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HELMINTH FAUNA IN CARNIVORAN MAMMALS FROM UZBEKISTAN

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Helminth Fauna in Carnivoran Mammals from Uzbekistan. Safarov, A., Khan, A., Azimov, D., Akramova, F., Saparov, K., Ben Said, M. — Helminths, or parasitic worms, are a group of organisms that can infect various animal species, including humans. In Uzbekistan, previous studies on the helminth fauna of mammals have focused mainly on domestic animals and some wildlife species, with little attention paid to carnivorous mammals. This study aims to provide the first comprehensive survey of the

carnivore helminth fauna in Uzbekistan. In this study, helminths were collected from 1002 carnivorans (Canidae, n = 710; Mustelidae, n = 167; and Felidae, n = 125) from five locations in Uzbekistan (Northeastern, Eastern, Central, Southern and Northwestern). A total of 71 helminth species were identified in domestic and wild carnivores by necropsy and faecal examination, of which 36, 23, 9, and 3 species belonged to the higher taxon Nematoda, Cestoda, Trematoda and Acanthocephala respectively. The highest number of helminth species was found in studied Canidae (51 species), followed by Felidae (40 species) and Mustelidae (35 species). The overall infection rate of carnivores was 79.8 %. Infection intensity ranged from a single specimen to dozens of specimens. Statistical analysis showed that the diversity of helminth species is significant among members of the Canidae, with foxes having 42 species and dogs having 41 species ($P < 0.05$). Our study shows that the parasitic worm species that inhabiting carnivorous mammals in Uzbekistan are a diverse and complex group capable of causing helminthiases, that can be dangerous to livestock and humans.

Key words: helminths, Carnivora, Canidae, Felidae, Mustelidae, Uzbekistan.

Introduction

Carnivora is one of the most interesting orders of mammals, whose ecological adaptation has reached the widest range from aquatic to arboreal forms. In this context, carnivores represent a convenient object for helminthologists, since many issues of the formation of faunal complexes of parasites inherent in certain taxonomic and ecological groups of hosts can be considered on their example (Gibson et al., 2014).

All components of parasitic systems, regardless of their level of organization, are associated to varying degrees with physical, geographical and biological components that determine the specific landscape and hydrological conditions of biogeocenoses (Chaĭka SIu, 1998). The influence of these factors on the qualitative and quantitative characteristics of the parasitofauna is enhanced by their complex effect, which influences the epidemiological processes of parasitic diseases occurring in specific areas (Kołodziej-Sobocińska, 2019). In this context, the link between the helminthofauna of carnivores and other vertebrates, including humans, deserves special attention (Wells et al., 2018; White and Razgour, 2020).

Mammals of Uzbekistan are represented by 8 orders: Insectivora (Insectivores), Chiroptera (Bats), Lagomorpha (Hare-like), Rodentia (Rodents), Carnivora (Carnivores), Artiodactyla (Artiodactyls), Perissodactyla (Ungulates), Tylopoda (Calluses) (Shernazarov et al., 2006; Kashkarov et al., 2020). The relationship of the helminth fauna of carnivorans was established with representatives of the orders Insectivora, Lagomorpha, Rodentia, Artiodactyla, Perissoactyla, and Tylopoda.

Several researchers including Petrov (1926), Schleicher (1949), and Zhdanova (1949) studied the helminth fauna of dogs in Uzbekistan. Their studies revealed 22 species of parasitic worms belonging to the higher taxa Cestoda, Acanthocephala, and Nematoda were present in the area. The authors found that the Taeniidae and Dipilididae families of cestodes, and the Ancylostomatidae, Ascarididae, and Anisakidae families of nematodes, were widely distributed among the dogs they studied.

The dominant taxonomic groups in both dog populations were found to be cestodes of the genera *Dipilidium, Taenia, Echinococcus, Multiceps,* and nematodes of the genera *Toxoscaris, Toxocara, Ancylostoma.*

Materials on the helminthofauna of dogs of Uzbekistan are summarized by Sultanov et al. (1975) in the monograph "Helminths of domestic mammals of Uzbekistan", which reports the presence of 32 species of parasitic worms in dogs, of which 17 species can parasitize the human body at various stages of development, which is confirmed by known literature data (Matchanov et al., 1977; Bronstein and Tokmolaev, 2004; Macpherson et al., 2013; Azimov et al., 2015; Safarov, 2020; Safarov et al., 2022, 2023).

To date, previous studies have become substantially outdated, which is confirmed by recent studies on the helminth fauna of dogs in Uzbekistan (Safarov, 2020; Safarov et al., 2021). The data (Delyanova, 1958; Matchanov, 1967) do not support the detection of several species of helminths in dogs *(Spirometra erinaceieuropaei, Diplopylidium nölleri, Mesorchis denticulatus, Brachylaemus* sp., *Crenosoma vulpis,* and *Toxocara mystax*). The mentioned helminth species in most cases parasitize wild representatives of predatory mammals of Uzbekistan, which does not contradict previously published works (Irgashev and Sadykov, 1966; Kairov, 1965; 1968; Koschanov, 1972; Safarov et al., 2022).

Among carnivores, a number of species are of great practical importance. The fur of river otter, mink and others is highly valued in domestic and foreign markets. They are, admittedly, hosts of dangerous pathogens of helminthiasis of animals and humans. However, the list of works on the parasite fauna of Carnivorous mammals of Uzbekistan is relatively small (Muminov, 1963; Kairov, 1965; Koshanov, 1972; Safarov et al., 2021, 2022). At the beginning of the 21st century, only one fundamental monograph by Safarov et al. (2021) was published, in which the parasites of dogs of the Tashkent megalopolis are considered.

Information on the helminth fauna of individual representatives of carnivorous animals of Karakalpakstan was significantly updated and supplemented in the dissertation study "Helminths of Carnivorous mammals of Karakalpakstan" of Berdibaev (2021). However, comprehensive studies of the fauna, distribution features and helminth ecology of carnivorous mammals in the biogeocenoses of Uzbekistan have not been considered. Given the importance of this animal group, it is also quite relevant to study in detail their parasite fauna and their distribution in connection with the peculiarities of the modern ecological context of Uzbekistan.

This report showcases the findings of a research study on the fauna and distribution characteristics of helminths among carnivorous mammals in Uzbekistan. Additionally, the report touches upon certain ecological aspects of helminths. The study employed contemporary concepts regarding the classification and naming of helminths as outlined on the Fauna Europaea website (2020) https://fauna-eu.org.

Material and Methods

Study regions and collected samples

Over the course of four years, from March 2018 to November 2022, samples were collected from 1002 carnivorous mammals in various regions of Uzbekistan, including North-Eastern, Eastern, Central, Southern, and North-Western areas (table 1 and fig. 1). The samples were taken from members of three mammal families: Canidae (710 samples), Mustelidae (167 samples), and Felidae (125 samples), encompassing a range of ages and both sexes.

The samples were obtained from a variety of sources, including animals caught by hunters, those killed in car accidents (primarily dogs and jackals), and those that died naturally (mostly wild carnivorous mammals). Additionally, we examined fecal samples from dogs and cats housed at the "Mehr" animal protection organization, located in the Piskent district of the Tashkent region in Uzbekistan.

All animals were tested for rabies at the Virology Laboratory of the Republican State Center for Diagnosis of Animal Diseases and Food Safety before the helminthological examination. The carcasses were stored at a temperature of –20 °C prior to the necropsy. The necropsy was conducted using a whole-body post-mortem examination method, with all organs and tissues examined for the presence of helminths. Muscle samples were also collected and examined for the presence of *Trichinella* spp. The study was reviewed and approved by the Center's ethics committee.

Field work was carried out during the commercial period during the hunting seasons for wild animals — in autumn and winter. Rare animals — river otter, lynx, steppe cat, were studied in limited numbers, legally killed or killed by illegal hunting on the territory of southern Uzbekistan. The remaining species were obtained in the territory of North-Eastern, Eastern, Central and North-Western Uzbekistan. At the same time, the services of local hunters were used.

Domestic dogs and cats were studied in all seasons of the year in rural areas and settlements using well-known methods of Parasitology (Zewdu et al., 2010).

