ISSN 2075-5457 (print), ISSN 2220-9697 (online)

DOI: 10.26565/2075-5457-2025-44-10
UDC: 576.895.122

Comparative ecological analysis of the trematode fauna of fishes of the reservoirs cascade on the Kura River within Azerbaijan

Y.V. Shakaraliyeva

In 2007-2022, in four reservoirs forming a cascade on the Kura River, 1243 fish of 30 species were examined for trematode infection using the method of complete parasitological dissection. For this purpose, 283 fish of 21 species were examined in the Shamkir Reservoir, 276 fish of 21 species in the Yenikend Reservoir, 341 fish of 25 species in the Mingechevir Reservoir, and 343 fish of 26 species in the Varvara Reservoir. As a result of the conducted research, 39 species of trematodes were found, of which 11 species parasitize in the lenses of the eyes, 9 species in the intestines, 4 species in the muscles and under the skin, one species each in the bloodstream, vitreous body, stomach, oral cavity and esophagus, urinary bladder, ureters, and kidneys, heart, brain, skin and fins, muscles and mesentery, walls of the swim bladder and kidneys, scales; 2 species at the metacercaria stage live in various tissues of fish, and in the adult stage – In the intestines of predatory fish. Among the found trematodes, 14 species use fish only as a definitive host, 23 species parasitize in fish only at the larval stage, completing their development in fish-eating birds, 2 species use various fish as a second intermediate host, and predatory fish as a definitive host. When comparing the studied reservoirs, it turned out that the greatest number of trematode species was found in fish from the relatively small Varvara Reservoir, where fish were infected with 27 trematode species. This is due to the fact that most of this reservoir is shallow, has a weak current and a lot of aquatic vegetation, which creates favorable conditions for the development of mollusks – the first intermediate hosts of trematodes, and also attracts fish-eating birds, which are the final hosts of many species of fish trematodes. Next in terms of the number of fish trematode species is the Mingechevir Reservoir, where 25 species were found in fish. It is the largest among the reservoirs we studied and has large areas with a slow current. In the fish of the Shamkir Reservoir, which is the second largest, 20 trematode species were noted, and in the relatively small Yenikend Reservoir, where there is a fast current, 17 species of fish trematodes were recorded. In each reservoir, the species composition of fish trematodes is richer in those areas where there is no fast current, overgrowing with aquatic vegetation is observed and fish-eating birds are present. It turned out that in reservoirs located close to each other, same species are found more often than in reservoirs located far from each other. Since previous studies, which were conducted by different authors in the 1950s, 1970s and 2000s, the species composition of fish trematodes in reservoirs that form a cascade on the Kura River has been significantly enriched. Among the trematodes found, 14 species are pathogenic for fish and 2 species are dangerous to humans.

Key words: *fish, parasites, trematodes, Azerbaijan, Kura River basin, reservoirs*

Cite this article: *Shakaraliyeva Y.V. (2025) Comparative ecological analysis of the trematode fauna of fishes of the reservoirs' cascade on the Kura River within Azerbaijan. The Journal of V. N. Karazin Kharkiv National University. Series "Biology", p. 118-130 . https://doi.org/10.26565/2075-5457-2025-44-10*

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Received: 27.01.2025 / Revised: 12.04.2025 / Accepted: 16.04.2025

Introduction

The Kura is the largest river in the South Caucasus, its length is 1515 km, and the catchment area is 188 thousand km^2. About 906 km of its length passes through the Republic of Azerbaijan. Here, a cascade consisting of the Shamkir, Yenikend, Mingechevir and Varvara reservoirs was built on the Kura. Table 1 provides data on the main indicators of these reservoirs based on the literature (Republic of Azerbaijan. National Atlas 2014; Mustafayev, 2023). It is clear from it that they were built at different times, vary greatly in size and have a fairly rich ichthyofauna.

Till our studies, the trematodes of fish in these reservoirs had been studied very insufficiently. In the late 1950s, T.K. Mikailov (1975), who conducted a short-term parasitological study of fish in the Mingechevir Reservoir, found only 2 species of trematodes, N.Sh. Kazieva (1984), when studying the parasite fauna of fish in the Varvara Reservoir, noted 11 species of trematodes, and N.E. Ibragimova (2008), along with other parasites, noted 13 species of trematodes in fish in the Yenikend Reservoir. This was the limit of information on the trematode fauna of fish in the four reservoirs mentioned above. The purpose of this article is to present new data on the modern trematode fauna of fish in the cascade of reservoirs on the Kura and to conduct their comparative analysis.

Table 1. Main indicators of reservoirs included in the cascade on the Kura River (Abbreviations: ShR – Shamkir reservoir, YR – Yenikend reservoir, MR – Mingechevir reservoir, VR – Varvara reservoir)

Names of reservoirs	Year of construction	Area, km^2	Volume, million m^3	Number of species in the ichthyofauna
ShR	1982	115	2677	25
YR	2000	78	158	22
MR	1953	605	16070	27
VR	1956	22,5	60	27

Material and method

The material for this article is the results of parasitological studies of fish conducted in 2007-2022 in 12 various sections of the reservoir cascade on the Kura River (figure 1).

Fig. 1. Map of study area and locations of material collection points (collection points: 1, 2, 3 – in the Shamkir Reservoir; 4, 5 – in the Yenikend Reservoir; 6, 7, 8, 9, 10, 11 – in the Mingechevir Reservoir; 12 – in the Varvara Reservoir).

In total, we examined 1243 fish specimens of 30 species using the method of complete parasitological dissection (Bykhovskaya-Pavlovskaya 1985; Pronina, Pronin 2003; Dorovskikh, Stepanov 2009), including 283 fish of 21 species from the Shamkir Reservoir, 276 fish of 21 species from the Yenikend Reservoir, 341 fish of 25 species from the Mingechevir Reservoir, and 343 fish of 26 species from the Varvara Reservoir (table 2).

