection with cestodes is dominated by dry steppe semi-desert (12 species, 38.7%), and temperate-humid subtropical landscapes (10 species, 28.5%); the infection with nematodes is dominated by dry-steppe semi-desert (18 species, 58.1%), and temperate-humid subtropical landscapes (17 species, 48.6%). This is due to the presence of biotic and abiotic factors favorable for the development of cestodes, and nematodes in these landscapes.

No sharp zoning was observed in the grouping and spread of facultative species. The lowest infection with facultative species was recorded in the temperate-humid subtropical landscape (3 species, 7.8%), and the high infection in the humid-subtropical (11 species, 32.3%), temperate-warm broad-leaved mountain-forest (11 species, 37.9%), and forest-steppe landscapes (11 species, 40.7%).

Due to the number of species which specific to the zone, temperate-humid subtropical (6 species, 15.7%), and dry steppe semi-desert (5 species, 13.1%) landscapes located in the plain zone dominate over the foothills, and mountainous landscapes. No specific species were found in the temperate-warm broad-leaved mountain-forest, and forest-steppe landscapes.

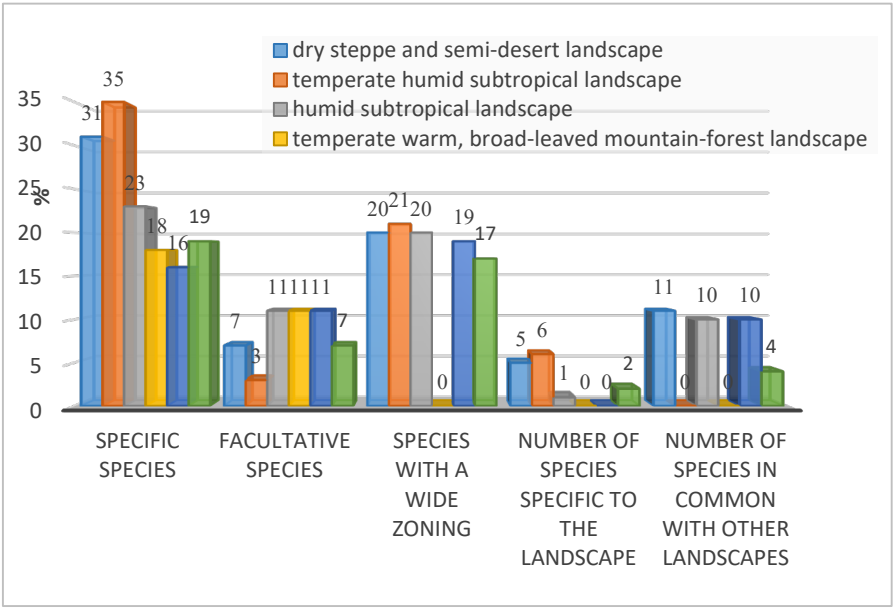
Species with wide zoning were found with high extensiveness

(52.6-70.3%) in all landscape-ecological zones, except for temperate-warm broad-leaved mountain-forest landscape.

11 (28.9%) of the species found in the dry steppe semi-desert landscape, 10 (29.4%) in the humid-subtropical landscape, 10 (37.6%) in the forest-steppe landscape, and 4 (15.3%) in the mountain-steppe landscape are common with helminth species of other landscapes (Graphic 5).

The number of biohelminths (24 species, 63.1%) predominates in temperate-subtropical landscapes, and the number of geohelminths (16 species, 47.0%) predominates in dry steppe semi-desert, and humid-subtropical landscapes.

Some species of helminths found in rodents have been found to be common with domestic and wild lagomorphs, predators, ungulates, poultry, and human helminths from the other systematic groups.



