Research Article

# Ecological and Faunistic Analysis of Helminths of Wild Mammals from the Order Carnivora in Karakalpakstan

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**Abstract** | The research was carried out between 2017 and 2022 on the territory of the Republic of Karakalpakstan. 53 species of helminths were identified during the research, representing 39 genera, 25 families, 13 orders, 4 classes and 3 phyla, with 17 species (32%) from the class Cestoda, 4 (8%) from Trematoda, 3 (6%) from Acanthocephala and 29 (55%) from Nematoda. The highest diversity of helminth species among the studied predators was recorded in the Fox – 40 species. It was followed by the Jungle Cat – 27 species, Golden Jackal – 25, Wolf – 22, Domestic Dog – 20 and Badger – 16 species. 4 species from the class Cestoda – *Joyeuxiella pasqualei* Diamare, 1893, *Taenia ovis* Cobbold, 1869, *Hydatigera krepkogorski* Schulz et Landa, 1934 and *Multiceps skrjabini* Popov, 1937, and 7 species from the class Nematoda – *Capillaria putorii* Rudolphi, 1819, *Uncinaria stenocephala* Railliet, 1854, *Crenosoma vulpis* Rudolphi, 1819, *Oxynema numidica* Seurat, 1915, *Cylicospirura subaequalis* Molin, 1860, *Pneumospirura capsulata* Gerichter, 1948 and genus *Dipetalonema sp.*, were for the first time identified in the fauna of Karakalpakstan.

**Keywords** | Helminths, Parasites, Carnivora, Mammals, Uzbekistan

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## INTRODUCTION

Carnivorous animals are known to be a source of dangerous parasitic diseases in humans and agricultural animals. Therefore, to identify pathogens of zooanthropozoonoses in wild carnivores and to develop measures to combat parasitic diseases is highly important from the scientific and practical aspects.

In Uzbekistan, the species composition, biology and ecology of helminths of carnivores have been studied by Tarannikov (1983), Azimov et al. (1991), Shakarboev (2009), Safarov et al. (2018), Azimov et al. (2019), Akramova et al. (2019) and other researchers. As a result, the species composition of helminths in some domestic and wild predatory animals in Uzbekistan has been specified. However, the fauna of helminths of predatory mammals in Karakalpakstan with specific natural environment has been studied very insufficiently.

26 species of wild mammals from the order Carnivora have been registered in the wildlife of Karakalpakstan (Ishunin, 1961; Palvaniyazov, 1974). They represent the families Canidae, Mustelidae, Hyanidae and Felidae (Shernazarov et al., 2006). In addition, 2 species of domestic predators – the Dog (Canidae) and the Cat (Felidae) – are recorded in Karakalpakstan in human settlements and natural areas adjoining them. For different ecological and ethological

reasons, various trophic and chorological relations are established between wild and domestic (dog and cat) predators, which also actively exchange parasites. Domestic carnivores are components of and important links in the ecological circulation of parasitic worms.

These carnivores successfully adapt to anthropogenic ecosystems and actively participate in the circulation of zoonotic helminthiases. In the contemporary environment, helminthiases of predatory mammals, on the one hand, are becoming increasingly widespread and, on the other hand, are showing a local increase in the epizootological tension (Gorokhov et al., 2011). The information provided above shows that studying helminths and helminthiases in wild carnivores in Karakalpakstan is important.

The purpose of the work is to study the fauna and some aspects of the ecology of helminths parasitising wild predators and to assess the current situation with zoonotic helminthiases in the territory of northwestern Uzbekistan (Karakalpakstan).

## MATERIALS AND METHODS

The studies were conducted between 2017 and 2022. The research was carried out between 2017 and 2022 on the territory of the Republic of Karakalpakstan (Figure 1). 258 individuals of wild predatory mammals and 15 individuals of the Domestic Dog were studied using the method of complete and partial helminthological dissection developed by Skryabin (1928). Most of the wild carnivores were provided by hunters (on verbal agreement with them). 19 of the animals died on roads, hit by vehicles. 10 carnivores were killed for research purposes on the basis of a permit. Domestic dogs were examined after they were killed by dog catchers. The predatory mammals were represented by 6 species the Wolf, Golden Jackal, Fox, Badger, Jungle Cat and Domestic Dog from the families Canidae, Felidae and Mustelidae. The collected Trematoda, Cestoda and Acanthocephala were preserved in 70° alcohol, and Nematoda in Barbagallo fluid.

