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Spirurida (Nematoda) parasites of animals in Uzbekistan

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We analysed our research data and available literature on the species composition of the order Spirurida, parasites of fish, birds and mammals in Central, North-Eastern and North-Western Uzbekistan, and established that Spirurida in this region are represented by 133 species belonging to the suborders Spirurina, Camallanina and Filariina. Spirurina includes 44 species, 14 of which are parasites of birds and 30 are parasites of mammals. Camallanina are represented by 15 species, most of which are fish parasites (11 species). The largest group is Filariina (84 species), composed of parasites of land and wetland birds (64 species) and mammals (20 species). The most widespread parasites represent the following genera: *Gongylonema*, *Physaloptera*, *Rictularia*, *Physocephalus*, *Spirocerca*, *Parabronema*, *Acuaria*, *Tetrameres*, *Camallanus*, *Philometra*, *Philometroides*, *Rhabdochona*, *Aprocta*, *Splendidofilaria*, *Ornithofilaria*, *Diplotriaena*, *Paronchocerca*, *Dirofilaria*, *Onchocerca* and *Setaria*. The studied Spirurida parasitise almost all organs and systems of the mentioned animals. Numerous species of invertebrates, mainly crustaceans and insects, participate in the life cycles of Spirurida. Parasitological studies of the *Cyclops* community ,inhabitants of diverse bodies of water in Uzbekistan, show how a number of species of Cyclopidae and *Gammarus* are infected with larval stages of Spirurida. These crustaceans are common in water bodies and show a prevalence of infection with Spirurida ranging from 0.1% to 0.5%. The intensity of infection is from 1 to 3 individuals. The Spirurida larvae found in crustaceans represented 8 species from the families Spiruridae, Tetrameridae, Camallanidae, Philometridae, Dracunculidae, and Gnathostomatidae. According to our research, crustaceans play a significant role in the circulation of pathogenic species and groups of Spirurida, which indicates the stability of the Spirurida-crustaceans-vertebrates parasitic system in the biogeocoenoses of Uzbekistan.

Keywords: helminths; nematodes; Spirurida; Spirurina; Camallanina; Filariina; Crustacea; Uzbekistan.

Introduction

With over 2,200 species in the world's fauna, Spirurida is one of the largest groups within the phylum Nematoda. Its representatives parasitise vertebrates from all classes. They are very common in birds, mammals and fish, many species and groups causing serious diseases in animals and humans. This is one of the reasons why Spirurida are in the focus of parasitologists all over the world. The results of research into the species diversity of Spirurida and their morphological and biological features are summarised in fundamental monographs (Yamaguti, 1961; Skrjabin et al., 1967; Anderson, 2000). The order Spirurida includes three suborders – Spirurina, Camallanina and Filariina (Yamaguti, 1961; Skrjabin, 1967). There are other views on the taxonomy of this order (Chabaud, 1974; Anderson, 2000). According to Chabaud (1974) and Anderson (2000) the order Spirurida includes two suborders, Spirurina and Camallanina. More recent works (Hodda, 2011) considerably expand the order Spirurida to include several suborders: Ascaridina, Dracunculina, Gnathostomatina, Oxyurina, Rhigonematina, and Spirurina (Hodda, 2011). This author rejects the suborders Camallanina and Filariina. Therefore, currently, there is no unified taxonomy of Spirurida, and parasitologists have to deal with various ones. Parasites of vertebrates representing Spirurida are undoubtedly among the most popular objects of research in Uzbekistan (Sultanov et al., 1975; Sultanov, 1993; Azimov et al., 2015). These authors studied the helminth faunas of separate groups of animals (birds and mammals) and recorded a number of species of nematodes from the order Spirurida. However, the list of works on the fauna, ecology, and distribution of Spirurida, parasites of vertebrates in Uzbekistan, is relatively small (Saparov, 2016; Saparov et al., 2012; Safarova et al., 2025; Shakarbaev et al., 2025; Temirova et al., 2025). The author studied the species diversity, distribution and ecology of nematodes from the suborder Filariina, parasites of birds and mammals in Uzbekistan.

Information on the entire order Spirurida (Spirurina, Camallanina and Filariina), parasites of fish, birds and mammals, is fragmentary and does not reflect the current situation. As this fairly large group of nematodes is of great significance, it is also quite important to conduct a comprehensive study of their fauna, distribution and ecology in connection with the current ecological situation in Uzbekistan. The goal of this research is to study the fauna of nematodes in the suborders Spirurina, Camallanina and Filariina, order Spirurida, their distribution and ecology in Uzbekistan.

Materials and methods

Representatives of nematodes from the order Spirurida (suborders Spirurina, Camallanina and Filariina) collected from domestic and wild

animals in three regions of Uzbekistan – Central, North-Eastern and North-Western – between 2020 and 2025 were used as material for this work. The material also included birds killed by hunters and those collected by fishermen in fishing nets. The parasitological dissection method was used to examine 5,268 individuals of vertebrates belonging to the classes of fish, birds and mammals (Table 1). Standard parasitological methods were utilised to dissect animals, find and extract helminths, and produce temporary and permanent preparations (Dubinina, 1971; Ivashkin et al., 1971; Bykhovskaya-Pavlovskaya, 1985). Nematoda were examined, measured, photographed and drawn using modern microscopic equipment (inverted microscope Olympus CK2-TR, research microscope Lomo, Binocular microscope ML-2200, and Trinocular microscope N-300 from Ningo Yongkin Optics). Species were identified by well-known monographs by Uzbek and foreign authors. Other guidelines were also used for certain groups of higher taxa (Baruš, 1978; Sonin & Baruš, 1996; Anderson 2000). Crustaceans from various bodies of water and insects were also collected and examined in order to study the biology and life cycles of dominant Spirurida species. The materials are provided below in this work.

Table 1
Species composition and scope
of parasitological research into animals in Uzbekistan