Graphic 5. The spread of rodent helminths in landscape-ecological zones in the Lankaran region

CHAPTER VII. THE ROLE OF RODENTS IN THE PRESERVATION AND SPREAD OF HELMINTHIC PATHOGENS OF HUMANS, MAMMALS, AND BIRDS IN NATURE

In recent years, the socio-economic transition in Azerbaijan, as well as in the Lankaran region, has led to a change in the relationship between humans and domestic animals. Due to the land reform in the country, the structure of natural landscapes inhabited by wild mammals, including rodents, has been changed and replaced by cultural landscapes. All this has led to a gradual narrowing of the habitats of rodents, an increase in their density in natural landscapes, and, consequently, a lack of food. For this reason, some species of rodents are widespread in various landscapes of the region and regularly inhabit human settlements or enter there, they contaminate the areas where they spread, including human settlements, with invading pathogens. These improve the relationship between humans and domestic animals with wild animals, including rodents. The infectious exchange occurs between wild mammals, including rodents, and domestic animals and humans when veterinary-sanitary rules are not strictly observed during such relations.

Taking into account all this, this chapter explains in detail the epizootiological and epidemiological significance of rodent helminths in the Lankaran region, the role of rodents in the transmission of some major helminthic pathogens to humans, and domestic animals.

It is known that rodents are natural carriers and spreaders of many invasive and infectious diseases in nature, including helminthic pathogens. Under favorable conditions, these pathogens can be transmitted to pets and humans.

As a result of the research, 47 species of helminth were characterized epidemiologically and epizootiologically, and 10 species were identified as potentially dangerous by infecting humans and domestic animals. Of the trematodes, *Echinostoma mijagawai* is of epizootiological importance for domestic waterfowl and chickens, *Gastrodiscoides*

hominis is of epizootiological importance for domestic pigs, and is of epidemiological importance for humans.

G.hominis is mainly spread among water voles. Given the fact that the species is also parasitic on humans and poses a potential threat to domestic pigs, the spread of water voles around habitats should be limited, and sanitary and hygienic norms should be strictly observed.

Taenia hydatigena, and *Alveococcus multilocularis species* of cestodes are of epizootiological importance for Canidae, and Feliformia in adult stage, ungulates in larval stage, are of epidemiological importance for humans, *Hydatigera taeniaeformis of cestode, Hepaticola hepatica of nematodes, Moniliformis moniliformis of acanthocephalans are of* epizootiological *significance for* Canidae, and Feliformia, epidemiological importances for humans, *Taenia pisiformis is of e*pizootiological importance for cats and dogs. *Hymenolepis diminuta,* and *Syphacia obvelata* are of epidemiological importance to humans. These species have been repeatedly found in humans in Azerbaijan and abroad in adult stage[13, 14, 15]. These species, found in various species of rodents in the Lankaran region, pose a potential threat to people living in those areas (Table 3).

The results of our research show that the domesticated and wild predators play an important role in the transmission of helminthic pathogens found in rodents to the synanthropic environment, and their spread among humans and domesticated ungulates. Therefore, the numbers of wild predators, especially wild d Canidae and Feliformia should be constantly monitored and regulated in the wild and synanthropic environment. The number of stray dogs and cats should not be allowed to get out of control, especially in residential areas and farms.

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[13] Алибеков, А.М. Оценка эпидемиологической ситуации по гельминтозам в Азербайджане. Фундам.исслед. 2011, №9, ч.3, с.377-381

[14] Кириллов, А.А., Кириллова, Н.Ю., Чихляев, Н.В. Эпидемиологический и эпизоотологический потенциал гельминтов позвоночных Средного Поволжья. Самарская Лука: проблемы региональной и глобальной экологии, 2014, т.23, №2, с.191-200.

[15] Mowlavi, G., Mobedi, J., Mammishi, S. Hymenolepis diminuta (Rudolphi,1819) infection in a child from Iran (Iran Journal Public Health, 2008?37 (2), p.120-123).