In addition, 42 samples of jackal excrement, 18 samples of wolve excrement, 38 samples of fox excrement, 56 sample of badger excrement and 11 samples of jungle cat excrement were collected. A total of 165 faecal samples were examined using known methods (Kotelnikov, 1974). The material was collected in February and March 2021. The faeces of domestic dogs were collected from the rectum, those of wild predators were taken from the ground within the Lower Amudarya Biosphere Reserve and on the Ustyurt Plateau. The faecal samples collected from each animal were put in plastic containers, labelled and stored in a refrigerator. Zoologists from the Karakalpak State University and Nukus State Pedagogical Institute helped identify in situ the species to which the excrement belonged. The eggs were measured and their images and descriptions in a guide were used to carry out a differential diagnosis of the eggs (Cherepanov et al., 1999). The eggs of *Uncinaria stenocephala* and *Ancylostoma caninum* differed in size (Cherepanov et al., 1999).

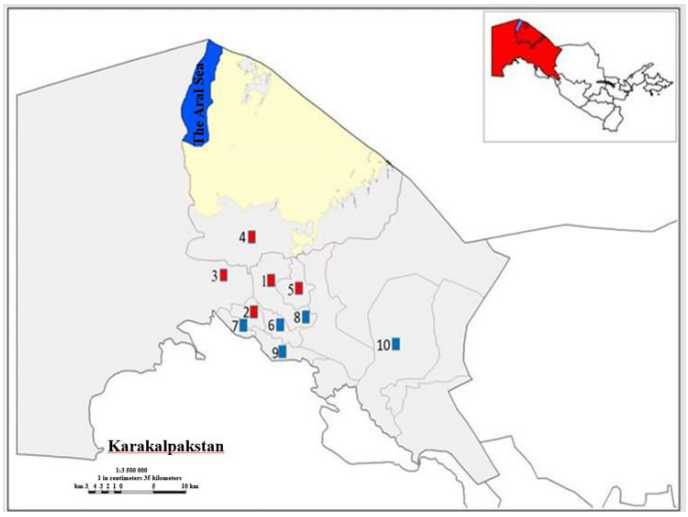


**Figure 1:** Map of the study area.
■ Stationary survey locations: 1, Bozatau district; 2, Kanlykul district; 3, Kungrad district; 4, Muynak district; 5, Chimbay district. ■ Transect survey locations: 6, Nukus district; 7, Shumanay district; 8, Kegeyli district; 9, Khojeyli district; 10, Beruni district.

The preparations were made following generally accepted methods (Khotenovsky, 1966; Sudarikov and Shigin, 1965). Microscopes MBI-6, MBS-10, LOMO and a range of binocular microscopes were used to study the morphology of the parasitic worms. To identify Trematoda, Cestoda and Acanthocephala species, the parasites were stained with carmine alum and used to make permanent and temporary preparations. To identify Nematoda species, the worms were treated with a 1:1 mixture of lactic acid and glycerol. The helminths were measured using a graduated eyepiece ruler.

A number of identifiers and monographs were used to identify helminth eggs and larvae in the faeces (Kotelnikov, 1974; Tokobaev, 1976; Kozlov, 1977).

Prevalence and infection intensity were used as indicators to evaluate the presence of parasites in the hosts organisms and their distribution across population.

The infection intensity data were statistically processed (Lakin, 1990).

## RESULTS AND DISCUSSION

In the biocoenoses of Karakalpakstan, 5 species of wild

carnivores and the domestic dog were examined for helminths. The total prevalence was 49.8%. 53 species of helminths were identified, representing 39 genera, 25 families, 13 orders, 4 classes and 3 phyla, with 17 species (32%) from the class Cestoda, 4 (8%) from Trematoda, 3 (6%) from Acanthocephala and 29 (55%) from Nematoda (Table 1).

Analysis of the material shows that Nematoda are represented by the largest number of species (29), followed by Cestoda (17) and Trematoda (4). Acanthocephala account for the smallest number of helminth species (3). The highest diversity of helminth species among the studied predators was recorded in the Fox–40 species, which was followed by the Jungle Cat (27 species), Golden Jackal (25), Wolf (22), Domestic Dog (20) and Badger (16 species) (Table 2).

**Table 1:** Species composition of the studied animals and helminth prevalence.

| Animals species[1] | Number of studied individuals | Infected % |
|---|---|---|
| *Canis aureus* (Linnaeus, 1758) | 91 | 52.7 |
| *Canis lupus* (Linnaeus, 1758) | 41 | 41.5 |
| *Vulpes vulpes subsp. karagan* (Erxleben, 1777) | 62 | 59.7 |
| *Meles meles subsp. leucurus* Hodgson, 1847 | 25 | 36.0 |
| *Felis chaus* Guldenstaedt, 1776 | 39 | 48.7 |
| *Canis familiaris (Canis lupus familiaris* Linnaeus, 1758) | 15 | 40.0 |

[1]Scientific names of species of carnivores and helminths were checked against information from https://fauna-eu.org/, https://itis.gov/

According to the research, 4 species from the class Cestoda – *J. pasqualei, T. ovis, H. krepkogorski* and *M.skrjabini*, and 7 species from the class Nematoda – *C. putorii, U. stenocephala, C. vulpis, O.numidica, C. subaequalis P. capsulata* and *Dipetalonema* sp., were recorded in the fauna of Karakalpakstan for the first time. The last nematode in the list is reported to be a new species for the fauna of the CIS countries.