Order	Species	Examined, individuals
	Fish	
Salmoniformes	*Oncorhynchus mykiss* Walbaum, 1792	105
Esociformes	*Esox lucius* Linnaeus, 1758	256
Cypriniformes	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	202
	Arystichthys nobilis (Richardson, 1845)	110
	Carassius gibelio (Bloch, 1782)	300
	Cyprinus carpio Linnaeus, 1758	260
	Schizothorax intermedius Kessler, 1972	58
	Abramis brama Linnaeus, 1758	48
	Rutilis rutilis (Linnaeus, 1758)	284
	Ctenopharyngodon idella (Valenciennes, 1844)	255
Siluriformes	*Silurus glanis* Linnaeus, 1758	252
	Clarias gariepinus Burchchell, 1822	36
Anabantiformes	*Channa argus* (Cantor, 1842)	101
Perciformes	*Sander lucioperca* Linnaeus, 1758	240
	Birds	
Podicipediformes	*Tachybaptus ruficollis* (Pallas, 1764)	11
	Podiceps grisegena (Boddaert, 1783)	10
	Podiceps cristatus (Linnaeus, 1758)	13
Pelecaniformes	*Pelecanus onocrotalus* (Linnaeus, 1758)	1
	Phalacrocorax carbo (Linnaeus, 1758)	12
	Phalacrocorax pygmaeus (Pallas, 1773)	1
Ciconiiformes	*Botaurus stellaris* (Linnaeus, 1758)	4
	Nycticorax nycticorax (Linnaeus, 1766)	5
	Egretta alba (Linnaeus, 1758)	5
	Ardea cinerea (Linnaeus, 1758)	6
	Plegadis falcinellus (Linnaeus, 1766)	1
Phoenicopteri-formes	*Phoenicopterus roseus* Pallas, 1811	1
Anseriformes	*Anser anser* (Linnaeus, 1758)	8
	Cygnus olor (J. F.Gmelin, 1789)	1
	Anser anser dom.	35
	Anas platyrhynchos (Linnaeus, 1758)	35
	Anas crecca (Linnaeus, 1758)	11
	Anas strepera (Linnaeus, 1758)	30
	Anas acuta (Linnaeus, 1758)	36
	Anas penelope (Linnaeus, 1758)	27
	Anas querquedula (Linnaeus, 1758)	25
	Anas clypeata (Linnaeus, 1758)	7
	Aythya ferina (Linnaeus, 1758)	15
	Aythya fuligula (Linnaeus, 1758)	11
	Bucephala clangula (Linnaeus, 1758)	7
	Mergellus albellus (Linnaeus, 1758)	9
	Netta ferina (Linnaeus, 1758)	13
	Anas platyrhynchos dom.	75
Falconiformes	*Haliaeetus albicilla* (Linnaeus, 1758)	1
	Circus aeruginosus (Linnaeus, 1758)	2
Gruiformes	*Gallinula chloropus* (Linnaeus, 1758)	9
	Fulica atra (Linnaeus, 1758)	25
Charadriiformes	*Himantopus himantopus* (Linnaeus, 1758)	7
	Tringa glareola (Linnaeus, 1758)	6
	Larus ridibundus (Linnaeus, 1758)	13
	Larus cachinnans (Pallas, 1811)	11
	Sterna albifrons Pallas, 1764	11
Galliformes	*Alectoris chukar* (J.E.Gray, 1830)	38
	Perdix perdix (Linnaeus, 1758)	3
	Coturnix coturnix (Linnaeus, 1758)	40
	Phasianus colchicus Linnaeus, 1758	23
	Gallus gallus dom.	85
	Meleagris gallopavo dom.	88
	Numida meleagris dom.	22
Passeriformes	*Sturnus vulgaris* Linnaeus, 1758	23
	Sturnus roseus (Linnaeus, 1758)	24
	Acridotheres tristis (Linnaeus, 1766)	36
	Pica pica (Linnaeus, 1758)	29
	Corvus cornix Linnaeus, 1758	32
	Corvus corone Linnaeus, 1758	34
	Mammals	
Lagomorpha	*Lepus capensis ssp tolai* Pallas, 1778	45
Rodentia	*Sciurus vulgaris* Linnaeus, 1758	17
	Spermophilus fulvus (Lichtenstein, 1823)	18
	Spermophilus pygmaeus (Pallas, 1778)	11
	Spermophilus relictus (Kashkarov, 1923)	27
	Allactaga major (Kerr, 1792)	15
	Allactaga severtzovi Vinogradov, 1925	60
	Stylodipus telum (Lichtenstein, 1823)	11
	Ondatra zibethicus (Linnaeus, 1766)	135
	Meriones libycus Lichtenstein, 1823	52
	Blanfordimys bucharicus (Vinogradov, 1930)	5
	Meriones meridianus (Pallas, 1773)	9
	Mus musculus Linnaeus, 1758	110
	Rattus norvegicus (Berkenhout, 1769)	274
Carnivora	*Canis aureus* Linnaeus, 1758	125
	Canis lupus Linnaeus, 1758	62
	Vulpes corsac (Linnaeus, 1768)	61
	Vulpes vulpes (Linnaeus, 1758)	68
	Martes foina (Erxleben, 1777)	43
	Mustela vison Schreber, 1777	26
	Mustela nivalis Linnaeus, 1766	35
	Meles meles (Linnaeus, 1758)	57
	Felis chaus Gueldenstaedt, 1776	43
	Felis catus Linnaeus, 1758	66
	Canis lupus familaris	125
Artiodactyla	*Sus scrofa* Linnaeus, 1758	18
	Cervus hanglu Wagner, 1844	7
	Capra sibirica (Pallas, 1776)	7
	Ovis vignei Blyth, 1841	3
	ssp. severtzovi Nasonov, 1914	7
	Saiga tatarica (Linnaeus, 1766)	11
	Gazella subgutturosa (Güldenstaedt, 1780)	13
	Ovis aries dom.	84
	Capra hircus dom.	72
	Bos taurus dom.	70
Perissodactyla	*Equus caballus* dom.	18
Tylopoda	*Camelus dromedarius* Linnaeus, 1758	14
	Total:	5268

Results

We established that Spirurida are widespread in the studied regions of Uzbekistan. They are recorded in 6 orders of fish, 10 orders of birds, and 6 orders of mammals. The order Spirurida includes 133 species belonging to three suborders – Spirurina, Camallanina and Filariina. The largest of them is Filariina Skrjabin, 1915, represented by 74 species (Table 2). Camallanina is represented by 15 species. The suborder Spirurina includes 44 species. Representatives of the suborder Spirurina in the studied regions of Uzbekistan were recorded in mammals (30 species) and birds (14 species). Camallanina were detected in fish (11 species), birds (3 species), and mammals (1 species – *D. medinensis*). The suborder Filariina is represented by parasites of birds (54 species) and mammals (20 species).

The species diversity of Spirurida in the studied animals of Uzbekistan is quite high. We found 15 species in freshwater fish, 71 in birds, and 52 in mammals. Our data show that birds are parasitised by the largest number of nematode species from the order Spirurida. They are followed by mammals. With only 15 species identified in fish, this

group of vertebrates shows the lowest species diversity of nematodes. Probably, this is associated with the ecology and habitats of the hosts.

