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Ecological and Faunistic Studies of Wild Artiodactyl Helminths (Mammalia: Artiodactyla) of Karakalpakstan

F.D. Akramova[1], M.Sh. Toremuratov[1], U.A. Shakarbaev[1], D.A. Azimov[1], I.M. Arepbaev[2], S.I. Zayniev[3]

[1]Institute of Zoology of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan.
E-mail: ushakarbaev@mail.ru
[2]Karakalpak State University, Nukus city, Republic of Karakalpakstan, Uzbekistan.
[3]Tashkent State Pedagogical University, Tashkent, Uzbekistan.

Abstract: We found that the types of Artiodactyla in the biogeocenozak of Karakalpakstan are represented by 5 species: Sus scrofa nigripes Blan., Cervis elaphus bactrianus Lydek., Gazella subgutturosa Gueld., Saiga tatarica Linn., Ovis orientalis arcal Gmel. and in which 26 species of helminths that belong to the classes of Cestoda, Trematoda and Nematoda have been identified. Cestodes are represented by 6 species, trematodes - 2 and nematodes - 18. The species composition of the helminths of the studied animals is 14 species in pigs, 11 in Bukhara deer, 13 in saigas, and 14 in gazelles. The helminthes, common to these species of animals, are types of the genera Taenia, Echinococcus, Fasciola, Schistosoma, Gongylonema and Setaria.

By the nature of the biological cycle, the helminths recorded by us can be divided into two groups: monoxenic and heteroxenic. Monoxenic species include types of the families Trichosephalidae (three species), Trichostrongylidae (2 species), Dictyocaulidae (2 species), Syphaciidae (1 species), Ascarididae (1 species), life cycles that proceed without a change of owners. The development of 18 species of cestodes (6 species), trematodes (2 species) and nematodes (10 species) representatives are carried out with the obligatory participation of intermediate hosts.

Keywords: helminthofauna, ecology, artiodactyls, Karakalpakstan, Uzbekistan.

Introduction

According to theriological literature, there are 5 species of artiodactyls in the fauna of Karakalpakstan, which belong to three families - Suidae, Cervidae and Bovidae. Most of them are currently listed in the Red Book of Uzbekistan: Transcaspian (Ustyurt) Urial, saiga, gazelle and Bukhara deer - khongul (Zhumanov, 2017; Red Book of Uzbekistan, 2019).

Historically, the species of cloven-hoofed animals have attracted attention of zoologists of Uzbekistan and foreign researchers (Kolesnikov, 1952; Mambetzhumaev, 1959; Ishunin, 1961, Kontrimavichus, 1969; Paluaniyazov, 1970; Zakhidov, 1971; Reimov, 1985, Sokolov,

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1990; Bogdanov, 1990; Preladova et al., 1997; Bykova, Esipov, 2011; Bykova et al., 2016; Marmazinskaya et al., 2016; Zhumanov, 2017), who point out a general trend towards a decrease in the population of wild artiodactyls since the middle of the 20th century throughout the entire territory Uzbekistan, as well as a vast region of Karakalpakstan.

The main reason for the sharp decline in the number of natural populations of artiodactyls is the ecological crisis associated with the drying up of the Aral Sea, degradation of the animal habitat. The scale of poaching is becoming essential. These and other negative factors are widely known among scientists. To mitigate the consequences of environmental disasters in the region, complex measures have been developed, the practical implementation of which is not being fully implemented.

There is limited information on the study of the helminth fauna of wild artiodactyls in Karakalpakstan and Uzbekistan in general (Shapolatov, 1965, 1972; Sultanov et al., 1969; Kontrimavichus, 1969; Koschanov, 1972; Azimov, 1975; Dadaev, 1997; Saparov, 2016; Azimov et al., 2019) and they are fragmentary. These and other materials were summarized in the fundamental monograph by Azimov et al. (2015). Previously, the studied species of wild artiodactyls recorded a significant number of species of parasitic worms: saiga - 29 species, gazelle - 37, Bukhara deer - 17 and wild boar - 15 species.

The purpose of our work is to determine the current state of the fauna of wild artiodactyl helminths in Karakalpakstan.

Materials and methods

Studies of wild populations of artiodactyls were carried out in the ecosystems of the Kyzylkum, Ustyurt and the lower reaches of the Amu Darya, including the drained floors of the Aral Sea in 2016 - 2021.