A brief description of the nematode (according to the original material) newly discovered in the territory of CIS countries. The body is white, thread-like and elegant (delicate). The cuticle is smooth. The tail is blunt. The male is 62 mm long and 0.32 mm wide. The general appearance is similar to that of *Dipetalonema dracunculoides* (Cabbold, 1870), but the localisation was different. We recorded *Dipetalonema* sp. in the right ventricle of a jackal's heart.

Due to the insufficiency of the material, we referred this nematode as *Dipetalonema* sp. The material is stored in the zoological collection of the Institute of Zoology, Academy of Sciences of the Republic of Uzbekistan, under No. 24 (Figure 2).

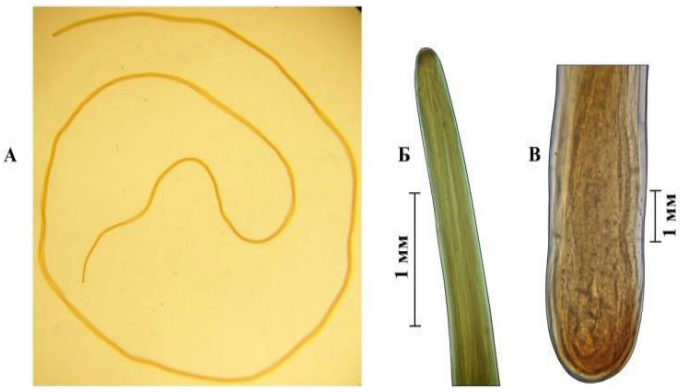


**Figure 2:** *Dipetalonema* sp. A, general appearance of nematode; B, head end; C, tail end.

**Table 2:** Diversity of the helminth fauna of carnivorous animals in Karakalpakstan.

| Helminth species | Host species | | | | | |
|---|---|---|---|---|---|---|
| | Wolf | Golden Jackal | Fox | Badger | Jungle Cat | Dog |
| **Trematoda Rudolphi, 1808** | | | | | | |
| *Plagiorchis elegans* Rudolphi, 1802 | - | + | + | - | - | - |
| *Echinochasmus perfoliatus* Ratz, 1908 | - | - | + | - | - | - |
| *Mesorchis denticulatus* Rud., 1802 | - | - | + | - | - | - |
| *Alaria alata* Krause, 1914 | + | + | + | + | + | + |
| **Cestoda Rudolphi, 1808** | | | | | | |
| *Spirometra erinacei-europei* Rudolphi, 1819 | - | + | + | + | + | + |
| *Dipylidium caninum* Linnaeus, 1758 | + | + | - | + | + | + |
| *Diplopylidium nőlleri* Skrjabin, 1924 | + | - | + | - | + | - |
| *Joyeuxiella echinorhynchoides* Sonsino, 1889 | - | + | + | - | - | - |
| *Joyeuxiella pasqualei* Diamare, 1893 | - | - | + | - | - | - |