Table 2
Species diversity of Spirurida in the studied animals of Uzbekistan

Species	Host
Spirurina	
Gongylonema neoplasticum (Fibiger et Ditlevsen, 1914)	Mammals
Gongylonema problematicum Schulz, 1924	〃
Gongylonema pulchrum Molin, 1857	〃
Abbreviata leiperi (Skrjabin, 1924)	〃
Abbreviata kasachstanica Markov et Paraskiv, 1956	〃
Physaloptera massino Schulz, 1926	〃
Physaloptera preputialis Linstow, 1889	〃
Physaloptera sibirica Petrow et Gorbunow, 1931	〃
Rictularia cahirensis Jägerakiold, 1904	〃
Rictularia amurensis Schulz, 1927	〃
Rictularia merionesi Davlatov, 1970	〃
Rictularia affinis Jägerakiold, 1904	〃
Mastophorus muris (Gmelin, 1790)	〃
Physocephalus skrjabini Andrejko, 1964	〃
Physocephalus sexalatus (Molin, 1860)	〃
Protospirura armeniana Alojan, 1951	〃
Protospirura alata Rudolphi, 1819	〃
Spirocerca fedtschenkoi Davlatov, 1970	〃
Spirocerca lupi (Rudolphi, 1819)	〃
Spirocerca petrovi Gubanov, 1964	〃
Spirocerca vigisiana Kadenazii, 1946	〃
Spirocerca arctica (Petrow, 1927)	〃
Vigisospirura potekhini (Petrov et Potekhina, 1953)	〃
Streptopharagus kutassi (Schulz, 1927)	〃
Ascarops strongylina (Rudolphi, 1819)	〃
Spirura rytipleurites (Deslongonamps, 1824)	〃
Cylicospirura subaegualis (Molin, 1860)	〃
Parabronema skrjabini Rassowska, 1924	〃
Acuaria gruveli (Gendre, 1913)	Birds
Acuaria hamulosa (Diesing, 1861)	〃
Acuaria alii Rashed, 1960	〃
Acuaria brevispicula Maplestone, 1932	〃
Acuaria crassicauda (Creplin, 1829)	〃
Dispharynx nasuta (Rudolphi, 1808)	〃
Echinuria uncinata (Rudolphi, 1808)	〃
Cyrnea eurycerca Seurat, 1914	〃
Cyrnea spinosa (Gendre, 1929)	〃
Tetrameres fissispina (Diesing, 1861)	〃
Tetrameres nouveli (Seurat, 1914)	〃
Tetrameres ihullieri (Seurat, 1914)	〃
Oxyspirura pici Borgarenko, 1984	〃
Oxyspirura petrowi (Skrjabin, 1924)	〃
Gnathostoma hispidum Fedtschenko, 1872	Mammals
Gnathostoma spinigerum Owen, 1836	Mammals
Camallanina	
Camallanus lacustris (Zoega, 1776)	Fish
Camallanus truncatus (Rudolphi, 1819)	〃
Procamallanus siluri Osmanov, 1964	〃
Phylometra abdominalis Nybelin, 1928	〃
Phylometra ovata (Zeder, 1803)	〃
Phylometra rischta Skrjabin, 1923	〃
Phylometroides sanguinea (Rudolphi, 1819)	〃
Rhabdochona denudata (Dujardin, 1845)	〃
Rhabdochona sulaki Saidov, 1953	〃
Rhabdochona filamentosa (Bychowskaja – Pawlowskaja, 1936)	〃
Desmidocercella numidica (Seurat, 1920)	Birds, Fish
Desmidocerca aerophila Skrjabin, 1915	Birds
Dracunculus medinensis (Linnaeus, 1758)	Mammals
Avioserpens gallardi Chabaud et Campana, 1949	Birds
Avioserpens mosgovoyi Suprjaga, 1965	〃
Filariina	
Aprocta cylindrica Linstow, 1883	〃
Aprocta caprimulgi (Kazubski, 1958)	〃
Aprocta crassa Railliet et Henry, 1910	〃
Aprocta matronensis Railliet et Henry, 1910	〃
Aprocta rotundata (Linstow, 1903)	〃
Aprocta obtusa (Dujarden, 1845)	〃
Aproctoides striata Sonin, 1961	〃
Squamofilaria coraciae (Gmelin, 1790)	〃
Pseudoprocta decorata Hsi Chiech Li, 1933	〃
Splendidofilaria pawlowskyi Skrjabin, 1923	〃
Splendidofilaria brevispiculum Singh, 1949	〃
Splendidofilaria mavis (Leiper, 1909)	〃
Splendidofilaria gvozdevi Sonin et Barus, 1978	〃
Splendidofilaria urogalli (Linstow, 1874)	〃
Sarconema eurycerca Wehr, 1939	〃
Sarconema pseudolabiata Belogurov, Daja et Sonin, 1966	〃
Skrjabinocta natali Borgarenko, 1990	〃
Ornithofilaria skrjabini (Petrov et Tshertkowa, 1949)	〃
Ornithofilaria papillocerca (Lubimov, 1946)	〃
Ornithofilaria mavis (Leiper, 1909)	〃
Vagrifilaria sinensis (Li, 1933)	〃
Parornithofilaria lienalis (Orloff, 1947)	〃
Diplotriaena ozouxi (Railliet et Henry, 1909)	〃
Diplotriaena falconis (Connal, 1912)	〃
Diplotriaena graculi (Maplestone, 1931)	〃
Diplotriaena henryi Blanc, 1919	〃
Diplotriaena isabellina Koroliowa, 1926	〃
Diplotriaena nochti Hoeppli et Hsu, 1929	〃
Diplotriaena obtusa (Rudolphi, 1802)	〃
Diplotriaena pungens (Schneider, 1866)	〃
Diplotriaena schikhobalovi Spasskaja, 1949	〃
Diplotriaena sokolovi Skrjabin ,1916	〃
Diplotriaena tricuspis (Fedtschenko, 1874)	〃
Diplotriaena unguiculata (Rudolphi, 1819)	〃
Diplotriaena microphallos Li, 1933	〃
Dicheilonema ciconiae (Schrank, 1788)	〃
Hamatospiculum cylindricum (Zeder, 1803)	〃
Hamatospiculum guttatum (Schneider, 1866)	〃
Petrovifilaria mongolica (Petrov et Ivaschkina, 1954)	〃
Serratospiculum guttatum (Schneider, 1866)	〃
Serratospiculum chungi Hoeppli et Hsu, 1929	〃
Serratospiculum tendo (Nitzsch, 1819)	〃
Lemdana behningi Lewaschoff, 1929	〃
Eulemdana clava (Wedl, 1856)	〃
Cardiofilaria pavlovskyi Strom, 1937	〃
Dirofilarionema ulari (Gagarin, 1954)	〃
Pseudalemdana corvicola (Schikhobalowa, 1948)	〃
Pelecitus fulicaeatrae (Diesing, 1861)	〃
Paronchocerca armenica Tshertkova, 1945	〃
Paronchocerca rousseloti Chabaud et Biocca, 1951	〃
Paronchocerca bumpae Anderson et Prestwood, 1969	〃
Paronchocerca mansoni Faust, 1966	〃

Species	Host
Paronchocerca tonkinensis (Chow, 1939)	〃
Paronchocerca sonini Borgarenko, 1984	〃
Parafilaria multipapillosa (Condamine et Dzouilly, 1878)	Mammals
Parafilaria antipini Ruchliadev, 1947	〃
Parafilaria bovicola Tubangui, 1934	〃
Dirofilaria immitis (Leidy,1865)	〃
Dirofilaria repens Railliet et Henry, 1911	〃
Dipetalonema vitae (Krepkogorskaya, 1933)	〃
Dipetalonema evansi (Lewis, 1882)	〃
Onchocerca reticulata Diesing,1841	〃
Onchocerca cervicalis Railliet et Henry, 1910	〃
Onchocerca caprae (Linstow, 1883)	〃
Onchocerca lienalis (Stiles, 1892)	〃
Onchocerca fasciata Railliet et Henry, 1910	〃
Skrjabinodera saiga Gnedina et Vsevolodov, 1947	〃
Setaria equina (Abildgaard, 1789)	〃
Setaria bernardi Railliet et Henry, 1911	〃
Setaria digitata (Linstow, 1906)	〃
Setaria labiatopapillosa (Alessandrini, 1848)	〃
Setaria cervi (Rudolphi,1819)	〃
Stephanofilaria stilesi Chitwood, 1934	〃
St. assamensis Pande, 1936	〃

The quantitative distribution of Spirurida in the studied animal groups is extremely uneven. Our results on the species composition of nematodes confirm the data of previous researchers (Osmanov, 1971; Sultanov et al., 1975; Saparov, 2016), who also noted the distribution of Spirurida in fish, birds and mammals in Uzbekistan. Our research resulted in the discovery of new Spirurida species in certain groups of hosts. Below we will discuss the taxonomy and species diversity of Spirurida in certain groups of vertebrate hosts in the current ecological conditions of Uzbekistan.