For the collection of helminthological material, killed animals (saiga, gazelle, Bukhara deer), seized from poachers, as well as those killed by predators and feral dogs in the territory of reserves and reserves of Karakalpakstan were used. Wild boars were studied by shooting during hunting seasons.

In total, 11 saigas, 13 gazelles, 7 Bukhara deer and 16 wild boars and 213 samples of faeces from these animals were examined.

The studies were carried out by the known methods of autopsy (Skryabin, 1928; Ivashkin et al., 1971) and ovoscopy of animal feces (Petrov, 1963). For a comparative analysis of the fauna of the helminths of the studied animals, we used previously collected (1959 - 1978) parasites from wild boar, saiga, gazelle and Bukhara deer on the territory of Karakalpakstan, as well as literature data.

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Results and discussion

We found that the types of Artyodactila in the biogeocenosis of Karakalpakstan are represented by 5 species: Sus scrofa nigripes Blan., Cervis elaphus bactrianus Lydek., Gazella subgutturosa Gueld., Saiga tatarica Linn., Ovis orientalis arcal Gmel. The population size in the natural conditions of the studied region is small. Therefore, four species of ruminants are included in the Red Book of Uzbekistan (2019) in the category of rare species. At present, Bukhara deer (khongul), gazelle and saiga are protected within the framework of reservations and nature reserves.

When studying a limited number of artiodactyls, we registered 26 species of helminths belonging to the classes Cestoda, Trematoda and Nematoda.

Wild boar helminth fauna is represented by the following species: Taenia hydatigena (Pallas, 1776) larvae, Echinococcus granulosus (Batsch, 1787) larvae, Fasciola gigantica (Cobbold, 1855) Schistosoma turkestanicum Skrjabin, 1913, Ascaris suum Goeze, 1782, Metastrongylus elongatus (Dujardin, 1846), M. pudendotectus Wostokow, 1905, M. salmi Gedoelst, 1923, Physocephalus sexalatus (Molin, 1860), Ascarops strongylina (Rudolphi, 1819), Gongylonema pulchrum Molin, 1857, Setaria bernardi Rail. et Henry, 1911, Trichocephalus suis Schrank, 1788, Gnatostoma hispidum Fedtchenko, 1872.

The Bukhara deer helminth fauna consists of representatives of three classes: Moniezia benedeni (Moniez, 1879), M. expansa (Rudolphi, 1810), Taenia hydatigena (Pallas, 1776), Echinococcus granulosus (Batsch, 1787), Fasciola gigantica (Cobbold, 1855) Schistosoma turkestanicum Skrjabin, 1913, Trichocephalus skrajabini (Baskakow, 1924), Dictyocaulus eckerti Skrjabin, 1931, Parabronema skrjabini Rassowska, 1924, Gongylonema pulchrum Molin, 1857, Setaria labiatapapillosa (Alessandrini, 1848).

Saiga helminth fauna consists of the following species: Moniezia expansa (Rudolphi, 1810), Avitellina centripunctata (Rivolta, 1874), Taenia hydatigena (Pallas, 1766) larvae, Echinococcus granulosus (Batsch, 1786), Fasciola gigantica (Cobbold, 1855) Schistosoma turkestanicum Skrjabin, 1913, Trichocephalus skrajabini (Baskakow, 1924), T. ovis Abildgaard, 1795, Marshallagia mongolica Schumakoritsch, 1936, Nematodirus gazellae Sokolova, 1948, Skrjabinema ovis (Skrjabin, 1915), Gongylonema pulchrum Molin, 1857, Setaria labiatapapillosa (Alessandrini, 1848).

The helminth fauna of the gazelle is also represented by the representatives of flat and round worms: Moniezia expansa (Rudolphi, 1810), Avitellina centripunctata (Rivolta, 1874), Multiceps multiceps (Leske, 1780) larvae, Taenia hydatigena (Pallas, 1766) larvae, Echinococcus granulosus (Batsch, 1786) larvae, Fasciola gigantica (Cobbold, 1855),

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Schistosoma turkestanicum Skrjabin, 1913, Trichocephalus skrajabini (Baskakov, 1924), Dictyocaulus filaria (Rudolphi, 1809), Nematodirus gazellae Sokolova, 1948, Skrjabinema ovis (Skrjabin, 1915), Parabronema skrjabini Rassowska, 1924, Gongylonema pulchrum Molin, 1857, Setaria labiatopapillosa (Alessandrini, 1848).

