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Crustaceans (Crustacea) in bodies of water in Uzbekistan as intermediate hosts of helminths of animals

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The article provides information on the participation of crustaceans (Crustacea) in the life cycles of helminths of domestic and wild (game and commercial) animals in Uzbekistan. To date, 730 species of parasitic worms have been registered, 114 of which parasitise fish, 376 – birds, and 240 – mammals. The most common of them represent the class Cestoda: *Bothriocephalus opsariichthydis*, *Schistocephalus pungitii*, *Ligula intestinalis*, *L. colymbi*, *Digramma interrupta*, *Gryporhynchus pusillus*, *Dicranotaenia coronula*, *Diorchis brevis*, *Diorchis ransomi*, *Diploposthe laevis*, *Drepanidotaenia lanceolata*, *Fimbraria fasciolaris*, *Microsomacanthus microsoma*, *M. compressa*, *Myxolepis collaris*, *Sobolevicanthus gracillus*, and *Diphyliobothrium ditremum*. The most epizootologically significant representatives of Nematoda included *Raphidascaris acus*, *Contracaecum microcephalum*, *Camallanus lacustris*, *Philometra ovata*, *Philometra rischta*, *Phylometroides sanguineus*, *Dracunculus medinensis*, *Avioserpens mosgovoyi*, *Ascaridia galli*, *Heterakis gallinarum*, *Tetrameres fissispina*, *Streptocara crassicauda*, *Echinuria uncinate*, and *Gnathostoma hispidum*. Parasitological studies of the *Cyclops* community (more than 30 species) in various bodies of water in Central, North-Eastern, and North-Western Uzbekistan show infection of 11 species of Cyclopidae with larval stages of cestodes and nematodes. Naturally, infected *Cyclops* widely inhabit diverse bodies of water and include the following species: *Macrocyclops albidus*, *M. fuscus*, *Eucyclops macrurus*, *E. serrulatus*, *Cyclops strenuus*, *Cyclops vicinus*, *C. heberti*, *Acanthocyclops trajani*, *Thermocyclops crassus* and *Mesocyclops leuckarti*. All of them are intermediate hosts to the helminths. The total prevalence of the larval stages of cestodes and nematodes in the studied *Cyclops* was 6.9%, with Cestoda larvae accounting for 5.7% and Nematoda – 1.2%. All cestode larvae found in *Cyclops* are of two types – procercoids and cysticercoids. The nematode larvae found in 7 crustacean species turned out to be representatives of the following families: Anisakidae, Camallanidae, Philometridae, Dracunculidae and Gnathostomatidae. We identified a total of 20 species of helminth larvae, whose mature forms parasitise fish, birds and mammals. Crustaceans play a significant role in the life cycles and circulation of pathogens and groups of parasites in bodies of water in Uzbekistan.

Keywords: Cestoda; Nematoda; larval stages; larval cysts; procercoids; cysticercoids; circulation; Uzbekistan.

Introduction

Modern parasitology knows quite a lot about the role of invertebrates as intermediate hosts for various helminth groups. Crustaceans in various bodies of water take part in the life cycles of parasitic worms (Moravec, 1994; Largue, 2017; Shields, 2022).

The life cycles of most cestodes and nematodes that parasitise fish and birds are connected with crustaceans inhabiting various bodies of water. There are a number of publications on the larval stages of parasitic worms in crustaceans (Jarecka, 1966; Molnar, 1966; Moravec, 1980), which summarize some patterns of the formation of larval stages of parasitic worms in the body of crustaceans in European bodies of water. A lot of research has been made into the crustaceans, intermediate hosts of helminths of animals, inhabiting diverse bodies of water in Poland and Hungary. Researchers in these countries study the life cycles of a number of Cestoda and Nematoda species, parasites of fish and wetland birds. They identified their main intermediate hosts infected in either way – spontaneously or experimentally. Similar studies were conducted in bodies of water in the Czech Republic (Ryšavy, 1961; Moravec, 1971, 2011). In general, researchers in these countries have identified a significant number of crustacean species in various bodies of water, which are intermediate hosts to helminths of fish, birds and mammals. So, planktonic crustaceans in general and copepods in particular turned out to be intermediate hosts to many parasitic worms from the classes Cestoda, Acanthocephala and Nematoda. To date, the number of crustaceans involved in the life cycles of helminths is more than 60 species (Moravec, 1994; Grabner, 1994; Grabner et al., 2015).

Crustaceans are important components of aquatic ecosystems and hosts for a wide variety of parasites (Hatcher et al., 2015; Lagrue, 2017). Larval stages of these parasites can have grave and highly diverse pathogenic effects on their crustacean hosts, such as increased mortality, castration, and phenotypic changes (Kennedy, 2006; Rode et al., 2013; Gehman & Byers, 2017). Despite high interest in the role of crustaceans in the life cycles of parasitic worms and the availability of convincing evidence, this problem has not been sufficiently addressed. There are many unresolved issues in this area of research, which require broader and in-depth study (Lagrue, 2017).

In Uzbekistan, the first studies of crustaceans involved in the life cycles of helminths of freshwater fish and wetland birds were conducted in some bodies of water in the northwest of the country (Allaniyazova, 1975, 1977). According to the author, crustaceans in the Dautkul lake system and lakes Ashikul and Tanakala in Karakalpakstan were infected with larval stages of several species of cestodes – parasites of fish and wetland birds. In these bodies of water, spontaneous infection with cestode larvae was recorded in the following copepods: *Macrocyclops fuscus*, *M. albidus*, *Eucyclops serrulatus*, *Ectocyclops phaleratus*, *Cyclops strenuus*, *Acanthocyclops viridis*, *Mesocyclops leuckarti*, *M. oithonoides*, and *M. cassis*. The total prevalence ranged from 0.3% to 0.6%. Mature forms of *Bothriocephalus opsariichthydis* from the class Cestoda were identified as parasites of fish, while some species of Hymenolepididae were recorded in wetland birds. However, outside the abovementioned work, crustaceans in the water bodies of Uzbekistan were not studied from the parasitological aspect. Moreover, there are still many unresolved issues in this area of research.

The goal of this work is to study the helminthological situation in bodies of water in three regions – Central, North-Eastern and North-Western Uzbekistan, and to specify basic biocoenotic relationships between parasites and crustaceans in the circulation of infections diseases of vertebrates.

Materials and methods

The material of the research is composed of crustaceans collected in bodies of water in three regions – Central, North-Eastern and North-Western Uzbekistan, between 2016 and 2025. Samples were taken using conventional hydrobiological and parasitological methods (Monchenko, 1974; Dobrokhotova, 1967; Mirabdullayev et al., 2012; Mustafayeva et al., 2017; Reid & Ueda, 2003). The crustaceans were taken from natural (lakes) and artificial (ponds and reservoirs) bodies of water in the spring, summer and autumn of each year in the specified period, using plankton and landing nets, scrapers and dredges. They were then counted under a binocular microscope on a Bogorov net (Mustafayeva et al., 2017).

In total, the research team studied about 450 samples from bodies of water in three regions of Uzbekistan (Fig. 1): Dengizkul and Tudakul, Kattakurgan Reservoir (Central Uzbekistan, Samarkand, Bukhara and Navoi Regions); Aydar-Arnasay lake system, Charvak, Tuyamuyun and Akhangaran Reservoirs, and a number of ponds (North-Eastern Uzbekistan, Tashkent, Syrdarya and Jizzakh Regions); Lake Sudochye, Karateren, Akushpa, Atakul, Akchakul, Saykul, Dautkul and Khojakul (North-Western Uzbekistan, Republic of Karakalpakstan, Fig. 1).

Crustaceans were examined for infection with larval stages of helminths (cestodes and nematodes) with a binocular or low-magnification microscope. From 10 to 15 *Cyclops* individuals were placed on a slide and covered with a coverslip. This number under each coverslip allows both counting crustaceans and detecting infected individuals. Helminth larvae were extracted from crustaceans with thin dissecting needles. The species of the host parasite larvae were identified in a laboratory. We counted a total of 8,070 individuals of copepods. About 3,346 of them were tested for infection with larval stages of cestodes and nematodes (Table 1, 2). Most (about 80%) of the detected helminth larvae were studied live and were used to carry out bioassays in order to confirm a parasite's species identity.

Of the 37 *Cyclops* species we studied, 11 were infected with larval stages of helminths (Tables 1 and 2).