To determine the species affiliation of fish, keys from various monographs were used (Abdurakhmanov, 1962; Naseka 2004; Bogutskaya et al., 2013; Mustafayev, 2023) and were guided by data on the current state of the ichthyofauna of Azerbaijan (Ibrahimov, Mustafayev, 2015; Kuljanishvili et al., 2020, 2021). We were dissected only recently dead fish. They were obtained from fish farms or caught by us in accordance with the permission of the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan. In some cases, the fish were frozen and delivered to the laboratory, where they were subjected to a complete parasitological dissection. The trematodes found by us as a result of dissection were fixed in a 70% ethyl alcohol solution for storage until the laboratory processing and identification. All trematodes, with the exception of representatives of the genus *Diplostomum*, after being removed from the alcohol solution, were soaked in distilled water for 10-15 hours, and then stained with alumino carmine. After staining, to

Table 2. Main indicators of reservoirs included in the cascade on the Kura River (For abbreviations, see Table 1)

Names of fish	ShR	YR	MR	VR
Family Esocidae				
Northern pike – *Esox lucius* Linnaeus, 1758				15
Family Cyprinidae				
Caspian roach – *Rutilus caspicus* (Jakovlev, 1870)	16	18	15	17
Caucasian chub – *Squalius agdamicus* (Kamensky, 1901)	12	11	10	
Caspian asp – *Aspius aspius taeniatus* (Eichwald, 1831)	12	10	11	9
Stone moroko – *Pseudorasbora parva* (Temminck et Schlegel, 1846)				12
Tench – *Tinca tinca* (Linnaeus, 1758)		9	12	11
Kura khramulya – *Capoeta capoeta* (Güldenstaedt, 1773)	15	15	12	14
Bulatmai barbel – *Barbus capito* (Güldenstaedt, 1773)	14	12	11	10
Kura shemaya – *Alburnus chalcoides* (Güldenstaedt, 1772)	15	17	15	14
Kura bleak – *A. filippi* Kessler, 1877	16	19	18	14
South Caucasian bleak – *A. charusini hohenackeri* Kessler, 1877			15	16
Schneider – *Alburnoides eichwaldi* (Filippi, 1863)	14	18	18	15
White bream – *Blicca bjoerkna transcaucasica* Berg, 1916			10	
Oriental bream – *Abramis brama orientalis* Berg, 1949	14	11	19	14
Caspian zahrte – *Vimba vimba persa* (Pallas, 1774)			10	8
Sharpbelly – *Hemiculter leucisculus* (Basilewsky, 1855)			15	12
European bitterling – *Rhodeus amarus* (Bloch, 1782)	16			14
Prussian carp – *Carassius gibelio* Bloch, 1782	17	16	18	19
European carp – *Cyprinus carpio* Linnaeus, 1758	15	18	17	15
Family Balitoridae				
Kura loach – *Oxynoemacheilus brandti* (Kessler, 1877)	12	10	11	13
Khvalin loach – *Cobitis amphilekta* Vasil’eva et Vasil’ev, 2012	10	11	14	15
Golden spined loach – Sabanejewa *aurata* (Filippi, 1865)	11	10	11	12
Family Siluridae				
Catfish – *Silurus glanis* Linnaeus, 1758	13	10	12	11
Family Poeciliidae				
Mosquitofish – *Gambusia affinis* (Baird et Girard, 1853)	15	17	19	18
Family Percidae				
Zander – *Sander lucioperca* (Linnaeus, 1758)	15	16	15	14
Perch – *Perca fluviatilis* Linnaeus, 1758				12
Family GOBİİDAE				
Round goby – *Neogobius melanostomus* (Pallas, 1814)	10	9	11	10
Monkey goby – *N. fluviatilis pallasi* (Berg, 1949)			10	9
Bighead goby – *Ponticola gorlap* (Iljin, 1949)	11	10	12	
Tubenose goby – *Proterorhinus marmoratus* (Pallas, 1814)	10	9		

remove excess paint, they were dipped for several minutes in a 70% ethyl alcohol solution acidified with hydrochloric acid. After this the worms were washed in 70% ethanol solution, then passed through an alcohol series with increasing concentration, respectively 80%, 90%, 96% and 100%, after which they were clarified in a drop of clove oil, placed in a drop of Canada balsam on a glass slide and covered with a coverslip. Metacercariae of trematodes of the genus *Diplostomum* were stained with acetic carmine using a special technique (Shigin, 1996). Determination of trematode species was made according to the relevant monographs (Bykhovskaya-Pavlovskaya, Kulakova 1987; Gaevskaya et al., 1975; Ibrahimov, 2012) taking into account modern data on trematode taxonomy (Gibson, 1996; Gibson et al., 2002; Jones et al., 2005).

Permanent preparations made in the manner described above are currently stored in the collection of the Department of Medical Biology and Genetics of the Azerbaijan Medical University.

Results and discussion

As a result of our research, 39 species of trematodes belonging to 3 orders, 13 families and 20 genera were found in fish living in the cascade of reservoirs on the Kura River (Table 3).

Table 3. Distribution of fish trematodes in reservoirs on the Kura River (For abbreviations, see Table 1)

