Research Article

Helminths of Predatory Fish in Uzbekistan

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Abstract | Based on the conducted studies, 35 species of helminths from 32 genera, 22 families, 13 orders, 4 classes and 3 phyla were identified in predatory fish from bodies of water in the middle course of the Syrdarya River. By their life cycle, 24 of the species recorded in predatory fish are biohelminths and 11 geohelminths. The helminths were recorded in predatory fish in the following proportions: Trematoda – 31.4%, Cestoda – 28.5%, Acanthocephala – 8.5% and Nematoda – 31.4%. The level of infection with helminths in predatory fish varies across bodies of water: middle course of the Syrdarya River – prevalence 0.7-30.0%, intensity of infection 1-72 individuals; Aidar Arnasay lake system – prevalence 0.9-27.8%, intensity of infection 1-46 individuals; Tuyabuguz reservoir – prevalence 2.1-26.6%, intensity of infection 1-38 individuals; fishing farms – prevalence 0.3-29.6%, intensity of infection 1-67 individuals; canals – prevalence 3.1-20.3%, intensity of infection 1-42 individuals.

Keywords | Helminths, Parasites, Predatory fish, Uzbekistan

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INTRODUCTION

Fish and fish products are a valuable, balanced and excellent dietary food, essential to human health. It is no less inferior in its nutritional value to beef and poultry, and is digested faster and better. Fish contains all essential amino acids, complete protein and saturated fatty acids. In addition, fish contains vital macro- and microelements and a range of vitamins, especially A, B and D. They contribute to a healthy development of the body, help remain young and with a clear mind, increase immunity and prevent many diseases (Moshu, 2014). Among other freshwater fish, predatory fish is particular important. In Uzbekistan this group of fish is largely represented by the zander, catfish and pike. These species are now actively bred by fish farms across Uzbekistan. Studying helminths parasitising predatory fish is important from the scientific and practical aspects.

Fish is susceptible to infections, some of which are dangerous to fish itself and often cause their mass die-off, while others threat humans and animals that feed on infected fish. In addition, infectious diseases dramatically reduce the quality of fish products: infected fish is usually exhausted, which results in a decrease in the contents of nutrients, such as fats, proteins and carbohydrates, as well as vitamins and minerals, in their meat. Some infectious diseases have clear signs and symptoms, which impairs the appearance of fish products. Infected fish, due to its low commercial and nutritional qualities, is used as food for humans and domestic animals with certain restrictions or is neutralised and disposed of, following special standards (Moshu, 2014).

The species composition, taxonomy, distribution, morphobiological and ecological features of dominant helminth species in the wels catfish *Silurus glanis* Linnaeus, 1758,

zander *Sander lucioperca* Linnaeus, 1758 and pike *Esox lucius* Linnaeus, 1758 were studied by foreign researchers, including Poulin and Valtonen (2001), Akinsanya & Otubanjo (2006), Dan-kishiya *et al.* (2013), Alcântara and Dias (2015), Ali *et al.* (2020) and Abdybekova *et al.* (2020).

The parasitic fauna of the wels catfish, zander and pike, the life cycles of dominant helminth species are studied and measures to prevent helminthiasis of fish in the CIS countries are proposed in research works by Petukhov, and Zhokhov (2003), Burdukovskaya (2006), Molodozhnikova and Zhokhov (2007), Shimalova (2008), Morozova (2011),Vastianova (2013), Gorbunova (2016), Golovina *et al.* (2017), Mineeva and Mineev (2019) and Kazarnikova (2021).

In Uzbekistan, research works on the species diversity and distribution of fish helminths include Kurbonova (2002), Karimov (2007), Safarova *et al.*, (2015, 2021); Allamuratova (2017), Kurbanova *et al.* (2018), Kurbanova and Nurullaev (2020) and Abduganiev (2021).

However, the works mentioned above cannot provide enough information about the species composition and distribution of helminths of predatory fish in bodies of water in the middle course of the Syrdarya River. Therefore, studying the species composition of helminths of predatory fish in this region and the helminthofaunas of individual fish species and their development is of great scientific and practical importance.

The goals of the research are to specify the species composition of helminths in predatory fish – the wels catfish, zander and pike – inhabiting bodies of water in the middle course of the Syrdarya River and to study the rate of their infection with those helminth species.

MATERIALS AND METHODS

The research was conducted in 2019-2023 in the Laboratory of General Parasitology at the Institute of Zoology under the Academy of Sciences of the Republic of Uzbekistan. A total of 782 fish individuals from bodies of water in the middle course of the Syrdarya River were studied, of which 274 individuals were wels catfish *Silurus glanis*, 241 zanders *Sander lucioperca* and 267 pikes *Esox lucius*. The fish was caught in the Syrdarya River, natural and artificial bodies of water connected with it, the Tuyabuguz reservoir, the Aidar-Arnasai lake system, 20 fish farms, and 2 canals (Fig.1). The species composition of fish was studied jointly with the Laboratory of Ichthyology and Hydrobiology at the Institute of Zoology.

