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Гельминты мелкого рогатого скота и влияние экологических факторов на формирование гельминтофауны

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В Нагорно-Ширванском и Ширван-Сальянском экономических районах, используемых в качестве зимних и летних пастбищ для развития скотоводства в Азербайджане, в 2012–2022 гг. проводили научно-исследовательские работы с целью таксономического изучения гельминтофауны мелкого рогатого скота и выявления инвазивных видов. Была исследована гельминтофауна мелкого рогатого скота, установлены интенсивность и экстенсивность заражения. В Нагорно-Ширванском экономическом районе у овец выявлено 32 вида нематод, четыре вида трематод и восемь видов цестод, у коз – 23 вида нематод, четыре вида трематод и шесть видов цестод. В Ширван-Сальянском экономическом районе у овец обнаружено 35 видов нематод, четыре вида трематод и пять видов цестод, у коз – 19 видов нематод, два вида трематод и пять видов цестод. У овец в обоих экономических районах выявлены нематоды, принадлежащие к 15 родам: *Chabertia*, *Bunostomum*, *Oesophagostomum*, *Trichostrongylus*, *Ostertagia*, *Marshallagia*, *Cooperia*, *Haemonchus*, *Nematodirus*, *Trichocephalus*, *Protostrongylus*, *Dictyocaulus*, *Muellerius*, *Cystocaulus*, *Gongylonema*. У коз обнаружены нематоды, относящиеся к 13 родам, виды, относящиеся к родам *Muellerius* и *Gongylonema*, не зафиксированы. В Нагорно-Ширванском экономическом районе в состав фауны трематод овец входили четыре вида, относящиеся к трем родам: *Fasciola hepatica*, *F. gigantica*, *Paramphistomum cervi*, *Dicrocoelium lanceatum.* В Ширван-Сальянском экономическом районе обнаружены четыре вида трематод у овец и два вида у коз. Фауна цестод у мелкого рогатого скота в экономических районах различалась. В Нагорно-Ширванском районе у овец выявлено восемь видов (*Moniezia expansa*, *M. benedeni*, *M. autumnalia*, *Avitellina centripunctata*, *Thysaniezia giardi*, *Cysticercus ovis*, *Echinococcus granulosus*, *Coenurus cerebralis*), у коз – шесть видов (*Moniezia expansa*, *M. benedeni*, *M. autumnalia*, *Avitellina centripunctata*, *Thysaniezia giardi*, *Echinococcus granulosus*). В Ширван-Сальянском экономическом районе у овец и коз обнаружено пять видов: *Moniezia expansa*, *M. benedeni*, *Avitellina centripunctata*, *Thysaniezia giardi*, *Echinococcus granulosus*. Гельминтофауна овец в Нагорно-Ширванском экономическом районе составила 44 вида, гельминтофауна коз – 33. В Ширван-Сальянском экономическом районе у овец зафиксировано 44 вида гельминтов, у коз – 26. Анализ результатов 10-летних исследований показывает, что за последние 5 лет на данной территории гельминтофауна мелкого рогатого скота стала более разнообразной, повысились интенсивность и экстенсивность заражения, наблюдается ассоциативное заражение гельминтами, отнесенными к разным классам.

Ключевые слова: гельминтофауна, нематоды, трематоды, цестоды, полное и неполное вскрытие, абиотические и биотические факторы

Helminths of small ruminants and the influence of environmental factors on the formation of helminth fauna