Helminths identification

Table 1. Species composition and number of examined hosts

Family	Species	Examined
Canidae	Golden jackal, *Canis aureus*	120
	Grey wolf, *Canis lupus*	62
	Domestic dog, *Canis familiaris*	399
	Korsak, *Vulpes corsac*	61
	Red fox, *Vulpes vulpes*	68
Mustelidae	Stone Marten, *Martes foina*	43
	American Mink, *Mustela vison*	26
	Least weasel, *Mustela nivalis*	35
	Eurasian Badger, *Meles meles*	57
	River otter, *Lutra lutra*	6
Felidae	Jungle cat, *Felis chaus*	43
	Steppe cat, *Felis lybica*	11
	Domestic cat, *Felis catus*	66
	Lynx, *Lynx lynx*	5
Total		1002

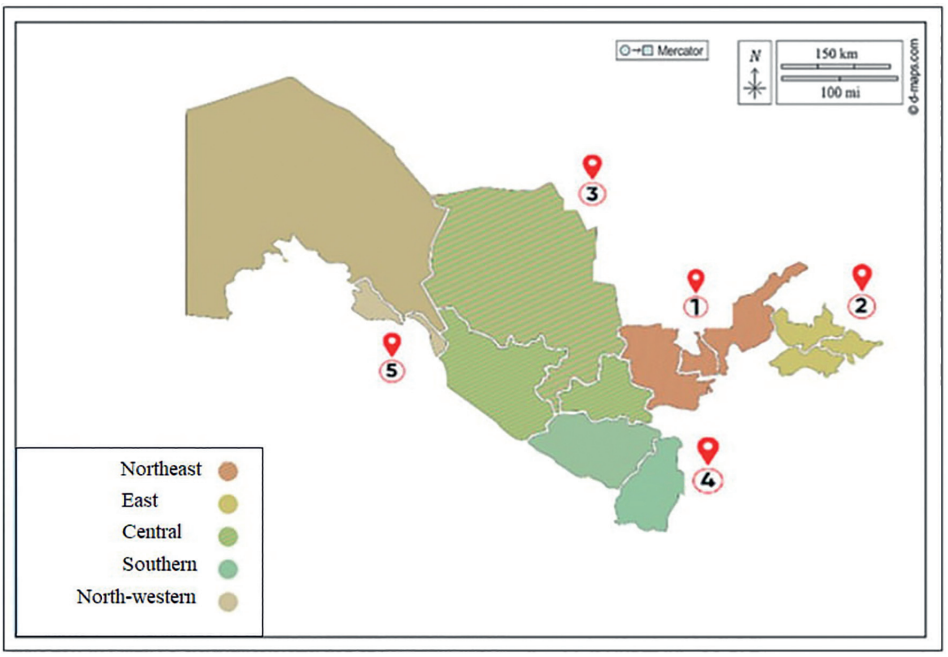

Fig. 1. Map showing investigated regions in Uzbekistan. 1— Northeast (Tashkent, Syrdaryn, Jizzakh regions); 2 — East (Fergana, Andijan, Namangan regions); 3 — Central (Samarkand, Bukhara, Navoi regions), 4 — Southern (Surkhandarya, Kashkadarya regions); 5 — North-Western (Khorezm region).

The study of collected helminths was conducted according to a generally accepted method — cestodes and trematodes were stained with carmine or hematoxylin, permanent preparations were prepared from them, acanthocephalans and nematodes were clarified in a mixture of glycerin and lactic acid (Khalil et al., 1994; Gibson et al., 2002). Measurement of cestodes, trematodes, acanthocephalans, and nematodes, photographs and drawings were made using light microscopes Olympus CK2-TR inverted microscope, Lomo research binocular — ML — 2200, N — 300 m Ningo Yongkin Optics trinocular microscope. Identification of cestodes, trematodes, acanthocephalans, and nematodes was carried out according to identification keys (Anderson,

Table 2. Helminth infections of investigated predatory mammals in Uzbekistan

Family	Species	Total	Positive	Infection rate (% ± C.I.[1])	P value (Chi[2])
Canidae	*Canis aureus*	120	101	84.1 ± 0.064	0.000* (30.91)
	Canis lupus	62	50	80.6 ± 0.098	–
	Canis familiaris	399	380	95.3 ± 0.021	–
	Vulpes corsac	61	49	80.3 ± 0.099	–
	Vulpes vulpes	68	63	92.6 ± 0.062	–
Mustelidae	*Martes foina*	43	21	49.0 ± 0.148	0.704 (1.98)
	Mustela vison	26	11	42.3 ± 0.19	–
	Mustela nivalis	35	16	46.2 ± 0.164	–
	Meles meles	57	23	40.2 ± 0.127	–
	Lutra lutra	6	4	66.6 ± 0.376	–
Felidae	*Felis chaus*	43	31	74.4 ± 0.133	0.570 (2.01)
	Felis lybica	11	7	63.6 ± 0.284	–
	Felis catus	66	40	60.5 ± 0.117	–
	Lynx lynx	5	4	NC	–
Total		1002	800	79.8 ± 0.025	–

Abbreviations. C.I.[1] — 95 % confidence interval; * — statistically significant, $p < 0.05$; NC — not calculated infection rate because the number of examined animals is ≤ 5.

Note. P value and Chi[2] between all species are < 0.001 and 106.98, respectively.

2000, 2009; Safarov et al., 2021, 2022). Other keys were also used for certain groups of higher taxa (Gibson et al., 2008).

Statistical analysis

The statistical analysis was performed using Epi Info 7 software (CDC, USA). The prevalence and its 95 % Confidence Interval (CI) were calculated, and differences among groups were assessed by chi-square testing and considered significant for $p \leq 0.05$.

Results

Diversity and overall prevalence of the helminths in carnivorous mammals

The helminth infection of studied animals was found to be quite high which was estimated at 79.8 % (table 2). *Canis familiaris* was statistically the most infected host species (95.3 %), while *Mustela vison* was the least infected (40.2 %) ($P < 0.001$, table 2). In total, 70 species of helminths belonging to the higher taxon Cestodes, trematodes, acanthocephals and Nematodes were identified. In the vast majority of cases, mixed infections by several types of parasites were recorded in infected animals, with 3 to 9 types of helminths being found (table 3).

In terms of the helminth species number, the first position is occupied by representatives of canids (Canidae) — 51 species; slightly smaller in felids (Felidae) — 40 species; the last place in this indicator is occupied by mustelids (Mustelidae) — 35 species (table 3).

Parasites species found in carnivorous mammals of various families are unevenly distributed as shown in table 4.

Table 3. Helminths of studied carnivoran mammals of various families

Helminth higher taxon	Helminth species	Host family		
		Canidae	Mustelidae	Felidae
Cestoda	*Diphyllobothrium latum*	+	+	+
	Spirometra erinaceieuropaei	+	+	+
	Dipylidium caninum	+	+	+
	Diplopylidium nőlleri	+	–	+
	Joyeuxiella echinorhynchoides	+	–	–
	Joyeuxiella pasqualei	–	–	+
	Joyeuxiella rossicum	+	–	+
	Taenia hydatigena	+	+	+
	Taenia macrocystis	+	–	+
	Taenia ovis	+	–	–
	Taenia pisiformis	+	+	+
	Taenia crassiceps	+	+	+
	Taenia laticollis	–	–	+
	Taenia martis	–	+	–
	Taenia mustelae	–	+	–
	Hydatigera krepkogorski	+	–	+
	Hydatigera taeniaeformis	+	+	–
	Multiceps multiceps	+	–	–
	Multiceps skrjabini	+	–	–
	Multiceps serialis	+	–	–
	Echinococcus multilocularis	+	–	+
	Echinococcus granulosus	+	–	+
	Mesocestoides lineatus	+	+	+

Trematoda	*Fasciola hepatica*	–	+	–
	Plagiorchis elegans	+	+	+
	Plagiorchis lutrae	–	+	–
	Dicrocoelium dendriticum	+	–	–
	Echinochasmus perfoliatus	+	–	–
	Euparyphium melis	–	+	–
	Mesorchis denticulatus	–	–	+
	Alaria alata	+	+	–
Acantho-cephala	*Corynosoma strumosum*	–	+	–
	Macrocanthorynchus catulinus	+	+	+
	Moniliformis moniliformis	+	+	+
Nematoda	*Capillaria plica*	+	+	+
	Capillaria putorii	+	+	+
	Capillaria mucronata	–	+	+
	Thominx aerophilus	+	+	+
	Trichocephalus vulpis	+	–	–
	Dioctophyme renale	+	+	+
	Strongyloides vulpis	+	–	–
	Strongyloides stercoralis	+	–	–
	Strongyloides martis	–	+	–
	Ancylostoma caninum	+	+	+
	Ancylostoma tubaeforme	–	–	+
	Uncinaria stenocephala	+	+	+
	Crenosoma vulpis	+	+	–
	Crenosoma petrowi	–	–	–
	Troglostrongylus badanini	–	–	+
	Toxascaris leonina	+	–	+
	Toxocara canis	+	–	+
	Toxocara mystax	+	–	+
	Oxynema numidica	+	–	+
	Spirura rytipleurites	–	–	+
	Petrowospirura lynxi	–	–	+
	Cylicospirura subaequalis	+	–	–
	Spirocerca arctica	+	–	–
	Spirocerca lupi	+	+	–
	Vigisospirura potekhini	–	+	–
	Vigisospirura skrjabini	–	+	–
	Physoloptera praeputialis	+	–	+
	Physoloptera sibirica	+	+	+
	Gnatostoma spinigerum	–	+	+
	Gongylonema pulchrum	+	–	–
	Pneumospirura capsulate	–	+	–
	Rictullaria affinis	+	–	+
	Rictularia cahirensis	+	–	+
	Filaria martis	–	+	–
	Dirofilaria immits	+	–	+
	Dirofilaria repens	+	–	+
Total number	70	51	35	40

Abbreviations. +/– — presence or absence of the helminth in animals.