The distribution of the identified species of helminths by hosts is presented in table. 1.

Table 1

The structure of the helminth fauna of artiodactyls of Karakalpakstan

Species	Hosts			
	Wild boar	**Bukhara deer**	**Saiga**	**Gazelle**
Moniezia expansa	-	+	+	+
Moniezia benedeni	-	+	-	-
Avitellina centripunctata	-	-	+	+
Taenia hydatigena	+	+	+	+
Echinococcus granulosus	+	+	+	+
Fasciola gigantica	+	+	+	+
Schistosoma turkestanicum	+	+	+	+
Trichocephalus ovis	-	-	+	-
Trichocephalus skrajabini	-	+	+	+
Trichocephalus suis	+	-	-	-
Marshallagia mongolica	-	-	+	-
Nematodirus gazellae	-	-	+	+
Dictyocaulus filarial	-	-	-	+
Dictyocaulus eckerti	-	+	-	-
Ascaris suum	+	-	-	-
Metastrongylus elongatus	+	-	-	-
M. pudendotectus	+	-	-	-
M. salmi	+	-	-	-
Physocephalus sexalatus	+	-	-	-
Ascarops strongylina	+	-	-	-
Parabronema skrjabini	-	+	-	+
Gongylonema pulchrum	+	+	+	+
Setaria labiatapapillosa	-	+	+	+

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Setaria bernardi	+	-	-	-
Skrjabinema ovis	-	-	+	+
Gnatostoma hispidum	+	-	-	-
Total:	**14**	**11**	**13**	**13**

The class Cestoda is represented in the studied territory by 5 species, of which 3 species M.expansa, M.benedeni, A.centripunctata parasitize in the mature state in ruminants, and two species, T.hydatigena and E.granulosus, in the larval phase.

Trematodes F.gigantica and Sch.turkestanicum in the studied artiodactyls, we classify them as facultative parasites of wild boars, and for Bukhara deer, saigas, and gazelles these species of trematodes are obligate parasites of the studied region.

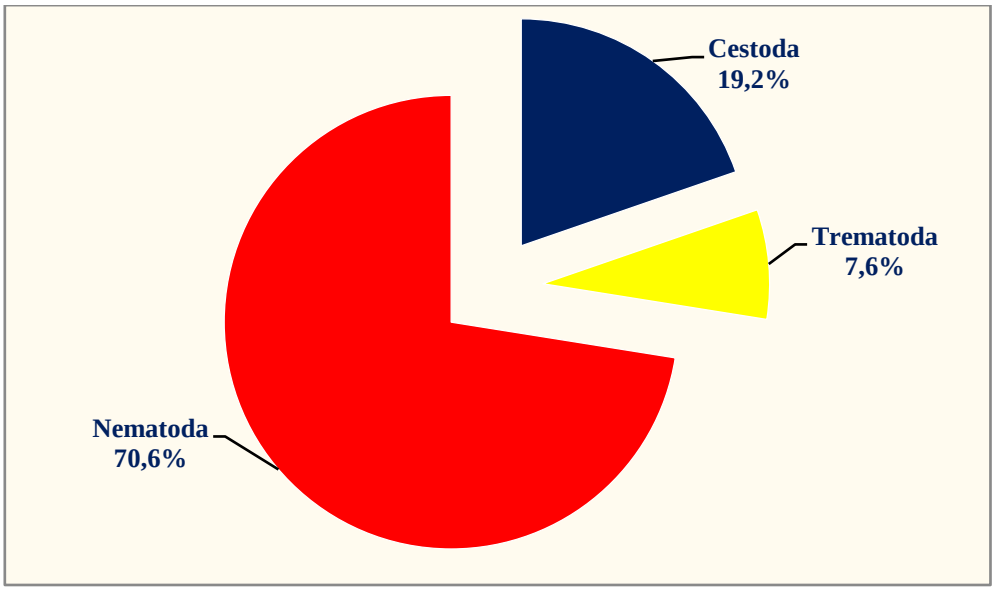

Figure 1. Ratios of large taxa of artiodactyl helminths of Karakalpakstan.