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Research works were conducted in the Mountain-Shirvan and Shirvan-Salyan economic districts used as winter and summer pastures for the development of cattle breeding in Azerbaijan in 2012–2022 for taxonomic study of helminth fauna of small ruminants and identification of the invasive species. The helminth fauna of small ruminants was investigated, and the intensity and extensiveness of infestation were determined. 32 species of nematodes, four species of trematodes and eight species of cestodes were detected in sheep in the Mountain-Shirvan economic region, 23 species of nematodes, four species of trematodes and six species of cestodes were detected in goats. 35 species of nematodes, four species of trematodes and five species of cestodes were found in sheep in the Shirvan-Salyan economic region, 19 species of nematodes, two species of trematodes and five species of cestodes were found in goats. Nematodes belonging to 15 genera were found in sheep in both economic regions – *Chabertia, Bunostomum, Oesophagostomum, Trichostrongylus, Ostertagia, Marshallagia, Cooperia, Haemonchus, Nematodirus, Trichocephalus, Protostrongylus, Dictyocaulus, Muellerius, Cystocaulus, Gongylonema*. In goats, no species belonging to the genera *Muellerius* and *Gongylonema* were found, and nematodes belonging to 13 genera were found. In the Mountain-Shirvan economic region, the sheep trematode fauna included four species belonging to three genera: *Fasciola hepatica, F. gigantica, Paramphistomum cervi, Dicrocoelium lanceatum*. In the economic region of Shirvan-Salyan, 4 species of trematodes were found in sheep and 2 species in goats. The fauna of cestodes in small ruminants differed in economic regions. In the Mountain-Shirvan region, 8 species were identified in sheep (*Moniezia expansa, M. benedeni, M. autumnalia, Avitellina centripunctata, Thysaniezia giardi, Cysticercus ovis, Echinococcus granulosus, Coenurus cerebralis*), and in goats – 6 species (*Moniezia expansa, M. benedeni, M. autumnalia, Avitellina centripunctata, Th. giardi, E. granulosus*). In the economic region of Shirvan-Salyan, 5 species were found in sheep and goats (*Moniezia expansa, M. benedeni, Avitellina centripunctata, Thysaniezia giardi, Echinococcus granulosus*). The helminth fauna of sheep in the Mountain-Shirvan economic region amounted to 44 species, and that of goats – 33 species. In the Shirvan-Salyan economic region, 44 species of helminths were found in sheep, and 26 species in goats. Analysis of the results of 10-year studies shows that for the last 5 years the helminth fauna of small ruminants in this area has become more diverse, the intensity and extensiveness of infestation have increased, and associative infestation with helminths belonging to different classes is observed.

Keywords: helminth fauna, nematodes, trematodes, cestodes, complete and incomplete autopsy, abiotic and biotic factors

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INTRODUCTION

In the context of climate change, ensuring food security and improving farm animal health for sustainable livestock development remain priority issues. Around 750 million people worldwide are engaged in livestock production, which plays a major role in the sustainable development of the agricultural sector. Although modern livestock farming is a fairly developed industry, the influence of abiotic factors still remains. Changes observed in recent years in the atmosphere, sea level rise, changes in the physical and chemical composition of soils, increased air temperature, higher annual precipitation, increased solar radiation, and excessive humidity affect the health, lifestyle and productivity of animals, have a direct impact on the ability to mate and the birth of offspring maximum [1–4].

In addition, abiotic factors affect the widespread distribution of parasites, the emergence of new diseases in animals, and the increase in the intensity of helminth infection [5–7]. Studies have found that housing conditions, as well as feeding, affect the intensity of helminth infection in animals [8, 9]. Specialists studying helminth distribution by ecological zones note that it is more appropriate to study helminth fauna in three main ecological landscapes - mountain, foothill and plain. Some authors recommend studying helminth fauna by topographic zones [10–13]. A number of scientists note that when studying helminth fauna by zones, it is important to take into account the age group of animals and the season of the year [14].

In this regard, the present study was conducted within the framework of landscape-ecological approach. The object of the study was helminth fauna of small ruminants in the Mountain-Shirvan and Shirvan-Salyan economic regions of Azerbaijan. The Mountain-Shirvan economic region includes Ismayillinsky, Shamakhinsky, Aghsuinsky and Gobustansky districts, while the Shirvan-Salyan economic region includes Neftchalinsky, Bilesuvarsky, Salyansky, Hajigabulsky and Shirvansky districts.

The helminth fauna of small ruminants in the territories belonging to the same landscape-ecological zone does not differ sharply, which is due to the similarity of environmental factors. Thus, a certain change in any of the environmental factors directly affects the species composition and distribution of helminths. Our long-term studies have confirmed that climate change has influenced helminth infestation of small ruminants and helminth fauna formation in the conditions of Azerbaijan.

Mountain-Shirvan and Shirvan-Salyan economic regions are regions of livestock development. Helminth fauna and predominant helminths of small ruminants in the territory of the Mountain-Shirvan and Shirvan-Salyan economic regions have not been studied before. For this reason, it was decided to conduct taxonomic study of helminth fauna of sheep and goats in these economic regions, to identify species causing infestation, to develop measures to control them.

MATERIAL AND METHODS

The research work was conducted in individual and farm livestock farms of the Mountain-Shirvan and Shirvan-Salyan economic regions. Pathological and anatomical material was collected from ecological landscapes of each region – mountainous, foothill and plain. During the 10-year research period (2012–2022), 8000 sheep and 6000 goats in the Mountain-Shirvan economic region and 10,000 sheep and 4000 goats in the Shirvan-Salyan economic region were studied using full and incomplete autopsy methods. Studies were conducted on the animals of different age groups (newborn lambs and goats, young animals from 1 year old and small ruminants over 2 years old). The number of helminths in one animal, the average relative ratio of the studied and diseased individuals were calculated by the Student's t-criterion. For this purpose, calculations were made for 800 studied sheep and 800 goats in both economic districts.