Spirurida of fish. A parasitological study of 2,467 individuals of 14 fish species belonging to 6 orders identified 11 species of nematodes from the suborder Camallanina in the following families: Camallanidae, Phylometridae, Rhabdochonidae, and Desmidocercidae (Table 3). Representatives of Spirurida from other suborders were not found.

Table 4
Spirurida of fish in Uzbekistan

Family	Number of species	Host	Infected, %	
			prevalence, %	intensity of infection, individuals
Camallanidae	3	*Cyprinus caprio* *Sander lucioperca* *Abramis brama*	14.5	3–24
Phylometridae	4	*Rutilus rutilus* *Abramis brama* *Scardinius erythrophthalmus* *Carassius gibelio* *Cyprinus caprio*	11.2–20.5	1–105
Rhabdochonidae	3	*Rutilus rutilus*	9.5–15.0	1–17
		Carassius gibelio *Cyprinus caprio*		
Desmidocercidae	1	*Rutilus rutilus* *Cyprinus caprio* *Silurus glanis* *Sander lucioperca*	1.5–3.0	1–5

Table 3 shows that fish in water bodies in Uzbekistan are infected with 11 species of Camallanina, specific parasites. The prevalence of infection ranges from 3.0 to 15.0%. The intensity of infection is from 1 to 10 individuals. *D. numidica* uses fish as a reservoir host.

Among the recorded nematodes, *C. lacustris* and species from the family Phylometridae are the most widespread and epizootologically significant.

In general, the species diversity of the studied order of nematodes of fish in bodies of water in Uzbekistan is low, but they have adapted well to parasitising fish.

Spirurida of birds. 71 species of helminths belonging to the suborders Spirurina, Camallanina and Filariina were found in birds of Uzbekistan. They are represented by species from the following families: Acuariidae Railliet, Henry & Sisoff, 1912; Spiruridae Oerley, 1885; Tetrameridae Travassos, 1914; Desmidocercidae Cram, 1927; Thelaziidae Skrjabin, 1915; Dracunculidae Stiles, 1907; Aproctidae Skrjabin & Shikhobalova, 1945; Splendidofilariidae (Chabaud et Choguet, 1953); Oswaldofilariidae Chabaud & Choquet, 1953; Diplotriaenidae Anderson, 1958. The species diversity of Spirurida in the studied birds is reflected in Table 5. Spirurida comprise the largest group of nematodes parasitising birds. In terms of species and taxonomic diversity, Spirurida strongly dominate in our material.

71 species of Spirurida from 30 genera and 10 families were recorded in the studied territories of Uzbekistan in land and wetland birds. The largest numbers of species were recorded in the families Diplotriaenidae (20), Splendidofilariidae (13), and Oswaldofilariidae (12). Other families (Aproctidae, Acuariidae, Spiruridae, Tetrameridae, Thelaziidae, and Desmidocercidae) are each represented by a small number of species (2-7). This distribution of species by family also reflects the overall picture of the species diversity of the studied nematodes.

Some nematode families found in Uzbekistan contain, with rare exceptions, only bird-specific species, while others include only a small portion of species infecting birds (Table 5). This can be the reason behind the large number of representatives of these families in our material.

Spirurida of mammals. We identified 51 species of Spirurida parasitizing mammals in Uzbekistan, belonging to 25 genera and 8 families (Table 6).

The families Onchocercidae (20 species) and Spiruridae (15 species) included the largest numbers of species. Other families – Gongylonematidae, Physalopteridae, Rictularidae, Habronematidae, Gnathostomatidae, and Dracunculidae – were represented by small numbers of species (1 to 5 each). These families belong to three suborders (Spirurina, Camallanina and Filariina), whose representatives are mammal-specific parasites. Representatives of Filariina, highly pathogenic species that cause serious diseases in agricultural and wild animals, prevail among Spirurida of mammals.

Table 5
Taxonomy and species diversity of Spirurida in birds of Uzbekistan

Family	Number of species	Host	Infected, %	
			prevalence, %	intensity of infection, individuals
		Spirurina		
Acuariidae	7	Galliformes (pheasant, grey partridge, quail)	9.1–11.5	3–21
		Passeriformes (magpie, starling, raven)	11.6–26.0	2–18
Spiruridae	2	Galliformes (pheasant, quail)	1.0–9.5	3–8
Tetrameridae	3	Ducks (mallard, gadwall, common teal)	13.0–25.5	1–7
		Herons (great white egret, grey heron)	9.0	1–3
		Gruiformes (common moorhen)	13.0	2–8
Thelaziidae	2	Passeriformes (magpie, carrion crow)	17.0	1–6
		Camallanina		
Desmidocercidae	2	Pelecaniformes (great and pygmy cormorants) Herons (grey heron)	1.5–5.5	1–7

Gulls (black-headed and Caspian gulls)				
Filariina				
Aproctidae	9	Birds (land and wetland)	18.0–26.5	1–13
Splendidofilariidae	13	Birds (land and wetland)	7.0–13.0	2–16
Oswaldofilariidae	12	Birds (land and wetland)	1.5–3.5	1–2
Diplotriaenidae	20	Birds (land and wetland)	11.5–38.0	3–15

Most of Spirurida species registered in Uzbekistan are studied quite well. This is credited to (Sonin, 1966, 1968, 1975, 1977; Chabaud, 1974; Anderson, 2000), who conducted special research into Spirurida of vertebrates. However, the opinions of specialists diverge regarding Spirurida, especially with respect to higher taxonomic units. Without going into a detailed analysis of these divergences, we note that in this paper we used the system developed by Ryzhikov and Sonin 1984, who include the suborders Spirurina, Camallanina and Filariina in this order.

Localisation of Spirurida. Spirurida infect various parts of the bodies of fish, birds and mammals – the definitive hosts of the parasites. At the same time, these groups of Nematoda show some specificities. Most Spirurina and Camallanina species parasitise the digestive tract of birds, mammals, and fish, and some also infect the body cavity and other organs. None of mature forms of Filariina species live in the digestive tract of birds and mammals. This is why below we provide an analysis of the localisation of Spirurina, Camallanina and Filariina, using parasites of birds as an example.

Localisation of Spirurina. By their localisation, Spirurina of birds can be divided into the following groups.

1. Parasites of the oesophagus. Nematodes from this group are usually embedded in the mucous membrane, and sometimes in the oesophageal tissue. Some species from the family Acuariidae are localised in the oesophagus.

2. Parasites of the glandular stomach. This organ is a habitat for representatives of the genera *Tetrameres*, *Echinuria*, and *Dispharynx*.

3. Parasites of the gizzard stomach. A large group of Spirurina are adapted to living under the cuticle of the gizzard stomach. This is a habitat for most species from the family Acuariidae and the genus *Cyrnea*.

4. Parasites living in the lumen of the digestive tract. This group mainly includes representatives of the genera *Physoloptera*.

5. Parasites of the eye orbit. This group includes nematodes from the genus *Oxyospirura*.

Localisation of Camallanina. In this suborder, we identified four species belonging to the genera *Desmidocercella* (2 species) and *Avioserpens* (2 species), which are parasites of birds.

1. Parasites of air sacs. These parasites include *D. numidica* and *D. aerophile*.

2. Parasites living under the oral mucosa represent the genus *Avioserpens* and are recorded only in north-western Uzbekistan.

Localisation of Filariina. Filariina of birds have adapted to living mainly in the following organs and body tissues.