Fig. 1. Map of Uzbekistan: *1* – Central Uzbekistan; *2* – North-Eastern Uzbekistan; *3* – North-Western Uzbekistan

Table 1
Helminth species composition in crustaceans spontaneously infected with larval stages of parasites in bodies of water in Uzbekistan

Species	No. of studied individuals	Region of Uzbekistan, date			GPS coordinates
		North-Western	North-Eastern	Central	
Macrocyclops albidus	120	05.2022	–	07.2023	39°46′25.86″N 66°14′49.45″E 40°35′32.53″N 67°36′38.27″E 41°51′00.97″N 60°53′37.21″E
	120	06.2022	07.2022	08.2023	39°47′18.33″N 64°56′15.59″E 41°35′32.65″N 70°05′58.76″E

Species	No. of studied individuals	Region of Uzbekistan, date			GPS coordinates
		North-Western	North-Eastern	Central	
					42°30′16.19″N 59°37′44.77″E
	120	10.2023	09.2024	10.2024	39°06′19.95″N 64°13′04.82″E
					40°59′23.85″N 69°18′42.32″E
					42°47′42.21″N 59°40′53.24″E
Macrocyclops fuscus	100	06.2022	06.2022	07.2023	39°47′57.70″N 66°18′05.01″E
					40°58′47.58″N 69°19′17.19″E
					41°52′02.23″N 60°51′57.13″E
	110	07.2022	08.2023	08.2023	39°53′12.24″N 64°56′09.99″E
					41°36′02.02″N 70°05′49.07″E
					42°30′36.47″N 59°37′57.61″E
	126	09.2023	10.2024	09.2023	39°02′22.19″N 64°22′22.15″E
					40°28′30.04″N 67°36′22.57″E
					42°47′27.81″N 59°41′01.88″E
Eucyclops macrurus	–	–	–	–	–
	116	08.2023	07.2023	06.2023	39°50′40.65″N 66°16′35.10″E
					40°29′24.88″N 67°33′17.80″E
					41°53′21.99″N 60°50′41.65″E
	100	10.2023	09.2024	07.2023	39°55′15.54″N 64°50′51.48″E
					41°36′16.46″N 70°05′28.14″E
					42°30′48.30″N 59°38′19.15″E
Eucyclops serrulatus	–	–	–	–	–
	190	07.2023	06.2024	07.2023	39°50′32.65″N 66°14′02.41″E
					40°31′36.15″N 67°38′28.74″E
					42°29′41.88″N 59°37′32.62″E
	100	08.2023	10.2024	08.2024	39°53′21.64″N 64°48′25.73″E
					41°36′40.60″N 70°05′41.48″E
					41°53′39.64″N 60°49′20.55″E
Cyclops strenuous	106	06.2022	07.2023	06.2023	39°01′55.76″N 64°12′19.15″E
					39°13′27.17″N 64°03′06.72″E
					41°03′32.05″N 70°12′30.38″E
	110	08.2023	08.2023	07.2023	41°36′40.60″N 70°05′41.48″E
					41°36′34.93″N 70°04′58.12″E
					42°47′35.01″N 59°41′33.67″E
	96	10.2023	10.2023	10.2023	43°13′21.01″N 60°23′20.92″E
					43°11′53.70″N 60°21′13.14″E
					41°03′00.42″N 70°12′47.78″E
Cyclops vicinus	110	07.2023	06.2024	07.2024	42°52′48.24″N 59°17′20.40″E
					42°53′15.37″N 59°19′04.50″E
					39°06′38.26″N 64°04′52.98″E
	100	08.2024	07.2024	08.2024	39°47′44.36″N 66°12′08.27″E
					41°03′15.04″N 70°13′57.82″E
					41°04′29.32″N 70°17′52.83″E
	116	09.2024	10.2024	09.2024	42°52′31.36″N 59°20′33.07″E
					42°51′22.77″N 59°19′07.00″E
					40°58′35.38″N 69°19′41.85″E
Acanthocyclops trajani	100	06.2022	06.2022	07.2024	43°28′12.53″N 58°24′43.30″E
					43°30′27.53″N 58°27′05.35″E
					41°04′08.44″N 70°15′14.96″E
	66	07.2022	08.2023	08.2024	40°58′12.46″N 69°17′18.54″E
					40°58′09.57″N 69°19′39.27″E
					43°23′01.32″N 58°32′55.36″E
	100	08.2023	10.2024	09.2024	42°22′16.39″N 59°54′23.87″E
					42°22′35.14″N 59°54′28.83″E
					39°48′03.96″N 64°44′24.41″E
Mesocyclops rubellus	70	07.2023	06.2024	07.2024	42°22′16.39″N 59°54′23.87″E
					42°22′35.14″N 59°54′28.83″E
					41°36′02.02″N 70°05′49.07″E
	100	08.2023	07.2024	08.2024	43°25′34.32″N 58°33′02.74″E
					43°26′06.33″N 58°34′38.18″E
					43°27′58.29″N 58°19′59.31″E
	110	10.2023	10.2024	09.2024	42°23′00.69″N 59°54′29.76″E
					42°23′07.34″N 59°54′47.39″E
					39°53′21.64″N 64°48′25.73″E
Thermocyclops crassus	88	07.2022	06.2024	07.2024	40°28′36.00″N 67°36′37.70″E
					42°29′41.88″N 59°37′32.62″E
					42°30′07.58″N 59°38′08.38″E
	100	08.2022	08.2024	08.2024	43°30′25.76″N 58°21′49.51″E
					43°29′07.58″N 58°21′56.79″E
					41°03′15.04″N 70°13′57.82″E
	110	10.2023	09.2024	09.2024	43°30′25.76″N 58°21′49.51″E
					43°29′07.58″N 58°21′56.79″E
					39°53′12.24″N 64°56′09.99″E
Mesocyclops leuckarti	108	07.2023	07.2023	07.2022	42°48′13.94″N 59°41′44.18″E
					42°48′13.25″N 59°40′55.34″E
					41°36′02.02″N 70°05′49.07″E
	100	08.2023	08.2023	08.2022	43°13′19.08″N 60°23′08.94″E

Species	No. of studied individuals	Region of Uzbekistan, date			GPS coordinates
		North-Western	North-Eastern	Central	
	110	10.2024	09.2023	10.2022	43°14′25.03″N 60°21′31.77″E 39°48′03.96″N 64°44′24.41″E 43°23′52.94″N 58°31′27.20″E 39°01′55.76″N 64°12′19.15″E 41°36′40.60″N 70°05′41.48″E
Mesocyclops ogunnus	114	07.2023	06.2022	07.2022	42°30′07.58″N 59°38′08.38″E 40°58′47.58″N 69°19′17.19″E
	100	08.2023	08.2023	09.2022	42°50′50.11″N 59°16′47.38″E 43°13′19.08″N 60°23′08.94″E 43°14′25.03″N 60°21′31.77″E
	110	06.2024	07.2024	08.2024	39°50′32.65″N 66°14′02.41″E 42°23′30.98″N 59°54′47.58″E 43°13′19.08″N 60°23′08.94″E 43°14′25.03″N 60°21′31.77″E

Table 2
The rate of infection with larval stages of helminths (cestodes and nematodes) in various bodies of water in Uzbekistan

Species	No. of studied individuals	Infected with larval stages			
		Cestoda		Nematoda	
Macrocyclops albidus	360	0.6	1 – 2	0.2	1 – 3
Macrocyclops fuscus	316	0.7	1 – 2	–	–
Eucyclops macrurus	296	0.4	1 – 2	0.1	1 – 2
Eucyclops serrulatus	290	0.5	1 – 2	–	–
Cyclops strenuus	302	0.6	1 – 2	0.2	1 – 3
Cyclops vicinus	316	0.7	1 – 2	0.2	1 – 3
Acanthocyclops trajani	266	0.1	1 – 2	0.2	1 – 2
Mesocyclops rubellus	280	0.5	1 – 2	–	–
Thermocyclops crassus	298	0.6	1 – 2	0.1	1
Mesocyclops leuckarti	318	0.7	1	0.1	1
Mesocyclops ogunnus	214	0.4	1	–	–

Results and discussion

We established that copepods (Crustacea: Copepoda) were common in various bodies of water in Uzbekistan. They were from 4 orders – Cyclopoida, Calanoida, Harpacticoida, and Poecilostomatoida. Cyclopoida showed the richest species diversity (Mirabdullaev et al., 2012). The order consists of 15 families. The family Cyclopoidae alone comprised about 50 species.

A study of 3,346 individuals of Cyclopoidea from natural and artificial bodies of water revealed helminth larvae (cestodes and nematodes) in 11 species of crustaceans.

The total prevalence of infection among the *Cyclops crustaceans* was 6.9%, with 5.7% infected with Cestoda and 1.1% with Nematoda. All cestode larvae found in *Cyclops* – larval cysts – belong to two types: procercoids and cysticercoids.