Names of the discovered trematodes	ShR	YR	MR	VR
Bucephalus polymorphus Baer, 1827		+		+
Rhipidocotyle companula (Dujardin, 1845)		+		+
Sanguinicola inermis Plehn, 1905				+
Asymphylodora demeli Markowsky, 1935		+	+	
A. imitans (Müling, 1898)			+	+
A. tincae (Modeer, 1790)			+	+
Phyllodistomum angulatum Linstow, 1907				+
Ph. elongatum Nybelin, 1926			+	+
Ph. simile Nybelin, 1926			+	
Azygia lucii (Mueller, 1776)				+
Allocreadium baueri Spassky et Roitman, 1960	+			
A.carparum Odening, 1959	+			
A.dogieli Kowal, 1950			+	+
A.isoporum (Looss, 1894)	+	+	+	+
Bunodera luciopercae (Mueller, 1776)			+	+
Sphaerostomum bramae Mueller, 1776	+	+	+	+
Diplostomum chromatophorum (Brown, 1931)	+	+	+	+
D. commutatum (Diesing, 1850)	+			+
D. gobiorum Shigin, 1965	+			+
D. helveticum (Dubois, 1923)	+	+	+	
D. mergi Dubois, 1932	+	+	+	+
D. nemachili Zhatkanbaeva et Schigin, 1986		+	+	
D. nordmanni Shigin et Sharipov, 1986	+			+
D. paracaudum Iles, 1959	+	+	+	
D. parviventosum Dubois, 1932	+		+	+
D. spathaceum (Rudolphi, 1819)	+		+	+
D. volvens Nordmann, 1832	+	+		
Tylodelphys clavata (Nordmann, 1832)	+	+	+	+
T. podicipina Kozicka et Niewiadomska, 1960	+	+	+	
Bolboforus confusus (Krause, 1914)				+
Hysteromorpha triloba (Rudolphi, 1819)	+	+	+	+
Conodiplostomum perlatum (Ciurea, 1911)			+	
Ornithodiplostomum scardinii (Schulman, 1952)	+		+	
Posthodiplostomum brevicaudatum (Nordmann, 1832)				+
P. cuticola (Nordmann, 1832)	+	+	+	+
Apharhyngostrigea cornu (Zeder, 1800)			+	
Ichthyocotylurus pileatus (Rudolphi, 1802)			+	+
Clinostomum complanatum (Rudolphi, 1819)	+	+	+	+
Metagonimus yakogowai Katsurada, 1912		+		+

Among the trematodes we found in fish inhabiting the cascade of reservoirs on the Kura River11 species (*Diplostomum chromatophorum, D. commutatum, D. gobiorum, D. helveticum, D. mergi, D. nemachili, D. nordmanni, D. paracaudum, D. parviventosum, D. spathaceum, D. volvens)* parasitize in the lenses of the eyes, 9 species *(Asymphylodora demeli, A. imitans, A. tincae, Allocreadium baueri, A. carparum, A. dogieli, A. isoporum, Bunodera luciopercae, Sphaerostomum bramae*) – in the intestine, 4 species (*Tylodelphys clavata, Bolboforus confusus, Hysteromorpha triloba, Clinostomum complanatum*) – in muscles and under the skin, 1 species (*Tylodelphys podicipina*) – in the vitreous body, 1 species (*Azygia lucii*) – in the stomach, oral cavity and esophagus, 1 species (*Phyllodistomum angulatum*) – in the urinary bladder and kidneys, 1 species (*Ph. elongatum*) – in the ureters, 1 species (*Ph. simile*) – in the bladder and ureters, 1 species (*Sanguinicola inermis*) – in the bloodstream, 1 species (*Conodiplostomum perlatum*) – on the skin, in the swim bladder and kidneys, 1 species (*Ornithodiplostomum scardinii*) – in the heart, 1 species

 ISSN 2075-5457 (print), ISSN 2220-9697 (online)

(*Posthodiplostomum brevicaudatum*) – in the eyes, in the brain, 1 species (*P. cuticola*) – in the skin and fins, 1 species (*Apharhyngostrigea cornu*) – in the muscles and mesentery, 1 species (*Ichthyocotylurus pileatus*) – in the walls of the swim bladders and kidneys, 1 species (*Metagonimus yakogowai*) – in the scales, 2 species (*Bucephalus polymorphus, Rhipidocotyle companula*) – at the metacercaria stage located in various fish tissues, in the adult live in the intestines of predatory fish; 14 species (*Sanguinicola inermis, Asymphylodora demeli, A. imitans, A. tincae, Bunodera luciopercae, Phyllodistomum angulatum, Ph. elongatum, Ph. simile, Azygia lucii, Allocreadium baueri, A. carparum, A. dogieli, A. isoporum, Sphaerostomum bramae*) use fish only as definitive hosts, 23 species (*Diplostomum chromatophorum, D. commutatum, D. gobiorum, D. helveticum, D. mergi, D. nemachili, D. nordmanni, D. paracaudum, D. parviventosum, D. spathaceum, D. volvens, Tylodelphys clavata, T. podicipina, Bolboforus confusus, Hysteromorpha triloba, Conodiplostomum perlatum, Ornithodiplostomum scardinii, Posthodiplostomum brevicaudatum, P. cuticola, Apharhyngostrigea cornu, Ichthyocotylurus pileatus, Clinostomum complanatum, Metagonimus yakogowai*) parasitize fish only at the larval stage (metacercaria). The exception to these lists are two species (*Bucephalus polymorphus and Rhipidocotyle companula*), which use various fish as a second intermediate host and complete their development in the intestines of piscivorous fish.

The found species of trematodes, as well as all trematodes in general, have a weakly expressed specificity in relation to their hosts. Among them, only *Asymphylodora tincae* parasitizes in the intestines of mainly one species of fish – tench, although it is often, but in much smaller quantities, noted in the digestive tract of various predatory fish, as result of apparently, to eating infested tenches. Relatively narrow circle of hosts is shown by the trematode *Diplostomum gobiorum*, which parasitizes only in the lenses of the eye of goby fish, *D. nemachili*, living only in the lenses of the eye of fish belonging to the genus *Nemachilus*; as well as adult individuals of *Bucephalus polymorphus* and *Rhipidocotyle companula*, which parasitize only in the intestines of various freshwater predatory fish, their metacercariae are parasites of fish tissues. *Bunodera luciopercae* is also a parasite of freshwater predatory fish, but its metacercariae live in crustaceans; *Phyllodistomum angulatum* and *Ph. simile* are parasites of the bladder, ureters and kidneys of freshwater predatory fish; *Azygia lucii* is a typical parasite with an digestive tract of pike, and is much less common in other fish; *Sanguinicola inermis, Phyllodistomum elongatum, Asymphylodora demeli, A. imitans, Allocreadium baueri, A. carparum, A. dogieli, A. isoporum, Sphaerostomum bramae, Diplostomum parviventosum, D. nordmanni, Tylodelphys clavata, Hysteromorpha triloba, Conodiplostomum perlatum, Ornithodiplostomum scardinii, Apharhyngostrigea cornu* are specific parasites of cyprinid fish. In contrast, metacercariae of the trematodes *Diplostomum chromatophorum, D. commutatum, D. helveticum, D. mergi, D. paracaudum, D. spathaceum, D. volvens, Tylodelphys podicipina, Bolboforus confusus, Posthodiplostomum brevicaudatum, P.cuticola, Ichthyocotylurus pileatus, Clinostomum complanatum, Metagonimus yakogowai* have a significantly wider range of hosts and parasitize in the tissues of fish of various families.