*Tables continued on next pages.....*

| Helminth species | Host species | | | | | |
|---|---|---|---|---|---|---|
| | Wolf | Golden Jackal | Fox | Badger | Jungle Cat | Dog |
| *Joyeuxiella rossicum* Skrjabin. 1923 | - | - | - | - | + | - |
| *Taenia hydatigena* Pallas, 1766 | + | + | + | - | - | + |
| *Taenia macrocystis* Diesing, 1850 | - | - | + | - | + | |
| *Taenia ovis* Cobbold, 1869 | - | + | - | - | - | + |
| *Taenia pisiformis* Bloch, 1780 | + | - | + | - | - | - |
| *Hydatigera krepkogorski* Schulz et Landa, 1934 | - | - | + | - | + | - |
| *Hydatigera taeniaformis* Batsch, 1786 | - | + | - | - | - | - |
| *Multiceps multiceps* Leske, 1780 | + | + | + | - | - | + |
| *Multiceps skrjabini* Popov, 1937 | + | - | - | - | - | - |
| *Echinococcus multilocularis* Leuckart, 1863 | - | + | + | - | - | - |
| *Echinococcus granulosus* Batsch, 1786 | + | + | + | - | - | + |
| *Mesocestoides lineatus* Goeze, 1782 | + | + | + | + | + | + |
| **Nematoda Rudolphi, 1808** | | | | | | |
| *Capillaria putorii* Rudolphi, 1819 | - | - | + | + | - | - |
| *Thominx aerophilus* Creplin, 1839 | - | - | + | + | + | - |
| *Trichocephalus vulpis* Froelich, 1789 | - | + | + | - | - | + |
| *Dioctophyma renale* Goeze, 1782 | - | + | - | - | + | - |
| *Strongyloides vulpis* Petrow, 1941 | - | - | + | - | - | + |
| *Ancylostoma caninum* Ercolani, 1859 | + | + | + | + | + | - |
| *Uncinaria stenocephala* Railliet, 1854 | + | - | + | + | + | + |
| *Crenosoma vulpis* Rudolphi, 1819 | + | - | + | + | - | + |
| *Troglostrongylus badanini* Muminov, 1964 | - | - | - | - | + | - |
| *Toxascaris leonina* Linstow, 1902 | + | + | + | - | + | + |
| *Toxocara canis* Werner. 1782 | + | + | + | + | + | + |
| *Toxocara mystax* Zeder, 1800 | + | + | + | - | + | + |
| *Oxynema numidica* Seurat, 1915 | - | - | - | - | + | - |
| *Spirura rytipleurites* Deslongchamps, 1824 | - | - | + | - | - | - |
| *Cylicospirura subaequalis* Molin, 1860 | - | - | + | - | - | - |
| *Spirocerca arctica* Petrow, 1927 | - | - | + | - | - | - |
| *Spirocerca lupi* Rudolphi, 1809 | + | - | - | - | - | - |
| *Vigisospirura potekhini* Petrow et Potekhina, 1953 | - | - | - | + | + | - |
| *Vigisospirura skrjabini* Tschernikowa, 1934 | - | - | + | - | - | - |
| *Physaloptera praeputiale* Linstow, 1888 | - | - | + | - | + | - |
| *Physaloptera sibirica* Petrow et Gorbunow, 1931 | - | + | + | + | + | + |
| *Gongylonema pulchrum* Molin, 1857 | - | - | + | - | - | - |
| *Pneumospirura capsulata* Gerichter, 1948 | - | - | - | + | - | - |
| *Rictularia affinis* Jagerskiold, 1904 | + | + | + | - | + | + |
| *Rictularia cahirensis* Jagerskiold, 1904 | + | - | + | - | + | - |
| *Dipetalonema sp.* | - | + | - | - | - | - |
| *Dirofilaria immitis* Leidy, 1856 | + | + | + | - | + | + |
| *Dirofilaria repens* Railliet et Henry, 1911 | + | + | + | - | + | + |
| *Dracunculus medinensis* L., 1758 | - | + | - | - | + | |
| **Acanthocephala Rudolphi, 1801** | | | | | | |
| *Macracanthorynchus hirudinaceus* Pallas, 1781 | + | - | + | + | - | - |
| *Macracanthorhynchus catulinus* Kostylew, 1927 | - | + | + | + | + | + |
| *Moniliformis moniliformis* Bremser, 1811 | + | - | + | + | + | - |