In addition, the research team used and analysed material collected between 1990 and 2018 by the staff of the Laboratory of General Parasitology at the Institute of Zoology. The material was helminthologically dissected, collected, prepared for the study and examined at the laboratory, using generally accepted methods (Bykhovskaya-Pavlovskaya, 1985; Chernysheva et. al., 2009). Species of parasites were identified with the help of microscopes МБС-1, МБИ-3, МБИ-4Б Olympus CK 2 b and a Biolar binocular microscope provided with a Levenhuk C-Series 5M picsels microphotometer, according to relevant reference books (Key to parasites of freshwater fish fauna of the USSR, 1987; Sudarikov *et al.*, 2006; Khalil *et al.*, 1994; Moravec, 1994). Living parasites were stained with a weak solution of neutral red.

The helminth larvae were studied in live and whole-mount preparations. For the study, 1,056 temporary and permanent preparations were made. The helminths were divided into

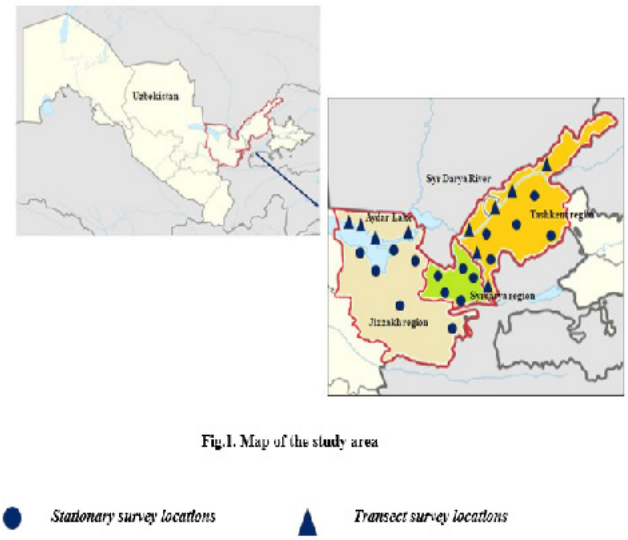

Fig.1. Map of the study area

Figure 1: Map of the study area.

groups by their taxonomy. Plerocercoids of cestodes were stained with quartz carmine. Larvae of nematodes and acanthocephalans were decolorised in a mixture of lactic acid and glycerin (50:50). In most cases, helminth species were identified in temporary preparations, and rarely in permanent ones. The helminths were measured with an eyepiece micrometer; all parameters are given in millimetres.

To characterise the rate of infection with helminths in predatory fish, the research team used parasitological indicators, such as prevalence and intensity of infection (Bykhovskaya-Pavlovskaya, 1985).

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

RESULTS AND DISCUSSION

Based on the conducted studies, 35 species of helminths from 32 genera, 22 families, 13 orders, 4 classes and 3 phylum were identified in predatory fish from various bodies of water in the middle course of the Syrdarya River (Table 1).

The helminths were detected in the stomach (2 species), gills (4 species), intestines (25 species), eyes (3 species), musculoskeletal layer (7 species), abdominal and other body cavities (8 species), liver (5 species), fins (1 species), gallbladder (2 species), gonads (1 species) and blood vessels (1 species). The research also shows that some species pose a serious threat to human health (*Dioctophyme renale*).

By their life cycle, 24 of the species recorded in predatory fish are biohelminths and 11 are geohelminths. In biohelminth life cycles, intermediate hosts are Cyclops, various species of arthropods, annelids, aquatic and terrestrial molluscs, amphibians, reptiles, fish, birds and mammals (Safarova *et al*., 2015; Shakarboyev *et al*., 2015).

The research resulted in the identification of 35 species of helminths from the classes Trematoda, Cestoda, Acanthocephala and Nematoda inhabiting fish in various bodies of water in the middle course of the Syrdarya River. Helminths from different classes were recorded in predatory fish in the following proportions: Trematoda – 31.4%, Cestoda – 28.5%, Acanthocephala – 8.5% and Nematoda – 31.4%. Therefore, the helminthofauna of predatory fish is dominated by nematodes, trematodes and cestodes (Fig.2).

Helminthofauna of the wels catfish (*Silurus glanis* Linnaeus, 1758). The study identified 29 species of parasites in the wels catfish: Trematoda – 10 species, Cestoda – 7, Nematoda – 9 and Acanthocephala – 3 species. They belong to 27 genera, 19 families, 13 orders, 4 classes and 3 phylum.

Therefore, Trematoda comprise 34.5% of the catfish helminthofauna, Nematoda – 31.03%, Cestoda – 24.1% and Acanthocephala – 10.3%.

Table 1: Taxonomy of helminths of predatory fish from the bodies of water in the middle course of the Syrdarya River.