The class Nematoda is characterized by the highest species diversity in Karakalpakstan - we have noted 19 species. In the investigated area, 3 species were recorded - Trichocephalidae Baird, 1853: Trichocephalus ovis, T. skrjabini, T.suis; Metastrongylidae Leiper, 1908: Metastrongylus elongatus, M.punendotectus, M.salmi; Dictyocaulidae Rail. et Henry, 1907 are represented by 2 species - Dictyocaulus filaria and D. eckerti. The remaining 8 families contain from one to two common types of nematodes characteristic of the respective host animals (fig. 1). The number of helminth species found in individual representatives of artiodactyls is very similar.

Our data on the quantitative composition of the artiodactyl helminth fauna show that the structure of helminth communities depends on the habitat of the host animals and their

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ecological relationships with the components of different types of landscapes (water, wet, and terrestrial). This is especially significant for species and groups of helminths that develop with the participation of intermediate hosts. For two species of cestodes – T. hydatigena and E. granulosus, the studied animals act as an intermediate host.

The quantitative distribution of artiodactyl helminths in the studied region is extremely uneven. The structure of helminth fauna is dominated by nematodes (19 species) and cestodes (5). Trematodes are represented by only two species - F.gigantica and Sch. turkestanicum, which are widespread among the ungulates of the region.

The poorest in quantitative composition are trematodes (2), apparently due to the peculiar ecological characteristics of the studied artiodactyls. The results of our renewed studies of animal helminth fauna confirm, in general, the data of previous researchers (Koshanov, 1972; Dadaev, 1997), with the only difference that in the structure of parasite communities, there was a significant depletion due to the loss of a number of parasitic worm species. The list of helminth species given earlier (Shapolatov, 1965, 1972; Koshanov, 1972; Dadaev, 1997) includes 52 species. They are distributed according to the owners of the wild boar - 20 species, the Bukhara deer - 16, the saiga - 20 and the gazelle - 32. The helminth communities of these animals in the modern ecological conditions of the studied region consist of 26 species, most of them are obligate parasites of the corresponding groups of artiodactyls.

We have noted the dominance of species and groups of parasites, the developmental cycles of which proceed with the participation of intermediate hosts in the habitats of the studied mammals. A number of helminth species of the artiodactyls we studied - F. hepatica, D. dendriticum, many species of the genera Nematodirus and Oesophagostomum, were previously recorded in other natural zones of Uzbekistan (Shapolatov, 1965, 1972; Koschanov, 1972; Dadaev, 1997), which were not related with the helminth fauna of animals of the studied region.

Based on the foregoing, we considered it expedient to dwell on the ecological and taxonomic characteristics of the modern fauna of artiodactyl helminths in the studied region, where taxa of helminths of the family, suborders, orders, as well as data on the number of species recorded in different families of mammalian hosts, are presented in a systematic order (table 2).

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Table 2

Taxonomic diversity of wild artiodactyl helminths of Karakalpakstan

Taxon	Number		Distribution of helminth species by families of artiodactyls		
	Generic	Species	Boars	Deer	Bovids
Class Cestoda Order Cyclophyllida Suborder Anoplocephalata					
Family Anoplocephalidae	1	2	-	2	1
Family Avitellinidae	1	1	-	-	1
Suborder Taeniata					
Family Taeniidae	3	3	2	2	3
By order	**5**	**6**	**2**	**4**	**5**
Class Trematoda Order Fasciolida Suborder Fasciolata					
Family Fasciolidae	1	1	1	1	1
By order	**1**	**1**	**1**	**1**	**1**
Order Schistosomatida Suborder Schistosomata					
Family Schistosomatidae	1	1	1	1	1
By order	**1**	**1**	**1**	**1**	**1**
Class Nematoda Order Trichocephalida Suborder Trichocephalata					
Family Trichosephalidae	1	3	1	1	2
By order	**1**	**3**	**1**	**1**	**2**
Order Strongylida Suborder Strongylata					
Family Trichostrongylidae	2	2	-	-	2
By order	**2**	**2**	**-**	**-**	**2**
Order Pseudaliida Suborder Pseudaliata					