Of the total number of species (51) of helminths of Canidae, cestodes comprised 36 %, trematodes 9.8 %, Acanthocephals 3.9 % and nematodes 47 %. Practically, similar layouts are observed in both mustelids and felids. According to table 4, it is observed that nema-

Table 4. The number of helminth species of individual classes in studied carnivorous mammals of various families

Family	Total	Parasites of carnivorous mammals											
		Cestoda			Trematoda			Acanthocephala			Nematoda		
		Nb of species	Rate (% ± C.I.[1])	P value (Chi[2])	Nb of species	Rate (% ± C.I.[1])	P value (Chi[2])	Nb of species	Rate (% ± C.I.[1])	P value (Chi[2])	Nb of species	Rate (% ± C.I.[1])	P value (Chi[2])
Canidae	51	19	37.3 ± 0.13	0.50 (0.43)	5	9.8 ± 0.08	0.52 (0.41)	2	3.9 ± 0.05	0.41 (0.67)	24	47.0 ± 0.13	0.56 (0.32)
Mustelidae	35	10	28.5 ± 0.14	–	5	14.2 ± 0.11	–	3	8.5 ± 0.09	–	18	51.2 ± 0.16	–
Felidae	40	15	37.5 ± 0.15	–	5	15.5 ± 0.1	–	2	5.0 ± 0.06	–	22	50.5 ± 0.15	–

Abbreviations. Nb of species — number of species; C.I.[1] — 95 % confidence interval.

todes make up the majority of representatives in Canidae, Mustelidae, and Felidae, accounting for 47 %, 81.2 %, and 50.5 %, respectively. Cestodes, on the other hand, constitute, respectively, 28.5 %, 37.5 %, and 36 % of the representatives in these three animal groups.

Helminthfauna of Canidae

In total 5 canids species (jackal, wolf, domestic dog, corsac and fox) were investigated in the present study. As mentioned in table 4, 51 species of parasitic worms were recorded in studied canids, which are unevenly distributed among individual host species.

Helminths of domestic dog (*Canis lupus familiaris*)

Studied dogs in rural and urban populations of Uzbekistan were significantly infested with helminths. Of the 399 individuals of examined dogs, helminths were found in 380 (95.3 %) (table 2). The helminths found during their identification turned out to be representatives of 32 species belonging to 4 classes — Cestoda, Trematoda, Acanthocephala and Nematoda (table 5).

Table 6 shows the occurrence of certain associations of the parasitofauna of a domestic dog with vertebrates of other classes. Of the total number of canine parasites, according to our own research, the largest number occurs in terrestrial vertebrates in mammals of other orders (table 6).

Helminths of the jackal (*Canis aureus* Linnaeus, 1758)

In this study of 120 jackal individuals, helminths were found in 101 with an infection prevalence of 84.1 % (table 2). The intensity of the infection varied from one to dozens of specimens.

The helminths we found turned out to be representatives of the classes Cestoda, Trematoda, Acanthocephala and Nematoda. The modern helminth fauna consisted of 26 species: *Diphyllobothrium latum* (Linnaeus, 1758), *Dipylidium caninum* (Linnaeus, 1758), *Taenia hydatigena* Pallas, 1766, *Taenia ovis* (Cobbold, 1869), *Hydatigera taeniaeformis* (Batsch, 1786), *Multiceps multiceps* (Leske, 1780), *Echinococcus granulosus* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Plagiorchis elegans* (Rudolphi, 1802), *Alaria alata* (Goeze, 1792), *Macrocanthorynchus catulinus* Kostylew, 1927, *Capillaria plica* (Rudolphi, 1819), *Capillaria putorii* (Rudolphi, 1819), *Trichocephalus vulpis* Froelich, 1789, *Dioctophyma renale* (Goeze, 1782), *Strongyloides vulpis* Petrow, 1941, *Ancylostoma caninum* (Er-

Table 5. Species composition and taxonomic diversity of helminths of investigated domestic dogs in Uzbekistan

Higher taxon	Family	Species
Cestoda	Diphyllobothridae	*Diphyllobothrium latum*
	Dipylididae	*Dipylidium caninum*
		Joyeuxiella rossicum
	Mesocestoididae	*Mesocestoides lineatus*
	Taeniidae	*Taenia hydatigena*
		Taenia pisiformis
		Multiceps multiceps
		Multiceps skrjabini
		Hydatigera taeniae formis
		Echinococcus granulosus
Trematoda	Dicrocoeliidae	*Dicrocoelium dendriticum*
	Plagiorchidae	*Plagiorchis elegans*
	Alariidae	*Alaria alata*
Acanthocephala	Oligacanthorinchidae	*Macrocanthorynchus catulinus*
Nematoda	Capillariidae	*Capillaria plica*
	Trichocephalidae	*Trichocephalus vulpis*
	Dioctophymidae	*Dioctophyma renale*
	Strongyloididae	*Strongyloides stercoralis*
	Ancylostomatidae	*Ansylostoma caninum*
		Uncinaria stenocephala
	Crenosomatidae	*Crenosoma vulpis*
	Ascarididae	*Toxascaris leonina*
	Anisakidae	*Toxocara canis*
	Spiruridae	*Spirocerca lupi*
		Spirocerca arctica
	Physolopteridae	*Physoloptera preputialis*
		Physoloptera sibirica
	Gongylonematidae	*Gongylonema pulchrum*
	Rictulariidae	*Rictullaria affinus*
		Rictullaria cahirensis
	Onchocercidae	*Dirofilaria immitis*
		Dirofilaria repens

Table 6. The relationship of helminthfauna of dogs and other vertebrates according to the literature

Higher taxon	Total number	Number of helminth species shared between dogs and other vertebrates				
		Fish	Amphibians	Reptiles	Birds	Other orders of mammals
Cestoda	15	2	1	2	1	5
Trematoda	5	1	4	3	4	2
Acanthocephala	1	0	0	0	0	1
Nematoda	20	2	1	1	1	3
Total	41	5	6	6	6	11

colani, 1859), *Uncinaria stenocephala* (Railliet, 1884), *Toxascaris leonina* (Linstow, 1902), *Toxocara canis* (Werner, 1782), *Spirocerca lupi* (Rudolphi, 1809), *Physoloptera praeputialis* Linstow, 1888, *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Gongylonema pulchrum* Molin, 1857, *Dirofilaria immits* (Leidy, 1856), and *Dirofilaria repens* Railliet et Henry, 1911.

Nematodes (15 species) and cestodes (8 species) are the most widely represented. Of the total number of species (26), all cestodes (8 species), acanthocephalans (2 species) and acanthocephalans (1 species) develop with the participation of intermediate hosts, belong to heteroxenic parasites. Nematodes are represented by both heteroxenic and monoxenic species.

Helminths of wolf (*Canis lupus* Linnaeus, 1758)

Of the 62 studied wolves, 50 were infected with parasitic worms (80.6 %) (table 2). 26 helminth species belonging to cestodes (11 species), trematodes (2 species), acanthocephalans (2 species) and nematodes (11 species) were identified: *Diphyllobothrium latum* (Linnaeus, 1758), *Dipylidium caninum* (Linnaeus, 1758), *Diplopylidium nölleri* (Skrjabin, 1924), *Taenia hydatigena* Pallas, 1766, *Taenia ovis* (Cobbold, 1869), *Multiceps multiceps* (Leske, 1780), *Multiceps skrjabini* Popow, 1937, *Tetratirotaenia polyacantha* (Leuckart, 1856), *Echinococcus multilocularis* (Leuckart, 1863), *Echinococcus granulosus* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Plagiorchis elegans* (Rudolphi, 1802), *Alaria alata* (Goeze, 1792*), Macrocanthorynchus catulinus* Kostylew, 1927, *Moniliformis moniliformis* (Bremser, 1811), *Capillaria plica* (Rudolphi, 1819), *Capillaria putorii* (Rudolphi, 1819), *Trichocephalus vulpis* Froelich, 1789, *Dioctophyma renale* (Goeze, 1782), *Ancylostoma caninum* (Ercolani, 1859), *Toxascaris leonina* (Linstow, 1902), *Toxocara canis* (Werner, 1782), *Spirocerca lupi* (Rudolphi, 1809), *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Dirofilaria immits* (Leidy, 1856), and *Dirofilaria repens* Railliet et Henry, 1911.

The basis of the helminth fauna of wolves was cestodes and nematodes, most of which are parasites of domestic and game animals and humans.

Helminths of corsac (*Vulpes corsac* Linnaeus, 1768)

The total infection of corsacs with helminths was 80.3 %, 49 individuals out of 61 studied were found infected (table 2). The helminth fauna consists of 23 species: *Dipylidium caninum* (Linnaeus, 1758), *Diplopylidium nőlleri* (Skrjabin, 1924), *Taenia crassiceps* (Zeder, 1800), *Hydatigera taeniaeformis* (Batsch, 1786), *Tetratirotaenia polyacantha* (Leuckart, 1856), *Echinococcus multilocularis* (Leuckart, 1863), *Echinococcus granulosus* (Batsch, 1786), *Plagiorchis elegans* (Rudolphi, 1802), *Alaria alata* (Goeze, 1792), *Macrocanthorynchus catulinus* Kostylew, 1927, *Moniliformis moniliformis* (Bremser, 1811), *Thominx aerophilus* (Creplin, 1839), *Ancylostoma caninum* (Ercolani, 1859), *Uncinaria stenocephala* (Railliet, 1884), *Toxascaris leonina* (Linstow, 1902), *Toxocara canis* (Werner, 1782), *Toxocara mystax* (Leder, 1800), *Oxynema numidica* Linstow, 1899, *Spirocerca arctica* (Petrow, 1927), *Spirocerca lupi* (Rudolphi, 1809), *Physoloptera praeputialis* Linstow, 1888, *Physoloptera sibirica* Petrow et Gorbunov, 1931, and *Rictullaria affinus* Jägerskiold, 1904.