As expected, the studied water bodies differed in the number of trematode species found in them. There was not fount direct correlation between the number of trematode species in fish and the size of the reservoir. Thus, 27 species were found in the fish of the smallest Varvara Reservoir, and 25 species in the largest – Mingechevir Reservoir, 20 species were found in the fish living in the Shamkir Reservoir, and 17 species in the fish of the Yenikend Reservoir. Such distribution of the number of fish trematode species by reservoirs to a certain extent reflects the living conditions in each of them. Thus, the Varvara Reservoir, which is relatively small in size, has a low current speed and shallow depth, most of its area is covered with aquatic vegetation. Such conditions are very favorable for the habitation of mollusks – the first intermediate hosts of trematodes and fish-eating birds – the definitive hosts of many of them.

In the Mingechevir Reservoir, the number of trematode species was only one less than in the Varvara Reservoir. Although this reservoir is very deep, its coastal part has many shallow areas overgrown with aquatic vegetation, favorable for the development of mollusks and nesting of fish-eating birds. In addition, due to its large area and volume of this water body, the speed of the current in this is low. We collected material at 6 stations in the coastal part of Mingechevir. The trematode fauna of fish caught in different areas differs significantly, which is due to differences in habitat conditions. A relatively large number of trematode species were found in fish studied at stations 6, 7 and 8, which are located in the upper part of the reservoir, not far from the places where rivers flow. Due to the silt carried by the rivers, the depth in these areas is less, and the benthos composition is richer than in the lower part, there are accumulations of fish-eating birds, which are the final hosts of a number of fish trematode species. The species composition of trematodes was the richest (18 species) at station 7, which is located at the confluence of the Kura River into the reservoir, followed by station 8 in terms of the number of trematode fauna (15 species), located near the confluence of the Ganykh River, and in third place was station 6 (12 species) – near the confluence of the Gabyrry River. Next in terms of the number of species was station 11 (10 species), which is located at the outlet of the Kura River from the reservoir. Here, as at station 9 (9 species), there are also shallow areas, fish-eating birds are found. The smallest number (6) of fish trematode species was noted at station 10, where the coast is steep, and fish-eating birds are not found.

The Shamkir Reservoir is the third among the water bodies we have studied in terms of the number of trematode species we have found. In the upper part of this reservoir, where the Kura flows into and where station 1 is located, the current speed is quite significant. In this regard, the trematode fauna of fish here was the poorest (13 species) compared to the other two sections of this water body we have studied. The second place in terms of the number of trematode species (16 species) is occupied by station 2, where the current speed is very low, there is a small amount of aquatic vegetation, and waterfowl are observed. We found the largest number of trematode species (19) in fish living in the area of station 3, located not far from where the water leaves the reservoir. Here, an area has formed that resembles a small bay with an almost imperceptible current, an abundance of aquatic vegetation, and a significant number of fish-eating birds.

Among the reservoirs we studied, the smallest number of trematode species was found in fish living in the Yenikend reservoir, which is characterized by a clearly visible current throughout its length, weak overgrowth, and a small number of fish-eating birds. At stations 4 and 5 located in this reservoir, almost the same trematode species were found, the number of species was 14 and 13, respectively.

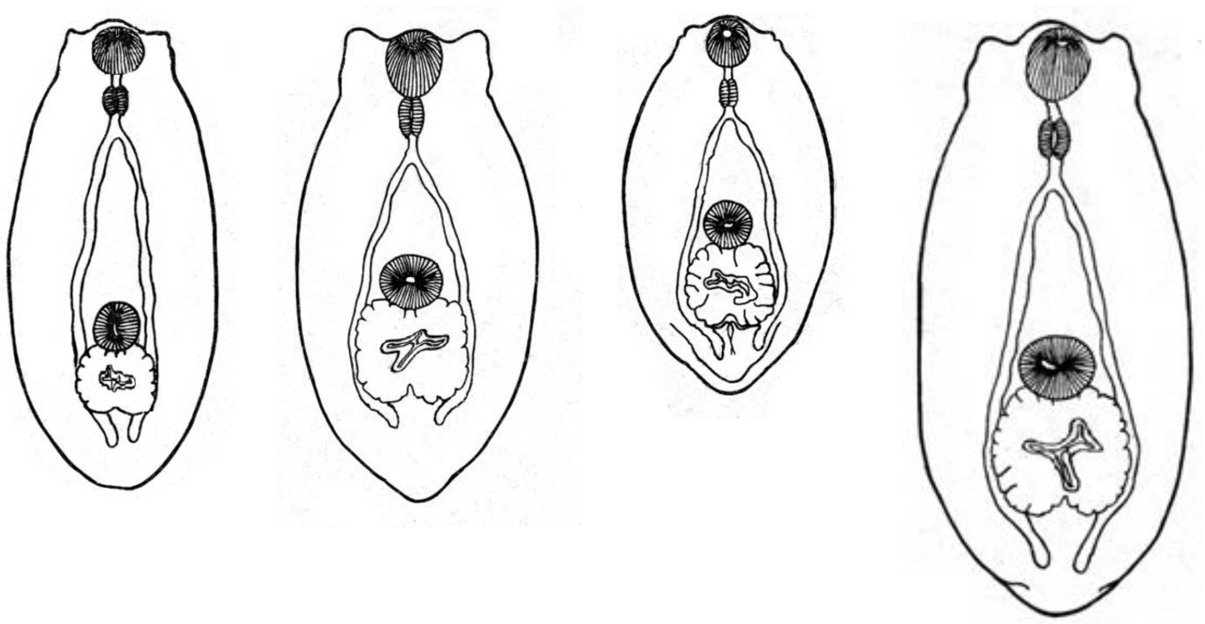
Since all four reservoirs we examined belong to the basin of one river, the Kura, and are located close to each other, the species composition of trematodes and fish trematodes has significant similarities. This is also due to the fact that, together with the water flowing out of the reservoirs located upstream, infected intermediate hosts and cercariae of trematodes are carried to the reservoirs located downstream, and the species that complete their development in fish-eating birds and mammals are carried by their final hosts to all these reservoirs. Moreover, the closer the reservoirs are located to each other, the more similarities are observed in the fauna of trematodes. Thus, a comparatively high coefficient of similarity according to Czekanowski-Sorensen (Czekanowski 1913; Sorensen 1948) in this respect is observed in the nearby Shamkir and Yenikend (64.9%), Yenikend and Mingechevir (60.5%), and Mingechevir and Varvara (60.4%) reservoirs. However, there are significantly more differences between the trematode faunas of reservoirs located far from each other, so the similarity between Shamkir and Mingechevir is 56.6%, Shamkir and Varvara – 55.3%, and Yenikend and Varvara – 50.0%.