**Table 3:** Distribution of helminths of foxes by their dominance in Karakalpakstan.

| Helminth category | Helminth species | Infection indicators | |
|---|---|---|---|
| | | Prevalence, % | Infection intensity, individuals |
| Dominant | *Strongyloides vulpis* | 42.0 | 4.9 ± 0.92 |
| | *Toxocara canis* | 40.3 | 20.4 ± 1.81 |
| | *Crenosoma vulpis* | 40.3 | 4.0 ± 0.63 |
| | *Multiceps multiceps* | 38.7 | 6.4 ± 0.41 |
| | *Toxascaris leonina* | 37.0 | 14.8 ± 1.32 |
| | *Rictularia cahirensis* | 35.4 | 4.4 ± 0.54 |
| | *Trichocephalus vulpis* | 33.8 | 4.2 ± 0.52 |
| | *Mesocestoides lineatus* | 32.2 | 2.7 ± 0.24 |
| | *Taenia hydatigena* | 30.6 | 3.4 ± 0.30 |
| | *Toxocara mystax* | 30.6 | 8.6 ± 0.72 |
| | *Spirura rytipleurites* | 30.6 | 3.0 ± 0.31 |
| Subdominant | *Echinochasmus perfoliatus* | 24.1 | 1.7 ± 0.13 |
| | *Cylicospirura subaequalis* | 24.1 | 1.5 ± 0.21 |
| | *Rictularia affinis* | 24.1 | 1.8 ± 0.41 |
| | *Alaria alata* | 22.5 | 1.3 ± 0.09 |
| | *Echinococcus multilocularis* | 21.0 | 2.8 ± 0.24 |
| | *Uncinaria stenocephala* | 21.0 | 2.2 ± 0.13 |
| Intermediate | *Physaloptera sibirica* | 19.3 | 1.9 ± 0.16 |
| | *Dirofilaria immitis* | 19.3 | 1.2 ± 0.09 |
| | *Taenia pisiformis* | 17.7 | 1.7 ± 0.64 |
| | *Plagiorchis elegans* | 17.7 | 0.9 ± 0.05 |
| | *Hydatigera krepkogorski* | 17.7 | 1.1 ± 0.08 |
| | *Thominx aerophilus* | 17.7 | 0.8 ± 0.05 |
| | *Spirocerca arctica* | 17.7 | 1.6 ± 0.24 |
| | *Vigisospirura skrjabini* | 17.7 | 2.0 ± 0.15 |
| | *Physaloptera praeputiale* | 17.7 | 1.7 ± 0.21 |
| | *Macracanthorynchus hirudinaceus* | 16.1 | 0.8 ± 0.15 |
| | *Mesorchis denticulatus* | 14.5 | 0.9 ± 0.24 |
| | *Joyeuxiella echinorhynchoides* | 14.5 | 1.5 ± 0.31 |
| | *Echinococcus granulosus* | 14.5 | 1.7 ± 0.42 |
| | *Capillaria putorii* | 14.5 | 0.9 ± 0.05 |
| | *Ancylostoma caninum* | 14.5 | 1.1 ± 0.08 |
| | *Gongylonema pulchrum* | 14.5 | 1.7 ± 0.17 |
| | *Spirometra erinacei-europei* | 13.0 | 1.0 ± 0.08 |
| Rare | *Joyeuxiella pasqualei* | 8.0 | 0.9 ± 0.05 |
| | *Diplopylidium nőlleri* | 8.0 | 0.8 ± 0.05 |
| | *Dirofilaria repens* | 8.0 | 0.4 ± 0.12 |
| | *Moniliformis moniliformis* | 6.4 | 0.4 ± 0.22 |
| | *Taenia macrocystis* | 6.4 | 0.9 ± 0.05 |
| | *Macracanthorhynchus catulinus* | 4.8 | 0.8 ± 0.05 |

The relatively small number of helminths found in wolves, badgers and dogs is apparently associated with the composition of the food consumed by the predators and the individual characteristics of their organisms.

According to the studies, the number of helminth species varies from host to host. 75.5% of the helminth species were found in foxes, 51.0% in jungle cats, 48.0% in golden jackals, 41.5% in wolves, 38.0% in domestic dogs and 30.2% in badgers. As we can see, the largest number of species was observed in foxes, which is associated with their ecology and distribution (Table 3).

The ecological and faunistic analysis of the helminthofauna of predatory mammals was based on the helminth distribution principle proposed by Romashova et al. (2014). According to the classification of Fedorov (1986), taking into account the indicators such as prevalence and infection intensity, two groups of helminths were identified: primary and secondary species (Table 3). Primary helminth species include dominant, subdominant and intermediate species; secondary species are rare and casual ones (Romashova et al., 2014).

The helminths recorded in foxes are so diverse that, in our opinion, they are characterised by two main environmental factors: relatively large populations and ecological flexibility. The helminths found in foxes are characterised by high species diversity, high infection intensity and a wide range of trophic relations with the host.

Compared to other wild mammals, foxes in Karakalpakstan are quite numerous in either natural ecosystems or recreational and agricultural areas. Consequently, they play an important role in the circulation of infection in a number of natural foci and in ensuring the functional stability of these foci. Therefore, we have analysed helminthological material reflecting quantitative indicators of the circulation of zoonotic helminthiases. The fox is an active and vital link in this process. A significant part of the helminth species found in foxes in the study area should be considered as potential pathogens of helminthiases (*T. hydatigena, T. canis, T. leonina, D. immitis, M. multiceps, E. granulosus* and *D. repens*). The most significant of the listed helminths from the medical and veterinary aspects are *E. granulosus, E. multilocularis, Toxocara canis, Toxascaris leonina Dirofilaria immitis, Dirofilaria repens* and *Dracunculus medinensis*. Our data are consistent with the data of other researchers (María Soledad Moleón et al., 2015; Fiocchi et al., 2016; Jacek et al., 2020).

The highest prevalence was shown by 8 Nematoda species: *Strongyloides vulpis* (42.0%), *Crenosoma vulpis* (40.3%), *Toxocara canis* (40.3%), *Toxascaris leonina* (37.0%), *Rictularia cahirensis* (35.4%), *Trichocephalus vulpis* (33.8%), *Spirura rytipleurites* (30.6%), *Toxocara mystax* (30.6%). They were followed by other 12 nematode species: *Rictularia affinis* (24.1%), *Cylicospirura subaequalis* (24.1%), *Uncinaria stenocephala* (21.0%), *Physoloptera sibirica* (19.3%), *Dirofilaria imittis* (19.3%), *Physoloptera praeputiale* (17.7%), *Vigisospirura skrjabini* (17.7%), *Thominx aerophilus* (17.7%),

*Spirocerca arctica* (17.7%), *Gongylonema pulchrum* (14.5%), *Ancylostoma caninum* (14.5%) and *Capillaria putori* (14.5%). Only one species – *Dirofilaria repens* – showed a prevalence of less than 10%.