The helminth communities found in carnivorous animals were composed of 12 species of nematodes, seven species of cestodes, two species of trematodes, and two species of acanthocephalans. These species are considered typical for carnivorous animals. By the nature of the life cycle, the noted helminth species are representatives of heteroxenic and monoxenic forms, in the circulation of which corsac populations participate in the biogeocenoses of Uzbekistan.

Helminths of the fox (*Vulpes vulpes* (Linnaeus, 1768))

A helminthological study of 68 individuals of foxes from Uzbekistan revealed parasitic worms in 63. The prevalence of infection was very high (92.6 %) (table 2). The intensity of infection varied considerably ranging from a single to several dozens of specimens.

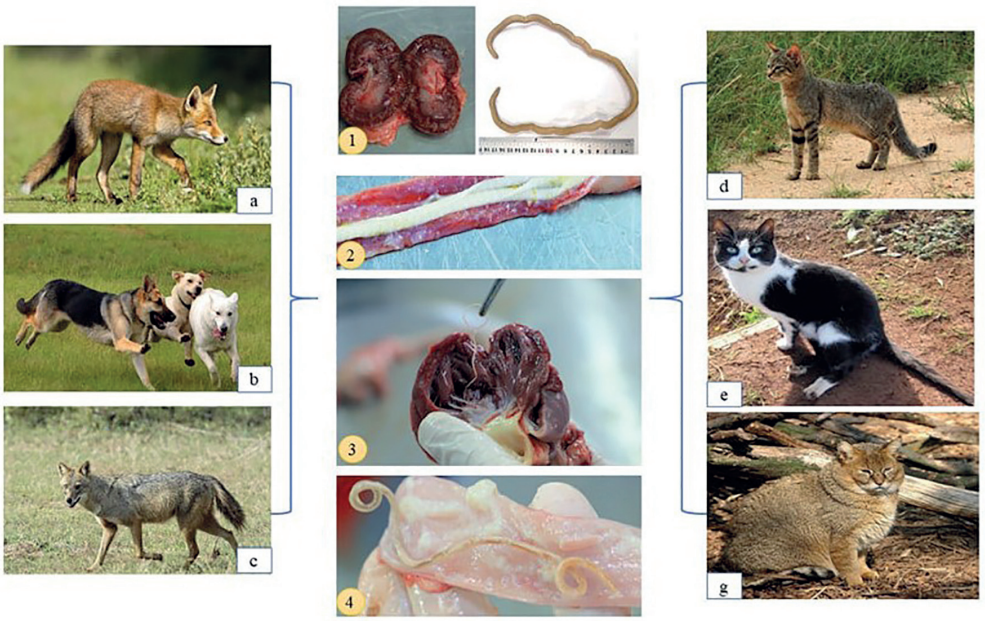

Fig. 2. Carnivorans of Uzbekistan and some of their helminths: a — *Vulpes vulpes;* b — *Canis familiaris;* c — *C. aureus;* d — *Felis lybica;* e — *F. catus; g — F. chaus;* 1 — *Dioctophyma renale;* 2 — *Taenia hydatigena;* 3 — *Dirofilaria immits;* 4 — *Toxocara canis.*

The fauna of fox helminths consisted of 42 species: *Diphyllobothrium latum* (Linnaeus, 1758), *Spirometra erinaceieuropaei* (Rudolphi, 1819), *Dipylidium caninum* (Linnaeus, 1758), *Diplopylidium nőlleri* (Skrjabin, 1924), *Joyeuxiella echinorhynchoides* (Sonsino, 1884), *Joyeuxiella pasqualei* (Diamara, 1893), *Joyeuxiella rossicum* (Skrjabin, 1923), *Taenia hydatigena* Pallas, 1766, *Taenia macrocystis* (Diesing, 1850), *Taenia pisiformis* (Bloch, 1780), *Hydatigera krepkogorski* (Schulz et Landa, 1934), *Hydatigera taeniae formis* (Batsch, 1786), *Tetratirotaenia polyacantha* (Leuckart, 1856), *Echinococcus multilocularis* (Leuckart, 1863), *Echinococcus granulosus* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Dicrocoelium dendriticum* (Rudolphi, 1819), *Plagiorchis elegans* (Rudolphi, 1802), *Echinochasmus perfoliatus* (Ratz, 1908), *Alaria alata* (Goeze, 1792), *Macrocanthorynchus catulinus* Kostylew, 1927, *Moniliformis moniliformis* (Bremser, 1811), *Capillaria plica* (Rudolphi, 1819), *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, 1884), *Crenosoma vulpis* (Rudolphi, 1819), *Toxascaris leonina* (Linstow, 1902), *Toxocara canis* (Werner, 1782), *Toxocara mystax* (Leder, 1800), *Oxynema numidica* Linstow, 1899, *Spirura rytipleurites* (Deslongchamps, 1824), *Spirocerca lupi* (Rudolphi, 1809), *Physoloptera praeputialis* Linstow, 1888, *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Gongylonema pulchrum* Molin, 1857, *Dirofilaria immits* (Leidy, 1856), and *Dirofilaria repens* Railliet et Henry, 1911. Some dominant helminth species are presented in figure 2.

Of the total number of species (n = 42) of fox helminths, approximately 50 % can parasitize domestic, commercial animals and humans.

Helminth fauna of Mustelidae

In total, 5 species of mustelids (stone marten, American mink, badger, weasel and river otter) infected with parasitic worms were investigated. The features of the helminth fauna of the studied species of martens are presented below.

Helminths of the stone marten (*Martes foina* (Erxleben, 1777))

In the study of 43 marten individuals, helminths were detected in 21. The infection rate was 49.0 % (table 2). The collected parasites were representatives of 17 species belonging to cestodes (6 species), trematodes (1 species) and nematodes (10 species): *Taenia crassiceps* (Zeder, 1800), *Taenia hydatigena* Pallas, 1766, *Taenia martis* (Zeder, 1803), *Taenia mustelae* Gmelin, 1790, *Hydatigera taeniaeformis* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Alaria alata* (Goeze, 1792), *Capillaria mucronata* (Molin, 1858), *Capillaria plica* Rudolphi, 1819, *Capillaria putorii* Zeder, 1800, *Thominx aerophilus* (Creplin, 1839), *Dioctophyma renale* (Goeze, 1782), *Uncinaria stenocephala* (Railliet, 1884), *Crenosoma vulpis* (Rudolphi, 1819), *Filaroides martis* (Werner, 1782), *Spirocerca lupi* (Rudolphi, 1809), and *Filaria martis* Gmelin, 1790.

Helminths of the American mink (*Mustela vison* Schreber, 1777)

As shown in table 2, 11 out of 26 individuals were found infected with 18 species of helminths reported for the first time in Uzbekistan. These species are *Diphyllobothrium latum* (Linnaeus, 1758), *Taenia crassiceps* (Zeder, 1800), *Taenia martis* (Zeder, 1803), *Taenia mustelae* Gmelin, 1790, *Taenia pisiformis* (Bloch, 1780), *Mesocestoides lineatus* (Goeze, 1782), *Plagiorchis elegans* (Rudolphi, 1802), *Euparyphium melis* (Schrank, 1788), *Alaria alata* (Goeze, 1792), *Corynosoma strumosum* (Rudolphi, 1802), *Capillaria plica* Rudolphi, 1819, *Capillaria putorii* Zeder, 1800, *Thominx aerophilus* (Creplin, 1839), *Dioctophyma renale* (Goeze, 1782), *Strongyloides martis* Petrow, 1940, *Uncinaria stenocephala* (Railliet, 1884), *Crenosoma petrowi* Morosov, 1939, and *Filaroides osleri* (Cobbold, 1879).

Mink helminths are represented by cestodes (6 species), trematodes (2 species), acanthocephalans (1 species) and nematodes (11 species). By the nature of the life most helminths found, except for nematodes *Strongyloides martis* and *Uncinaria stenocephala,* develop with the participation of intermediate and paratenic hosts.

Helminths of badger (*Meles meles* (Linnaeus, 1758))

Out 57 individuals, 23 were found infected with helminths belonging to 19 species (table 2). Cestodes were represented by 5 species, trematodes — by 1 species, acanthocephalans — by 2 species, nematodes — by 11 species. The core of the helminth fauna of badger in Uzbekistan was comprised by cestodes and nematodes characteristic of predatory mammals: *Spirometra erinaceieuropaei* (Rudolphi, 1819), *Dipylidium caninum* (Linnaeus, 1758), *Taenia crassiceps* (Zeder, 1800), *Taenia martis* (Zeder, 1803), *Mesocestoides lineatus* (Goeze, 1782), *Alaria alata* (Goeze, 1792), *Macrocanthorynchus catulinus* Kostylew, 1927, *Moniliformis moniliformis* (Bremser, 1811), *Capillaria plica* Rudolphi, 1819, *Capillaria putorii* Zeder, 1800, *Thominx aerophilus* (Creplin, 1839), *Ancylostoma caninum* (Ercolani, 1859), *Uncinaria stenocephala* (Railliet, 1884), *Crenosoma vulpis* (Rudolphi, 1819), *Vigisospirura potekhini* (Petrow et potekhina, 1953), *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Gnathostoma spinigerum* Owen, 1836, *Pneumospirura capsulata* Gerichter, 1948, *Filaria martis* Gmelin, 1790.

The collected species were localized mainly in the organs of the digestive system (16 species), as well as the respiratory system (2 species) and subcutaneous tissue (1 species).