Phylum	Class	Order	Family	Number of species		
				Silurus glanis	*Esox lucius*	*Sander lucioperca*
Plathelminthes Schneider, 1873	Trematoda	Bucephalidida	Bucephalidae	1	2	2
		Fasciolida	Bunoderidae	1	1	1
			Allocreadiidae	1	-	-
			Orientocreadiidae	1	-	-
		Clinostomida	Clinostomatidae	1	1	-
		Strigeidida	Diplostomidae	5	4	4
	Cestoda	Pseudophyllida	Triaenophoridae	1	2	2
			Bothriocephalidae	1	-	1
			Ligulidae	-	-	1
		Proteocephalida	Proteocephalidae	2	-	-
		Cyclophyllida	Dilepididae	3	3	-
Acanthocephales Rudolphi, 1808	Acanthocephala	Neoechinorhynchida	Neoechinorhynchidae	1	1	1
		Palaeacanthocephala	Paracanthocephalidae	1	1	-
			Pomphorhynchidae	1	1	1
Nemathelminthes Schneider, 1866	Nematoda	Trichocephalida	Capillariidae	1	1	-
		Dioctophymida	Dioctophymidae	1	1	-
		Spirurida	Rhabdochonidae	2	-	-
			Desmidocercidae	-	-	1
			Camallanidae	1	1	1
			Philometridae	-	1	-
			Gnathostomatidae	1	-	1
		Ascaridida	Anisakidae	3	2	3
3	4	13	22	29	22	19

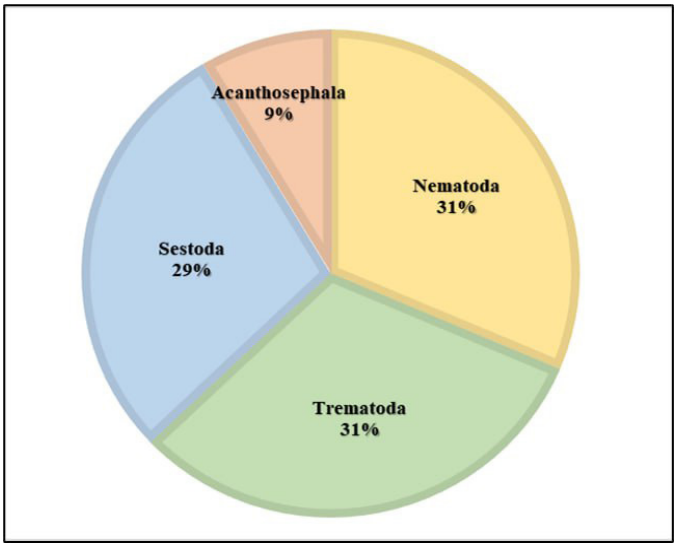

Figure 2: Taxonomy of helminths of predatory fish.

The results show that 86 (31.4%) out of 274 individuals of catfish were infected with helminths. Of the 29 recorded helminth species, 13 were in a larval form and 16 were mature. The research results are consistent with previous studies (Karimov, 2007; Safarova *et al*., 2015; Shakarboyev *et al*., 2015).

The study shows that predatory fish is quite heavily infected with the following species: *Rhipidocotyle campanula* (20.0%), *Gnathostoma hispidum* (21.1%), *Neoechinorhynchus rutile* (24.0%), *Contracaecum spiculgerum* and *Triaenophorus nodulosus* (26.0%).

The species that showed highest prevalence were *Camallanus truncatus* (16.0%), *Dioctophyme renale* (17.2%), *Pomphorhynchus laevis* (18.3%), *Raphidascaris acus* (19.3%), *Diplostomum spathaceum* (22.3%) and *Bothriocephalus opsariichthydis* (30.1%), their intensity of infection ranging between 1 and 65 individuals. The lowest prevalence was recorded for *Tylodelphus clavata* (1.5%), *Paracanthocephalus curtus* (2.1%), *Contracaecum microcephalum* (2.5%), *Silurotaenia siluri* (2.7%) and *Rabdochona gnedini* (3.0%). The intensity of infection was 1-9 individuals.

Helminthofauna of the zander (*Sander lucioperca* Linnaeus, 1758). The study identified 19 species of helminths in the zander *Sander lucioperca*, 4 species of which were from the class Cestoda, 7 from Trematoda, 6 from Nematoda and 2 from Acanthocephala. They belonged to 17 genera, 12 families, 8 orders, 4 classes and 3 phylum. Trematoda comprised 36.8% of the zander helminthofauna, Nematoda 31.5%, Cestoda 21.1% and Acanthocephala 10.5%. The results of the study showed that, of the examined 241 individuals of the zander, 80 (33.2%) were infected with helminths. Of the 19 identified helminth species, 9 were a larval form and 10 were mature.

The most common helminth species were: Trematoda – *Diplostomum spathaceum* (larvae), Cestoda – *Ligula intestinalis* (larvae) and *Bothriocephalus opsariichthydis,* and Nematoda – *Desmidocercella numidica* (larvae).