The procercoids are represented by the genera *Ligula* Bloch, 1782 and *Bothriocephalus* Rudolphi, 1808. The cysticercoids belonged to the following genera: *Dicranotaenia* Railliet, 1892; *Diorchis* Clerc, 1903; *Diploposthe* Jacobi, 1896; *Drepanidotaenia* Railliet, 1892; *Fimbraria* Froelich, 1802; *Microsomacanthus* Lopez-Neyre, 1942; *Sobolevicanthus* Spassky et Spasskaja, 1954, from the family Hymenolepididae Perrier, 1897, whose mature forms parasitise birds, mainly wetland ones. The prevalence of larval stages of cestodes in some species of *Cyclops* varied from 0.4 to 0.7%. The prevalence of nematode larvae varied within 0.1–0.2%. Nematode larvae were representatives of the Anisakidae, Camallanidae, Phylometridae, Gnathostomatidae, Dracunculidae families . Our research for the first time discovered larvae of *Avioserpens* Wehr et Chitwood, 1934 and *Dracunculus* Reichard, 1759 (Dracunculidae Railliet et Henry, 1915). Mature *Avioserpens* parasitise in the subcutaneous tissue of birds, while *Dracunculus* parasitise mammals, including humans.

All recorded cestode and nematode larvae demonstrate seasonality and are found in the warm season, starting from early May and until mid-September. The highest rate of infection with parasitic worm larvae in *Cyclops* in the water bodies of Uzbekistan is observed in July–August and by September it noticeably decreases. We already did not detect any infected *Cyclops* in late October. In the body of *Cyclops*, we found procercoids, cysticercodes or larvae of only one and very rarely two nematode species.

Therefore, 11 crustacean species – *Macrocyclops albidus*, *M. fuscus*, *Eucyclops macrurus*, *E. serrulatus*, *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops trajani*, *Mesocyclops rubellus*, *Thermocyclops crassus*, *Mesocyclops leuckarti*, and *M. ogunnus* can participate as intermediate hosts in the life cycles of cestodes (11 species) parasites of fish, birds and mammals. In 7 of these species – *Macrocyclops albidus*, *Eucyclops macrurus*, *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops trajani*, *Thermocyclops crassus* and *Mesocyclops ogunnus* – we recorded infectious nematode larvae. We verified the species of most of the larvae found experimentally by infecting domestic ducks and fish.

The cestode larvae in our material are represented by 12 species belonging to three families (Bothriocephalidae, Diphyllobothriidae and Hymenolepididae), the intermediate hosts of which are 11 species of *Cyclops* (Table 3). Naturally infested Cyclops, as a rule, contained 1–2 larvae of one species of cestodes. Nematode larvae represent the families Anisakidae, Camallanidae, Phylometridae, Dracunculidae and Gnathostomatidae.

The data in Table 3 also indicate that in the studied bodies of water in Uzbekistan, *Cyclops* do not develop specific cestodes and nematodes. It means that the same species of *Cyclops* are infected by larval stages of a number of helminth species, which is probably associated with the trophic and ecological characteristics of *Cyclops*. *Cyclops* are permanent inhabitants of various types of water bodies, while their large numbers in warm seasons and their presence as the main food objects in the diets of fish and other vertebrates accounts for extensive spread of helminth larvae.

Knowing the range of hosts of parasitic worms, as well as their general biology and ecology, we can identify sources and ways in which animals become infected with parasites in specific areas, which is extremely important for developing preventive measures against helminthiasis of agricultural and wild game animals. In this context, special attention should be paid to the study of the morpho-biological features of the larval stages of some groups of cestodes and nematodes developing in crustaceans in the water bodies of Uzbekistan.

Currently, we have sufficient materials showing the diversity of the fauna of cestode and nematode larvae developing in the bodies of their crustacean intermediate hosts. The morphologies of procercoids and cysticercoids parasitising crustaceans in various bodies of water in Uzbekistan do not fundamentally differ from those provided in well-known research works (Rubicka, 1957; Jarecka, 1958, 1960; Ryšavy, 1961), with the exception of *Cyclops*. Some drawings of cestode larvae are borrowed from the above-mentioned works. The morphometric parameters of the studied parasite larvae are based on original research.

Table 3
Participation of crustaceans in the life cycles of helminths of vertebrates in Uzbekistan

Species	Hosts	
	intermediate	definitive
Cestoda		
Bothriocephalus opsariichthidis	*Cyclops Strenuous, Cyclops vicinus, Acanthocyclops trajani, Mesocyclops leuckarti, Eucyclops serrulatus*	Fish, carps and predators (catfish, zander)
Ligula intestinalis	*Cyclops Strenuous, Acanthocyclops trajani, Eucyclops macrurus*	Wetland birds
Dicranotaenia coronula	*Mesocyclops leuckarti, Eucyclops macrurus*	Wetland birds
Diorchis brevis	*Cyclops vicinus, Thermocyclops crassus*	Wetland birds
Diorchis elisae	*Cyclops strenuus*	Wetland birds
Diorchis ransomi	*Cyclops vicinus*	Wetland birds
Diploposthe laevis	*Macrocyclops albidus, Acanthocyclops trajani*	Wetland birds
Diploposthe skrjabini	*Macrocyclops albidus, Mesocyclops leuckarti*	Wetland birds
Drepanidotaenia lanceolata	*Acanthocyclops trajani, Cyclops strenuus, Cyclops vicinus, Eucyclops macrurus*	Wetland birds
Fimbraria fasciolaris	*Macrocyclops albidus, Macrocyclops fuscus, Mesocyclops crassus, Mesocyclops leuckarti*	Wetland birds
Microsomacanthus microsoma	*Cyclops vicinus*	Wetland birds
Sobolevicanthus gracillus	*Acanthocyclops trajani, Cyclops vicinus, Cyclops strenuus, Mesocyclops crassus, Mesocyclops leuckarti, Eucyclops macrurus*	Wetland birds
Nematoda		
Contracaecum microcephalum	*Cyclops strenuus, Cyclops vicinus, Macrocyclops albidus*	Wetland birds
Camallanus lacustris	*Macrocyclops albidus, Eucyclops macrurus, Mesocyclops leuckarti*	Fish – Perciformes
Phylometra ovata	*Acanthocyclops trajani, Macrocyclops albidus, Macrocyclops fuscus, Cyclops vicinus*	Fish – Cypriniformes, Salmoniformes
Phylometra rischta	*Cyclops strenuus, Cyclops vicinus, Mesocyclops leuckarti, Eucyclops macrurus*	Fish – Cypriniformes, Salmoniformes
Phylometroides sanguinea	*Cyclops vicinus, Acanthocyclops trajani, Macrocyclops fuscus, Mesocyclops leuckarti, Thermocyclops crassus*	Fish – Cypriniformes
Dracunculus medinensis	*Cyclops strenuus, Cyclops vicinus, Macrocyclops albidus, Eucyclops macrurus*	Mammals – dogs, humans
Avioserpens mosgovoyi	*Cyclops vicinus, Cyclops strenuus, Thermocyclops crassus, Mesocyclops leuckarti*	Wetland birds
Gnathostoma hispidum	*Macrocyclops albidus, Cyclops vicinus, Cyclops strenuus*	Mammals – pigs

Bothriocephalus opsariichthidis Yamaguti, 1934

Intermediate host: copepods – *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops trajani*, *Mesocyclops leuckarti*, *Eucyclops serrulatus*.

Site: body cavity.

Discovery locations: Uzbekistan (bodies of water in the basins of the Amu Darya, Syr Darya and Zeravshan).

Biology. The life cycle includes one intermediate host – copepods *Cyclops*, *Acanthocyclops*, *Macrocyclops* and other. Mature cestodes, localised in the intestines of fish (Cypriniformes and predators), secrete eggs that fall into the water with excrement. Here, within 3–7 days, the coracidium develops and emerges from the egg. *Cyclops* swallow the coracidia floating in the water, which develop in the former's body into invasive larvae – procercoids. In our material, the procercoids of *B. opsariichthydis* have an elongated, transparent body, 0.55–0.65 mm long and 0.15–0.12 mm wide. At the posterior end there is a small rounded sarcomere. In the sarcomere, there are three pairs of embryonic hooks (Fig. 2).

Feeding on zooplankton, fish, especially fry, swallows the infected *Cyclops*. As the fish digests the *Cyclops*, the released larva (procercoid) attaches to the intestinal wall and after 2–3 weeks turns into a mature helminth. The mature cestodes are white, the body is elongated, ribbon-like and reaches 15–25 cm in length and 1–4 mm in width. They parasitise mainly numerous species of carp-like and predatory fish (catfish, zander). *Bothriocephalus* is widespread in the water bodies of Uzbekistan (Osmanov, 1971; Urazbayev et al., 1973; Safarova, 2017; Abduganiyev, 2022).