Helminths of weasel (*Mustela nivalis* (Linnaeus, 1766))

In 35 weasels from the desert zones of Northwestern (Karakalpakstan, Ustyurt, Kyzylkum), Eastern and Northeastern Uzbekistan, helminths were found in 16 individuals. The infection rate was 46.2 % (table 2). A total of 9 species of parasites were identified as following: cestodes — 2 species, trematodes — 2 species, acanthocephalans — 1 species

and nematodes — 4 species: *Taenia mustelae* Gmelin, 1790, *Mesocestoides lineatus* (Goeze, 1782), *Euparyphium melis* (Schrank, 1788), *Alaria alata* (Goeze, 1792), *Macrocanthorynchus catulinus* Kostylew, 1927, *Capillaria putorii* Zeder, 1800, *Strongyloides martis* Petrow, 1940, *Filaria martis* Gmelin, 1790, *Gnathostoma spinigerum* Owen, 1836.

Helminths of the river otter (*Lutra lutra* (Linnaeus, 1758))

Of 6 specimens of river otter seized from poachers on December 5, 2022 in the reservoirs of the Hissar district of Surkhandarya region, 4 animals were found infected with helminths belonging to cestodes, trematodes and nematodes: *Diphyllobothrium latum, Spirometra erinaceieuropaei, Mesocestoides lineatus, Fasciola hepatica, Alaria alata, Plagiorchis lutrae, Dioctophyma renale, Physoloptera sibirica, Rictullaria affinis, Strongyloides martis.*

In total, 10 specis of helminths have been identified for the first time in Uzbekistan. The intensity of infection of the detected trematodes varied from 2 to 13 specimens. *D. latum, M. lineatus, F. hepatica, A. alata* and *D. renale* are parasites of farm animals and humans.

Helminthofauna of Felidae

In this study, 4 species of wild and domestic cats from Uzbekistan were surveyed for helminths' infection. Of the total number of 125 dissected individuals, 82 (65.6 %) were found infected with helminth parasites.

Helminths of jungle cat (*Felis chaus* Guldenstaedt, 1776)

Out of 43 studied individuals of the jungle cat, helminth were found in 31 with an infection rate of 74.4 % (table 2). 23 species were identified, namely: *Spirometra erinaceieuropaei* (Rudolphi, 1819), *Dipylidium caninum* (L., 1758), *Diplopylidium nőlleri* (Skrjabin, 1924), *Joyeuxiella rossicum* (Skrjabin, 1923), *Taenia hydatigena* Pallas, 1766, *Taenia macrocystis* (Diesing, 1850), *Hydatigera krepkogorski* (Schulz et Landa, 1934), *Hydatigera taeniaeformis* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Macrocanthorynchus catulinus* Kostylew, 1927, *Moniliformis moniliformis* (Bremser, 1811), *Thominx aerophilus* (Creplin, 1839), *Dioctophyma renale* (Goeze, 1782), *Ancylostoma caninum* (Ercolani, 1859), *Troglostrongylus badanini* Muminov, 1964, *Toxascaris leonina* (Linstow, 1902), *Vigisospirura potekhini* (Petrow et potekhina, 1953), *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Gnathostoma spinigerum* Owen, 1836, *Rictularia cahirensis* Jägerskiold, 1904, *Dirofilaria immits* (Leidy, 1856), *Dirofilaria repens* Railliet et Henry, 1911.

Cestodes were represented by 9 species, acanthocephalans by 2 species and nematodes by 11 species. The noted helminth species are characteristic of predatory mammals, with the exception of *Troglostrongylus badanini* Muminov, 1964, which was not found in other carnivorans.

Helminths of the steppe cat (*Felis lybica* Forster, 1780)

Of 11 studied individuals, helminths were detected in 7 (63.6 %) (table 2). In total, 15 helminth species, cestodes and nematodes, were identified: *Spirometra erinaceieuropaei* (Rudolphi, 1819), *Dipylidium caninum* (L., 1758), *Diplopylidium nőlleri* (Skrjabin, 1924), *Joyeuxiella rossicum* (Skrjabin, 1923), *Taenia macrocystis* (Diesing, 1850), *Taenia pisiformis* (Bloch, 1780), *Echinococcus multilocularis* (Leuckart, 1863), *Mesocestoides lineatus* (Goeze, 1782), *Uncinaria stenocephala* (Railliet, 1884), *Toxascaris leonina* (Linstow, 1902), *Toxocara mystax* (Leder, 1800), *Oxynema numidica* Linstow, 1899, *Vigisospirura potekhini* (Petrow et Potekhina, 1953), *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Rictullaria affinus* Jägerskiold, 1904.

Helminths of domestic cat (*Felis catus* Linnaeus, 1758)

Out of 65 domestic cats, helminths belonging to Cestoda, Acanthocephala and Nematoda were found in 40 individuals. The total infection rate was 60.5 % (table 2). The inten-

sity of the infection was low, ranging from a single to several dozen specimens. In total, 23 species were revealed including 12 species of cestodes and 11 species of nematodes. All recorded species were heteroxenous helminths: *Dipylidium caninum* (Linnaeus, 1758), *Diplopylidium acanthotetra* (Parona, 1886), *Joyeuxiella pasqualei* (Diamara, 1893), *Joyeuxiella rossicum* (Skrjabin, 1923), *Taenia hydatigena* Pallas, 1766, *Taenia crassiceps* (Zeder, 1800), *Taenia laticollis* Rudolphi, 1819, *Taenia macrocystis* (Diesing, 1850), *Taenia pisiformis* (Bloch, 1780), *Hydatigera taeniaeformis* (Batsch, 1786), *Echinococcus granulosus* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Capillaria putorii* Zeder, 1800, *Ancylostoma caninum* (Ercolani, 1859), *Uncinaria stenocephala* (Railliet, 1884), *Toxascaris leonina* (Linstow, 1902), *Toxocara canis* (Werner, 1782), *Spirura rytipleurites* (Deslongchamps, 1824), *Physoloptera praeputialis* Linstow, 1888, *Physoloptera sibirica* Petrow et Gorbunov, 1931, *Rictullaria affinus* Jägerskiold, 1904, *Dirofilaria immits* (Leidy, 1856), *Dirofilaria repens* Railliet et Henry, 1911.

Helminths of lynx (*Lynx lynx* (Linnaeus, 1758))

In this study, 5 individuals killed by poachers in the South and Northeast of Uzbekistan in 2020–2022 were investigated and two species of cestodes (*Taenia mystax* and *T. macracystis*) were reported for the first time. Four individuals were infected with helminths, of which 16 species belonging to Cestoda (7 species) and Nematoda (9 species) were identified: *Spirometra erinaceieuropaei* (Rudolphi, 1819), *Taenia hydatigena* Pallas, 1766, *Taenia laticollis* Rudolphi, 1819, *Taenia pisiformis* (Bloch, 1780), *Hydatigera taeniaeformis* (Batsch, 1786), *Echinococcus granulosus* (Batsch, 1786), *Mesocestoides lineatus* (Goeze, 1782), *Capillaria plica* Rudolphi, 1819, *Capillaria putorii* Zeder, 1800, *Thominx aerophilus* (Creplin, 1839), *Ancylostoma caninum* (Ercolani, 1859), *Ancylostoma tubaeforme* (Zeder, 1800), *Uncinaria stenocephala* (Railliet, 1884), *Toxocara canis* (Werner, 1782), *Toxocara mystax* (Leder, 1800), *Petrowospirura lynxi* Matschulsky, 1952.

Features of life cycle of helminth fauna of carnivorous mammals of Uzbekistan

Parasites registered in predatory mammals, with the exception of a few species *(Fasciola hepatica,* and *Dirocoelium dendriticum)* belong to obligate helminths of the studied animals.

According to the nature of the biological cycle, the helminths of carnivorous mammals recorded by us can be divided into two groups: monoxenous species (development without the participation of an intermediate host) and heteroxenous species (development with the participation of an intermediate host). Heteroxenous parasites in our material were represented by 61 species (85.9 %) of the total helminth fauna. These included all cestodes (23 species), trematodes (9 species), acanthocephalans (3 species) and nematodes (26 species).

Discussion

Several studies on the helminth fauna of carnivorous animals were carried out in Uzbekistan between 1950 and 1975 (Delyanova, 1958; Irgashev, 1958; Matchanov, 1959; Murtazayev, 1964; Matchanov, 1967; Sadykov, 1967; Sultanov, 1969; Baratov, 1971; Reimov, 1972; Sultanov et al., 1975). The authors registered 32 species of helminths belonging to Cestoda, Trematoda, Acanthocephala, and Nematoda in dogs from Northeastern, Eastern, Central and Northwestern Uzbekistan. Total helminth infection in dogs ranged from 83.5 to 94.5 %. The species composition of helminths in rural dog populations in the studied

regions of Uzbekistan varied from 18 to 28 species. In the urban dog populations of the cities of Samarkand, Bukhara, Navoi, Ferghana and the metropolis of Tashkent, the parasitic worm fauna ranged from 8 to 20 species (Safarov, 2020).