These species of helminths are characteristic of the zander and are widespread in all studied bodies of water. A high rate of infection was shown by *Rhipidocotyle campanula, Bolboforus confusus* (larvae), *Bucephalus polymorphis, Pomphorhynchus laevis, Raphidascaris acus, Bunodera luciopercae, Contracaecum spiculigerum, Camallanus spiculigerum* (larvae) and *Camallanus truncatus*; a low rate of infection was demonstrated by *Hysteromorpha triloba, Triaenophorus nodulosus, Neoechinorhynchus rutile* and *Gnathostoma hispidum* (larvae).

Cestoda *Bothriocephalus opsariichthydis* is a typical species parasitising predatory fish, mainly the wels catfish and zander. This Cestoda species was found in every body of water. The intermediate hosts of this species are crustaceans from the genus Cyclops.

Trematoda *Bunodera luciopercae* is also a helminth of predatory fish showing a relatively high intensity of infection and prevalence. The zander was much less infected with trematode metacercariae *Tylodelphus clavata* (larvae).

Nematoda *R. acus* is a typical parasite of predatory fish, which was recorded in several bodies of water. Acanthocephala *Pomphorhynchus laevis* was also recorded in several bodies of water, and *Neoechinorhynchus rutile* only in one.

The results showed that the zander was strongly infected with the following helminth species: *Raphidascaris acus* and *Pomphorhynchus laevis* (12.4%), *Camallanus truncatus* (15.0%), *Diplostomum spathaceum* (21.1%) and *Bothriocephalus opsariichthydis* (24.0%). The intensity of infection ranged from 1 to 44 individuals. Fish was less infected with nematodes than with helminths from other classes.

The formation of the zander parasitofauna depends on the geographical location, size, depth, temperature and hydrochemical regimes, hydrobiont composition, age, seasonal dynamics and other parameters of the water body, as well as the presence of intermediate hosts in the parasite's life cycle (Bauer *et al*., 1977).

The development of epizootics among zander populations strictly depends on the existence of the following closely interrelated links: presence of intermediate hosts; host susceptibility; specific environmental conditions influencing the mechanism of transmitting pathogens and contributing to the development of the epizootic process and the cyclicity of the pathogens, the mechanisms of which have

not yet been fully studied (Rumiantsev, 1996).

Helminthofauna of the pike (*Esox lucius* Linnaeus, 1758) The research identified 22 species of helminths in the pike, which belonged to 21 genera, 14 families, 12 orders, 4 classes and 3 phyla. 8 species (36.4 %) of them were from the class Trematoda, 5 (22.7%) from Cestoda, 6 (27.3%) from Nematoda and 3 (13,6%) from Acanthocephala. The species composition of helminths of pike in the middle reaches of the Syrdarya River did not differ significantly from that in other regions of Uzbekistan (Karimov, 2007; Allamuratova, 2017).

The most common species of pike helminths were: Trematoda – *Bunodera luciopercae*, *Tylodelphus clavata* and *Diplostomum spathaceum*; Cestoda – *Triaenophorus nodulosus* and *Triaenophorus crassus*; Acanthocephala – *Pomphorhynchus laevis*; Nematoda – *Raphidascaris acus*, *Dioctophyme renale* and *Camallanus truncatus*. These species of helminths are characteristic of predatory fish and are common in bodies of water in the middle course of the Syrdarya River.

The studies showed that 87 individuals of pike (32.6%) out of 267 were infected with helminths.

The pike was most heavily infected with the following helminth species: *Raphidascaris acus* (12.3%), *Capillaria tomentosa* (13.4%), *Dioctophyme renale* (15.0%), *Camallanus truncatus* (16.1%) and *Diplostomum spathaceum* (19.5%). The intensity of infection ranged from 1 to 35 individuals. Cestoda were not common in pikes and showed a prevalence of 0.7 to 2.7% and an intensity of infection ranging from 1 to 9 individuals.

The helminthofauna of predatory fish was dominated by 9 species (*Rhipidocotyle campanula, Bunodera luciopercae*, *Diplostomum spathaceum* (larvae), *Bothriocephalus opsariichthydis, Ligula intestinalis* (larvae), *Pomphorhynchus laevis, Dioctophyme renale* (larvae), *Camallanus truncates* and *Raphidascaris acus* (larvae)), which were recorded in all the studied bodies of water.

Four of the dominant species were in the larval form, for which predatory fish is a secondary or reservoir host.

The highest intensity of infection with helminths was recorded in the wels catfish, which was followed by the pike and the zander, which showed the lowest intensity of infection.

7 species of helminths important from the epizootic aspect were recorded in predatory fish: *Rhipidocotyle campanula*, *Diplostomum spathaceum* larvae, *Botriocephalus opsariichthydis*, *Ligula intestinalis* (larvae), *Pomphorhynchus laevis, Dioctophyme renale* (larvae) and *Camallanus truncatus*. In the changed environment, they may cause a wide spread of diseases.

Therefore, most of the parasites found in mature pikes in bodies of water in the middle reaches of the Syrdarya turned out to be common in a number of water bodies across Central Asia. Pike-specific parasites common in other regions are practically not recorded in the middle reaches of the Syrdarya.