Of the two trematode species (*Phyllodistomum elongatum* and *Allocreadium isoporum*) found in the 1950s (Mikailov, 1975) in fish from the Mingechevir Reservoir, we also found both. Of the 11 trematode species (*Rhipidocotyle companula, Phyllodistomum elongatum, Diplostomum commutatum, D. helveticum, D. mergi, D. paracaudum, D. spathaceum, Tylodelphys clavata, Hysteromorpha triloba, Clinostomum complanatum, Metagonimus yakogowai*) found in fish from the Varvara Reservoir in 1973-76 (Kazieva, 1984), we did not find only *Diplostomum helveticum* and *D. paracaudum*. In addition, we also found the following trematodes in the fish of this reservoir: *Bucephalus polymorphus, Sanguinicola inermis, Asymphylodora imitans, A. tincae, Bunodera luciopercae, Azygia lucii, Allocreadium dogieli, A.isoporum, Sphaerostomum bramae, Diplostomum chromatophorum, D. gobiorum, D. nordmanni, D. parviventosum, Bolboforus confusus, Posthodiplostomum brevicaudatum, P. cuticola, Ichthyocotylurus pileatus*, which were not noted by this author. Due to the fact that we found a significant number of species of trematodes new to this reservoir, the similarity coefficient of the trematode fauna indicated by this author and noted by us was low and amounted to 31.6%.

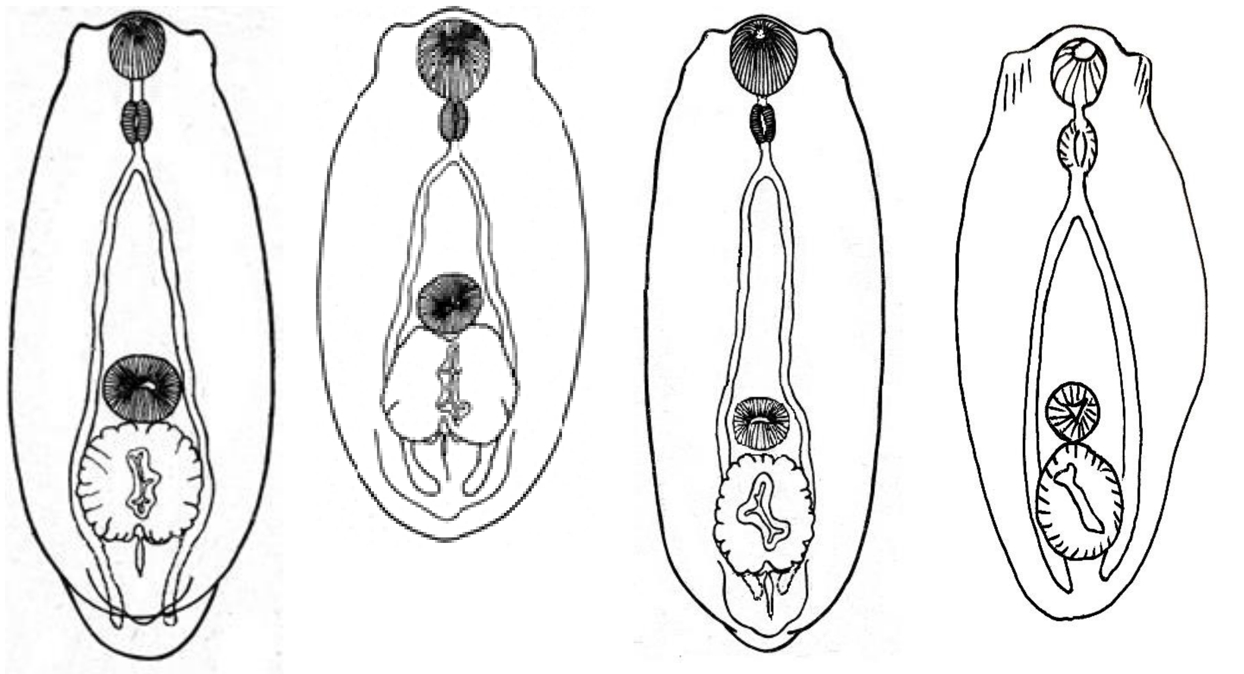
Of the 12 species of trematodes (*Bucephalus polymorphus, Rhipidocotyle companula, Diplostomum mergi, D. paracaudum, D. chromatophorum, D. spathaceum, Asymphilodora kubanica, Hysteromorpha triloba, Posthodiplostomum cuticola, Clinostomum complanatum, Ascocotyle coleostoma, Metagonimus yokogawai*), indicated according to the results of studies conducted in 2001-2005 (Ibragimova, 2008) in the Yenikend Reservoir, we found all, with the exception of *Ascocotyle coleostoma*. In addition, we also found *Allocreadium isoporum, Sphaerostomum bramae, Diplostomum commutatum, D. helveticum, D. nemachili* and *Tylodelphys clavata* in the fish of this reservoir, which were not noted by this author. As a result, the similarity coefficient of the trematode fauna noted by this author and noted by us was 69.1%.