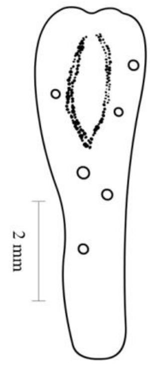

Fig. 2. *Bothriocephalus opsariichthydis* Yamaguti, 1934: procercoid extracted from the body cavity of *Cyclops strenuus*

Ligula intestinalis (Linnaeus, 1758)

Intermediate host: copepods – *Cyclops strenuus*, *Acanthocyclops trajani*, *Mesocyclops leuckarti*, *M. ogunnus*.

Site: body cavity.

Discovery locations: bodies of water in Uzbekistan.

Biology. The life cycle inludes two intermediate hosts. Numerous species of crustaceans and daphnia have been recorded as the first intermediate hosts. In our material, the first intermediate hosts of this cestode were crustaceans from the genera *Cyclops*, *Acanthocyclops*, *Mesocyclops*, and the second ones – carp-like fish. The parasites develop in natural conditions according to the following pattern. Mature ligulae are localised in the intestines of the definitive hosts – fish-eating birds, where they release eggs. Together with the excrement of birds, the cestode eggs get into the water. In the water, a coracidium enters the egg. The coracidium – a ciliated larva – leaves the egg through the operculum and swims freely in the water, where they are swallowed by *Cyclops* and *Diaptomus* – the first intermediate hosts, in whose body procercoids develop from coracidia. The infected crustaceans are swallowed by fish (the second intermediate host), in the abdominal cavity of which the procercoids develop into large belt-shaped plerocercoids. Fish-eating birds – the definitive hosts – eat infected fish, in whose intestines the plerocercoids become mature and release eggs into the external environment (water) (Fig. 3).

Liguli are common in fish-eating birds (Arepbayev, 2024). Plerocercoids pose a particular danger to fish, which are the second intermediate hosts in the water bodies of the studied region (Osmanov, 1971; Safarova, 2017; Abduganiyev, 2022).

Dicranotaenia coronula (Dujardin, 1845)

Intermediate host: copepods – *Mesocyclops ogunnus*, *M. leuckarti*, *Thermocyclops crassus*.

Site: body cavity.

Discovery locations: bodies of water in Uzbekistan.

Biology. The life cycle involves intermediate hosts (crustaceans) and reservoir hosts (mollusks from the genus *Lymnaea*) (Spasskaya, 1966).

In our material, the intermediate hosts of this cestode are Cyclopoida from the genera *Mesocyclops* and *Thermocyclops*, in whose body cavities we recorded cysticercoids. Cysticercoids of *D. coronula* have the following features: the cyst is oval, the average size is 0.14–0.19 mm with a short sarcomere at the posterior end. On the scolex there are rounded suckers and a proboscis with a single crown of 24 hooks. The sucker is 0.03 x 0.03 mm in diameter, the length of the proboscis hooks is 0.017 mm (Fig. 4), which corresponds to the data of (Jarecka, 1958). Wetland birds become become infected by swallowing *Cyclops* parasitised with cysticercoids of Cestoda. Mature forms are intestinal parasites of wetland birds (Arepbayev, 2024).

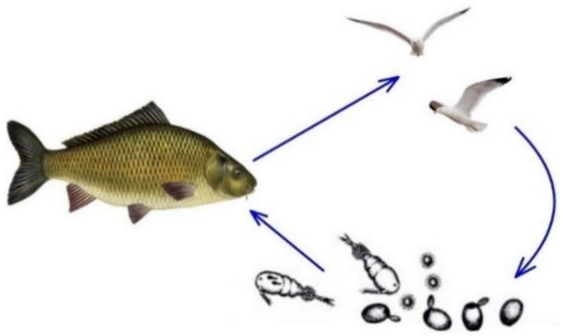

Fig. 3. Life cycle of *Ligula intestinalis* (Linnaeus, 1758): procercoid – in the body cavity of *Cyclops*; plerocercoids – in fish

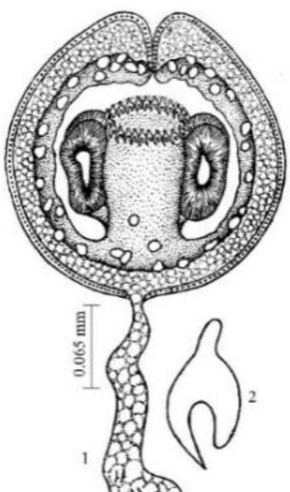

Fig. 4. *Dicranotaenia coronula* (Dujardin, 1845) Railliet, 1892: *1* – cysticercoid; *2* – proboscis hook in a cysticercoid (based on Jarecka, 1958)

Diorchis brevis Rubicka, 1957

Intermediate host: copepods – *Cyclops vicinus*, *Thermocyclops crassus*.

Site: body cavity.

Discovery locations: bodies of water in Uzbekistan.

Biology. In bodies of water in Uzbekistan, *Cyclops vicinus* and *Thermocyclops crassus* act as intermediate hosts, in whose organisms cysticercoids develop.

The cysticercoids concentrate in the body cavity of the crustaceans. The cyst is spherical, with an average diameter of 0.201–0.205 mm. The proboscis hooks range from 0.04 to 0.06 mm in length. The suckers are clearly visible, its edges covered with small spikes. The cysticercoid has a long tail; the morphology of the cysticercoid corresponds with the data of Rubicka (1957).

Birds become infected during warm periods by swallowing infected *Cyclops*. Mature forms of cestodes are localised in the intestines of wetland birds (Arepbayev, 2024).

Diorchis elisae (Skrjabin, 1914)

Intermediate host: copepods – *Cyclops strenuus*.

Site: body cavity.

Discovery locations: various types of water bodies in Uzbekistan.

Biology. In the studied bodies of water, we identified infected *Cyclops strenuus*, in whose body cavities we detected cysticercoids of *D. elisae*. Their morphology was identical to that described by other researchers (Jarecka, 1958). The cyst is spherical, with a funnel-shaped depression at the anterior end and a long thin tail. The scolex has four rounded suckers, 0.07x0.07 mm in size. The proboscis has 10 hooks, 0.026 mm long.

Mature cestodes parasitise in the intestine of wetland birds, mainly Anseriformes (Arepbayev, 2024).

Diorchis ransomi Schultz, 1940

Intermediate host: copepods – *Cyclops vicinus*.

Site: body cavity.

Discovery locations: various types of water bodies in Uzbekistan.

Biology. The life cycle involves intermediate hosts – crustaceans (Spasskaya, 1966). In bodies of water in Uzbekistan, we identified cysticercoids of this Cestoda species in a population of *Cyclops vicinus*. The cyst is surrounded by a translucent membrane. The scolex is 0.140–0.166 mm, the proboscis is 0.12–0.15 x 0.060–0.072 mm, the proboscis hooks are 0.034–0.036 mm. Birds become infected with cysticercoids of Cestoda in the warm season by swallowing infected *Cyclops* (Fig. 5).

Adult cestodes are localised in the intestines of wetland birds (Arepbayev, 2024).

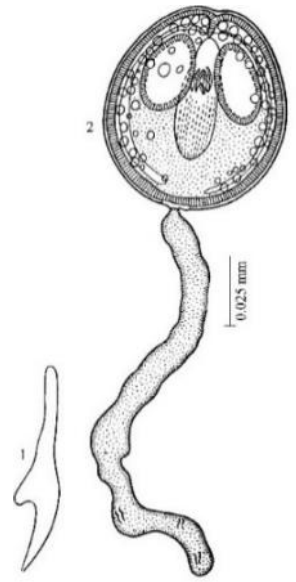

Fig. 5. *Diorchis ransomi* Schultz, 1940: *1* – proboscis hook in a cysticercoid; *2* – mature cysticercoid (based on Ryšavy, 1961, with our amendments)

Diploposthe laevis (Bloch, 1782)

Intermediate host: *Macrocyclops albidus*, *Acanthocyclops trajani*.

Site: body cavity.

Discovery locations: bodies of water in Uzbekistan.

Biology. The life cycle involves intermediate hosts – freshwater crustaceans *Macrocyclops albidus*, *M. fuscus*, *Acanthocyclops viridis* (Copepoda), *Cypridopsis vidua*, and *Heterocypris incongruenis* (Ostracoda) in many parts of Europe and Asia (Spasskaya, 1966).

In bodies of water in Karakalpakstan, we identified cysticercoids of *D. laevis* in two species – *M. albidus* and *A. trajani*.