RESULTS AND DISCUSSION

The helminth fauna of sheep studied in mountainous, foothill and plain landscapes of the Mountain-Shirvan economic region included 44 species. The nematode fauna included 32 species from 15 genera. In the foothill and plain

landscapes of the economic region 15 species of nematodes with high extensiveness and intensity of infestation were recorded: *Chabertia ovina* (EI = 47,6, II = 17–210) *, *Bunostomum trigonocephalum* (EI = 39,0, II = 11–165), *Oesophagostomum venulosum* (EI = 37,9, II = 46–341), *Oe. columbianum* (EI = 37,2, II = 25–357), *Trichostrongylus axei* (EI = 39,7, II = 27– 315), *Tr. vitrinus* (EI = 35,7, II = 19–165), *Ostertagia ostertagi* (EI = 39,5, II = 48–456), *O. circumcincta* (EI = 31,1, II = 15–369), *Marshallagia marshalli* (EI = 38,5, II = 41– 316), *Cooperia oncophora* (EI = 31,5, II = 21–156), *Haemonchus contortus* (EI = 43,5, II = 71–396), *Nematodirus abnormalis* (EI = 54,9, II = 35–101), *Dictyocaulus filaria* (EI = 30,3, II = 5–21), *Protostrongylus kochi* (EI = 35,2, II = 11–52), *P. hobmaieri* (EI = 31,4, II = 15–47).

In goats 33 species of helminths, including 23 species of nematodes were detected. In mountainous, foothill and plain landscapes of the Mountain-Shirvan economic region ten species of nematodes with high extensiveness and intensity of infestation have been observed in goats: *Chabertia ovina* (EI = 33,4, II = 5–56), *Bunostomum phlebotomum* (EI = 32,2, II = 15–151), *B. trigonocephalum* (EI = 30,0, II = 11–125), *Trichostrongylus axei* (EI = 32,8, II = 17–85), *Tr. capricola* (EI = 31,7, II = 23–166), *Tr. vitrinus* (EI = 40,6, II = 25–176), *Marshallagia marshalli* (EI = 30,1, II = 28–196), *Haemonchus contortus* (EI =34,6, II = 57–223), *Trichocephalus ovis* (EI = 31,1, II = 33–338), *Dictyocaulus filaria* (EI = 30,0, II = 9–51). Species related to genera *Gongylonema* and *Muellerius* were not detected in goats (see Table 1).

No zonality was observed in the distribution of the nematodes. Depending on the age group of animals and season, moderate to high levels of infestation were observed in all natural landscapes. In sheep in the Mountain-Shirvan economic region out of the detected four species of trematodes belonging to three genera, three species were distinguished by higher extensiveness and intensity of infestation: *Dicrocoelium lanceatum* (EI = 67,5, II = 19–455), *Fasciola hepatica* (EI = 47,5, II = 25–393), *Paramphistomum cervi* (EI = 40,7, II = 45–485). In goats, two species were distinguished from four trematode species by this criterion: *Fasciola gigantica* (EI = 36,2, II = 37–291), *Dicrocoelium lanceatum* (EI = 31,8, II = 21–256).

Eight species of cestodes categorized into six genera were recorded in sheep reared in different landscapes of the Mountain-Shirvan economic region. Of these, two species had more extensive and intense infestations: *Moniezia expansa* (EI = 71,7, II = 3–15), *Echinococcus granulosus* (EI = 41,3, II = 3–21). In goats, one species with high extensiveness and intensity of infestation was identified among six species of cestodes assigned to four genera – *Moniezia expansa* (EI = 41,2, II = 7–18) (see Table 2).

Analyzing the dynamics of helminth infestation of small ruminants in the Mountain-Shirvan economic region by landscapes, it can be noted that the intensity of nematode infestation of sheep and goats in the foothill and plain landscapes of the Ismayillinsky, Shamakhinsky and Aghsuinsky districts did not have sharp differences. On the mountain plateau and in the lowland landscapes of Gobustan with low relief, sheep were infected with nematodes characteristic of desert and semi-desert pastures. Moreover, depending on the age group of animals and time of year, the rates were relatively high.