Among the parasites we noted in the cascade of reservoirs on the Kura River, *Sanguinicola inermis, Diplostomum chromatophorum, D. commutatum, D. gobiorum, D. helveticum, D. mergi, D. nemachili, D. nordmanni, D. paracaudum, D. parviventosum, D. spathaceum, D. volvens, Posthodiplostomum cuticola* and *Ichthyocotylurus pileatus* according to the literature (Atayev, Zubairova, 2015) are pathogens of fish, *Metagonimus yakogowai* (Baryshnikov, 2014; Ibrahimov et al., 2016) and *Clinostomum complanatum* are dangerous for humans (Parket et al., 2009; Hara et al., 2014; Song et al.; 2018; Kim et al., 2023). Figure 2 shows the most pathogenic metacercariae for fish of the genera *Diplostomum* and *Posthodiplostomum*.

 ISSN 2075-5457 (print), ISSN 2220-9697 (online)



D. chromatophorum *D. commutatum* *D. gobiorum.* *D. helveticum*



D. mergi *D. nemachili* *D. nordmanni* *D. paracaudum*

 ISSN 2075-5457 (print), ISSN 2220-9697 (online)

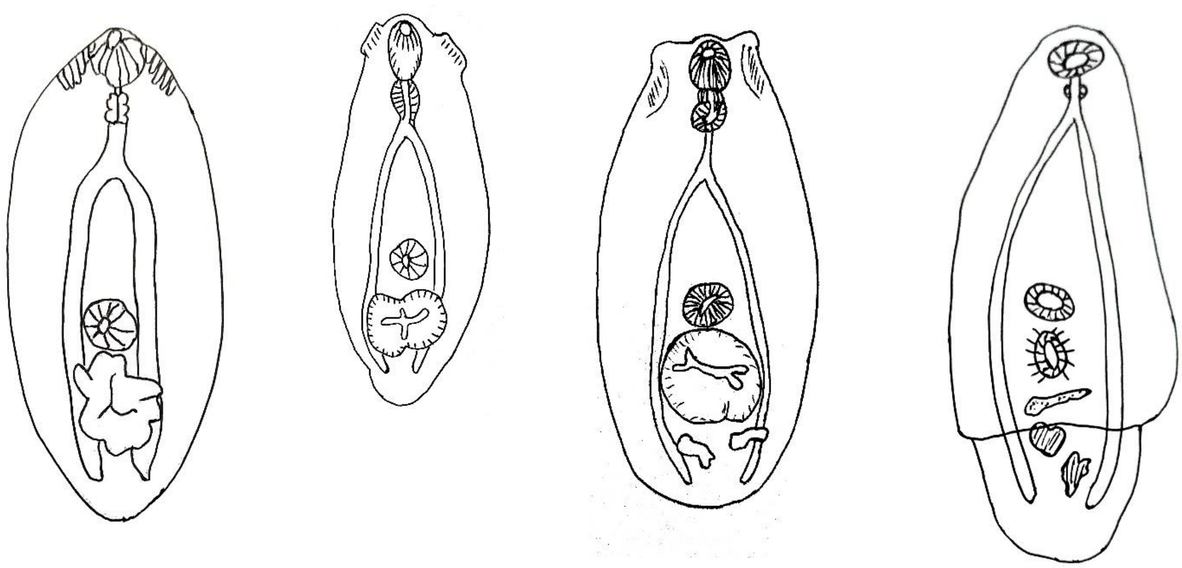


Fig. 2. Pathogenic for fish metacercariae of trematodes of the genera *Diplostomum* and *Posthodiplostomum* (original drawings)

Conclusion

As a result of parasitological examination of *1243* fish specimens belonging to 30 species caught from four reservoirs forming a cascade on the Kura River, 39 species of trematodes were found, of which 14 species use fish only as *definitive* hosts, 23 species parasitize fish only at the larval stage, and 2 species use fish as both a second intermediate and *definitive* host. The following number of trematode species were found in different reservoirs: 20 in the Shamkir Reservoir, 17 in the Yenikend Reservoir, 25 in the Mingechevir Reservoir, and 27 in the Varvara Reservoir. In each reservoir, the species composition of fish trematodes is richer in areas where there is no fast current, overgrowing with aquatic vegetation is observed, and fish-eating birds are present. It turned out that reservoirs located nearby have more common species than reservoirs located far from each other. Since previous studies conducted by various authors in the 1950s, 1970s and 2000s, the fauna of fish trematodes has been significantly enriched. Among the trematodes found, 14 species are pathogenic for fish and 2 species are dangerous to humans.