The cysticercoid is relatively small in size, the cyst is thin-walled and oval in shape. At the anterior end of the cyst there is a funnel-shaped depression, a rather long tail sticks out from the posterior end. The scolex bears four small rounded suckers. The proboscis has 10 hooks. The size of the cysticercoid cyst developing in the body cavity of *Macrocyclops albidus* and *Acanthocyclops trajani* varies from 0.18–20 x 0.15–0.16 mm to 0.20–0.22 x 0.17–0.18 mm. The suckers are 0.04 mm in diameter, the proboscis hooks are 0.016–0.019 mm (Fig. 6).

According to our observations, birds become infected in the warm season (summer and early autumn) by swallowing *Cyclops* parasitised with cysticercoids of Cestoda. Mature forms are intestinal parasites of wetland birds, mainly Anseriformes (Arepbayev, 2024).

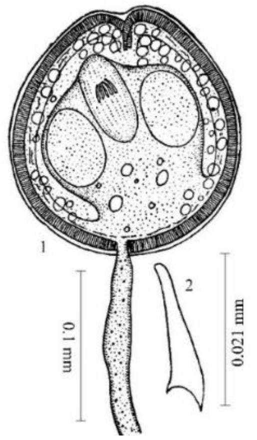

Fig. 6. *Diploposthe laevis* (Bloch, 1782) Jacobi, 1897:
1 – cysticercoid; *2* – hook in a cysticercoid
(based on Ryšavy, 1961, with our amendments)

Drepanidotaenia lanceolata (Bloch, 1782)

Intermediate host: copepods – *Acanthocyclops trajani*, *Cyclops strenuas*, *C. vicinus*, *Eucyclops macrurus*.

Site: body cavity.

Discovery locations: bodies of water in Uzbekistan.

Biology. They develop with the participation of intermediate hosts – crustaceans. According to our research, Cyclopoida in the studied bodies of water act as intermediate hosts of *Drepanidotaenia*.

Cysticercoids of this cestode naturally infected four species of *Cyclops* – *A. trajani*, *C. strenuas*, *C. vicinus*, and *E. macrarus*. The cysticercoids were recorded in the body cavity. The intensity of infection was, as a rule, one larva in one *Cyclops* individual. We found out that *Cyclops* became infected in late spring (May), summer and early autumn.

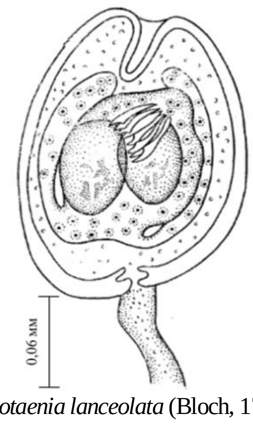

Fig. 7. *Drepanidotaenia lanceolata* (Bloch, 1782) Railliet, 1892

Cysticercoids of *D. lanceolata* have the following morphological features: the cyst is oval-shaped, its average size is 0.115 x 0.095 mm; there are 8 hooks on the proboscis, the hook length is 0.034 mm, the suckers are oval, 0.057 x 0.036 mm in size. A long tail extends from the rear end (Fig. 7).

Ducks and geese become infected in warm weather, when they swallow *Cyclops* infected with cysticercoids. It takes 18–20 days for *Drepanidotaenia* to develop in the body of geese and ducks. Mature forms lose segments with numerous eggs inside. The segments decompose in the external environment (water) and numerous eggs spread around and are swallowed with water by *Cyclops*. Cysticercoids develop in the body of infected *Cyclops* within 10–12 days. Ducks and geese become infected when they swallow *Cyclops* with cesticercoids of *D. lanceolata*. This occurs in the warm season (late spring, summer and early autumn). The parasite continues to live in a bird's body for about a year.

Adult cestodes are localised in the intestines of birds (domestic and wild Anseriformes). Quite a large parasite reaching 10–12 cm in length and with a maximum width of 10–12 mm, *D. lanceolata* is widespread in ducks and geese in Asia, Europe, America, Canada and other countries and is highly important from the epizootological aspect. It is also very common in wetland birds, especially domestic and wild Anseriformes in Uzbekistan. Parasitesed young ducks and geese often die in the farms of Uzbekistan (Arepbayev, 2024).

Fimbriaria fasciolaris (Pallas, 1781)

Intermediate host: *Macrocyclops albidus*, *Macrocyclops fuscus*, *Mesocyclops crassus*, *M. leuckarti*.

Site: body cavity.

Discovery locations: Uzbekistan (various types of water bodies).

Biology. *Fimbriaria* develop in the same way as *Hymenolepis* do. Many species of crustaceans, mainly from the families Cyclopidae and Gammaridae are recorded as intermediate hosts of *F. fasciolaris* (Spasskaya, 1966; Petrochenko & Kotelnikov, 1976).

Feeding on organic matter, including particles of faeces floating in water, crustaceans very easily swallow *Fimbriaria* eggs. In the body of crustaceans, cysticercoids develop within 7 and 15 days. The development period depends on the temperature of the water body. Thus, at a temperature of 20–25 °C, cysticercoids fully develop in 7–8 days.

The cysticercoids extracted from the body cavities of *Cyclops* are characterised by the following features.

The cysticercoid has a rounded shape. The cyst is small, rounded, with a funnel-shaped depression at the anterior end. The tail is long and thin. The embryonic hooks are located on the terminal part of the tail. The scolex fills the entire internal cavity of the cyst and has four rounded suckers 0.030–0.029 mm in size. There are 8 hooks in the proboscis. The total size of the cyst is 0.142 x 0.140 mm.

Birds become infected by eating crustaceans with cysticercoids of the cestode. *Fimbriaria* develop in the bodies of domestic ducks within 8-11 days. The lifespan of *F. fasciolaris* is several months. Mature forms of the cestode are localised in the intestines of the bird. The length of the strobila is 20–40 cm, the width is 4–5 mm. This is a common species.

Microsomacanthus microsoma (Creplin, 1829)

Intermediate host: *Cyclops vicinus*, *Eucyclops serrulatus*.

Site: body cavity.

Discovery locations: Various types of water bodies in Uzbekistan.

Biology. The life cycle involves *Cyclops* (*C. vicinus*, *E. serrulatus*), as well as molluscs *Lymnaea auricularia* as reservoir hosts.

Cyclops are intermediate hosts. Feeding on organic matter, they eat cestode eggs and become infected. In the body of the crustaceans, the larva develops going through a complex metamorphosis. The larva ultimately develops into its infectious cysticercoid stage (Fig. 8). The larvae have oval-shaped cysts, 0.268–0.296 x 0.232 mm in diameter, without a tail appendage. The number of hooks in the scolex is 8. Their definitive hosts, birds, become infected when they swallow crustaceans with water. Otherwise, wetland birds get the infection by eating aquatic molluscs *L. auricularia* invaded with cysticercoids of the parasite. The cysticercoids develop into adult cestodes in 13–15 days.

Contracaecum microcephalum (Rudolphi, 1819)

Intermediate hosts: Cyclops – *Cyclops vicinus*, *Macrocyclops albidus*.

Site: body cavity.

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

Biology. The life cycle of this Nematoda species includes two groups of intermediate hosts. The first group consists of copepods (*Cyclops*, *Macrocyclops*), while the second one is composed of various fish – Cyprinidae, Percidae, Esocidae (Bauer, 1987). In intermediate hosts, 3rd-stage larvae develop in the body cavity, enclosed in cysts that are infectious for fish-eating birds. Mature forms are localised in the stomach of fish-eating birds (Arepbayev, 2024).

Camallanus lacustris (Zoega, 1776)

Intermediate hosts: *Macrocyclops albidus*, *Eucyclops macrurus*, *Mesocyclops leuckarti*.

Site: body cavity.

Discovery locations: Uzbekistan (various types of water bodies).