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Family Dictyocaulidae	1	2	-	1	1
Suborder Metastrongylata					
Family Metastrongylidae	1	3	3	-	-
By order	**2**	**5**	**3**	**1**	**1**
Order Oxyurida Suborder Oxyurata					
Family Syphaciidae	1	1	-	-	1
By order	**1**	**1**	**-**	**-**	**1**
Order Ascaridida Suborder Ascaridata					
Family Ascarididae	1	1	1	-	-
By order	**1**	**1**	**1**	**-**	**-**
Order Spirurida Suborder Spirurata					
Family Physolopteridae	2	2	2	-	-
Family Habronematidae	1	1	-	1	1
Family Gongylonematidae	1	1	1	1	1
Suborder Filariata					
Family Setariidae	1	2	1	1	1
Suborder Gnatastomata					
Family Gnatastomidae	1	1	1	-	-
By order	**6**	**7**	**5**	**3**	**3**

When locating helminth taxa within classes, we used the system adopted in the works of Shchultz and Gvozdev (1970), as well as D.A. Azimova et al. (2015).

Among the wild artiodactyls of Karakalpakstan, representatives of three classes of helminths are registered - Cestoda, Trematoda and Nematoda.

Class Cestoda. In the studied artiodactyls of the region, six cestode species of the order Cyclophyllida were recorded. Three of them are representatives of the suborder Anoplocephalata (Family Anoplocephalidae - 2 species and Avitellinidae - 1). Anoplocephalates are found in Cervidae and Bovidae. These cestodes are characteristic parasites of ruminants. The suborder Taeniata is represented in the modern fauna of

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artiodactyls by the family Taeniidae (genera Taenia, Multiceps, and Echinococcus), whose representatives parasitize in the intestines of carnivorous mammals in the mature stage.

Class Trematoda. Trematodes found in artiodactyls of Karakalpakstan belong to two groups of this class.

The order Fasciolida is represented by the genus Fasciola (family Fasciolidae). In the studied region, this genus is represented by one species - F. gigantica. Mature populations of trematodes parasitize, practically, mainly in domestic and wild ruminants.

The order Schistosomatida is represented by one species - Sch.turkestanicum, which is widespread in biogeocenoses of Karakalpakstan among domestic and wild mammals. Cercariae of this schistosome cause cercariosis in humans (Azimov et al., 2019). Schistosomiasis of animals caused by Sch. turkestanicum is a serious veterinary problem in the region and belongs to natural focal helminthiases. This is evidenced by the infection of the population of wild mammals: rodents, lagomorphs, carnivores, artiodactyls and equids - inhabitants of biogeocenoses (Azimov, 1975, 1986; Azimov et al., 2019;).

Class Nematoda. The nematodes found in artiodactyls of the studied region belong to 6 orders, which make up the core of the helminth fauna.

The order Trichocephalida with the type and the only genus Trichocephalata in our material contains 3 species that belong to the family Trichosephalidae, which parasitize representatives of Suidae, Cervidae, and Bovidae. The found species of trichocephalus are monoxenic, i.e. develop without the participation of an intermediate host.

According to our research, the order Strongylida includes the genus Strongylata with the families Trichostrongylidae, 2 genera and 2 species, which were recorded in the goitered gazelle population.

The order Pseudaliida contains two suborders. The nematodes of the suborder Pseudaliata are parasites of mammals. In the fauna of artiodactyls of Karakalpakstan, parasites of the family Dictyocaulidae, consisting of two species, have been recorded. These species turned out to be parasites in the respiratory system of the gazelle and deer populations.

The suborder Metastrongylata unites representatives of the family Metastrongylidae, consisting of three species - pig lung parasites.

In our collections, mature nematodes of only one species of the genus Skrjabinema of the family Syphacidae were found, belonging to the suborder Oxyurata of the order Oxyurida. The noted nematodes are localized in the large intestine of gazelles.

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The order Ascaridida unites nematodes of the suborder Ascaridata, parasitizing in all classes of vertebrates. In artiodactyls of the studied region, one species of the genus Ascaris of the family Ascarididae was recorded. Mature nematodes are found only in wild boars.

Order Spirurida is a fairly large group of nematodes, uniting several suborders. In our collections, spiruridae are represented by 3 suborders - artiodactyl parasites.

From the suborder Spirurata, nematodes of 3 families were found in the considered group of mammals. The Physolopteridae family is represented by 2 species belonging to the genera - Ascarops and Physocephalus, which are recorded only in cavanas.