Depending on the landscape, the infestation of trematodes was different. Thus, the extensiveness and intensity of infestation of *Dicrocoelium lanceatum* in Gobustan, *Paramphistomum cervi* in Aghsu, *Fasciola hepatica* and *F. gigantica* in Ismail and Shamakhi were higher. The results of the analyses confirm that the mentioned trematodes have natural foci in these landscapes.

Cestodes infestation among the sheep kept in different landscapes of the Mountain-Shirvan economic region was different. At the same time, some species were dominant. *Avitellina centripunctata*, *Thysaniezia giardia* were most often recorded in small ruminants studied in Gobustan and were species characteristic for this region. *Moniezia expansa*, *M. benedeni* and *M. autum-*

* Hereinafter data on extensiveness of invasion (EI) are given in %, on invasion intensity (II) – in copies.

Табл. 1. Фауна нематод мелкого рогатого скота в Нагорно-Ширванском экономическом районе
Table 1. Fauna of small ruminant nematodes in the Mountain-Shirvan economic region

Species	Sheep (n = 8000)		Goats (n = 6000)	
	EI	II	EI	II
Chabertia ovina	3807/47,6	17–187	2001/33,4	5–56
Bunostomum phlebotomum	2075/25,9	3–13	1932/32,2	15–151
B. trigonocephalum	3123/39,0	11–165	1800/30,0	11–125
Oesophagostomum venulosum	3038/37,9	46–341	1296/21,6	17–163
Oe. columbianum	2976/37,2	25–357	–	–
Trichostrongylus axei	3174/39,7	27–315	1966/32,8	17–85
Tr. capricola	2120/26,5	15–76	1900/31,7	23–166
Tr. colubriformis	2306/28,8	12–345	1291/21,5	7–25
Tr. probulurus	2288/28,6	15–257	872/14,5	8–18
Tr. skrjabini	570/7,1	1–7	774/12,9	6–12
Tr. vitrinus	2858/35,7	19–165	2438/40,6	25–176
Tr. assadovi	576/7,2	1–9	–	–
Ostertagia ostertagi	3158/39,5	48–456	1614/26,9	13–137
O. circumcincta	2488/31,1	15–369	1473/24,6	15–113
O. trifurcata	534/6,7	2–9	769/12,8	7–18
O. mentulata	689/8,6	1–10	757/12,6	5–21
Marshallagia marshalli	3082/38,5	41–316	1804/30,1	28–196
Cooperia oncophora	2520/31,5	21–156	1775/29,6	17–182
Haemonchus contortus	3476/43,5	71–396	2074/34,6	57–223
Nematodirus abnormalis	4396/54,9	35–101	1001/16,7	17–62
N. helvetianus	1768/22,1	27–85	–	–
Trichocephalus ovis	706/8,8	15–41	1863/31,1	33–338
T. skrjabini	584/7,3	2–9	902/15,0	11–39
Gongylonema pulchrum	449/5,6	1–4	–	–
Dictyocaulus filaria	2420/30,3	5–21	2538/42,3	9–51
Protostrongylus hobmaieri	2508/31,4	15–47	–	–
P. kochi	2818/35,2	11–52	1745/29,1	16–43
P. davtian	631/7,9	1–5	–	–
P. raillieti	548/6,9	2–11	–	–
P. skrjabini	702/8,8	1–4	–	–
Muellerius capillaris	1086/13,6	15–36	–	–
Cystocaulus nigrescens	534/6,7	3–15	756/12,6	3–16

nalia dominated in the mountainous and foothill landscapes of Ismayilli, Shamakhi, Aghsu and were noted as characteristic species for these landscapes. In the epizootology of infection of sheep with *Echinococcus granulosus*, *Susticeercus ovis*, *C. cerebralis*, zonality was not observed, however, in all regions of studies these species were characterized by different intensity and extensiveness of infestation.

The helminth fauna of sheep in plain, desert and semi-desert landscapes of the Shirvan-Salyan economic region included 44 species. 35

Табл. 2. Фауна трематод и цестод мелкого рогатого скота в Нагорно-Ширванском экономическом районе
Table 2. Fauna of small ruminant trematodes and cestodes in the Mountain-Shirvan economic region