**Table 4:** Distribution of helminths of the Jungle Cat in Karakalpakstan by dominance.

| Helminth category | Helminth species | Infection indicators | |
|---|---|---|---|
| | | Prevalence, % | Infection intensity, individuals |
| Dominant | *Taenia macrocystis* | 41.0 | 5.5 ± 0.62 |
| | *Joyeuxiella rossicum* | 38.4 | 3.8 ± 0.52 |
| | *Toxocara canis* | 38.4 | 24.1±1.63 |
| | *Toxascaris leonina* | 35.8 | 12.6±0.74 |
| | *Physaloptera praeputiale* | 33.3 | 3.4 ± 0.31 |
| | *Rictularia affinis* | 30.7 | 4.3 ± 0.42 |
| Subdominant | *Physaloptera sibirica* | 28.2 | 4.1 ± 0.73 |
| | *Alaria alata* | 28.2 | 2.7 ± 0.33 |
| | *Uncinaria stenocephala* | 28.2 | 4.7 ± 0.76 |
| | *Oxynema numidica* | 28.2 | 2.8 ± 0.54 |
| | *Rictularia cahirensis* | 28.2 | 4.5 ± 0.65 |
| | *Hydatigera krepkogorski* | 23.0 | 2.4 ± 0.36 |
| | *Mesocestoides lineatus* | 23.0 | 3.5 ± 0.73 |
| | *Macracanthorhynchus catulinus* | 23.0 | 2.1 ± 0.34 |
| | *Moniliformis moniliformis* | 23.0 | 1.8 ± 0.23 |
| | *Thominx aerophilus* | 23.0 | 1.6 ± 0.54 |
| | *Dioctophyma renale* | 23.0 | 2.3 ± 0.62 |
| | *Troglostrongylus bodanini* | 23.0 | 2.5 ± 0.41 |
| | *Toxocara mystax* | 23.0 | 7.8 ± 0.83 |
| | *Vigisospirura potekhini* | 23.0 | 3.7 ± 0.52 |
| Intermediate | *Diplopylidium nölleri* | 20.5 | 3.4 ± 0.43 |
| | *Ancylostoma caninum* | 20.5 | 2.6 ± 0.34 |
| | *Spirometra _rinaceid-europei* | 18.4 | 1.6 ± 0.15 |
| | *Dipylidium caninum* | 18.0 | 4.2 ± 0.64 |
| | *Dirofilaria immitis* | 18.0 | 1.7 ± 0.26 |
| | *Dirofilaria repens* | 10.2 | 0.6 ± 0.052 |
| Rare | *Dracunculus medinensis* | 7.6 | 0.3 ± 0.043 |

Currently, the epidemiological and epizootological crisis associated with diseases caused by this group of nematodes is increasing. In particular, dirofilariasis, toxocariasis and toxocaridosis of wild animals in the coming years may form natural foci of infection in Karakalpakstan.

Trematoda showed the following prevalence: *Echinochasmus perfoliatus* 24.1% and *Alaria alata* 22.5%. Currently, the range of definitive hosts for the trematode *Alaria alata* is growing. The prevalence of Cestoda in wild animals varies greatly (Korol et al., 2106). High values (20-40%) were recorded in 4 species *Taenia hydatigena, Multiceps multiceps, Alveococcus multilocularis* and *Mesocestoides lineatus*. Somewhat lower prevalence (10-20%) was registered in other 5 species: *Spirometra erinacei-europei, Joyeuxiella echinorhynchoides, Taena pisiformis, Hydatigera krepkogorski* and *Echinococcus granulosus*. The Cestoda species *Diplopylidium nölleri, Joyeuxiella pasqualei* and *Taenia macrocystis* showed a prevalence of less than 10%. 3 species of Acanthocephala were recorded in wild animals. *Macracanthorynchus hirudinaceus* showed a prevalence of 16.1%. The prevalence of *Macracanthorhynchus catulinus* and *Moniliformis moniliformis* was 4.8% and 6.4%, respectively. The research into the helminthofauna of the Fox resulted in some completely new information complementing that in previously published works (Koshanov, 1970; Shakarboev, 2009).