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

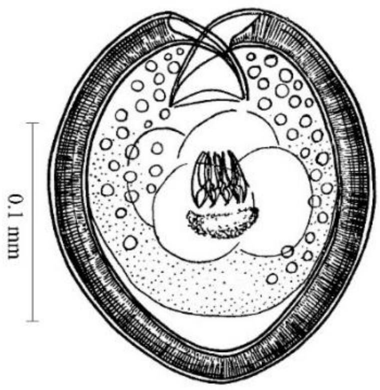

Fig. 8. *Microsomacatithus microsoma* (Creplin, 1829) Lopez-Neyra, 1942: general view of the cysticercoid

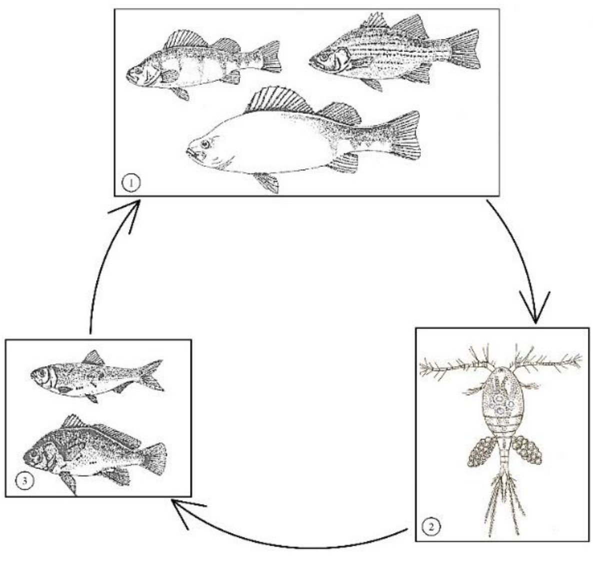

Fig. 9. *Camallanus lacustris* (Zoega, 1776):
1 – definitive hosts; *2* – intermediate hosts; *3* – paratenic hosts

Females of *C. lacustris* are viviparous. Larvae go out into the water with faeces. There they are swallowed by *Cyclops*, in whose cavity the larvae molt twice, become infectious and reach their definitive hosts. In the body of the definitive hosts – perches, the parasites reach sexual maturity and after a month numerous larvae develop in the uterus of adult females. It has also been noted (Moravec, 1971, 1994) that some species of carp may participate as reservoir hosts in the life cycle of this nematode. Thus, definitive hosts (Percidae) become infected in two ways: by swallowing infected *Cyclops* and by eating their reservoir hosts, carps, containing the larvae of the parasites, which they take by eating *Cyclops* (Fig. 9). The results of our studies confirm the known data in the literature (Moravec, 1971, 1994).

Mature nematodes concentrate in the intestine of Percidae (Osmanov, 1971; Safarova, 2017).

Phylometra ovata (Zeder, 1803)

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

Site: body cavity.

Discovery locations: bodies of water in Uzbekistan.

Biology. The first intermediate hosts are copepods *Acanthocyclops*, *Macrocyclops*, *Megacyclops*, and *Diacyclops* (Molnar, 1966). In our material they were represented by *Cyclops* – *A. trajani*, *M. albidus*, *M. fuscus*, and *C. vicinus*, who contained infection larvae (L_3).

Cyclops become infected by eating larvae that settle on the bottom of a reservoir. Infectious larvae (L_3) develop in the body cavity of *Cyclops*. The latter infect the definitive host, fish, mainly carp, when it eats the crustaceans (Fig. 10).

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

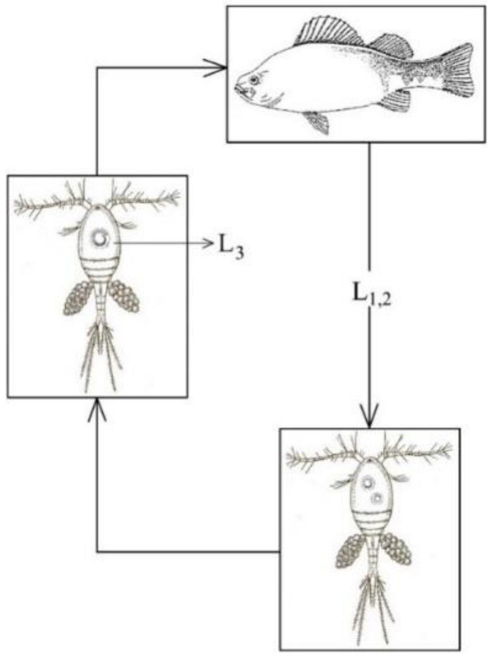

Fig. 10. *Phylometra ovata* (Zeder, 1803):
Phylometra's life cycle; $L_{1,2}$ – larvae; L_3 – infectious larva

Philometroides sanguineus (Rudolphi, 1819)

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

Site: body cavity.

Discovery locations: Uzbekistan (various types of water bodies).

Biology. The life cycle of this Nematoda species is quite well studied (Yashchuk, 1974; Moravec, 1994). In our material, intermediate hosts to *Ph. sanguineus* are various representatives of *Cyclops*, *Acanthocyclops*, *Macrocyclops*, *Mesocyclops*, and *Thermocyclops*, which become infected by eating stage-1 (L_1) larvae that have come out of the female parasite. After 5–6 days, the larvae become infectious. The definitive hosts, carps, become infected by eating the parasitised crustaceans. If heavily infected, the fish can die.

Adult forms of this nematode are widespread in carps in the water bodies of Uzbekistan (Osmanov, 1971; Safarova, 2017).

Dracunculus medinensis (Linnaeus, 1758)

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

Site: body cavity.

Discovery locations: Uzbekistan (stagnant bodies of water).

Biology. The life cycle involves aquatic crustaceans, *Cyclops*, as intermediate hosts (Anderson, 2000). The parasite is viviparous. It concentrates in the subcutaneous tissue of the definitive host, mainly the extremities. The female nematodes, upon contact with water, perforate the skin of the host and throw out live larvae from the uterus. The larvae excreted by the female may reach 8-10 million individuals in number and are swallowed by *Cyclops*. The size of the first stage larvae (L_1) ranges 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 infectious stage (L_3), when they are capable of infecting 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. Infection of humans and animals occurs when drinking raw water from stagnant bodies of water (lakes, pools) abounding in infected *Cyclops* (Fig. 11). In the body of the final hosts, the parasites reach sexual maturity within 9–14 months (Anderson, 2000).

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

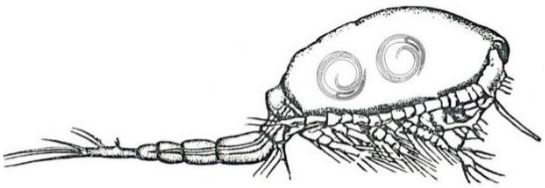

Fig. 11. *Dracunculus medinensis* (Linnaeus, 1758): cyclop infected with *Dracunculus medinensis* larvae

Avioserpens mosgovoyi Suprjaga, 1965

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

Site: body cavity.

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

Biology. The parasite is viviparous, parasitising under the skin of wetland birds. Female nematodes, perforating the skin, release mobile larvae into the water. Since the intermediate hosts are crustaceans, and the reservoir hosts are fish fry, tadpoles and larvae of aquatic insects, it is natural that the definitive hosts are birds associated with the aquatic environment. Loons, grebes, Ciconiiformes and Anseriformes, that is, representatives of most orders of wetland birds, are registered as the parasite's definitive hosts. In our material, the intermediate hosts of *Avioserpens mosgovoyi* were *Cyclops* – *Cyclops vicinus*, *C. strenuus*, *Thermocyclops crassus*, and *Mesocyclops leuckarti*. In the body cavity of *Cyclops*, within 8–10 days, found – invasive larvae (L_3) stages (Fig. 12).

Reservoir hosts may also participate in the life cycle: fish fry, mainly Cypriniformes, tadpoles and dragonfly larvae. Definitive hosts become infected when they eat intermediate (*Cyclops*) or reservoir hosts. After 26–30 days, the parasites reach sexual maturity. Females begin to secrete numerous live larvae (Anderson, 2000).

In Karakalpakstan, mature forms of nematodes have been recorded in the subcutaneous tissue of grebes and Anseriformes (Arepbayev, 2024).

Gnathostoma hispidum Fedtshenko, 1872

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

Site: body cavity.

Discovery locations: Uzbekistan (various types of water bodies).

Biology. The parasite's life cycle involves intermediate hosts – *Cyclops*. The eggs released into a body of water, and in 9–10 days, first stage larvae emerge from them. The larvae are swallowed by *Cyclops* (*Cyclops*, *Macrocyclops* and other). As they reach the digestive tube of *Cyclops*, the first stage larvae (L_1) penetrate the hemocoel, where after 5 days they molt and in 10–12 days become infectious (Fig. 13), capable of iparasitising their final hosts.

Reservoir (=paratenic) hosts – fish and amphibians – can also participate in the life cycle of this parasite. In our material, the reservoir hosts were carps. Pigs become infected by drinking water containing infected *Cyclops* or by eating reservoir hosts. Mature forms of *Gnathostoma hispidum* are localised in the aesophagus and stomach of pigs (Sultanov et al., 1975; Anderson, 2000).

Crustaceans are a very diverse group, ranging from those barely visible to the naked eye to large crabs. The vast majority of species live in fresh and salt water. Aquatic crustaceans is a group that shows one of the highest species diversity on earth and is an important link in many food chains.