1. Parasites of the ocular and nasal cavities (species from the genus *Aprocta*, family Aproctidae).

2. Parasites of air sacs and body cavities (species from the genus *Diplotriaena*, family Diplotriaenidae).

3. Parasites of subcutaneous tissue (species from the genus *Ornithofilaria*).

4. Parasites of muscle tissue (species from the genus *Sarcanema*).

5. Parasites of the circulatory and lymphatic system (species from the genus *Paronchocerca*).

6. Parasites of synovial sacs (*Pelecitus fulicaeatrae*).

Discussing the localisation of Spirurida, it is necessary to specify the permanent habitats of individual species and groups of nematodes in the body of a definitive host. In our material, the suborder Spirurina is mainly represented by parasites of the digestive tract of birds. Representatives of Camallanina show a similar localisation pattern. However, the localisation of mature forms of Filariina is completely different. They mainly parasitise closed systems – the bloodstream, subcutaneous tissue and body cavities.

Biology of Spirurida. The life cycles of all representatives of Spirurida are characterised by a change of hosts. They are thus heteroxenous parasites. A wide range of invertebrates, mainly crustaceans and insects, are identified as intermediate hosts (Kabilov, 1983; Moravec, 1994; Anderson, 2000). Definitive hosts become infected when they eat infected arthropods, which depends on the types of trophic and topical relations in the parasite-intermediate host-definitive host system (Ivashkin, 1961). Depending on the type of landscape and geographical zone, various species of arthropods become obligate intermediate hosts. Spirurida larvae are localised in the body cavity of intermediate hosts. In some cases, reservoir hosts, mainly fish, are included in the life cycles.

Table 6
Spirurida of mammals in Uzbekistan

Family	Number of species	Host	Infected, %	
			prevalence, %	intensity of infection, individuals
Spirurina				
Gongylonematidae	7	representatives of the orders Lagomorpha, Rodenta, Carnivora, Artiodactyla, Perissodactyla and the suborder Tylopoda	3.5–55.0	1–24
Physalopteridae	2	representatives of many orders	5.0–17.5	1–11
Rictulariidae	3	many species of mammals	4.8–12.0	1–5
Spiruridae	15	many species of mammals	7.2–15.5	1–17
Habronematidae	1	wild and domestic representatives of Artiodactyla	25.0–64.5	1–175
Gnathostomatidae	2	some representatives of Carnivora and Artiodactyla	2.0–5.0	1–9
Camallanina				
Dracunculidae	1	representatives of Carnivora	0.8	1
Filariina				
Onchocercidae	20	representatives of many orders	4.5–66.3	1–48

Given that the life cycles of Spirurida (Spirurina, Camallanina, and Filariina) infecting various animals – fish, birds, and mammals – in Uzbekistan are poorly studied, we possess extremely scarce and outdated information on the intermediate hosts of helminths, including Spirurida (Kabilov, 1983). The study of Spirurida as parasites of vertebrates must include the specification of the role of various arthropods in the biology and circulation of infection in the biogeocoenoses of Uzbekistan.

Crustaceans as intermediate hosts of Spirurida. In order to specify the prevalence of larval stages of Spirurida in crustaceans in the water bodies of Uzbekistan, we collected and studied *Cyclops* and Amphipoda from lakes, reservoirs and other bodies of water in Central, North-Eastern and North-Western Uzbekistan (Table 7). Based on a parasitological study of 12,748 crustacean individuals representing 9 species, we identified the larval stages of 8 species of Spirurida belonging to the families Camallanidae, Phylometridae, Gnathostomatidae, Dracunculidae and Tetrameridae (Table 7). The prevalence of infection in crustaceans, depending on the species, ranged from 0.1% to 0.5%, with an infection intensity of 1 to 3 of larval individuals. The invasive larvae of the studied Spirurida were found in the body cavity in a coiled or semi-coiled position. We did not record any specificity of nematode larvae to crustaceans. It means that the larval stages of a wide range of nematode species develop in the same *Cyclops* species, which is probably associated with *Cyclops*' trophic and ecological features. *Cyclops* are permanent inhabitants of various types of water bodies. Their abundance in the warm season and their presence in the

diet of fish and other vertebrates leads to a rapid spread of helminth larvae. Mature forms of these Spirurida parasitise fish, birds and mammals. Thus, the material we have provided above shows a fairly diverse fauna of nematode larvae developing in *Cyclops* in bodies of water in Uzbekistan and the role of these crustaceans in the life cycle of a number of species of parasites.

Table 7
Natural prevalence of larval stages of Spirurida in crustaceans

Species	Examined, individuals	Infected with nematode larvae	Prevalence, %
Macrocyclops albidus	1210	*Camallanus lacustris* *Phylometra ovata* *Phylometra rischta* *Phylometroides sanguinea* *Gnathostoma hispidum*	0.1–0.5
Macrocyclops fuscus	1010	*Phylometra ovata* *Phylometroides sanguinea* *Gnathostoma hispidum*	0.1–0.3
Cyclops vicinus	1856	*Phylometra ovata* *Phylometra rischta* *Phylometroides sanguinea* *Dracunculus medinensis* *Avioserpens mosgovoyi* *Gnathostoma hispidum*	0.1–0.2
Cyclops strenuus	1340	*Phylometra ovata* *Phylometra rischta* *Dracunculus medinensis* *Avioserpens mosgovoyi* *Gnathostoma hispidum*	0.1–0.3
Eucyclops macrurus	1128	*Phylometra rischta* *Dracunculus medinensis*	0.1–0.2
Mesocyclops leuckarti	1690	*Camallanus lacustris* *Phylometra rischta* *Phylometroides sanguinea* *Avioserpens mosgovoyi*	0.1–0.2
Acanthocyclops trajani	1216	*Phylometra rischta* *Phylometroides sanguinea*	0.1–0.3
Thermocyclops crassus	1258	*Phylometroides sanguinea* *Avioserpens mosgovoyi*	0.1–0.2
Gammarus lacustris	2040	*Tetrameres fissispina*	0.2

Below we provide some biological features of Spirurida developing in crustaceans in bodies of water in Uzbekistan.

Class Nematoda Rudolphi, 1808
Order Spirurida Chitwood, 1933
Suborder Spirurina Railliet, 1944
Family Tetrameridae Travassos, 1914
Genus *Tetrameris* Creplin, 1848
Tetrameres fissispina
Definitive hosts: birds, mainly Anseriformes.
Intermediate hosts: Amphipoda – *Gammarus lacustris*.
Localisation: body cavity.
Discovery area: Central, North-Eastern and North-Western Uzbekistan.

Biology. Intermediate hosts are crustaceans from the order Amphipoda – *Gammarus lacustris*, which are widespread in bodies of water in Uzbekistan. Eggs do not develop in the external environment. The parasite develops only in the body of an intermediate host, in the body cavity of Amphipoda. The invasive larvae (stage 3) migrate to the muscles and gills of Amphipoda. Encystation; the diameter is 0.09–0.11 mm. The life cycle may also include reservoir hosts, which in Uzbekistan are several species of fish from the carp family (Safarova, 2017). Birds become infested by parasites when they eat infected Amphipoda, as well as fish (Fig. 1).

Family Camallanidae Railliet et Henry, 1915
Genus *Camallanus* Railliet et Henry, 1915
Camallanus lacustris (Zoega, 1776)
Definitive hosts: fish.
Intermediate hosts: *Macrocyclops albidus*, *Eucyclops macrurus*, *Mesocyclops leuckarti*.
Localisation: body cavity.
Discovery area: Uzbekistan (diverse bodies of water).