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Supplementary files

Table S1. Percentage identities of *Oncomelania quadrasi* and *Oncomelania robertsoni* CO1

Species			*O. quadrasi*
	Accession	**E value**	**DQ112287.1**
O. robertsoni	DQ212800.1	0.0	87.77%
O. robertsoni	DQ212803.1	0.0	87.62%
O. robertsoni	DQ212805.1	0.0	87.62%
O. robertsoni	KR002675.1	0.0	87.25%
O. robertsoni	DQ212797.1	0.0	86.83%
O. robertsoni	DQ212798.1	0.0	86.83%
O. robertsoni	DQ212813.1	0.0	86.83%
O. robertsoni	DQ212799.1	0.0	86.68%
O. robertsoni	DQ212801.1	0.0	86.68%
O. robertsoni	DQ212802.1	0.0	86.68%
O. robertsoni	DQ212806.1	0.0	86.68%
O. robertsoni	DQ212807.1	0.0	86.68%
O. robertsoni	DQ212808.1	0.0	86.68%
O. robertsoni	DQ212809.1	0.0	86.68%
O. robertsoni	DQ212810.1	0.0	86.68%
O. robertsoni	DQ212812.1	0.0	86.68%
O. robertsoni	DQ212811.1	0.0	86.36%
O. robertsoni	JF284697.1	0.0	86.36%
O. robertsoni	AF531547.1	0.0	85.91%

O.: Oncomelania; S1: Supplementary 1

 ISSN 2075-5457 (print), ISSN 2220-9697 (online)

Table S2. Percentage identities of *Oncomelania hupensis* and *Omcomelania robertsoni* CO1

Species			***O. hupensis***
	Accession	**E value**	**GU367391.1**
O. robertsoni	DQ212802.1	0.0	88.99%
O. robertsoni	DQ212797.1	0.0	88.77%
O. robertsoni	DQ212798.1	0.0	88.77%
O. robertsoni	DQ212803.1	0.0	88.71%
O. robertsoni	DQ212805.1	0.0	88.71%
O. robertsoni	DQ212800.1	0.0	88.67%
O. robertsoni	KR002675.1	0.0	88.29%
O. robertsoni	AF531547.1	0.0	87.84%
O. robertsoni	DQ212813.1	0.0	87.77%
O. robertsoni	DQ212808.1	0.0	87.62%
O. robertsoni	DQ212809.1	0.0	87.62%
O. robertsoni	DQ212810.1	0.0	87.62%
O. robertsoni	DQ212812.1	0.0	87.62%
O. robertsoni	JF284697.1	0.0	87.30%
O. robertsoni	DQ212799.1	0.0	86.99%
O. robertsoni	DQ212801.1	0.0	86.99%
O. robertsoni	DQ212804.1	0.0	86.99%
O. robertsoni	DQ212806.1	0.0	86.99%
O. robertsoni	DQ212807.1	0.0	86.99%
O. robertsoni	DQ212811.1	0.0	86.68%

O.: Oncomelania; S2: Supplementary 2

Table S3. Megablast results on *Oncomelania robertsoni* Sichuan Plain SCB

Species			***O. robertsoni***
	accession	**E value**	**KR002675.1**
O. robertsoni	DQ212808.1	0.0	99.67%
O. robertsoni	DQ212809.1	0.0	99.67%
O. robertsoni	DQ212810.1	0.0	99.67%
O. robertsoni	DQ212812.1	0.0	99.67%
O. robertsoni	DQ212797.1	0.0	99.50%
O. robertsoni	DQ212798.1	0.0	99.50%
O. robertsoni	DQ212813.1	0.0	99.50%
O. robertsoni	JF284697.1	0.0	98.49%
O. robertsoni	DQ212799.1	0.0	97.83%
O. robertsoni	DQ212801.1	0.0	97.83%
O. robertsoni	DQ212802.1	0.0	97.83%
O. robertsoni	DQ212804.1	0.0	97.83%
O. robertsoni	DQ212806.1	0.0	97.83%
O. robertsoni	DQ212807.1	0.0	97.83%
O. robertsoni	DQ212811.1	0.0	97.49%
O. robertsoni	DQ212800.1	0.0	95.48%
O. robertsoni	DQ212803.1	0.0	95.32%
O. robertsoni	DQ212805.1	0.0	95.32%
O. robertsoni	AF531547.1	0.0	91.20%

O.: Oncomelania; S3: Supplementary 3

 ISSN 2075-5457 (print), ISSN 2220-9697 (online)

Table S4. Megablast results on Oncomelania robertsoni Sichuan Anning River Valley (China) – SAV

Species	accession	E value	*O. robertsoni* AF213339.1
O. robertsoni	DQ212814.1	0.0	100%
O. robertsoni	DQ212815.1	0.0	100%
O. robertsoni	DQ212816.1	0.0	100%
O. robertsoni	DQ212831.1	0.0	98.90%
O. robertsoni	DQ212834.1	0.0	98.90%
O. robertsoni	DQ212835.1	0.0	98.90%
O. robertsoni	DQ212836.1	0.0	98.90%
O. robertsoni	DQ212822.1	0.0	98.75%
O. robertsoni	DQ212825.1	0.0	98.75%
O. robertsoni	DQ212826.1	0.0	98.75%
O. robertsoni	DQ212827.1	0.0	98.75%
O. robertsoni	DQ212828.1	0.0	98.75%
O. robertsoni	DQ212830.1	0.0	98.75%
O. robertsoni	DQ212832.1	0.0	98.75%
O. robertsoni	DQ212833.1	0.0	98.75%
O. robertsoni	DQ212817.1	0.0	98.59%
O. robertsoni	DQ212823.1	0.0	98.59%
O. robertsoni	DQ212824.1	0.0	98.59%
O. robertsoni	DQ212818.1	0.0	98.43%
O. robertsoni	DQ212819.1	0.0	98.43%
O. robertsoni	DQ212820.1	0.0	98.43%
O. robertsoni	DQ212828.1	0.0	98.43%
O. robertsoni	DQ212821.1	0.0	98.28%
O. robertsoni	DQ212837.1	0.0	98.28%
O. robertsoni	DQ212838.1	0.0	98.28%
O. robertsoni	DQ212839.1	0.0	98.28%
O. robertsoni	DQ212840.1	0.0	98.28%
O. robertsoni	DQ212841.1	0.0	95.77%
O. robertsoni	DQ212842.1	0.0	95.77%
O. robertsoni	DQ212843.1	0.0	95.77%
O. robertsoni	DQ212845.1	0.0	95.77%
O. robertsoni	DQ212847.1	0.0	95.77%
O. robertsoni	DQ212849.1	0.0	95.77%
O. robertsoni	DQ212851.1	0.0	95.77%
O. robertsoni	DQ212848.1	0.0	95.61%
O. robertsoni	EU079378.1	0.0	92.16%
O. robertsoni	JF284697.1	0.0	92.16%
O. robertsoni	DQ112250.1	0.0	91.69%
O. robertsoni	DQ212844.1	0.0	91.07%
O. robertsoni	DQ212846.1	0.0	91.07%