Species	Sheep (n = 8000)		Goats (n = 6000)	
	EI	II	EI	II
Fasciola hepatica	3800/47,5	25–393	1185/19,8	25–143
F. gigantica	1852/23,2	15–234	2172/36,2	37–291
Dicrocoelium lanceatum	5398/67,5	19–455	1910/31,8	21–256
Paramphistomum cervi	3258/40,7	45–485	1745/29,1	11–67
Moniezia expansa	5738/71,7	3–15	2474/41,2	7–18
M. benedeni	2004/25,1	1–7	1744/29,1	9–17
M. autumnalia	1234/15,4	0–5	1208/20,1	7–15
Avitellina centripunctata	1860/23,3	0–7	1267/21,1	5–11
Thysaniezia giardi	968/12,1	1–5	1339/22,3	6–9
Echinococcus granulosus	3304/41,3	3–21	1416/23,6	12–41
Cysticercus ovis	2018/25,2	1–18	–	–
C. cerebralis	43/0,54	1–3	–	–

species of nematodes were identified in sheep, united in 15 genera. In all ecological landscapes of the region, 19 species with high extensiveness and intensity of invasion were found in sheep: *Chabertia ovina* (EI = 39,5, II = 15–97), *Oesophagostomum venulosum* (EI = 41,0, II = 63–381), *Oe. columbianum* (EI = 41,9, II = 37–265), *Trichostrongylus probulurus* (EI = 39,6, II = 25–178), *Tr. colubriformis* (EI = 37,9, II = 22–163), *Tr. vitrinus* (EI = 37,4, II = 21–128), *Tr. capricola* (EI = 31,4, II =19–83), *Ostertagia ostertagi* (EI = 44,2, II = 51–475), *O. circumcincta* (EI = 42,5, II = 46– 386), *Marshallagia marshalli* (EI = 40,2, II = 56–328), *Cooperia oncophora* (EI = 39,4, II = 36–225), *C. punctata* (EI = 33,7, II = 19–195), *Haemonchus contortus* (EI = 46,6, II = 85–452), *Nematodirus spathiger* (EI = 63,6, II = 65–273), *N. abnormalis* (EI = 56,6, II = 51–241), *N. oiratianus* (EI = 51,1, II = 45–176), *N. helvetianus* (EI = 32,3, II = 19– 102), *Protostrongylus kochi* (EI = 35,5, II = 7–45), *P. hobmaieri* (EI = 31,9, II = 14–38).

The goat helminth fauna included 26 species, including 19 species of nematodes belonging to 13 genera. Seven species were characterized by high extensiveness and intensity of infestation: *Chabertia ovina* (EI = 33,1, II = 3–31), *Oesophagostomum venulosum* (EI = 30,7, II = 21–146), *Trichostrongylus vitrinus* (EI = 37,8, II = 31–162), *Ostertagia ostertagi* (EI = 34,6, II = 23–166), *Haemonchus contortus* (EI = 35,5, II = 65– 250), *Trichocephalus ovis* (EI = 34,7, II = 33– 326), *Protostrongylus kochi* (EI = 34,4, II = 9–39). Species of the genera Gongylonema and Muellerius have not been observed in goats (see Table 3).

In the Shirvan-Salyan economic region, the areas of intensive nematode infestation of small ruminants were pastures around villages, which are considered as natural foci (2013–2016). This area has expanded in recent years. Intense rains as well as anthropogenic factors (construction of artificial lakes and irrigation canals) created favorable conditions for nematode development

Табл. 3. Фауна нематод мелкого рогатого скота в Ширван-Сальянском экономическом районе
Table 3. Fauna of small ruminant nematodes in the Shirvan-Salyan economic region