Information on the helminth fauna of wild carnivores in Uzbekistan is currently limited. The first studies focusing on the helminth fauna of predatory mammals in Uzbekistan were conducted by the renowned Russian zoologist Professor A. P. Fedchenko. He led a scientific expedition that worked in the territory of former Turkestan between 1868 and 1871. Fedchenko, together with G. Krabbe and Linstov, conducted research on Turkestan dogs and identified five species of parasitic worms present in their intestines: *Taenia hydatigena*, *Multiceps multiceps*, *Dipylidium caninum*, *Toxocara canis*, and *Spirocerca lupi* (Safarov et al., 2022).

Despite this early work, there has been little additional research on the helminth fauna of wild carnivores in Uzbekistan. Our study therefore aims to build on this earlier work and provide a more comprehensive understanding of the parasitic worms present in the intestines of wild carnivores in the region.

Additionally, the list of works on helminths' distribution and ecology is relatively small (Irgashev, 1958; Muminov, 1963; Kairov, 1965; Koschanov, 1972; Matchanov et al., 1973; Taryannikov, 1983). The authors' research was devoted to the study of the helminthfauna of individual species of carnivorous mammals from the Samarkand, Syrdarya regions and Karakalpakstan, where about 26 species of parasitic worms (cestodes, trematodes, acanthocephalans and nematodes) were recorded. The data of previous studies have become noticeably outdated, which is confirmed by data of the study of helminthfauna of carnivorous animals of Karakalpakstan (Berdibaev, 2021).

In this study, 53 helminth species were detected in 278 individuals of carnivorous mammals (jackal, wolf, fox, badger and jungle cat). The total infection rate of the studied animals was 50.4 %. The diversity of helminth species is not the same among the studied wild carnivore species. The highest number of species was found in the fox population (n = 40), with a total of 27, 25 and 22 helminth species reported in the jungle cat, jackal and wolf, respectively. The lowest number of species was found in the badger (16 species).

Taking into account the known literature data and the results of our research, it is possible to state that the helminth fauna of dogs in Uzbekistan comprises 41 species. Of these, cestodes are represented by 15 species, trematodes by 5 species, acanthocephalans by 1 species, and nematodes by 20 species (table 7).

All recorded helminth species (41) belong to common parasites of carnivorous mammals, including domestic dogs of Uzbekistan, from both rural (41) and urban (21) populations. There is a noticeable depletion of the helminth fauna of urban dog populations, due to the characteristics of the urban environment. The helminth communities that we observed in rural dog populations are uneven across the different natural areas of Uzbekistan (table 7). Helminth species diversity is highest in the Northeastern (33 species) and Northwestern (32 species) regions. The poorest helminth fauna (18 species) was found in the territory of the Eastern region.

The results we obtained on the helminth fauna of dogs of rural populations partly confirm the data of previous studies (Delyanova, 1958; Matchanov, 1959; Baratov, 1971), summarized by Sultanov et al. (1975) in the monograph "Helminths of domestic mammals of Uzbekistan", where 32 species of parasitic worms were reported. Previously discovered parasitic worm species in Uzbekistan dogs (Delyanova, 1958; Matchanov, 1959) were not included. The present study identified five species of trematodes in these dogs, which are *Plagiorchis elegans* (Rudolphi, 1802), *Mesorchis denticulatus* (Rudolphi, 1802), *Alaria alata*

Table 7. Summary data on helminthfauna of dogs in Uzbekistan according to the literature

Higher taxon	Species	Helminths of dogs	
		Rural	Urban
Cestoda	*Diphyllobothrium latum* (Linnaeus, 1758)	+	–
	Spirometra erinaceieuropaei (Rudolphi, 1819)	+	+
	Dipylidium caninum (Linnaeus., 1758)	+	+
	Joyeuxiella rossicum (Skrjabin, 1923)	+	+
	Diplopylidium nőlleri (Skrjabin, 1924)	+	+
	Mesocestoides lineatus (Goeze, 1782)	+	+
	Taenia hydatigena Pallas, 1766	+	+
	Taenia ovis (Cobbold, 1896)	+	–
	Taenia pisiformis (Bloch, 1780)	+	–
	Taenia macrocystis (Diesing, 1850)	+	–
	Multiceps multiceps (Leske, 1780)	+	+
	Multiceps serialis (Gervais, 1847)	+	–
	Multiceps skrjabini Popow, 1937	+	–
	Echinococcus granulosus (Batsch, 1786)	+	+
	Echinococcus multilocularis (Leuckart, 1863)	+	–
Trematoda	*Dicrocoelium dendriticum* (Rudolphi, 1819)	+	–
	Plagiorchis elegans (Rudolphi, 1802)	+	–
	Echinochasmus perfoliatus (Ratz, 1908)	+	–
	Mesorchis denticulatus (Rud, 1802)	+	–
	Alaria alata (Goeze, 1792)	+	–
Acanthocephala	*Macrocanthorynchus catulinus* (Kostylew, 1927)	+	+
Nematoda	*Capillaria plica* (Rudolphi, 1819)	+	–
	Capillaria putorii (Zeder, 1800)	+	–
	Thominx aerophilus (Creplin, 1839)	+	–
	Trichocephalus vulpis Froelich, 1789	+	+
	Dioctophyma renale (Goeze, 1782)	+	+
	Ancylostoma caninum (Ercolani, 1859)	+	+
	Uncinaria stenocephala (Railliet, 1884)	+	+
	Filaroides osleri (Cobbold, 1879)	+	–
	Toxascaris leonina (Linstow, 1902)	+	+
	Toxocara canis (Werner, 1782)	+	+
	Toxocara mystax (Leder, 1800)	+	–
	Spirocerca lupi (Rudolphi, 1809)	+	+
	Spirocerca arctica (Petrow, 1927)	+	–
	Physoloptera praeputialis (Linstow, 1899)	+	+
	Gongylonema pulchrum (Molin, 1857)	+	+
	Rictullaria affinus (Jagerskiold, 1904)	+	+
	Rictullaris cahirensis (Jagerskiold, 1904)	+	–
	Dirofilaria immits (Leidy, 1856)	+	+
	Dirofilaria repens (Railliet et Henry, 1911)	+	+
	Dracunculus medinensis (Linnaeus, 1758)	+	–
Total number		41	21

Abbreviations. +/– — presence or absence of the helminths of dogs in rural or urban areas.

(Goeze, 1792), *Echinochasmus perfoliatus* Ratz, 1908 and *Brachylaemus* sp.; 1 species of cestodes — *Spirometra erinaceieuropaei* (Rudolphi, 1819) and 3 species of nematodes — *Thominx aerophilus* (Creplin, 1839), *Filaroides osleri* (Cobbold, 1879) and *Rictularia cahirensis* Jägerskiold, 1904.

The distribution of these species in the biogeocenoses of Uzbekistan is characterized by a limited nature. They are found in a small number of dogs studied on the territory of Karakalpakstan and the Tashkent region. It is characteristic that during the entire research period (2018-2022), we did not identify these species.

Relatively, the helminth fauna of dogs in the studied cities (Nukus, Samarkand, and Tashkent) is similar and includes from 20 to 22 species.

The species of helminths found in dogs can be divided into 2 groups: those of medical and sanitary importance (Cestodes — *Diphyllobothrium latum, Dipylidium caninum, Taenia hydatigena, Multiceps multiceps, Echinococcus granulosus, Echinococcus multilocularis;* Nematodes — *Dioctophyma renale, Toxocara canis, Gongylonema pulchrum, Dirofilaria repens, Dracunculus medinensis)*; of economic importance.

The distribution of parasite communities depends on the peculiar ecological characteristics of natural and urbanized territories.

The role of dogs in the spread of zoonoses has long held the attention of biologists and parasitologists with medical and veterinary profiles. Numerous publications bear witness to this in particular generalized work on dog endo- and ectoparasites in both natural and urbanized territories (Arkhipova, 2004; Arkhipov & Arkhipova, 2004; Morgan, 2013; Dantas-Torres & Domenico Otranto, 2016). Dog populations, as an integral part of societal life, have been found to be infected with a general group of helminths, most of which can parasitize in the larval or mature stage in the human body and domestic animals. The most widely known of them are echinococcosis, cenurosis, hymenolepidosis, diphyllobothriosis, ancylostomosis, toxacarosis, toxascariasis, dirofilariasis and dioctophimosis.

Any adverse events or factors in the life of society are always accompanied by epidemics of the aforementioned animal and human helminthiasis, causing enormous economic damage. Given the actual infection of dogs with zoonotic pathogens, it should be assumed that in modern conditions the problems of improving dog populations against parasitic diseases and protecting pets and humans have not lost their relevance. All this requires controlling the number of dog populations in urbanized territories - megacities and other settlements (Chomel, 2014; Idikaa et al., 2017; Norkobilov et al., 2020; Safarov et al., 2018, 2021, Wu et al., 2021; Safarov et al., 2022; Deak et al., 2022).

According to the literature data (Anderson, 2000; Azimov et al., 2015; Safarov, 2020; Safarov et al., 2021), the biological cycle was studied in 13 species of cestodes, five species of trematodes, one species of acanthocephalans, and ten species of nematodes. The development of 29 species of helminths of the studied dogs occurs with the participation of intermediate hosts and 12 species in a direct way. The transmission of helminth larvae into the final host is carried out in different ways, which are considered when describing the biocenotic relationships of predatory mammals and their parasites.