Biology. The life cycle includes intermediate hosts – *Megacyclops*, *Macrocyclops*, *Mesocyclops*, *Acanthocyclops*, *Eucyclops*, and *Cyclops* (Moravec, 1971). In our material, the intermediate hosts of this nematode are *Cyclops* – *Macrocyclops albidus*, *Eucyclops macrurus*, *Mesocyclops leuckarti*.

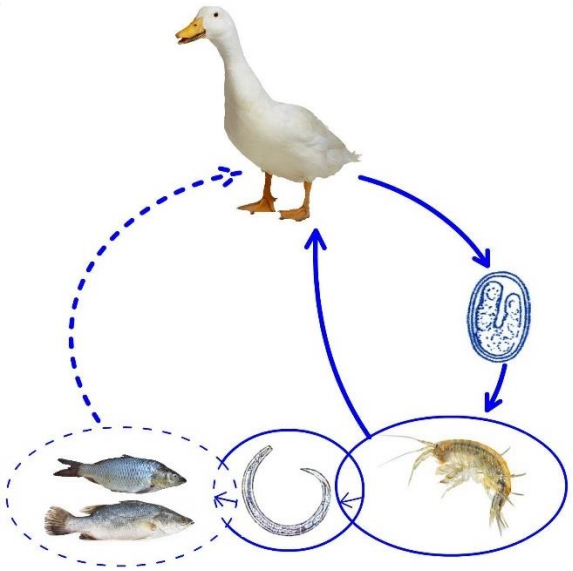

Fig. 1. *Tetrameres fissispina* life cycle pattern

Females of *C. lacustris* are viviparous. The larvae with faeces enter the water, where they are swallowed by *Cyclops*, in whose cavities the larvae molt twice, become invasive and infect their definitive hosts. In the body of the perch, their definitive host, the parasites mature, and one month later numerous larvae form in the uterus of adult females. It is also possible (Moravec, 1971, 1994) that some carp species participate as reservoir hosts in the life cycle of this nematode. Thus, the definitive hosts (Percidae) become infected in two ways: by ingesting infected *Cyclops* or eating reservoir hosts, carps infested with Camallanina larvae, which they receive by feeding on *Cyclops* (Fig. 2). The results of our research confirm the well-known literature data (Moravec, 1971, 1994).

Mature nematodes are localised in the intestines of perches (Osmanov, 1971; Pugachev, 2004; Safarova, 2017).

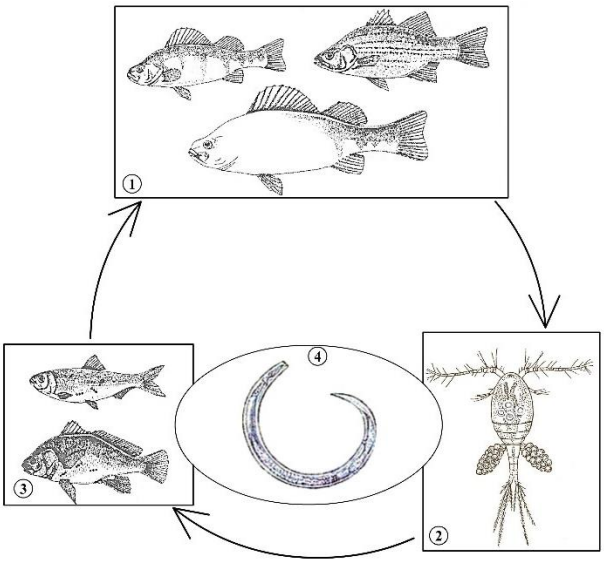

Fig. 2. *Camallanus lacustris* (Zoega, 1776): *1* – definitive hosts; *2* – intermediate hosts; *3* – paratenic hosts; *4* – L_3 invasive larva

Family Phylometridae Baylis et Daubney, 1926
Genus *Phylometra* Costa, 1845
Phylometra ovata (Zeder, 1803)
Definitive hosts: fish.

Intermediate hosts: *Acanthocyclops trajani*, *Macrocyclops albidus*, *Macrocyclops fuscus*, and *Cyclops vicinus*.

Localisation: body cavity.

Discovery area: Uzbekistan (Lakes Karateren, Atakul, Akchakul, Saykul and other bodies of water).

Biology. The first intermediate hosts are copepods – *Acanthocyclops*, *Macrocyclops*, *Megacyclops*, and *Diacyclops* (Molnár, 1966, 1980). In our material, they were *Cyclops* – *A. trajani*, *M. albidus*, *M. fuscus*, and *C. vicinus*, in which invasive larvae were recorded (L_3).

Cyclops become infected by eating larvae that settle on the bottom of a water body. Invasive larvae develop in the body cavity of *Cyclops* (L_3), and definitive hosts (fish, mainly cyprinids) become infected through eating parasitised *Cyclops* (Fig. 3).

Adult nematodes are localised in the following parts of the body: females in the body cavity, digestive tract; males in the wall of the swim bladder and sometimes in the body cavity of carps in bodies of water in Uzbekistan (Osmanov, 1971; Safarova, 2017).

Genus *Philometroides* Yamaguti, 1935

Philometroides sanguinea (Rudolphi, 1819)

Definitive hosts: fish.

Intermediate hosts: copepods – *Cyclops vicinus*, *Acanthocyclops trajani*, *Macrocyclops fuscus*, *Mesocyclops leuckarti*, and *Thermocyclops crassus*.

Localisation: body cavity.

Discovery area: Uzbekistan (diverse bodies of water).

Biology. The life cycle of this nematode species is studied quite well (Yashchuk, 1974; Nakajima & Egusa, 1977; Moravec, 1994). In our research, we identified species from the genera *Cyclops*, *Acanthocyclops*, *Macrocyclops*, *Mesocyclops*, and *Thermocyclops* as intermediate hosts of *Ph. sanguinea*. The latter become infected by eating first-stage larvae (L_1) emerging from the body of the female parasite. After 5–6 days, the larvae become invasive. The definitive hosts, carp, become infected by eating the infested crustaceans. When infested with too many parasites, fish die (Vismanis & Nikulina, 1968; Vasilkov et al., 1989).

Mature forms of this nematode are widespread in carp in various bodies of water in Karakalpakstan (Osmanov, 1971; Safarova, 2017).

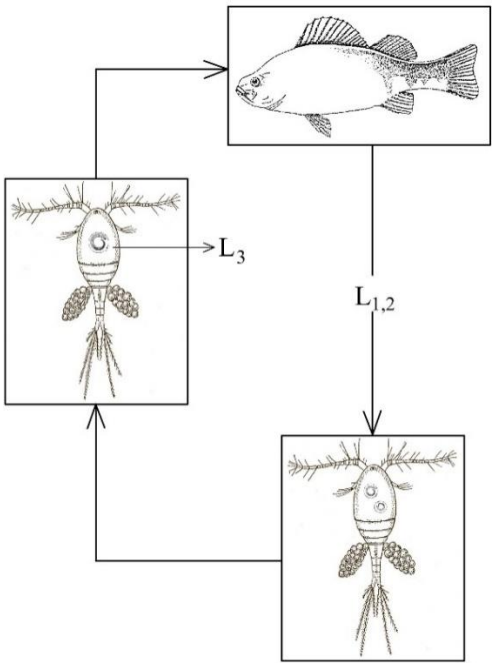

Fig. 3. *Phylometra ovata* (Zeder, 1803): *Phylometra* development pettern; $L_{1,2}$ – larvae; L_3 – invasive larva

Family Dracunculidae Leiper, 1912

Genus *Dracunculus* Reichard, 1759

Dracunculus medinensis (Linnaeus, 1758)

Definitive hosts: predatory mammals.