The families Habronematidae and Gongylonematidae are represented by one species from the genera Parabronema and Gongylonema, respectively. Gabronemes were found in the population of saigas and gazelles.

The suborder Filariata in the fauna of artiodactyl helminths of Karakalpakstan is represented by the families Setariidae. From this family, two species of the genus Setaria are noted: S. bernardi was found in wild boars and S. labiatapapillosa in representatives of Cervidae and Bovidae.

From the suborder Gnatostomata, only one nematode species, Gnatostoma hispidum, belonging to the family Gnatostomidae, was found in artiodactyls of the studied region. These nematodes were found in wild boars.

In total, the Spirurida order in the studied animals of Karakalpakstan includes seven nematode species belonging to 6 genera, 5 families and 3 suborders.

Thus, in the studied artiodactyls in the vast territory of Karakalpakstan, 26 species of helminths have been registered to date, including cestodes - 6 species, trematodes - 2 and nematodes - 18 species. The number of helminth species parasitizing in certain groups of artiodactyls is represented by 14 species in pigs, 11 species in Bukhara deer, 13 in saiga and 14 in gazelle. Common to these animal species are representatives of the genera Taenia, Echinococcus, Fasciola, Schistosoma, Gongylonema and Setaria.

By the nature of the biological cycle, the helminths of the studied artiodactyls recorded by us can be divided into two groups: monoxenous and heteroxenous. Monoxenous should include representatives of the families Trichosephalidae (3 species), Trichostrongylidae (2 species), Dictyocaulidae (2 species), Syphaciidae (1 species), Ascarididae (1 species), life cycles which proceed without changing hosts. The development of 18 species of representatives of cestodes (6 species), trematodes (2 species) and nematodes (10 species) is carried out with the obligatory participation of intermediate hosts.

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Various groups of invertebrates and vertebrates have been registered as intermediate hosts of the noted 18 species of helminths of the studied animals, according to literature data (Shultz, Gvozdev, 1970; Azimov et al., 2015, 2019;) (table 3).

Table 3

Intermediate hosts of wild artiodactyl helminths of Karakalpakstan

Helminth taxa	Number of species	The hosts	
		Intermediate	Definitive
Cestoda: Anoplocephalata	3	Oribatids, Collembola	Cervidae, Bovidae
Taeniata	3	Boars, Deer, Bovids	Canidae
Trematoda: Fasciolata	1	Freshwater molluscs	Suidae, Cervidae, Bovidae
Schistosomata	1	Freshwater molluscs	Suidae, Cervidae, Bovidae
Nematoda: Metastrongylata	3	Oligochaetes	Suidae
Spirurata	4	Beetles, Flies	Suidae, Cervidae, Bovidae
Filariata	2	Mosquitoes	Suidae, Cervidae, Bovidae
Gnatastomata	1*	Cyclops	Suidae

* - Reservoir hosts - fish (O.V. Golovin, 1956 - quoted from A.A. Mozgovoy, 1967)

The life cycles of helminths are diverse. Various groups of invertebrates and vertebrates are involved in their implementation as intermediate hosts. According to table 4, as intermediate hosts of helminths of wild boars, Bukhara deer, saigas and gazelles of Karakalpakstan were noted: for representatives of cestodes of the suborder Anoplocephalata - oribatid ticks and collembolans; for the suborder Taeniata - vertebrates, representatives of the studied boars, deer and bovids. The development of species of suborders of trematodes - Fasciolata and Schistotomata - occurs with the participation of aquatic mollusks. The intermediate hosts of nematodes were for the suborder Metastrongylata - oligochaetes; for Spirurata - beetles and flies; for Filariata - mosquitoes and for the suborder Gnastomata - cyclops. In the latter case, i.e. the life cycle of G. hispidum includes fish that play the role of a paratenic (=reservoir) host.

Thus, ecological links between intermediate and definitive hosts of helminths are realized in time and space, and contribute to the formation and functioning of parasitic

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systems of different types. These systems in our material are represented by three and four components. The known groups of helminths of the studied artiodactyls form triple parasitic systems (parasite-intermediate host-definitive host). An exception to this rule is the parasitic system formed by only one nematode species from the order Spirurida - G. hispidum, where reservoir hosts, fish, are included in the parasitic system. Here the parasitic system operates with the participation of four components (parasite - intermediate host - reservoir host - definitive host).