Table 3

Species of rodents of epizootiological and epidemiological importance in Lankaran region

Helminths	Development stages	Epidemiological significance	Epizootiological significance	Significance stage
Gastrodiscoides hominis Lewis et Mc.Connal,1876	Adult	+	Domesticated pigs	Adult
Echinostoma mijagawai İshii,1932	Adult	-	Duck, goose, chicken	Adult
Hymenolepis diminuta Rudolphi,1819	Adult	+	-	Adult
Taenia pisiformis,larvae (Bloch,1780)	Intermediate, larvae	-	“dog-like” carnivorans, and "cat-like" carnivorans	Adult
Taenia hydatigena,larvae Pallas,1766	Intermediate, larvae	+	“dog-like” carnivorans, and "cat-like" carnivorans, domesticated ungulates	Adult, larvae
Hydatigera taeniaeformis,larvae (Batsch,1786)	Intermediate, larvae	+	“dog-like” carnivorans, and "cat-like" carnivorans	Adult
Alveococcus multilocularis,larvae (Leuckart,1863)	Intermediate, larvae	+	“dog-like” carnivorans, and "cat-like" carnivorans, ruminants	Adult, larvae
Hepaticola hepatica (Bancroft,1893)	egg	+	“dog-like” carnivorans, and "cat-like" carnivorans, ruminants	Adult, egg
Syphacia obvelata (Rudolphi,1802)	Adult	+	-	Adult
Moniliformis moniliformis (Bremser,1811)	Adult	+	Dog, cat	Adult

As can be seen, rodents play an important role in the conservation of helminthic pathogens in humans, mammals, and birds in nature and in their transmission to the synanthropic environment by playing the role of definitive, intermediate, reservoir, and facultative host. In addition, they play an important role in the food chain of various animals (predators, birds, reptiles, etc.) in the biocenosis. Therefore, preventive and control measures should be strengthened to rehabilitate humans, domesticated predators, ungulates, and birds from helminthic pathogens in a synanthropic environment.

RESULTS

1. For the first time in Azerbaijan, the helminth fauna of rodents was studied in the Lankaran region, and 47 species of helminths were found to be parasitic. The helminth fauna consists of 7 species of trematodes, 14 species of cestodes, 1 species of acanthocephala, and 25 species of nematodes. According to the development cycle, 26 species were identified as biohelminths and 21 species as geohelminths.
2. For the first time in Azerbaijan, 12 species of helminths *(Brachylaemus recurvus, Psilostomum arvicola, Andrya montana, Paranoplocephala dentata, Catenotaenia dendritica, Rodentolepis straminea, Thominx gastrica, Trichoonigomia, Trichocepligus carlieri, carlieri, Thominx gastrica, Trichocephalus carlieri)* in rodents were discovered by us in the Lankaran region. The spread of rodent helminths in the Lankaran region was studied, and *Catenotaenia dendritica* (*Goeze,* 1782) Janicki, 1904 and *Heligmosomoides glareoli* (Baylis, 1928*)* species were identified as specific for the mountain-steppe landscape; *H.yorkei* Schulz, 1926 and *Thominx gastrica* (Baylis, 1926) species were identified as specific to the Caucasian fauna.
3. For the first time, the spread of rodent helminths in different landscape-ecological zones of the Lankaran region was studied, and 38 species (4 - trematodes, 13 - cestodes, 20 - nematodes and 1 - acanthocephala) in the dry-steppe semi-desert landscape (with repeated species); 38 species in temperate-humid subtropical landscape (7 -

trematodes, 12 - cestodes, 18 - nematodes, 1 - acanthocephala); 34 species in the humid-subtropical landscape (5 - trematodes, 12 - cestodes, 16 - nematodes, 1 - acanthocephala); 29 species in the temperate-warm broad-leaved mountain-forest landscape (2 - trematodes, 12 - cestodes, 14 - nematodes, 1 - acanthocephala); 27 species (1 trematode, 11 cestodes, 15 nematodes) in forest-steppe landscape, and 26 species (11 cestodes, 14 nematodes, 1 acanthocephala) were found in the mountain-steppe landscape.