The occurrence of helminths in predatory fish varies across water bodies in the middle course of the Syrdarya. From 7 to 26 helminth species were registered in the studied bodies of water. The smallest number (7 species) was recorded in canals and the largest number in fish farms (26 species). Research results for each group of bodies of water are given below.

Middle course of the Syrdarya River. The research team established that the parasitofauna of predatory fish consisted of 21 species belonging to 4 classes: Trematoda, Cestoda, Acanthocephala and Nematoda (Table 2). In the studied bodies of water in the middle course of the Syrdarya River, predatory fish occupies the second place in terms of the number of helminth species. Of all the recorded helminth species, 12 were mature forms and 9 larval forms.

Trematodes and nematodes dominate the parasitofauna of predatory fish in the water bodies of the middle reaches of the Syrdarya. Each group is represented by 7 species. Cestoda are represented by 5 species and Acanthocephala by 2 species. The prevalence of trematodes *Rhipidocotyle campanula*,

The prevalence of the cestode *Bothriocephalus opsariichthydis* was 27.8%, which was close to the data recorded for predatory fish in the middle reaches of the Syrdarya River (32.1%). The intensity of infection was 1-46 individuals. 2 species were from each of the classes Acanthocephala and Nematoda. The prevalence ranged from 0.9% to 17.4%, and the intensity of infection was 2-39 individuals.

mature trematodes *Bunodera luciopercae*, metacercariae of *Diplostomum spathaceum* (larvae), and *Tylodelphus clavata* (larvae**)** in predatory fish is high (from 10.4% to 30.0%). This makes it possible to regard this group of helminths as permanent parasites of these fish species. Among nematodes infecting predatory fish, high prevalence (from 20.1% to 25.1%) is shown by *Camallanus truncatus*, *Raphidascaris acus* (larvae), *Contracaecum spiculgerum* (larvae), *Dioctophyme renale* (larvae) and *Capillaria tomentosa*. Therefore, 71.4% of the nematodes registered in the middle reaches of the Syrdarya River cause severe damage to predatory

Table 2: Rate of infection in predatory fish in the middle reaches of the Syrdarya River

No.	Helminth species	Fish species	Prevalence, %	Intensity of infection, individuals	Abundance, individuals
Trematoda					
1	*Rhipidocotyle campanula*	zander, wels catfish, pike	12.4	2-12	9.3±0.6
2	*Bucephalus polymorphis*	zander, pike	7.5	2-9	5.1±0.4
3	*Bunodera luciopercae*	zander, pike, wels catfish	15.1	2-17	12.5±1.2
4	*Orientocreadium siluri*	wels catfish	5.5	2-13	10.3±0.6
5	*Allocreadium siluri*	wels catfish	10.1	3-11	8.6±0.6
6	*Diplostomum spathaceum* (larvae)	zander, pike, wels catfish	30.0	2-27	15.5±1.4
7	*Tylodelphus clavata* (larvae)	zander, pike, wels catfish	10.4	2-24	12.5±0.6
Cestoda					
8	*Triaenophorus nodulosus*	zander, pike, wels catfish	8.4	2-28	18.3±1.1
9	*Bothriocephalus opsariichthydis*	wels catfish, zander	32.1	1-72	45.5±2.4
10	*Ligula intestinalis* (larvae)	zander	13.5	2-12	9.2±0.6
11	*Paradilepis scolecina* (larvae)	pike	0.7	1-9	5.0±0.4
12	*Gryporhynchus pusillus* (larvae)	wels catfish, pike	6.4	2-27	15.5±1.4
Acanthocephala					
13	*Neoechinorhynchus rutili*	zander, pike, wels catfish	7.1	1-24	12.5±0.6
14	*Pomphorhynchus laevis*	zander, pike, wels catfish	19.1	3-56	39.5±2.4
Nematoda					
15	*Capillaria tomentosa*	pike, wels catfish	21.1	1-19	12.5±2.4
16	*Dioctophyme renale* (larvae)	wels catfish, pike	23.3	2-13	9.4±0.6
17	*Rhabdochona denudata*	wels catfish	10.2	1-16	11.5±2.4
18	*Desmidocercella numidica* (larvae)	zander	4.1	1-19	12.4±2.4
19	*Camallanus truncatus*	zander, pike, wels catfish	25.1	1-37	19.5±1.6
20	*Raphidascaris acus* (larvae)	zander, pike, wels catfish	20.1	2-28	18.3±1.1
21	*Contracaecum spiculgerum* (larvae)	zander, pike, wels catfish	17.4	1-19	12.4±2.4

fish. This also indicates the studied bodies of water provide favourable conditions for the development of nematodes. Among cestodes, high prevalence is recorded for the species *Bothriocephalus opsariichthydis* (32.1%), while among Acanthocephala species, *Pomphorhynchus laevis* is the most infectious (prevalence 19.1%).

Thus, the studies established that the qualitative and quantitative composition of the parasitofauna of predatory fish in the Syrdarya River depended on specific hydrological and hydrobiological regimes, as well as the composition of the ichthyofauna in this river's basin. Our research confirms the results of previous studies (Karimov, 2007; Safarova *et al*., 2021).