Intermediate hosts: copepods – *Cyclops strenuus*, *Cyclops vicinus*, *Macrocyclops albidus*, and *Eucyclops macrurus*.

Localisation: body cavity.

Discovery area: Uzbekistan (stagnant bodies of water).

Biology. The life cycle includes intermediate hosts – aquatic crustaceans, *Cyclops* (Muller, 1971; Anderson, 2000). The worms are viviparous. They are localised in the subcutaneous cellular tissue of the definitive host, mainly in the extremities. When in water, female nematodes perforate the host's skin and eject live larvae from the uterus. The secreted larvae may reach 8–10 million in number. They are swallowed by *Cyclops*. The sizes of the first stage larvae (L_1) range from 0.55–0.75 x 0.015–0.025 mm to 0.60–0.80 x 0.016–0.027 mm. In the body of *Cyclops*, the larvae molt and reach the invasive stage (L_3), capable of infecting the definitive hosts. The size of these larvae is 0.460–0.476 x 0.030–0.032 mm; they are located in the body cavity of *Cyclops* in a coiled position. Humans and animals become infected when they drink raw water from stagnant bodies of water (lakes, ponds) teeming with infected *Cyclops* (Fig. 4). In the body of the definitive hosts, the parasites reach sexual maturity within 9–14 months (Kassirskiy & Plotnikov, 1962; Schultz & Gvozdev, 1976; Anderson, 2000).

Mature forms of *Dracunculus medinensis* are localised in the subcutaneous tissue of humans, monkeys, and predatory mammals (Murtazaev, 1965; Anderson, 2000).

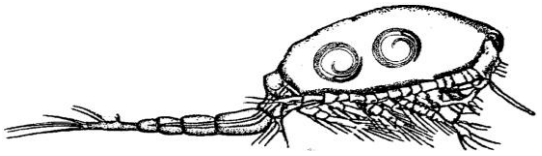

Fig. 4. *Dracunculus medinensis* (Linnaeus, 1758): *Cyclops* infested with parasitic larvae; Genus *Avioserpens* Wehr et Chitwood, 1934

Avioserpens mosgovoyi Suprjaga, 1965

Definitive hosts: wetland birds.

Intermediate hosts: copepods – *Cyclops vicinus*, *Cyclops strenuus*, *Thermocyclops crassus*, and *Mesocyclops leuckarti*.

Localisation: body cavity.

Discovery area: Uzbekistan (lakes and other stagnant bodies of water).

Biology. The life cycle was studied by Supryaga (1965, 1971). These are viviparous parasites living under the skin of wetland birds. Female nematodes, perforating the skin, secrete motile larvae into water. Since the intermediate hosts are crustaceans, and the reservoir hosts are fish fry, tadpoles, and larvae of aquatic insects, it is natural that birds associated with the aquatic environment are definitive hosts. Loons, grebes, Ciconiiformes, Anseriformes and Gruiformes, that is, most orders of wetland birds, are registered as the definitive hosts of this parasite. In our material, *Cyclops* (*Cyclops vicinus*, *C. strenuus*, *Thermocyclops crassus*, and *Mesocyclops leuckarti*) were the intermediate hosts of *Avioserpens mosgovoyi*. Within 8–10 days, the stage 1 larvae (L_1) develop in the body cavity of *Cyclops* into the invasive stage 3 larvae (L_3).

Reservoir hosts can also take part in the life cycle: fish fry, mainly carps, tadpoles and dragonfly larvae. Definitive hosts are infected when they eat intermediate (*Cyclops*) or reservoir hosts (Fig. 5). After 26–30 days, the parasites reach sexual maturity. Females begin to secrete numerous live larvae.

In Uzbekistan, mature forms of nematodes in subcutaneous tissue have been observed in grebes, copepods, and Gruiformes (Turemuratov, 1964; Arepbayev, 2024).

Family Gnathostomatidae Railliet, 1895

Genus *Gnathostoma* Owen, 1836

Gnathostoma hispidum Fedtshenko, 1872

Definitive hosts: mammals (pigs).

Intermediate hosts: *Cyclops* – *Macrocyclops albidus*, *M. fuscus*, *Cyclops strenuus*, *C. vicinus*.

Localisation: body cavity.

Discovery area: Uzbekistan (diverse bodies of water).

Biology. The life cycle of this parasite features the participation of intermediate hosts, *Cyclops* (Golovin, 1956).

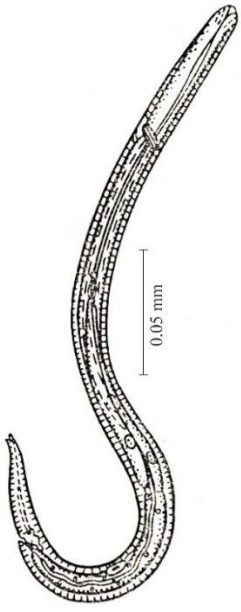

Fig. 5. *Avioserpens mosgovoi* Suprjaga, 1965: an invasive larva from the body cavity of *Cyclops* (*Cyclops vicinus*)

After 9–10 days, stage 1 larvae emerge from the eggs in a body of water and are swallowed by copepods (*Cyclops*, *Macrocyclops* and other). When they enter the digestive tube of *Cyclops*, the stage 1 larvae (L_1) penetrate into the hemocoel, where they molt after 5 days and become invasive on the 10–12th day (L_3), capable of infecting definitive hosts (domestic and wild pigs). Reservoir (=paratenic) hosts – fish and amphibians – can also participate in the life cycle of *Gnathostoma hispidum*. In our material, the reservoir hosts were carps. Pigs become infected when drinking water containing infected *Cyclops* or eating reservoir hosts (Fig. 6).

Mature forms of *Gnathostoma hispidum* are localised in the oesophagus and stomach of pigs (Sultanov et al., 1975; Anderson, 2000; Galat & Yatusevich, 2015).

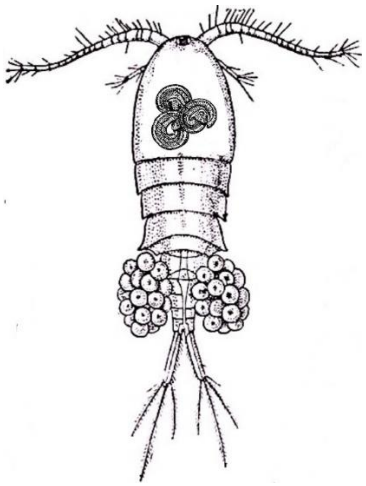

Fig. 6. *Gnathostoma hispidum* Fedtshenko, 1872: *Cyclops* infected with the parasite's larvae

Crustaceans are a very diverse group, their size varying from creatures barely visible to the naked eye to large crabs. The vast majority of their species live in fresh waters and seas. Aquatic crustaceans include some of the most numerous species on earth, which play an important role in many trophic chains.

Copepods (Copepoda) form the largest subclass of the class Maxillopoda. The total number of species in this group is more than 10,000, which are distributed worldwide in oceans, fresh water bodies, and hot springs. The total weight exceeds 1 billion metric tonnes, which makes these animals the basic diet of marine fish (Burnie & Pavlov, 2002). At the same time, many of them may be intermediate hosts of helminths.