Species	Sheep (n = 10 000)		Goats (n = 4000)	
	EI	II	EI	II
Chabertia ovina	3950/39,5	15–97	1325/33,1	3–31
Bunostomum phlebotomum	2400/24,0	9–38	1098/27,5	11–238
B. trigonocephalum	2919/29,1	17–61	–	–
Oesophagostomum venulosum	4101/41,0	63–381	1226/30,7	21–146
Oe. columbianum	4199/41,9	37–265	–	–
Trichostrongylus axei	2340/23,4	35–102	1165/29,1	11–62
Tr. capricola	3140/31,4	19–83	1196/29,9	17–35
Tr. colubriformis	3793/37,9	22–163	1065/26,6	9–31
Tr. probulurus	3966/39,6	25–178	895/22,4	5–26
Tr. skrjabini	588/5,8	5–15	–	–
Tr. vitrinus	3744/37,4	21–128	1513/37,8	31–162
Tr. assadovi	748/7,4	7–23	–	–
Ostertagia ostertagi	4423/44,2	51–475	1384/34,6	23–166
O. circumcincta	4253/42,5	46–386	1196/29,9	15–106
O. trifurcata	1769/17,6	9–21	–	–
O. occidentalis	2092/20,9	11–29	–	–
O. mentulata	811/8,1	7–16	–	–
Marshallagia marshalli	4020/40,2	56–328	1161/29,0	13–187
Cooperia oncophora	3946/39,4	36–225	1106/27,7	17–141
C. punctata	3377/33,7	19–195	–	–
Haemonchus contortus	4660/46,6	85–452	1421/35,5	65–250
Nematodirus abnormalis	5665/56,6	51–241	830/20,8	19–73
N. helvetianus	3238/32,3	19–102	–	–
N. fillicolis	2001/20,0	15–76	–	–
N. oiratianus	5116/51,1	45–176	–	–
N. spathiger	6361/63,6	65–273	–	–
Trichocephalus ovis	780/7,8	16–27	1389/34,7	33–326
T. skrjabini	723/7,2	11–23	608/15,2	7–15
Gongylonema pulchrum	1803/18,0	3–14	–	–
Dictyocaulus filaria	2361/23,6	3–18	1146/28,7	8–25
Protostrongylus hobmaieri	3192/31,9	14–38	–	–
P. kochi	3550/35,5	7–45	1374/34,4	9–39
P. raillieti	923/9,2	3–7	–	–
Muellerius capillaris	2493/24,9	15–33	–	–
Cystocaulus nigrescens	1222/12,2	5–13	1144/11,4	1–12

in the environment, which caused regular infestation of animals.

In the study regions, of the four trematode species assigned to three genera, three species were characterized by high extensiveness and intensity of infestation: *Dicrocoelium lanceatum* (EI = 65,4, II = 62–481), *Fasciola hepatica* (EI = 54,7, II = 28–379), *Paramphistomum cervi* (EI = 36,0, II = 26– 243). Of the two trematode species parasitizing in goats, *Fasciola gigantica* was characterized by greater extensiveness and intensity of infestation (EI = 38,4, II = 18–135).

The fauna of sheep cestodes included five species classified into four genera. In sheep examined at all sites, the species *Echinococcus granulosus* was noted as having high extensiveness and intensity of infestation (EI = 37,4, II = 5–21). The goat cestode fauna consisted of five species assigned to four genera. Of these, *Moniezia expansa* was identified as having high extensiveness and intensity of infestation in all regions (EI = 30,4, II = 5–9) (see Table 4).

Shirvansky, Bilesuvarsky, Hajigabulsky, Salyansky and Neftchalinsky districts belonging to the Shirvan-Salyan economic region have plain, desert and semi-desert landscapes. Since the formation of helminth fauna of animals is directly influenced by the ecological environment, relief, climate and humidity in these regions, the dynamics of helminth infestation of small ruminants did not differ sharply. The lowest rates of helminth infestation of small ruminants were observed in the Shirvansky district.

Of the 35 nematode species detected in sheep, the following species were most frequently recorded: *Chabertia ovina*, *Oesophagostomum venulosum*, *Oe. columbianum*, *Trichostrongylus capricola*, *Tr. colubriformis*, *Tr. probulurus*, *Tr. vitrinus*, *Ostertagia ostertagi*, *O. circumcincta*, *Marshalla-gia marshalli*, *Cooperia oncophora*, *C. punctata*, *Haemonchus contortus*, *Nematodirus abnorma-lis*, *N. helvetianus*, *N. oiratianus*, *N. spathiger*, *Protostrongylus hobmaieri*, *P. kochi*. The remaining 16 species included in the nematode fauna of sheep were characterized by low intensity and extensiveness of infestation, although they were considered typical species for the sheep kept in the region.

Of the 19 species of the nematodes found in goats, the species *Chabertia ovina*, *Oesophagostomum venulosum*, *Trichostrongylus vitrinus*, *Ostertagia ostertagi*, *Haemonchus contortus*, *Trichocephalus ovis*, *Protostrongylus kochi* were registered more frequently. In general, during the years of study, nematode infestations in small ruminants developed in an upward trend in the region, irrespective of the age of the animals and climate change.