Aidar-Arnasai lake system (AALS). In this studied area, 12 species of helminths from 4 classes were registered in predatory fish (Table 3). The classes Trematoda and Cestoda predominate among helminths of predatory fish, with 4 species recorded in each group. Among trematodes, the highest prevalence is shown by *Diplostomum spathaceum* (larvae) (14.7%), the lowest by *Rhipidocotyle campanula* (6.4%). The intensity of infection is 1-21 individuals.

Tuyabuguz reservoir. 8 helminth species from 4 classes were registered in predatory fish in the Tuyabuguz reservoir (Table 4). The class Trematoda dominated and weas represented by 3 species. The prevalence of the species *Diplostomum spathaceum* (larvae) and *Bunodera luciopercae* was relatively high (33.0% and 12.6%, respectively). The intensity of infection was 1-14 individuals. The highest prevalence among in the Tuyabuguz reservoir was shown by *Bothriocephalus opsariichthydis* (26.6%) from the class Cestoda. This was followed by the nematode *Camallanus truncatus* (18.5%). The intensity of infection with these helminths species in predatory fish ranged from 1 to 35 individuals. One species from the class Acanthocephala *(Pomphorhynchus laevis)* with a prevalence of 12.7% was recorded in this body of water. The intensity of infection was 4-38 individuals. Fish in other bodies of water showed a relatively high rate of infection with this species.

Table 3: Rate of infection with helminths in predatory fish in the Aidar-Arnasai lake system.

No.	Helminth species	Fish species	Prevalence, %	Intensity of infection, individuals	Abundance, individuals
Trematoda					
1	*Rhipidocotyle campanula*	zander, wels catfish, pike	6.4	1-7	3.1±0.4
2	*Bunodera luciopercae*	zander, pike, wels catfish	13.3	2-12	9.3±0.6
3	*Diplostomum spathaceum* (larvae)	zander, pike, wels catfish	14.7	2-21	15.5±0.6
4	*Tylodelphus clavata* (larvae)	zander, pike, wels catfish	9.8	2-17	12.5±1.2
Cestoda					
5	*Triaenophorus nodulosus*	zander, pike, wels catfish	3.3	3-12	9.3±0.6
6	*Bothriocephalus opsariichthydis*	wels catfish, zander	27.8	2-46	30.5±2.4
7	*Ligula intestinalis* (larvae)	zander	13.4	2-5	2.5±0.4
8	*Neogryporhynchus cheilancristrotus* (larvae)	wels catfish	3.3	1-9	5.0±0.4
Acanthocephala					
9	*Paracanthocephalus curtus*	pike, wels catfish	0.9	2-8	3.5±0.4
10	*Pomphorhynchus laevis*	zander, pike, wels catfish	12.2	3-39	28.5±2.4
Nematoda					
11	*Camallanus truncatus*	zander, pike, wels catfish	17.4	2-24	14.5±0.6
12	*Raphidascaris acus* (larvae)	zander, pike, wels catfish	13.2	3-16	11.3±1.1

Table 4: Rate of infection with helminths in predatory fish in the Tuyabuguz reservoir.

No.	Helminth species	Fish species	Prevalence, %	Intensity of infection, individuals	Abundance, individuals
Trematoda					
1	*Bucephalus polymorphis*	zander, pike	5.5	2-5	2.5±0.4
2	*Bunodera luciopercae*	zander, pike, wels catfish	12.6	1-9	5.0±0.4
3	*Diplostomum spathaceum* (larvae)	zander, pike, wels catfish	33.0	2-14	10.5±1.2
Cestoda					
4	*Triaenophorus crassus*	pike, zander	2.1	1-6	3.0±0.4
5	*Bothriocephalus opsariichthydis*	wels catfish, zander	26.6	4-35	22.5±2.4
Acanthocephala					
6	*Pomphorhynchus laevis*	zander, pike, wels catfish	12.7	4-38	25.5±2.4
Nematoda					
7	*Rhabdochona denudata*	wels catfish	10.3	1-13	11.5±1.2
8	*Camallanus truncatus*	zander, pike, wels catfish	18.5	3-29	17.3±1.1

Therefore, our study of the helminthofauna of predatory fish in the Tuyabuguz reservoir revealed a widespread distribution of diplostomiasis, bunoderosis, botryocephalosis, pomphorhynchosis and camallanosis in it.

Bodies of water in fish farms. In 2019-2023, research work was carried out in a number of bodies of water in fish farms in the Syrdarya and Tashkent regions. 26 species of helminths belonging to 4 classes were registered in predatory fish in fishing farms (Table 5). There were 10 helminth species from the class Trematoda, whose prevalence ranged from 3.3% to 27.7%. The highest prevalence was shown by *Diplostomum spathaceum* (larvae) (27.7%), and the lowest by *Bolboforus confusus* (larvae) (3.3%). The intensity of infection was 1-22 individuals. 6 species of trematodes are parasitic in the larval form and 4 in the mature form.