Martens in Uzbekistan are represented by 11 species and subspecies belonging to 6 genera — *Mustela* Linnaeus, 1785; *Vormela* Blasius, 1844; *Martes* Pinel, 1792; *Mellivora* Storr, 1780; *Meles* Brisson, 1762; and *Lutra* Brisson, 1762 (Shernazarov et al., 2006). The representatives of these genera were found to be hosts for helminths, as reported in cases of infestation of some species of martens (such as bandages, stone martens, and badgers) in Uzbekistan (Kontrimavichus, 1969; Koshanov, 1972). The author recorded 5 species of helminths (2 species of cestodes and 3 of nematodes).

The feline family in Uzbekistan is represented by 10 species and 4 subspecies that live in diverse biocenoses and are important components of biodiversity. In helminthological terms, the cats of Uzbekistan belong to poorly studied objects. The available information on the helminth fauna of certain species is fragmentary (Muminov & Alloyarov, 1963; Koschanov, 1972) and rather outdated.

Cestodes and nematodes are the core of the helminth faunal complexes of carnivorans of Uzbekistan.

As mentioned earlier, the total helminth infection of carnivoran mammals was 79.8 %. The intensity of infection varied considerably from a single to several dozen specimens. In the vast majority of cases, mixed infections of several types of parasites were recorded in infected animals with 3 to 9 species of helminths, which, it should be assumed, have a serious effect on the body, leading to the death of intensely infected animals.

When discussing the presented material, it should be noted that the registered parasites of dogs in other vertebrates belong to different stages of development. Fishes, amphibians, reptiles, birds and some orders of mammals act as intermediate or reservoir hosts, corresponding species or groups of canine parasites in natural and urbanized areas.

Thus, the relationship of the parasitofauna of domestic dogs with representatives of other classes of vertebrates is very close, of the 41 species of dog parasites in Uzbekistan, 34 use in their transmission representatives of other classes: fishes — 12.2 %, amphibians, reptiles and birds — 14.6 %, and other orders of mammals — 26.8 %. As it should be, a large percentage of dog helminths is recorded in mammals of other orders.

The results of our research conducted in all regions of Uzbekistan covering a large number of species of predatory mammals also showed a rather rich fauna of helminths consisting of representatives of the classes Cestoda, Trematoda, Acanthocephala and Nematoda. In total, we have registered 71 species of helminths. It is characteristic that the species diversity of the parasite community of domestic and wild predatory mammals is associated with the parasite's fauna of many species and groups of animals in Uzbekistan. In this respect, the helminthfauna of predatory animals is unique and plays an important role in the formation of helminthic faunal complexes of other vertebrates, including humans. Carnivorous animals serve as reservoir to a number of species that infect representatives of other orders of mammals and classes of vertebrates. The role of almost all species of cestodes, several species of nematodes of the genera *Dirofilaria, Ancylostoma, Toxocara, Spirocerca* in the occurrence of zoonotic helminthiasis is particularly significant (Bronstein & Tokmalaev, 2004; Safarov et al., 2021, 2022). In this case, predatory mammals participate as obligate hosts of helminths, dispersing the invasive elements in diverse landscapes.

Interest in the study of the helminthfauna of carnivorous carnivores does not wane at present. Numerous publications reflect the results of research on various issues of the helminth community of both domestic and wild carnivores (Vieria et al., 2008; Shulyak & Arkhipov, 2010; Subotin, 2011; Tulov, 2013; Romashova et al., 2014; Yakubovsky, 2015; Ibragimov, Fataliev, 2015; McAllister et al., 2019). This is explained by two reasons. On the one hand, among the helminthis of carnivorous mammals, there are a significant number of agents of dangerous helminthiasis of both domestic animals and humans. On the other hand, all cestodes, trematodes, acanthocephalans and two types of nematodes with their unique life cycles are research objects with a general zoological and general biological orientation. These circumstances, as we believe, are also relevant at the present time.

The information presented by us on the helminthfauna of carnivorous mammals of Uzbekistan, one of the important regions of Central Asia, will serve as a basis for further long-term monitoring of the helminthological situation and conducting anti-helminthic measures for agricultural and commercial animals and humans.

Conclusion

Our research has shown that the helminth fauna of carnivorous mammals in Uzbekistan consists of 71 species belonging to cestodes, trematodes, acanthocephalans and nematodes. The distribution of helminth species in individual carnivore groups is very uneven. The greatest diversity of species was recorded in canids (51 species), slightly fewer helminth species were found in felids (40 species), while the helminth fauna of mustelids is markedly depleted (35 species).

The complex of species that make up the fauna of parasitic worms of predatory mammals in Uzbekistan significantly complements previous literature data on the diversity of helminth species and their role in the occurrence of zoonotic helminthiasis. In this regard, predators deserve special attention as a source of helminthiasis pathogens that are very dangerous for humans and livestock, such as diphyllobatriosis, dipylidiosis, echinococcosis, cenurosis, cysticercosis, mesocystoidosis, dioctophimosis, toxocarosis, dirofilariasis. In the spread of these helminthiases in the natural and urbanized areas of Uzbekistan, we believe that the main source of invasion is domestic dogs, due to their large numbers.

Knowledge of the helminth fauna of carnivorous mammals, the distribution of dominant species and groups of parasitic worms, is extremely important for the justification and implementation of anti-helminthic measures. The control of helminthiases in dogs is an important link in the prevention of zoonotic diseases in humans and livestock.

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Data availability. All relevant data is enclosed within the manuscript.

Code availability. Not applicable.

Declarations

Ethics approval and consent to participate the study was reviewed and approved by the center's ethics committee (approval code: No. 7 protocol on 31 March 2022).

Consent for publication. Not applicable.

Conflicts of interest. The authors declare no conflicts interests.

Author contributions. Alisher Safarov (AS) designed this study, collected samples and epidemiological data, wrote the manuscript; Firuza Akramova (FA) performed the identification of helminths; Mourad Ben Said (MBS) performed the statistical analysis. Mourad Ben Said (MBS), Adil Khan (AK), Djalaliddin Azimov (DA) and Kalandar Saparov (KS) edited and finalized it. All these authors approved the final version of the manuscript.

References

Anderson, R. C. 2000. *Nematoda parasites of Vertebrates their development and transmission*. CAB International, New York, 1–650.

Anderson, R. C., Chabaud, A. G. & Willmott, S. 2009. *Keys to the Nematode Parasites of Vertebrates, Archival Volume*. CABI, Wallingford, 1–424.

Arkhipova, D. R., 2004. Zoogeography of dirofilariasis of dogs in Russia. *Materials scientific conferees VIGIS*. Moscow, 5, 142 [In Russian].

Arkhipov, I. A., Arkhipova, D. R. 2004. *Dirofilariasis*. Rosselkhozakademiya, Moscow, 1–194.

Azimov, D. A., Dadaev, S. D., Akramova, F. D. & Saparov, K. A., 2015. *Helminths of ruminants of Uzbekistan*. Fan, Tashkent, 1–223 [In Russian].

Baratov, V. A. 1971. *Sheep Coenuruses in the South of Uzbekistan*. PhD Thesis, Samarkand Institute of Agricultur, Samarkand, Uzbekistan, 1–24 [In Russian].

Berdibaev, A. S. 2021. *Helminths of predatory mammals (Mammalia: Carnivora) Karakalpakstan*. PhD Thesis, Tashkent, 1–46 [In Russian].

Bronstein, A. M. & Tokmalaev, A. K. 2004. *Parasitic diseases of man: protozoa and helminthiasis*. Moscow, 1–206. *Med*., **30** (2), 159–161 [In Russian].

Chaĭka SIu. Parasitism — the existence of organisms as a component of parasitic systems. *Parazitologiia*, 1998 Jan–Feb, 32 (1), 3–10. Russian. PMID: 9612817 [In Russian].

Chomel, B. B. 2014. Emerging and Re-Emerging Zoonoses of Dogs and Cats. *Animals (Basel)*, **4** (3), 434–445.

Dantas-Torres, F. & Otranto, D. 2014. Dogs, cats, parasites, and humans in Brazil: openingthe black box. *Parasit Vectors*, 7, 22.

Deak, G., Safarov, A., Xie, X. C., Runting, W., Mihalca, A. D. & Šlapeta, J. 2022. Fleas from the Silk Road in Central Asia: identification of *Ctenocephalides canis* and *Ctenocephalides orientis* on owned dogs in Uzbekistan using molecular identification and geometric morphometrics. *Parasit Vectors*, 15, 345.

Delyanova, R. S. 1958. Helminth fauna of dogs on the territory of Uzbekistan. *Uzb. Biol. J*., 5, 47–57 [In Russian].

Gibson, D., Bray, R., Hunt, D., Georgiev, B., Scholz, T., Harris, P., Bakke, T., Pojmanska, T., Niewiadomska, K., Kostadinova, A., Tkach, V., Bain, O., Durette-Desset, M., Gibbons, L., Moravec, F., Petter, A., Dimitrova, Z., Buchmann, K., Valtonen, E. & de Jong, Y. 2014. Fauna Europaea: Helminths (Animal Parasitic). *Biodiversity Data Journal*, 2: e1060.

Gibson, D. J., Jones, A. & Bray, R. A. 2002. *Keys to the Trematoda. Volume 1*. CABI, London, UK, 1–544.

Ibragimov, R. Sh. & Fatimev, G. G. 2015. The current state of helminthofauna of canids (Canidae) in Azerbaijan. *Izvestiya NAANA Baku, Elm*, 1, 35–39 [In Russian].