As already mentioned, the helminth fauna of the studied animals consists of 26 species, most of which are associated with many groups of both domestic and wild mammals in the study area (fig. 2).

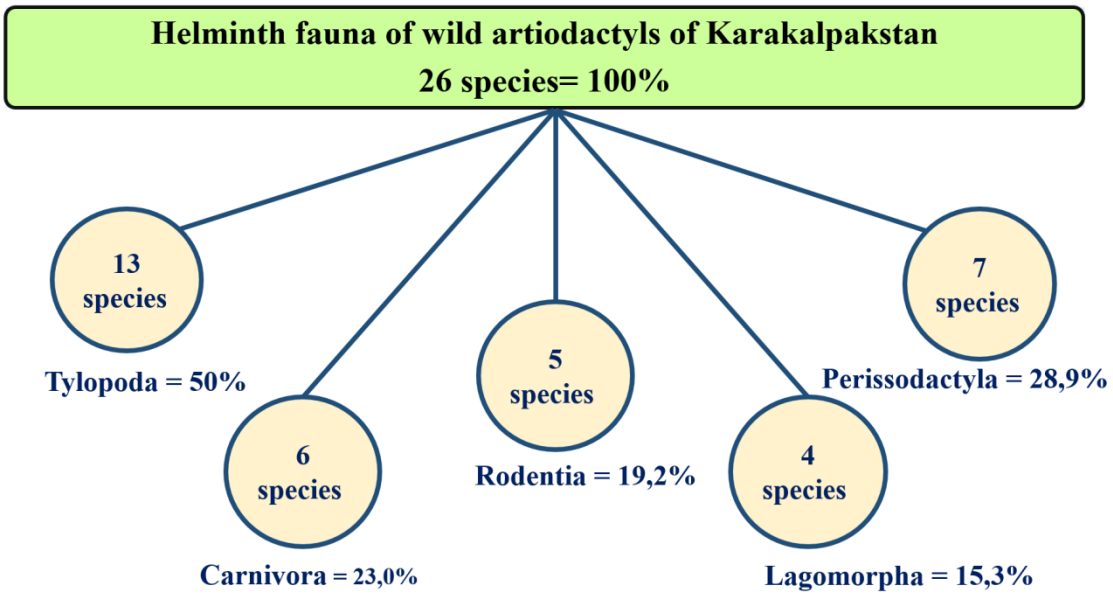

Figure 2. Relationship between the helminth fauna of the studied animals (Artiodactyla) and other groups of mammals.

Thus, the relationship of the helminth fauna of wild artiodactyls with other mammals is very close. All 26 species represented in the helminth fauna of the studied artiodactyls (wild boar, Bukhara deer, saiga, gazelle) turned out to be parasites of domestic ruminants and non-ruminants. Six species of cloven-hoofed helminths of the studied region can also parasitize humans.

The given data indicate that wild artiodactyls have quite a lot of common types of helminths with mammals of the main orders. This is probably due to the common habitat of the considered groups of animals in the modern ecological conditions of Karakalpakstan.

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Conclusion

In wild boar, Bukhara deer, saiga and gazelle, 26 species of parasitic worms have been recorded in the natural conditions of Karakalpakstan. The species diversity of helminths is small; it was 14 species in wild boar, 11 in Bukhara deer, 13 in saiga and 14 species in gazelle. The species found are representatives of three classes of helminths: Cestoda, Trematoda and Nematoda. The greatest species diversity is characterized by nematodes, somewhat fewer cestode species, and the trematode fauna is noticeably depleted.

Representatives of Taenia, Echinococcus, Fasciola, Schistosoma, Gongylonema were found to be common to the studied animals. This is due to the well-known similarities in the way of life and nutrition of animals.

Summarizing the presented materials on the relationship of the helminth fauna of the studied cloven-hoofed animals with other orders of mammals, it can be noted that it is rather close. This indicator varies depending on the host group from 15,3 to 100%.

In the natural conditions of the study area, where all sectors of animal husbandry are developed, there is an interchange of the corresponding groups of parasitic worms between wild and domestic ungulates. Other groups of mammals play the role of definitive or intermediate hosts of helminths of representatives of the genera Taenia and Echinococcus. All these circumstances must be taken into account when developing and conducting antiepizootic measures.

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