Table 5: Rate of infection with helminths in predatory fish in bodies of water in fish farms

No.	Helminth species	Fish species	Prevalence, %	Intensity of infection, individuals	Abundance, individuals
Trematoda					
1	*Rhipidocotyle campanula*	zander, wels catfish, pike	11.6	1-9	5.0±0.4
2	*Bucephalus polymorphis*	Zander, pike	5.1	2-6	3.0±0.4
3	*Bunodera luciopercae*	zander, pike, wels catfish	14.3	2-14	12.5±1.2
4	*Allocreadium siluri*	wels catfish	9.6	2-7	4.0±0.4
5	*Diplostomum spathaceum* (larvae)	zander, pike, wels catfish	27.7	2-19	12.5±2.4
6	*Bolboforus confuses* (larvae)	zander, pike, wels catfish	3.3	2-12	9.3±0.6
7	*Posthodiplostomum cuticola* (larvae)	wels catfish	7.1	2-6	3.0±0.4
8	*Hysteromorpha triloba* (larvae)	zander, pike, wels catfish	4.6	1-10	5.0±0.5
9	*Clinostomum complanatum* (larvae)	wels catfish, pike	8.3	1-13	10.3±0.6
10	*Tylodelphus clavate* (larvae)	zander, pike, wels catfish	12.2	2-21	15.5±0.6
Cestoda					
11	Triaenophorus crassus	pike, zander	2.2	2-15	11.3±1.1
12	Bothriocephalus opsariichthydis	wels catfish, zander	29.6	1-67	42.5±2.4
13	*Ligula intestinalis* (larvae)	zander	11.3	2-9	5.1±0.4
14	*Proteocephalus osculatus*	wels catfish	6.0	2-21	15.5±0.6
15	*Silurotaenia siluri*	wels catfish	0.7	1-5	2.0±0.4
16	*Paradilepis scolecina* (larvae)	pike	0.3	1-4	2.5±0.4
17	*Dilepis unilateralis* (larvae)	wels catfish, pike	4.7	2-13	9.3±0.6
Acanthocephala					
18	Neoechinorhynchus rutili	zander, pike, wels catfish	3.3	1-19	12.5±2.4
19	*Paracanthocephalus curtus*	pike, wels catfish	1.7	3-12	9.3±0.6
20	*Pomphorhynchus laevis*	zander, pike, wels catfish	10.3	3-48	32.5±2.4
Nematoda					
21	Capillaria tomentosa	pike, wels catfish	14.4	1-14	10.5±0.6
22	*Dioctophyme renale* (larvae)	wels catfish, pike	17.0	2-12	9.3±0.6
23	*Rhabdochona gnedini* (larvae)	wels catfish	3.1	3-11	8.6±0.6
24	*Contracaecum microcephalum* (larvae)	zander, wels catfish	2.0	2-8	5.5±0.6
25	Philometra obturans	pike	10.1	2-18	12.5±2.4
26	*Gnathostoma hispidum* (larvae)	zander, wels catfish	2.3	1-13	10.5±2.4

Table 6: Rate of infection with helminths in predatory fish in canals

No.	Helminth species	Fish species	Prevalence, %	Intensity of infection, individuals	Abundance, individuals
Trematoda					
1	*Rhipidocotyle campanula*	zander, wels catfish, pike	7.5	2-8	5.1±0.4
2	*Clinostomum complanatum* (larvae)	wels catfish, pike	4.6	1-11	8.3±0.6
3	*Diplostomum spathaceum* (larvae)	zander, pike, wels catfish	15.1	2-18	13.5±1.2
Cestoda					
4	Bothriocephalus opsariichthydis	wels catfish, zander	20.3	1-42	2.5±2.4
5	*Triaenophorus nodulosus*	zander, pike, wels catfish	3.1	1-11	8.6±0.6
Nematoda					
6	*Dioctophyme renale* (larvae)	wels catfish, pike	13.4	2-9	5.1±0.4
7	*Camallanus truncatus*	zander, pike, wels catfish	6.2	2-17	12.5±1.2

The next class in terms of the number of species identified in predatory fish is Cestoda, which is represented by 7 species. The highest prevalence in this group of parasites was 29.6% (*Bothriocephalus opsariichthydis*), the lowest was 0.3% (*Paradilepis scolecina* (larvae). The intensity of infection ranged from 1 to 67 individuals. Three species of cestodes are parasitic in the larval stage, and 4 in the adult form.

The class Nematoda registered in predatory fish is represented by 6 species, 4 of which are parasitic in the larval stage, and 2 in the adult form. In the studied bodies of water, the prevalence of nematodes in predatory fish ranged from 2.0% to 17.0%. The intensity of infection was 1-22 individuals.

Of the 3 species representing the class Acanthocephala, the lowest prevalance (1.7%) was shown by *Paracanthocephalus curtus*, and the highest by *Pomphorhynchus laevis* (10.3%). The intensity of infection was 1-48 individuals.

The rate of infection with helminths in predatory fish in fishing farms was relatively high compared with other bodies of water: the largest number of pathogens causing serious fish diseases was recorded in these objects.