O.: Oncomelania; S4: Supplementary 4

Table S5. Megablast results of *Oncomelania robertsoni*

Species	accession	E value	*O. robertsoni* AF531547.1	Location SCB
O. robertsoni	DQ212846.1	0.0	97.63%	SAV
O. robertsoni	DQ212844.1	0.0	97.46%	SAV
O. robertsoni	DQ112252.1	0.0	96.79%	YEB
O. robertsoni	DQ112250.1	0.0	96.79%	SAV
O. robertsoni	JF284691.1	0.0	96.15%	SAV
O. robertsoni	EU079378.1	0.0	96.15%	SAV
O. robertsoni	AF253075.1	0.0	95.89%	YEB
O. robertsoni	DQ212852.1	0.0	95.72%	YEB

ISSN 2075-5457 (print), ISSN 2220-9697 (online)

Table S5. Megablast results of *Oncomelania robertsoni*

Species	accession	E value	*O. robertsoni* AF531547.1	Location SCB
O. robertsoni	DQ212850.1	0.0	95.40%	SAV
O. robertsoni	AF253074.1	0.0	95.55%	YEB
O. robertsoni	AF213339.1	0.0	91.88%	SAV
O. robertsoni	DQ212836.1	0.0	91.54%	SAV
O. robertsoni	DQ212812.1	0.0	91.20%	SCB
O. robertsoni	KR002675.1	0.0	91.20%	SCB
O. robertsoni	DQ212851.1	0.0	90.52%	SAV
O. robertsoni	DQ212803.1	0.0	90.19%	SCB

*O.: Oncomelania,*Sichuan Anning River Valley (China)-SAV, Sichuan Plain (China)-SCB, Yunnan: Erhai Basin-YEB; S5: Supplementary 5

Порівняльний екологічний аналіз фауни трематод риб каскаду водосховищ на р. Кура в Азербайджані

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У 2007–2022 роках. методом повного паразитологічного перерізу у чотирьох водосховищах, що утворюють каскад на р. Кура, на зараженість трематодами досліджено 1243 екземплярів риби 30 видів. З цією метою у Шамкірськом водосховищі досліджено 258 риб 21 виду, Єнікендському – 252 риб 21 виду, Мінгечавірському – 341 риб 25 видів, Варваринському – 338 риб 26 видів. В результаті проведених досліджень виявлено 39 видів трематод, з них 11 видів паразитують у кришталиках очей, 9 видів у кишечнику, 4 види в м'язах та під шкірою, по одному виду у кровотоку, склоподібному тілі очей, шлунке, порожнині рота та стравоході, сечовому міхурі, сечоводах та нирках, серці, головному мозку, шкірі та плавцях, м'язах, стінках плавального міхура, нирках та лусе; 2 види на стадії метацеркарію мешкають у різних тканинах риб, а на дорослій стадії – у кишечнику хижих риб. Серед знайдених трематод 14 видів використовують рибу тільки як остаточного господаря, 23 види паразитують у рибі тільки на личинковій стадії, завершуючи свій розвиток у рибоїдних птахів, 2 види використовують різних риб як другого проміжного господаря, а хижих риби як остаточного господаря. При порівнянні досліджуваних водойм виявилося, що найбільша кількість видів трематод виявлена у риб відносно невеликого Варварінського водосховища, де риби були заражені 27 видами трематод. Це пов'язано з тим, що більша частина цього водоймища мілководна, має слабку течію і багато водної рослинності, це створює сприятливі умови для розвитку молюсків – перших проміжних господарів трематод, а також залучає рибоїдних птахів, які є остаточними господарями багатьох видів трематод риб. Наступним за кількістю видів трематод риб є Мінгечавірське водосховище, де у риб виявлено 25 видів. Воно є найбільшим серед досліджуваних нами водойм і має великі площі з повільною течією. У рибах Шамкірського водосховища, другого за величиною, відмічено 20 видів, а порівняно невеликому Єнікендському водосховищі, де є швидка течія, зареєстровано 17 видів трематод риб. У кожній водоймі видовий склад трематод риб багатший на тих ділянках, де немає швидкої течії, спостерігається заростання водною рослинністю та присутні рибоїдні птахи. Виявилося, що у водоймах, розташованих близько друг від друга, одні й самі види зустрічаються частіше, ніж у водоймах, розташованих далеко друг від друга. З часів попередніх досліджень, що проводилися різними авторами у 1950-х, 1970-х та 2000-х роках, видовий склад трематод риб у водосховищах, що утворюють каскад на р. Кура значно збагатилася. Серед знайдених трематод 14 видів патогенні для риб та 2 види небезпечні для людини.

Ключові слова: *риба, паразити, трематоди, Азербайджан, басейн річки Кура, водосховища*

Цитування: *Shakaraliyeva Y.V. Comparative ecological analysis of the trematode fauna of fishes of the reservoirs' cascade on the Kura River within Azerbaijan. Вісник Харківського національного університету імені В. Н. Каразіна. Серія «Біологія», 2025, 44 с. 118-130. https://doi.org/10.26565/2075-5457-2025-44-10*

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Подано до редакції: 27.01.2025 / Прорецензовано: 12.04.2025 / Прийнято до друку: 16.04.2025