Табл. 4. Фауна трематод и цестод мелкого рогатого скота в Ширван-Сальянском экономическом районе

Table 4. Fauna of small ruminant trematodes and cestodes in the Shirvan-Salyan economic region

Species	Sheep (*n* = 10 000)		Goats (*n* = 4000)	
	EI	II	EI	II
Fasciola hepatica	5479/54,7	28–379	–	–
F. gigantica	1426/14,2	11–229	1536/38,4	18–135
Dicrocoelium lanceatum	6544/65,4	62–481	921/23,0	32–268
Paramphistomum cervi	3609/36,0	26–243	–	–
Moniezia expansa	2679/26,7	1–7	1214/30,4	5–9
M. benedeni	690/6,9	0–3	945/23,6	2–11
Avitellina centripunctata	1456/14,5	3–11	1020/25,5	9–17
Thysaniezia giardi	1429/14,2	4–9	1132/28,3	7–15
Echinococcus granulosus	3744/37,4	5–21	953/23,8	11–27

The infestation with trematodes was different depending on the landscape. Thus, sheep in Hadjigabul and Bilasuvar were infected mainly with *Dicrocoelium lanceatum*, in Salyan and Neftchal - with *Fasciola hepatica*. Paramphistomum cervi infestation of sheep was characterized by moderate intensity in the study regions. In goats in Salyansky and Neftchalinsky regions the infestation of *Fasciola gigantica* was more intensive, *Dicrocoelium lanceatum* species had medium intensity in all study regions.

Cestodes *Avitellina centripunctata*, *Thysaniezia giardia* are characterized by moderate intensity of infestation of sheep and goats and are typical species for desert and semi-desert pastures. More intensive infestation was observed: in sheep - by larval stage of *Echinococcus granulosus*, in goats by adults of *Moniezia expansa*. In the studied regions, *Moniezia expansa* infestation was higher in goats than in sheep. In general, cestode infestation was assessed as low on local farms and relatively high on nomadic farms.

Twelve species of nematodes have been found in sheep in both economic areas: *Chabertia ovina* (83,6 ± 1,99), *Oesophagostomum venulosum* (215,8 ± 7,36), *Oe. columbianum* (198,3 ± 6,4), *Trichostrongylus vitrinus* (75,2 ± 5,17), *Ostertagia ostertagi* (127,6 ± 6,16), *O. circumcincta* (111,7 ± 4,21), *Marshallagia marshalli* (136,9 ± 6,54), *Cooperia oncophora* (149,8 ± 7,33), *Haemonchus contortus* (276,4 ± 7,68), *Nematodirus abnormalis* (43,5 ± 3,68), *Protostrongylus hobmaieri* (33,4 ± 2,42), *P. kochi* (36,8 ± 2,54). The listed species were characterized by high intensity and extensiveness of infestation irrespective of the age group of animals and climate change. Four species of nematodes prevailed in goats in both economic regions: *Chabertia ovina* (73,9 ± 1,92), *Trichostrongylus vitrinus* (63,5 ± 1,94), *Haemonchus contortus* (128,4 ± 3,78), *Trichocephalus ovis* (76,7 ± 2,69). These helminth species had a high rate of infestation.

Three species of trematodes were found in the studied sheep in both economic regions, which were characterized by high intensity and extensiveness of invasion regardless of the age group of animals and climatic variability: *Fasciola hepatica* (86,7 ± 5,34), *Dicrocoelium lanceatum* (148,4 ± 5,76), *Paramphistomum cervi* (68,8 ± 1,85). *Fasciola gigantica* (27.60 ± 2.16), which caused high infestation of animals, was recorded more often in goats in this territory. Due to favorable ecological environment the species *Dicrocoelium lanceatum* has intensively spread in recent years in all landscapes, causing even mass death of sheep.

In sheep in both economic regions, regardless of the age group of animals and climate variability, cestodes of *Echinococcus granulosus* were characterized by high intensity and intensity of invasion (12.7 ± 1.63), causing echinococcosis. In goats in both economic regions, cestodes *Moniezia expansa* (18.80 ± 2.28) were predominant, causing high infestation of animals.

CONCLUSION

Analyzing the results of 10-year studies in the Mountain-Shirvan and Shirvan-Salyan economic districts, it can be noted that the intensity and extensiveness of helminthiasis of small ruminants for the last 5 years have been developing upward. Except for some species of trematodes and cestodes, increased intensity of helminth infestation of small horned cattle in both economic districts was observed. High statistical indicators were observed mainly in sheep in the Shirvan-Salyan economic region. Thus, in the mentioned economic region, represented mainly by flat landscapes and arid deserts, the nematode fauna of sheep surveyed before 2017 had 32 species, the fauna of the nematodes detected with high intensity and intensity of invasion had 11 species [14]. According to the results of recent years, the nematode fauna increased to 35 species, of which 19 species were intensively detected and invasive. Some species of nematodes, characteristic of more plain areas, were also found in animals in mountainous and foothill landscapes of the Shirvan region. Cold-loving nematode species characteristic of mountainous areas have been observed in the lowland landscapes of the Shirvan-Salyan economic region.