The amount of research made into their involvement in the life cycles of Spirurida in Uzbekistan is relatively small (Allaniyazova, 1975, 1978). The author reports that a number of *Cyclops* species in bodies of water in Karakalpakstan are intermediate hosts of cestodes, parasites of fish and wetland birds. Having studied more than 8,000 crustaceans, she estimated the prevalence of infection with cestode larvae at 0.3% to 0.6%. The author identified the larval forms of the following species: *Bothriocephalus opsariichthydis*, *Diorchis elisae*, *D. ransomi*, *D. stefanskii*, *Diploposthe laevis*, and *Confluaria capillaroides*. The following *Cyclops* species were spontaneously infected with the larvae of the mentioned cestodes: *Macrocyclops albidus*, *M. fuscus*, *Eucyclops serrulatus*, *E. macruroides*, *E. macrurus*, *Ectocyclops phaleratus*, *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops viridis*, *Microcyclops viridis*, *Mesocyclops leuckarti*, *M. oithonoides*, and *M. crassus* (Allaniyazova, 1978).

Similar research was carried out in bodies of water in Southern Kazakhstan (Dobrokhotova, 1967). Having studied various types of bodies of water (lakes, ponds, reservoirs and other stagnant bodies of water, as well as rivers) in southern Kazakhstan, the author identified 9 species of *Cyclops* as intermediate hosts of Hymenolepididae, parasites of wetland birds: *Mesocyclops oithonoides*, *M. crassus*, *M. leuckarti*, *Eucyclops serrulatus*, *Macrocyclops albidus*, *Cyclops strenuus*, *Paracyclops fimbriatus*, *Acanthocyclops viridis*, and *A. gigas*. The prevalence of infection in *Cyclops* ranged from 0.7–0.8% to 4–6%. The author notes that cysticercoids of 7 cestode species were found in infected *Cyclops*: *Fimbraria fasciolaris*, *Microsomacanthus paracompressa*, *Sobolevicanthus gracillus*, *Microsomacanthus paramicrosoma*, *M. spiralibursata*, *Dicranotaenia coronula* and *Drepanidotaenia lanceolata* (Dobrokhotova, 1967). These studies covered crustaceans acting as intermediate hosts of the parasites, as well as birds, their definitive hosts. Our research resulted in the discovery of larvae of some nematode species, including from the order Spirurida, in *Cyclops*, which corresponds to the known data from the world literature (Moravec, 1980, 1994; Moravec & Scholz, 1990; Anderson, 2000).

The following invasive nematode larvae we identified in *Cyclops* in Uzbekistan are of particular interest: *Camallanus lacustris*, *Philometroides sanguinea*, *Dracunculus medinensis*, and *Avioserpens mosgovoyi*. They demonstrate relative stability of the parasite-host systems (nematodes-crustaceans-vertebrates), which are implemented through food chains and ensure the circulation of infection in the studied area. The results of our studies of crustaceans in Uzbekistan's bodies of water as intermediate hosts of vertebrate helminths complement well-known works, which are generalised in fundamental monographs, summaries, and guides into helminths (Bauer, 1987; Moravec, 1994; Anderson, 2000; Pugachev, 2004). Moreover, we believe that our data on the biocoenotic relationships of helminths, which are implemented through components of the parasitic system food channels, expand the known range of intermediate hosts of nematodes – parasites of fish, birds, mammals, and humans. At the same time, we also assume that the modest results of our research will contribute to further developments and are important for preserving the population of agricultural and game animals and controlling the spread of parasitic worms from the order Spirurida.

Studying the role of crustaceans in the biological cycles of helminths is of great interest for understanding the evolution and life cycles of some groups of helminths and their distribution patterns, and important for the control of helminthiases of agricultural and game animals with the help of obtained data. Crustaceans as intermediate hosts of nematodes, parasites of fish, wetland birds, and mammals, have been studied in many European (Ryšavy, 1964; Moravec, 1994), Asia (Sinha, 1988), and some American countries (Moravec, 1974) (Table 8), where numerous species of crustaceans infected with larval stages of helminths have been identified. In addition, the above-mentioned authors have conducted extensive experimental studies.

Table 8
Crustaceans in various bodies of water
as intermediate hosts of nematodes (based on literary data)

Helminth species	Intermediate hosts	Authors
Contracaecum microcephalum	*Acanthocyclops viridis, A. vernalis, Arctodiaptomus gracilis, Cyclops strenuus, E. macruroides, Macrocyclops albidus, M. fuscus, Mesocyclops crassus, M. leuckarti*	Anderson, 2000
Tetrameres fissispina	*Gammarus lacustris*	Golovin, 1956; Anderson, 2000
Camallanus lacustris	*Megacyclops viridis, Macrocyclops albidus, Acanthocyclops vernalis, Mesocyclops leuckarti, Eucyclops serrulatus, Cyclops strenuus*	Pugachev, 2004; Moravec, 1971
Phylometra ovata	*Acanthocyclops vernalis, A. viridis, Cyclops strenuus, Macrocyclops albidus, Megacyclops gigas*	Moravec, 1971, 1980
Phylometra rischta	*Cyclops strenuus, Macrocyclops albidus, Acanthocyclops viridis*	Molnár, 1980; Moravec, 1980
Phylometroides sanguinea	*Cyclops strenuus, C. kolensis, Acanthocyclops viridis, Macrocyclops albidus, Eucyclops serrulatus, E. macruroides*	Yashchuk, 1974
Dracunculus medinensis	*Cyclops strenuus, C. decipiens, C. fimbriatus, C. hyalinus, C. inopinus, C. iranicus, C. karvei, C. leuckarti, C. microspinulata, C. nigerianus, Thermocyclops oithonoides, C. rylovi, C. tinctus, C. variens, C. vermifes*	Muller, 1971
Avioserpens mosgovoyi	*Diaptomus gracilis, Cyclops strenuus*	Supryaga, 1971; Moravec, 1994; Moravec & Scholz, 1990
Gnathostoma hispidum	*Acanthocyclops viridis, Cyclops strenuus, C. vicinis, Eucyclops serrulatus, Macrocyclops albidus, Mesocyclops leuckarti, Thermocyclops hyalinus, Th. oithoides*	Golovin, 1956

We consider that the interconnection of various bodies of water ensures the extremely wide distribution of crustaceans and nematodes from the families Spiruridae, Camallanidae, Philometridae, Dracunculidae, and Gnathostomatidae. On the other hand, the relatively low prevalence of infection with larval stages of nematodes in crustaceans can be an indicator of a relatively stable parasitological situation in the studied region.

Conclusion

Nematodes from the order Spirurida are widespread in the biocoenoses of Uzbekistan. We registered 133 species belonging to three suborders – Spirurina, Camallanina and Filariina. They are parasites of fish, birds and mammals, causing serious diseases in commercial and game species of vertebrates.

By their life cycle, the studied Spirurida are heteroxenous forms of nematodes. Crustaceans inhabiting bodies of water in Uzbekistan act as intermediate hosts for most species of these parasites. Most of crustaceans naturally infected with Spirurida larvae are from the families Cyclopidae and Gammaridae. 8 species of nematode larvae parasitise representatives of these two families. Mature forms of these larvae are parasites of vertebrates (fish, birds, and mammals).

Successful implementation of biocoenotic relationships between Spirurida and their hosts contributes to the circulation of infection in natural complexes over the studied territory.

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