**Table 5:** Distribution of helminths of the Golden Jackal in Karakalpakstan by dominance.

| Helminth category | Helminth species | Infection indicators | |
|---|---|---|---|
| | | Prevalence, % | Infection intensity, individuals |
| Dominant | *Toxocara canis* | 51.6 | 12.6 ± 1.1 |
| | *Toxascaris leonina* | 50.5 | 8.3 ± 0.5 |
| | *Multiceps multiceps* | 31.8 | 3.5 ± 0.4 |
| | *Toxocara mystax* | 30.7 | 4.6 ± 0.6 |
| Subdominant | *Trichocephalus vulpis* | 26.3 | 3.5 ± 0.4 |
| | *Taenia hydatigena* | 25.2 | 2.6 ± 0.2 |
| | *Mesocestoides lineatus* | 23.0 | 2.0 ± 0.1 |
| | *Rictularia affinis* | 23.0 | 1.5 ± 0.1 |
| | *Dirofilaria immitis* | 23.0 | 1.1 ± 0.08 |
| Intermediate | *Echinococcus multilocularis* | 20.8 | 2.0 ± 0.1 |
| | *Physaloptera sibirica* | 18.6 | 1.4 ± 0.08 |
| | *Dipylidium caninum* | 18.6 | 2.0 ± 0.1 |
| | *Spirometra erinacei-europei* | 17.5 | 2.1 ± 0.6 |
| | *Hydatigera taeniaformis* | 15.3 | 3.0 ± 0.18 |
| | *Taenia ovis* | 14.2 | 1.8 ± 0.04 |
| | *Echinococcus granulosus* | 14.2 | 2.3 ± 0.15 |
| | *Ancylostoma caninum* | 14.2 | 2.7 ± 0.17 |
| | *Dioctophyma renale* | 13.1 | 1.6 ± 0.54 |
| | *Joyeuxiella echinorhynchoides* | 12.0 | 1.1 ± 0.8 |
| Rare | *Plagiorchis elegans* | 9.8 | 1.4 ± 0.16 |
| | *Macracanthorhynchus catulinus* | 9.8 | 0.5 ± 0.7 |
| | *Alaria alata* | 8.7 | 1.9 ± 0.04 |
| | *Dirofilaria repens* | 8.7 | 0.3 ± 0.13 |
| | *Dracunculus medinensis* | 5.4 | 1.2 ± 0.18 |
| | *Dipetalonema* sp. | 1.0 | 0.01 ± 0.05 |

2 Cestoda species (*Joyeuxiella pasqualei* and *Taenia ovis*) and 3 Nematoda species (*Capillaria putorii, Cylicospirura subaequalis* and *Dipetalonema* sp.) were recorded for the first time in wild animals in the study area.

Thus, in anthropogenic ecosystems, zoonotic helminthiasis of foxes can play the role of an additional ecological link in the circulation of helminthiases. Only 4 dominant helminth species were recorded in the Jungle Cat (Table 4).

In the natural ecosystems of Karakalpakstan, jackals form quite a large group of predators (Palvaniyazov, 1974). Our research identified 25 helminth species in this predator (Table 5). The infection rate in the Golden Jackal in our studies is much higher compared to the data of other researchers, either in Uzbekistan (Koshanov, 1970) or in other countries (Ćirović et al., 2013).

22 helminth species were identified in wolves, of which 2 are dominant, 5 subdominant, 14 intermediate and 1 rare (Table 6). Intermediate species comprise most of the helminthofauna of wolves (63.6%). The portion of dominant and subdominant species is 31.8%.

**Table 6:** Distribution of helminths of the Wolf in Karakalpakstan by dominance.

| Helminth category | Helminth species | Infection indicators | |
|---|---|---|---|
| | | Prevalence, % | Infection intensity, individuals |
| Dominant | *Toxascaris leonina* | 34.1 | 8.0±1.1 |
| | *Multiceps multiceps* | 31.7 | 4.0±0.4 |
| Subdominant | *Taenia hydatigena* | 26.8 | 3.2±0.3 |
| | *Diplopylidium nőlleri* | 22.0 | 2.1±0.1 |
| | *Crenosoma vulpis* | 22.0 | 1.1±0.08 |
| | *Toxocara canis* | 22.0 | 9.8±0.9 |
| | *Rictularia cahirensis* | 22.0 | 2.1±0.1 |
| Intermediate | *Dipylidium caninum* | 19.5 | 2.6±0.2 |
| | *Taenia pisiformis* | 19.5 | 1.2±0.08 |
| | *Multiceps skrjabini* | 19.5 | 1.2±0.08 |
| | *Mesocestoides lineatus* | 17.0 | 2.0±0.1 |
| | *Macracanthorynchus hirudinaceus* | 17.0 | 1.3±0.08 |
| | *Moniliformis moniliformis* | 17.0 | 1.0±0.04 |
| | *Toxocara mystax* | 17.0 | 4.4±0.6 |
| | *Spirocerca lupi* | 17.0 | 2.3±0.1 |
| | *Echinococcus granulosus* | 14.6 | 1.7±0.1 |
| | *Uncinaria stenocephala* | 14.6 | 1.4±0.09 |
| | *Rictularia affinis* | 14.6 | 1.5±0.1 |
| | *Alaria alata* | 12.2 | 0.8±0.05 |
| | *Ancylostoma caninum* | 12.2 | 1.2±0.08 |
| | *Dirofilaria immitis* | 12.1 | 0.7±0.05 |
| Rare | *Dirofilaria repens* | 7.3 | 0.4±0.002 |

It was established that the helminthofauna of the Badger included 1 dominant, 2 subdominant, 7 intermediate and 6 rare species (Table 7). Most of the parasites in the helminthofauna of the Badger are intermediate and rare species.