4. For the first time in Azerbaijan, the spread of rodent helminths on hosts in the Lankaran region was analyzed, and in gray rats - 15, house mice - 29, ural field mouse - 26, gray hamster - 8, Persian jird - 7, Tristram's jird - 9, water vole-16, common vole-12, and social vole-18 species of helminths were found to be parasitic.
5. For the first time, Persian jird, and Tristram's jird was recorded by us as an intermediate host in the larval stage of the *Taenia hydatigena* species, house and forest mice were recorded by us as the definitive hosts for the *Trichocephalus carlieri* species.
6. For the first time in Lankaran region, 10 species of rodent helminths of epizootiological and epidemiological importance: *Gastrodiscoides hominis, Echinostoma mijagawai, Taenia pisiformis, T.hydatigena, Hydatigera taeniaeformis, Alveococcus multilocularis, Hymenolepis diminuta, Hepaticola hepatica, Syphacia obvelata* and *Moniliformis moniliformis* were identified as a serious threat to humans and pets.
7. For the first time, the role of rodents in the formation of natural foci of gastroescoidosis, hymenolepidiosis, taeniasis, and alveococcosis, which pose a serious threat to human and domestic animals health, was identified and appropriate control measures were developed.

PREVENTIVE MEASURES

1. Taking into account the widespread of gastrodiscoidosis, hymenolepiasis, alveococcosis, and taeniasis pathogens *(Gastrodiscoides hominis, Hymenolepis diminuta, Alveococcus multilocularis, Taenia hydatigena, Hydatigera taeniaeformis)* among rodents in Lan-

karan region, and commonize with the helminths of humans, and domesticated ungulates, their definitive hosts (dogs and cats) should be dewormed in a synanthropic environment, and stray dogs and cats unsuitable for farms should be neutralized.

This work should be carried out by regional employees of the Republican Veterinary Service Laboratories.

2. In order to prevent the transmission of pathogens of gastrodiscoidosis, cysticercosis, alveococcosis, etc., which parasitize rodents in the larval stage and pose a serious threat to human health, to the definitive hosts, and to eliminate the foci of spread, the foci of the spread of rodents which are intermediate hosts of these helminthic pathogens in the synanthropic environment should be eliminated.

This work should be carried out by the employees of the regional departments of the Republican Anti-Plague Station.

3. In order to prevent the transmission of cysticercosis and alveococcosis pathogens (larval stage of teniidiosis) which parasitize in wild, domesticated ungulates, and other herbivores, to the definitive hosts in synanthropic environment, and to eliminate the foci of spread, the animals should be slaughtered at slaughterhouses. Control over the release or neutralization of infected or excreted organs of animals slaughtered in nature corners, public catering and tourism facilities, roadsides, and other areas, as well as internal organs of birds and animals, hunted during the hunting season should be strengthened.

This work should be regularly monitored by the employees of regional departments of the Ministry of Ecology and Natural Resources, and employees of the Republican Veterinary Service.

4. The general preventive and control measures proposed against this or other helminthic pathogens are as follows:

- grazing of flock of sheep, and herd of cattle should not be allowed in wildlife reserves;
- existing anti-poaching measures should be strengthened;
- Recommendations of relevant parasitologists, along with other ecologists, should be taken into account when preparing an action plan for the protection and enhancement of wildlife;
- In order to protect wildlife from infectious and invasive pathogens and to strengthen the promotion of health measures in nature, the rubric

"For Healthy Nature" should be opened in the official media of the Republic and specialized scientists should be involved in this work.

LİST OF PUBLİSHED SCİENTİFİC WORKS ON THE TOPİC OF THE DİSSERTATİON:

1. Fətəliyev, Q.H., Aslanova, E.K. Lənkəran təbii vilayətində ev siçanının helmintlərinin növ müxtəlifliyi və onların yayılmasının landşaft-ekoloji xüsusiyyətləri // - Bakı: AMEA Zoologiya İnstitutunun əsərləri, - 2014. Cild 32, №1, - s. 44-48.
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4. Aslanova, E.K. Lənkəran təbii vilayətinin düzənlik qurşağında gəmiricilərin helmint faunası və onun bioekoloji xüsusiyyətləri // - Bakı: AMEA-nın Xəbərləri, biologiya və tibb elmləri seriyası, - 2016. Cild 71, №1, - s. 81-88.
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