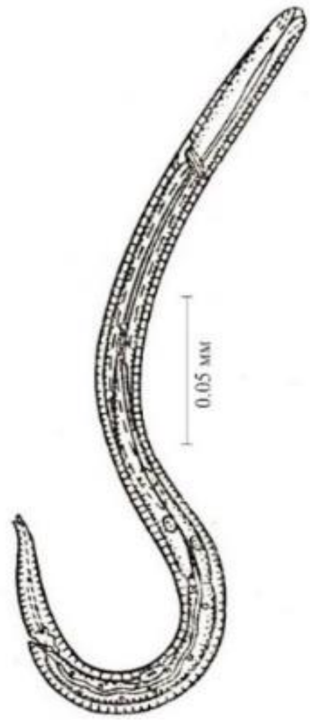

Fig. 12. *Avioserpens mosgovoyi* Suprjaga, 1965: infectious larva that has come out from the body cavity of *Cyclops vicinus*

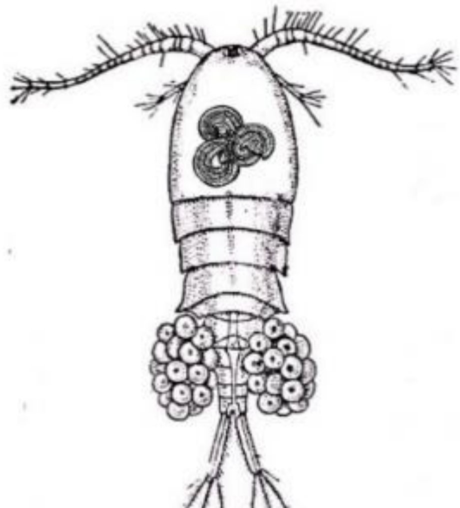

Fig. 13. *Gnathostoma hispidum* Fedtshenko, 1872: a representative of *Cyclops* infected with the parasite's larvae

Copepods (Copepoda) form the largest subclass within the class Maxillopoda. The total number of species in this group is more than 10,000, which are distributed throughout the world in the oceans, fresh water, and hot springs. The total weight exceeds a billion tons, and it is the basis of the diet of marine fish. At the same time, some of them can be intermediate hosts to helminths – cestodes and nematodes (Table 3, 4). Our study also confirms the importance of copepods in the life cycles of helminths from the classes Cestoda and Nematoda in the water bodies of Uzbekistan (Table 3).

Table 4 shows that crustaceans are intermediate hosts to a number of helminth species. The latter use crustaceans in their larval stages and later use trophic ways to enter the body of a definitive host. These issues are widely addressed by parasitologists in a number of European, Asian and American countries (Moravec, 1994; Lagrue, 2017; Schields, 2022).

Table 4
Crustaceans – intermediate hosts (according to literature data)

Species of helminths	Intermediate hosts	Author, year
Bothriocephalus opsariichthydis	*Cyclops strenuus, Mesocyclops leuckarti, M. oithonoides, M. crassus, M. dubovskii, M. taihensis, Acanthocyclops vernali, A. bicuspidatus, Arctodiaptomus bacillifer*	Tseng-Sheng, 1932, 1933; Dobrokhotova, 1967, 1973; Musselius, 1973; Allaniyazova, 1977
Ligula intestinalis	*Cyclops strenuus, Acanthocyclops bicuspidatus, A. viridis, Mesocyclops oithonoides, Eudiaptomus gracilis, E. graciloides*	Musselius, 1973
Dicranotaenia coronula	*Physocypris fadeevi, Cyclocypris laevis, C. ovum, C. globosa, Eucypris virens, Heterocypris incongruens, Mesocyclops oithonoides, Notodromas monocha, Cypridopsis vidua*	Ryšavy, 1961; Rubicka, 1957
Diorchis brevis	*Cypridopsis vidua*	Rubicka, 1957
Diorchis elisae	*Cypridopsis vidua, Cyclops laevis, Diaptomus vulgaris, Notodromas monacha*	Jarecka, 1958; Ryšavy, 1961
Diorchis ransomi	*Cypridopsis vidua, Cyclops laevis, Diaptomus vulgaris, Notodromas monacha*	Rubicka, 1957, Ryšavy, 1961
Diploposthe laevis	*Macrocyclops albidus, M. fuscus, Acanthocyclops viridis, Cypridopsis vidua, Heterocypris incongruens*	Ryšavy, 1961
Diploposthe skrjabini	*Macrocyclops albidus, M. fuscus, Acanthocyclops viridis, Mesocyclops leuckarti, Cypridopsis vidua, Cyclops laevis*	Jarecka, 1958
Drepanidotaenia lanceolata	*Acanthocyclops bicuspidatus, A. vernalis, A. viridis, Cyclops diaphanus, C. dubowskii, C. vicinis, Eucyclops macruroides, E. macrurus, E. serrulatus, E. speratus, Macrocyclops albidus, M. fuscus, Mesocyclops crassus, M. leuckarti, M. oithonoides, Paracyclops fimbriatus, Diaptomus gracilis, D. spinosus*	Michailow, 1958; Dobrokhotova & Butenko, 1964; Dobrokhotova, 1967
Fimbraria fasciolaris	*Macrocyclops albidus, Acanthocyclops viridis, A. vernalis, A. gigas, A. bicuspidatus, Cypridopsis vidua, Cyclops laevis, C. strenuus, C. vicinis, Eucyclops serrulatus, Paracyclops fimbriatus, Mesocyclops crassus, M. oithonoides, M. leuckarti, Diaptomus vulgaris*	Dobrokhotova & Butenko, 1964
Microsomacanthus microsoma	*Eucyclops serrulatus, Cyclops agilis*	Oshmarin, Oparin, Rumel, 1958
Sobolevicanthus gracillus	*Acanthocyclops viridis, Diaptomus viridis, D. vulgaris, D. graciloides, Eucypris viriens, Cyclops vicinis, Cyclocypris dispersa, C. globose, Heterocypris incongruens, Dolerocypris faciata, Candona compressa, C. rostrata, C. neglesta, Cypridopsis vidua, Notodromas monacha, Paracyclops fimbriatus, Mesocyclops crassus, M. oithonoides*	Jarecka, 1958; Dobrokhotova & Kasymzhanova, 1964
Contracaecum microcephalum	*Acanthocyclops viridis, A. vernalis, Arctodiaptomus gracilis, Cyclops strenuus, E. macruroides, Macrocyclops albidus, M. fuscus, Mesocyclops crassus, M. leuckarti*	Semenova, 1979 (in Anderson, 2000)
Camallanus lacustris	*Megacyclops viridis, Macrocyclops albidus, Acanthocyclops vernalis, Mesocyclops leuckarti, Eucyclops serrulatus, Cyclops strenuus*	Moravec, 1971, 1994; Chandra & Chubb, 1992
Phylometra ovata	*Acanthocyclops vernalis, A. viridis, Cyclops strenuus, Macrocyclops albidus, Megacyclops gigas*	Molnar, 1966; Moravec, 1980
Phylometra rischta	*Cyclops strenuus, Macrocyclops albidus, Acanthocyclops viridis*	Molnar, 1966; Moravec, 1980
Phylometroides sanguinea	*Cyclops strenuus, C. kolensis, Acanthocyclops viridis, Macrocyclops albidus, Eucyclops serrulatus, E. macruroides*	Wierzbicki, 1960; Yashchuk, 1974
Dracunculus medinensis	*Cyclops strenuus, C. decipiens, C. fimbriatus, C. hyalinus, C. inopinus, C. iranicus, C. karvei, C. leuckarti, C. microspinulata, C. nigerianus, C. oithonoides, C. rylovi, C. tinctus, C. variens, C. vermifes*	Muller, 1971; Yelifari et al., 1997
Avioserpens mosgovoyi	*Diaptomus gracilis, Cyclops strenuus*	Sypryaga, 1971; Moravec, Scholz, 1990; Moravec, 1994
Gnathostoma hispidum	*Acanthocyclops viridis, Cyclops strenuus, C. vicinis, Eucyclops serrulatus, Macrocyclops albidus, Mesocyclops leuckarti, Thermocyclops hyalinus, Th. oithoides*	Golovin, 1956; Dissamern et al., 1966; Wang et al., 1976; Akahane et al., 1982, 1983

Yet, the list of works on the life cycles of helminths involving copepods in Uzbekistan is relatively small (Allaniyazova, 1975, 1977). The author reports that a number of *Cyclops* species in the water bodies of Karakalpakstan turned out to be intermediate hosts of cestodes, parasites of fish and wetland birds. In a study of more than 8,000 crustaceans, the author recorded that from 0.3% to 0.6% individuals were infected with cestode larvae. The larvae of the following species were identified: *Bothriocephalus opsariichthydis*, *Diorchis elisae*, *Diorchis ransomi*, *Diorchis stefanskii*, *Diploposthe laevis*, *Confluaria capillaroides*. The following *Cyclops* species were infected with the above-mentioned Cestoda larvae: *Macrocyclops albidus*, *M. fuscus*, *Eucyclops serrulatus*, *E. macruroides*, *E. macrurus*, *Ectocyclops phaleratus*, *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops viridis*, *Microcyclops viridis*, *Mesocyclops leuckarti*, *M. oithonoides*, *M. crassus* (Allaniyazova, 1977).