Such exchange of helminths is associated with climate change, as well as with the nomadic lifestyle of animals, regular infection with helminth eggs and larvae on migration routes.

Infection of small ruminants with trichostrongylids, characteristic of plain and semi-desert territories of the Shirvan-Salyan economic region, was observed throughout the year. Although trichostrongylids are not characteristic of mountainous, foothill and plain areas of the Mountain-Shirvan economic region, they were actively registered in the animals kept in different reliefs of the region. High intensity and intensity of infection were recorded in high-mountainous, foothill and plain landscapes, relatively small - in animals kept on mountain pastures (Gobustan).

The detection of trichostrongylids in all landscapes, which are more characteristic of lowland areas, is also closely related to the biology of these helminths. Favorable conditions in recent years in pastures due to increased humidity favor the development of trichostrongylid eggs and larvae to the stage of invasion. In warm and humid climates, trichostrongylids may remain viable from early spring to the last months of fall and cause repeated infestations of animals. One of the reasons for nematode infestation of small cattle in all seasons of the year is the presence of localized foci. Also, one of the main conditions is that trichostrongylids are geohelminths that do not need an intermediate host for their development and, easily reaching the stage of invasion, infect animals.

The presence of a large number of water bodies in the Mountain-Shirvan and Shirvan-Salyan economic regions has led to an increase in the density of intermediate hosts of trematodes - molluscs. Intensive distribution of intermediate hosts, as well as climate change and increased humidity led to infection of animals of all age groups with trematodes throughout the year. For example, four species of trematodes were detected in goats in the Mountain-Shirvan and two species (*Fasciola gigantica*, *Dicrocoelium lanceatum*) in the Shirvan-Salyan region. High infestation of sheep with *Dicrocoelium lanceatum* and goats with *Fasciola gigantica* was observed in both economic districts [15].

Since the regions within the Shirvan-Salyan economic region have the same geographical and ecological relief, there were no sharp differences in the species composition and epizootology of helminths. Infection of small ruminants with nematodes was observed with relatively different intensity in all seasons of the year. The mild winter favored the preservation of life of intermediate hosts of trematodes and cestodes and the continuation of infection, albeit to a weak extent, throughout the year.

Moniezia species, more typical for mountainous and foothill landscapes of the Mountain-Shirvan economic region, were also observed in small ruminants kept in the plains of the Shirvan-Salyan economic region. This is due to the active lifestyle of shell mites, the intermediate hosts of *Moniezia*, during the whole summer (the mites, hidden from sunlight in the lower layer of soil, come out again to pastures after rains and cause permanent infestation of animals). High intensity and extensiveness of *Moniezia expansa* infection in sheep and goats in the Mountain-Shirvan region was observed. Another actively detected species in this region was cestode *Susticerus ovis* in sheep. In the Shirvan-Salyan economic region high infestation of sheep with *Moniezia expansa* and goats with *Moniezia benedeni* was recorded. Other intensively detected species were *Thysaniezia giardi*, *Avitellina centripunctata* in goats. High cestode infestation was noted mainly in nomadic farms.

The results of the studies confirm the widespread distribution of zoonotic cestode *Echinococcus granulosus* in small ruminants in both economic regions. In recent years, climate change, the use of forested areas as pastures and habitat changes caused by animals searching for food have led to urbanization of wild animals in villages and cities. These factors have caused the frequent appearance of wild animals, especially foxes, even in the morning hours in villages and settlements. *Echinococcus granulosus* eggs

spread in feces of foxes caused intensive infection of small cattle with hydatid cysts and local, focal outbreak of echinococcosis. The expansion of the habitat of foxes, which are intermediate hosts for this species, and the increase in their population directly affected the spread of echinococcus (cases of intensive infection were observed in both economic regions).

In the Mountain-Shirvan and Shirvan-Salyan economic regions, the intensity and extensiveness of helminth infestation of small ruminants were relatively variable depending on the time of year and relief. It was found that pastures for grazing of small ruminants kept in private farms have signs of focality in nematodes, trematodes and cestodes. Permanent settlement of nomadic households in the region caused the spread of helminths in the plains and mountain landscapes, with helminth exchange having a continuous character. At the same time, global climate change (increased precipitation, intense precipitation in lowland regions in summer, higher humidity, milder winters) has resulted in helminth eggs and larvae remaining viable longer in the environment and causing reinvasion of animals.

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