Irgashev, I. Kh. 1958. On the issue of studying the helminth fauna of domestic and wild carnivores in the Samarkand region. *Uzb.biol. journal*, 5, 39–45 [In Russian].

Idikaa, I. K., Onuoraha, E. C., Obia, C. F., Umeakuanac, P. U., Nwosua, C. O., Onaha, D. N. & Chiejina, S. N. 2017. Prevalence of gastrointestinal helminth infections of dog in Enugu State, South Eastern Nigeria. *Parasite Epidemiol. Control*., 2, 97–104.

Kairov, I. Kh. 1965. To the helminthofauna of wild carnivores of Karakalpakia. *Bulletin of the Karakalpak Branch of the Academy of Sciences of the Uzbek SSR*, 3, 52–54 [In Russian].

Kairov, I. Kh. 1968. Helminths of fur trade animals of Karakalpakstan. *In*: *Fur trade animals of Karakalpakstan*. Fan, Tashkent, 272–305 [In Russian].

Kashkarov, R. D., Mitropolskaya, Yu, O., Gritsyna, M. A., Ten, A. G. & Abduraupov, T. V. 2020. *Fauna and monitoring system of vertebrates of the Tashkent region*. Tashkent, 1–504 [In Russian].

Khalil, L. F., Jones, A. & Bray, R. A. 1994. *Keys to the Cestode Parasites of Vertebrates*. CAB International, Wallingford, UK, 1–656.

Koschanov, O. K. 1972. *Helminths of wild granite Uzbek*. Ph.D. Thesis, Tashkent, 1–37 [In Russian].

Kołodziej-Sobocińska, M. 2019. Factors affecting the spread of parasites in populations of wild European terrestrial mammals. *Mam Res*, 64, 301–318.

Kontrimavichus, V. L. 1969. *Helminthofauna of martens and ways of its formation*. Science, Moscow, 1–432 [In Russian].

Macpherson, C. N. L. & Torgerson, P. R. 2013. Dogs and Cestode Zoonoses. *In*: *Dogs, Zoonoses and Public Health*. CABI, UK-USA, 127–152.

Matchanov, N. M. 1959. Helminth fauna of the Keles area dogs. *Uzb. Biol. J*., 6, 65–75 [In Russian].

Matchanov, N. M. 1967. To the helminth fauna of dogs in the Tashkent region. *Trudy Uzb. NIVI*, 18, 163–173 [In Russian].

Matchanov, N. M., Sadykov, V. M., Bekirov, R. E. 1973. Helminthofauna of some wild animals of Uzbekistan. *Proceedings of the Uzbek NIVI*., 20, 87–92 [In Russian].

Matchanov, N. M., Sagdieva, A. T., Sadykov, V. M. 1977. *Larval Teniidoses of Humans and Karakul Sheep*. Publishing House "Medicine", Tashkent, Uzbekistan, 1–512 [In Russian].

McAllister, Ch. T., Kinsella, J. M., Tkach, V. V. 2019. Helminth Parasites (Trematoda, Cestoda, Nematoda) of Select Mammals (Didelphimorpha, Chiroptera, Carnivora) from McCurtain County, Oklahoma. *Proc. Okla. Acad. Sci*, (99), 64–69.

Morgan, E. R. 2013. Dogs and Nematode Zoonoses. *In*: *Dogs, Zoonoses and Public Health*. CABI, UK-USA, 153–161.

Muminov, P. & Allayarov, A. M. 1963. Helminths of wild cats of Uzbekistan and their connection with the ecology of their hosts. *Uzbek biol. journal*, 6, 17–24 [In Russian].

Muminov, P. 1963. Materials on helminthofauna of wild carnivorous animals of Uzbekistan. *Uzbek biol. journal*, 6, 44–49 [In Russian].

Murtazayev, A. 1964. On the issue of the helminth fauna of the jackals of Karakalpakstan. *Proc. UzNIVI*, 17, 164–165 [In Russian].

Norkobilov, B., Safarov, A. A., Akramova, F., Azimov, D., Shakarbayev, U. & Berdibayev, A. 2020. The Cycle of Nematode *Dirofilaria Immitis* (Leidy, 1856) in the Ecological and Epizootological Chains of Canines in the Biocoenoses of Uzbekistan. *American Journal of Zoology*, **3** (1), 5–9.

Petrov, A. M. 1926. To the fauna of parasitic worms of domestic carnivores of Turkestan. *Proc. GIEV* (2), 93–95 [In Russian].

Reimov, R. 1972. *The experience of ecological and morphophysiological analysis of the mammalian fauna of the southern Aral Sea region*. Nukus, 1–726 [In Russian].

Romashova, E. N., Rogov, M. V., Romashov, B. V. & Nikulin, P. I. 2014. Helminths of wild carnivores of the Vorozhensk region. *Russian parasitol. zh-l, Moscow*, 1, 23–33 [In Russian].

Safarov, A., Akramova, F., Azimov, D., Mihalca, A. D. & Ionică A. M. 2021. Updates on the distribution and host spectrum of *Dirofilaria repens* in the Republic of Uzbekistan. *Parasitol. Res.*, 120, 3987–3992

Safarov, A., Mihalca, A. D., Park, G.-M., Akramova, F., Ionică , A. M., Abdinabiev, O., Deak, G. & Azimov, D. 2022. A Survey of Helminths of Dogs in Rural and Urban Areas of Uzbekistan and the Zoonotic Risk to Human Population. *Pathogens*, 11, 1085.

Safarov, A. A., Akramova, F. D. & Azimov, D. A. 2022. Nematodes of the genus *Dirofilaria* Railliet et Henry, 1911, parasites of carnivorous mammals in Uzbekistan: spread and ecology. *Russ. J. Parasitol.*, **16** (1), 101–111 [In Russian].

Safarov, A. A., Akramova, F. D., Shakarbaev, U. A. & Azimov, D. A. 2018. Parasitic fauna of domestic dog (*Canis familiaris* Dom.) of the modern metropolis of Tashkent. *Russ. J. Parasitol.*, **12** (4), 41–49 [In Russian].

Safarov, A. A., Norqobilov, B. T., Azimov, D. A., Akramova, F. D. & Mavlonov, S. I. 2021. *The Parasites of Dogs in Tashkent Metropolis*. Fan, Tashkent, Uzbekistan, 1–154 [In Russian].

Safarov, A., Ionică, A. M., Akramova, F., Shakarbaev, U., Briciu, V. T., Ieremia, A., Berdibaev, A. & Azimov, D. 2023. A case of recurrent human *Dirofilaria repens* infection in Uzbekistan. *Journal of Helminthology*, 97, e30, 1–4.

Schleicher, E. I. 1949. Dirofilariasis of subcutaneous tissue of dogs in Tashkent. *Proceedings of the Uzbek Institute of Epidemiology and Microbiology*, 3, 244–257 [In Russian].

Shernazarov, E. Sh., Vashetko, E. V. & Kreutzberg, E. A. 2006. *Vertebrates of Uzbekistan*. Fan, Tashkent, 1–174 [In Russian].

Shulyak, B. F. & Arkhipov, I. A. 2010. *Nematodes of dogs zoonoses and zooanthroponoses*. Consomed, Moscow, 1–495 [In Russian].

Subotin, A. M. 2011. *Parasitic systems of wild ungulates and carnivores and the basics of parasite prevention on the territory of Belarus*. PhD Thesis, Vitebsk, 1–48 [In Russian].

Taryannikov, V. I. 1983. Parasites of the jackal *Canis aureus L.* in the middle reaches of the Syrdarya River. *Parasitology*, **17** (6), 478–480.

Tulov, A. V. 2013. *Parasitocenosis of the jackal (Canis aures) in the biocenoses of the Northwestern Caucasus*. PhD Thesis biol. Sciences, Krasnodar, 1–24 [In Russian].

Vieria, F. M., Jose L., Luque, J. L. & Luis C., Muniz-Pereira, L. C. 2008. Checklists of helminth parasites in wild carnivore mammals from Brazil. *Zootaxa*, 721, 1–23.

Wells, K., Gibson, D. I., Clark, N. J., Ribas, A., Morand, S. & McCallum, H. I. 2018. Global spread of helminth parasites at the human-domestic animal-wildlife interface. *Glob Chang Biol.*, **24** (7), 3254–3265.

White, R. J. & Razgour, O. 2020. Emerging zoonotic diseases originating in mammals: a systematic review of effects of anthropogenic land-use change. *Mam Rev*, 50, 336–352.

Wu, X., Yu, V. Y., Huang, Z., Lu, J., Tang, W., Shen, S., Xia, L., Zhu, J., Wang, J., Chen, J., Chen, G., Bian, Y., Ward, M. P. & Zhao, H. 2021. Estimation of the Rural Dog Population within a Mega-City: An Example in Jiading District, Shanghai. *Front. Vet. Sci.* 8:630180.

Yakubovsky, M. V. 2015. *Helminths and associative helminthiasis of wild animals in the Republic of Belarus*. Minsk, 5, 17–25 [In Russian].

Zhdanova, M. G. 1949. On the issue of the helminthofauna of dogs in the city of Samarkand. *Proceedings of the Uzbek agrarian institute*, 7, 127–133 [In Russian].

Zewdu, E., Semahegn, Y., & Mekibib, B. 2010. Prevalence of helminth parasites of dogs and owners' awareness about zoonotic parasitesin Ambo town, central Ethiopia. *Ethiop. Vet. J.*, 14, 17–30

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