Canals. Helminths of predatory fish were studied in the Yuzhny Mirzachul and Dustlik canals in the Syrdarya region. The studies resulted in the identification of 7 species of helminths parasitising predatory fish in these bodies of water (Table 6).

The class Trematoda there was represented by 3 species, the prevalence of which ranged from 4.6% to 15.1%. The intensity of infection was 1-8 individuals. The classes Cestoda and Nematoda were represented by 2 species each; their prevalence ranged from 3.1% to 20.3% and the intensity of infection was between 1 to 42 individuals. Of the total of 7 identified species, three were larval forms – *Clinostomum planatum* (larvae), *Diplostomum spathaceum* (larvae) and *Dioctophyme renale* (larvae), and four were mature parasites – *Rhipidocotyle campanula, Bothriocephalus opsariichthydis, Triaenophorus nodulosus* and *Camallanus truncatus*.

CONCLUSIONS AND RECOMMENDATIONS

Our team of researchers obtained original data on the composition and quantitative characteristics of helminths of predatory fish in bodies of water in the middle course of the Syrdarya River.

Predatory fish was infected with 35 species of helminths from 32 genera, 22 families, 13 orders, 4 classes and 3 phyla. Of these, the class Trematoda was represented by 11 species (31.4%), Cestoda by 10 species (28.5%), Acanthocephala by 3 species (8.6%) and Nematoda by 11 species (31.4%). By their biological properties, 24 species were biohelminths and 11 geohelminths.

Throughout their life cycles, the detected helminths are exposed to various primary and secondary environmental factors. Therefore, the factors impacting these processes are both endogenous and exogenous. The endogenous factors may include specific reactions in the host organism, immunological incompatibility of the parasite and the host organism, as well as changes in the behaviour of predatory fish under the influence of various substances secreted by the parasitic organism. The exogenous factors may include all environmental factors in the aquatic coenosis inhabited by predatory fish (ambient temperature, mineralisation and ionic composition of water, solar energy, air and water movement and so on).

The rate of infection with helminths in predatory fish varies across bodies of water: middle course of the Syrdarya River – prevalence 0.7-30.0%, intensity of infection 1-72 individuals; Aidar Arnasay lake system – prevalence 0.9-27.8%, intensity of infection 1-46 individuals; Tuyabuguz reservoir – prevalence 2.1-26.6%, intensity of infection 1-38 individuals; fishing farms – prevalence 0.3-29.6%, intensity of infection 1-67 individuals; canals – prevalence 3.1-20.3%, intensity of infection 1-42 individuals.

The role of anthropogenic factors in the formation of the helminthofauna of predatory fish is great. Probably, its development in bodies of water in the middle course of the Syrdarya River started when people began to practise fishing and other commercial activities. Human economic activities result in the formation of favourable conditions for the development of a number of parasitic species, expansion of their ranges, while for other species these conditions may be unfavourable and lead to a relative shrinkage of their habitats or complete disappearance of some species.

For example, the studies of bodies of water in Karakalpakstan confirm that, 50-60 years ago (Kurbanova, 2002, 2020), the drying of the Aral Sea and the ecological crisis led to a sharp reduction in the species composition of helminths of fish (Allamuratova, 2011). A similar situation is observed in bodies of water in the middle reaches of the Syrdarya River, which is the result of the development of the Mirzachul desert. Specific human activities can become key factors for quantitative and qualitative changes in the helminth fauna of fish and the elimination of dangerous helminthiases.

Parasitic worms living in predatory fish are divided into two groups. *Biohelminths* change hosts during their life cycles. They infect the definitive host by leaving an intermediate host, or by their larvae penetrating passively or actively into the definitive host's organism (trematodes, cestodes and some species of nematodes). *Geohelminths* are characterised by a life cycle taking place entirely in one definitive host, with some stages developing in the external environment (most nematode species). In this case, the parasites penetrate the definitive host directly from the external environment.

The obtained data on the helminths' species composition are used to develop measures to control parasitic deseases of fish in bodies of water in the middle course of the Syr Darya. The results of the research into the helminthofauna of predatory fish should be taken into account when implementing fishing-related activities in bodies of water.

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NOVELTY STATEMENT

The current status of helminth species parasitising predatory fish (*Silurus glanis Sander lucioperca*, *Esox lucius*) in the middle course of the Syrdarya River was analysed for the first time. The research revealed 35 species of parasites in 32 genera, 22 families, 13 orders, 4 classes and 3 phyla, with 22 species identified as biohelminths, and 11 as geohelminths. 29 species of helminths were recorded in the wels catfish, 19 in the zander, and 22 in the pike. Prevalence ranged from 0.3% to 32.1%, and intensity of infection was between 1 and 72 individuals.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

AUTHOR'S CONTRIBUTION

The material was collected, the morphology studied and statistical data analysed by Oybek Abduganiev. The species were identified, the collected material analysed and handwritten copies of articles prepared by Erkinjon Shakarboev. Both authors have read and approved the manuscript.

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