Similar studies were carried out on the water bodies of southern Kazakhstan (Dobrokhotova, 1967). During the study of different types of water bodies (lakes, rivers, ponds and reservoirs) in Southern Kazakhstan, nine species of *Cyclops* were registered as intermediate hosts to Hymenolepididae parasitising wetland birds: *Mesocyclops oithonoides*, *M. crassus*, *M. leuckarti*, *Eucyclops serrulatus*, *Macrocyclops albidus*, *Cyclops strenuus*, *Paracyclops fimbriatus*, *Acanthocyclops viridis*, and *A. gigas*. In *Cyclops*, the total prevalence of infection was from 0.7–0.8% to 4–6%. According to the author, cysticercoids of 7 species of cestodes were found in the infected *Cyclops*: *Fimbraria fasciolaris*, *Microsomacanthus paracompressa*, *Sobolevicanthus gracillus*, *Microsomacanthus paramicrosoma*, *M. spiraliburrsata*, *Dicranotaenia coronula* and *Drepanidotaenia lanceolata*. The results of our studies were generally similar to the data of previous works (Dobrokhotova, 1967; Allaniyazova, 1975, 1977) with some exceptions. In our collections, larvae of some species of cestodes (*Confluaria capillaroides*, *Microsomacauthus spiraliharsata*) were not found in *Cyclops*, which requires further research. At the same time, in our studies, larvae of a number of nematode species were found in *Cyclops* in water bodies in Uzbekistan, the mature forms of which are parasites of fish, wetland birds and mammals, which correspond to known data from the world literature (Moravec, 1980, 1994; Moravec & Scholz, 1990; Anderson, 2000).

Particular interest are the infectious nematode larvae we found in *Cyclops* in Uzbekistan: *Camallanus lacustris*, *Filometroides sanguinea*, *Dracunculus medinensis*, and *Avioserpens mosgovoyi*, which demonstrate a sufficient stability of the parasite-host systems "nematodes-crustaceans" and "nematodes-crustaceans-vertebrates". The systems are based on food chains and ensure the circulation of infection in the studied territory. The results of our studies of crustaceans in the water bodies of Uzbekistan as intermediate hosts to helminths of vertebrates are consistent with the results of previous work, which are summarised in fundamental monographs, reports, and helminth identifiers (Bauer, 1987; Khalil et al., 1994; Moravec, 1994). Moreover, the data we have obtained on the biocoenotic connections of helminths, which are realised through the food channels of the components of the parasitic system, as we believe, expand the range of intermediate hosts of cestodes and nematodes – parasites of fish, birds, mammals and humans. At the same time, we also hope that the modest results of our research contribute to further developments and are important for preserving the population of agricultural and game animals and controlling the number of parasitic worms.

Table 5
Crustaceans as intermediate hosts to helminths of animals in various bodies of water in Asian countries

Country	Number of crustacean species infected with helminth larvae	Number of identified species of helminth larvae	
		Cestoda	Nematoda
China	8	1	7
Japan	7	–	7
Kazakhstan	10	10	–
Uzbekistan	16	12	8

The data in Table 5 are based on an analysis of published works by some authors from the mentioned countries (Wang et al., 1976; Wang & Zhao, 1980; Akahane et al., 1982, 1983) – China; (Kim et al., 1989; Ando et al., 1994; Nagasawa et al., 1994) – Japan; (Dobrokhotova, 1967) – Kazakhstan; (Allaniyazova, 1975, 1977) – Uzbekistan and the research data of this work.

Literary data and the results of our research show that the total number of crustacean species involved in the life cycles of cestodes and nematodes in the mentioned Asian countries is more than 25. In 17 species of these crustaceans (*Macrocyclops albidus*, *M. fuscus*, *Ectocyclops phaleratus*, *Eucyclops macrurus*, *E. macruroides*, *E. serrulatus*, *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops nanus*, *A. trajani*, *A. viridis*, *A. gigas*, *A. vernalis*, *Thermocyclops crassus*, *Mesocyclops leuckarti*, *M. oithonoides*, and *Paracyclops fimbriatus*) we recorded the larval stages of Cestoda from the following families: Bothriocephalidae, Diphyllobothriidae, Proteocephalidae and Hymenolepididae. 13 crustacean species (*Macrocyclops albidus*, *Eucyclops macrurus*, *E. serrulatus*, *Cyclops strenuous*, *C. vicinus*, *C. varicans*, *Acanthocyclops nanus*, *A. trajani*, *A. viridis*, *Thermocyclops crassus*, *Th. taikonensis*, *Th. hyalinus*, *Mesocyclops leuckarti*, and *M. taihorensis*) proved to be intermediate hosts to Nematoda, representatives of the families Anisakidae, Camallanidae, Phylometridae, Dracunculidae, and Gnathostomatidae.

The presented material indicates that the same crustacean species can be an intermediate host to both cestodes and nematodes. Such species include *Macrocyclops albidus*, *Eucyclops macrurus*, *E. serrulatus*, *Cyclops strenuus*, *C. vicinus*, *Acanthocyclops trajani*, *A. viridis*, *Thermocyclops crassus*, and *Mesocyclops leuckarti*. However, we did not record any crustacean individuals infected with simultaneously with larvae of cestodes and nematodes.

Thus, it is obvious that crustaceans in bodies of water in Uzbekistan play an important role in the life cycles of a number of species of helminths – parasites of fish, birds and mammals.

Table 5 shows that a significant number of crustacean species in Asian bodies of water are registered as intermediate hosts to cestodes and nematodes. The species composition of larval stages of helminths is the most diverse in crustaceans in the water bodies of Uzbekistan (20 species). It is followed by Kazakhstan, with 9 species of cystocercoids from the family Hymenolepididae identified in crustaceans in this country. The lowest number of species of parasite larvae was recorded in crustaceans in China and Japan, with 4 species in each of these countries (Wang et al., 1976; Akahane et al., 1983; Ando et al., 1994). The range of parasitic species infecting crustaceans in bodies of water in the studied countries depends on their environment and geography.

The study of the role of crustaceans in the biological cycles of helminths is of great interest both for understanding the evolutionary pathways of the development cycles of some helminth groups and the patterns of their distribution, and from the point of view of using these data in the practice of combating helminthiases of agricultural and game animals. Work on crustaceans as intermediate hosts of helminths – parasites of fish, wetland birds and mammals – has been carried out in many countries of Europe (Molnar, 1966; Moravec, 1980, 1994) and Asia (Wang et al., 1983; Sinha, 1988; Nagasawa et al., 1994) where numerous species of crustaceans infected with the larval stages of cestodes and nematodes have been identified. In addition, the authors have conducted extensive experimental studies.

It is probable that the connectivity between bodies of water in Uzbekistan is one of the main factors that ensure the dispersal of helminths Bothriocephalidae, Diphyllobothriidae, Hymenolepididae, Camallanidae, Philometridae, Dracunculidae, and Gnathostomatidae over vast territories. On the other hand, the rate of infection with larval stages of cestodes and nematodes in crustaceans can serve an indicator of the parasitological situation in bodies of water in Uzbekistan.

Conclusion

Crustaceans are widespread in various types of water bodies in Uzbekistan. Larval stages of helminths have been identified in 11 species of crustaceans belonging to 6 genera – *Macrocyclops*, *Eucyclops*, *Cyclops*, *Acanthocyclops*, *Mesocyclops*, and *Thermocyclops*. Most of the crustaceans naturally infected with cestodes larvae, cysticercoids and procercoids, in the water bodies of Uzbekistan are *Cyclops*. Nematode larvae were identified in only 7 species of *Cyclops*. Mature forms of the mentioned larvae (cestodes and nematodes) are parasites of fish, birds and mammals.

In general, the larval stages of 20 species of helminths were registered in the studied *Cyclops*. For 12 species of cestodes and 8 species of nematode *Cyclops* are intermediate hosts.

The existing biocoenotic relationship between helminths and their hosts contribute to the circulation of invasion in natural complexes. This requires systematic monitoring of crustaceans infected with larval stages of cestodes and nematodes, parasites of vertebrates, in order to predict and control the parasitological situation in water bodies.

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