Among five corsacs investigated in Samarkand region of Uzbekistan, species *A. alata, T. hydatigena, T. leonina, U. stenocephala* and *D. caninum* were found with similar levels of the infection (Young et al., 2019). All the carnivorous mammals are parasitиыed by *A. alata*, whose intermediate hosts are molluscs from the family Planorbidae and amphibians; their reservoir hosts are amphibians, reptiles, birds and mammals.

**Table 7:** Distribution of helminths of the Badger in Karakalpakstan by dominance.

| Helminth category | Helminth species | Infection indicators | |
|---|---|---|---|
| | | Prevalence, % | Infection intensity, individuals |
| Dominant | *Alaria alata* | 20.0 | 1.4 ± 0.09 |
| Subdominant | *Macracanthorhynchus catulinus* | 16.0 | 1.0 ± 0.08 |
| | *Toxocara canis* | 16.0 | 8.3 ± 0.5 |
| Intermediate | *Dipylidium caninum* | 12.0 | 2.3 ± 0.1 |
| | *Mesocestoides lineatus* | 12.0 | 1.7 ± 0.6 |
| | *Macracanthorynchus hirudinaceus* | 12.0 | 1.0 ± 0.08 |
| | *Moniliformis moniliformis* | 12.0 | 0.9 ± 0.05 |
| | *Crenosoma vulpis* | 12.0 | 1.2 ± 0.09 |
| | *Vigisospirura potekhini* | 12.0 | 1.5 ± 0.1 |
| | *Pneumospirura capsulata* | 12.0 | 1.1 ± 0.08 |
| Rare | *Spirometra erinacei-europei* | 8.0 | 0.8 ± 0.05 |
| | *Capillaria putorii* | 8.0 | 0.7 ± 0.05 |
| | *Thominx aerophilus* | 8.0 | 0.6 ± 0.05 |
| | *Ancylostoma caninum* | 8.0 | 1.1 ± 0.08 |
| | *Uncinaria stenocephala* | 8.0 | 1.0 ± 0.08 |
| | *Physaloptera sibirica* | 8.0 | 1.3 ± 0.09 |

## CONCLUSIONS AND RECOMMENDATIONS

Our studies identified 53 species of helminths in the predatory mammals of Karakalpakstan. Their distribution across the studied mammal species is the following: 16 species of parasitic worms were recorded in badgers, 22 in wolves, 25 in jackals, 27 in jungle cats and 40 in foxes. Most species and groups parasitise in the digestive system and occur as mixed infections.

A number of species (*A. alata*, *M. lineatus* and *T. canis*) were found to be common in all the studied host predators. The species *S. lupi* and *M. skrjabini* were recorded only in wolves, *G. pulchrum, V. skrjabini*, *S. arctica, C. subaequalis, S. rytipleurites, M. denticulatus, Ech. perfoliatus* and *J. pasqualei* only in foxes, *Dipetalonema* sp. and *H. taeniaformis* only in jackals, *O. numidica, T. bodanini* and *J. rossicum* only in jungle cats, *and P. capsulata* was found only in badgers.

The helminth fauna of foxes is very diverse in species composition (40 species). This is probably associated with the animal's ecology, population stability and trophic relationships.

Among the helminth species we have identified, some are important from the epidemiological and epizootological aspects. It is quite probable that wild and domestic predators exchange helminths. The overall helminthological situation in predatory mammals indicates the need for systematic monitoring and a complex of anti-helminthic measures.

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## NOVELTY STATEMENT

For the first time, the current state of wild animal helminths on the territory of Karakalpakstan was analyzed, 53 species were registered, belonging to 3 types, 4 classes, 13 genera, 25 families, 39 genera, of which 44 species belong to biohelminths and 9 species geohelminths;

## AUTHOR'S CONTRIBUTION

Materials was collected, morphological study and performed statistical analysis of data by Abat Berdibaev. Identification of species, analysis of collected materials and preparation of manuscripts of articles was carried out by Erkinjon Shakarboev. Both author read and approved the manuscript.

### Conflict of interest

The authors have declared no conflict of interest.

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