

The trematode cercariae fauna in Central Uzbekistan

U. Shakarbaev* ** F. Akramova*, D. Paluaniyazova***, B. Allamuratov***,
A. Kurbanova***, O. Samandarov***, I. Arepbaev***, D. Azimov*

**Institute of Zoology, Academy of Sciences of Uzbekistan, Tashkent, Republic of Uzbekistan*

***Alfraganus University, Tashkent, Republic of Uzbekistan*

****Karakalpak State University, Nukus, Republic of Uzbekistan*

Article info

Received 12.05.2025

Received in revised form 04.06.2025

Accepted 01.07.2025

*Institute of Zoology, Bogishamol st.,
232b, Tashkent, 100053, Republic
of Uzbekistan. Tel.: +99-894-625-
08-10. E-mail:
ushakarbaev@gmail.com*

*Alfraganus University, Yukori
Karakamish st., 2A, Tashkent,
100190, Republic of Uzbekistan.
Tel.: +99-894-625-08-10.
E-mail: ushakarbaev@gmail.com*

*Karakalpak State University,
Abdirov st., 1, Nukus, 230112,
Republic of Uzbekistan.
Tel.: +99-897-404-80-32.
E-mail: ushakarbaev@mail.ru*

Shakarbaev, U., Akramova, F., Paluaniyazova, D., Allamuratov, B., Kurbanova, A., Samandarov, O., Arepbaev, I., & Azimov, D. (2025). The trematode cercariae fauna in Central Uzbekistan. Biosystems Diversity, 33(3), e2536. doi:10.15421/012536

The results of the research show that molluscs in the water bodies of Central Uzbekistan were infected with trematode cercariae. The infection of Lymnaeidae, Planorbidae, Physidae and Thiaridae molluscs with trematode cercariae was studied, and larvae of 32 species were identified. The trematode cercariae fauna in Central Uzbekistan has been enriched with a number of new species: *Fasciola gigantica*, *Diplostomum helveticum*, *Calicophoron calicophorum*, *Liorchis scotiae*, *Gastrothylax crumenifer*, *Notocotylus ephemera*, *Skrjabinoeces similis*, *Strigea falconis*, *Philophthalmus lucipetus*, *Dendritobilharzia loossi*, *Gigantobilharzia acotylea*, *Gigantobilharzia* sp. The composition of these cercariae is distinguished by its diversity in the molluscs *Lymnaea auricularia* (14 species) and *Planorbis planorbis* (15 species). In general, it was found that the fauna of the detected cercariae belonged to 15 families of trematodes. 2 cercariae species were recorded in each of the molluscs *Physa fontinalis* and *Melanoides kainarensis*. It was shown that adult forms of the detected trematode cercariae occur in fish, birds and mammals. The importance of molluscs in the formation of the cercariae fauna was highlighted. During the research period, monitoring was carried out in the water bodies of the indicated regions. As an example, stationary studies were conducted on the molluscs *L. auricularia* and *P. planorbis* in the Tudakul Reservoir. During the study period in the upper part of the reservoir, the incidence of accidental infection with trematode parthenites and cercariae in *L. auricularia* mollusca was 22.0–32.6%, in the middle part, the infection rate was 7.6%, and in the lower part, this rate was 11.2–25.7%. A similar situation can be observed with the infection of another mollusca species *P. planorbis*, the difference from *L. auricularia* mollusca is that the infection rate is significantly lower. At the same time, the main factors influencing the formation of the cercariae fauna in the study area are presented.

Keywords: mollusca; trematode; cercaria; parthenites; intermediate host; definitive host; Uzbekistan.

Introduction

Cercariae play an important role in the life cycles of species of the class Trematoda. The life cycle of trematodes is distinguished by parthenogenesis and maritogenesis. The sexually mature hermaphrodite phase of trematodes is parasitic on vertebrates and serves as the definitive host. Cercariae are the larval stage of trematodes, usually developing in the organism of an intermediate host and subsequently becoming an invasive stage that infects the second intermediate or definitive host. Molluscs mainly serve as the first, and sometimes the second intermediate host of trematodes. Molluscs (Mollusca: Pulmonata) are widely distributed throughout the world, occupying a variety of habitats: from permanent to temporary water bodies, from simple spring basins to hot springs, from fresh to salty waters. The wide distribution and ecological diversity of molluscs play a decisive role in the development of intermediate hosts for trematodes (Kruglov, 2005).

Trematodes are the largest group of flatworms, containing from 18,000 (Littlewood & Bray, 2014) to 25,000 nominal species (Esch et al., 2002). With the exception of the Schistosomatidae, most species are hermaphroditic (Khalil, 2002; Pozdnyakov & Gibson, 2008). Trematodes are characterized by a complex life cycle with alternation of generations. While sexually mature organisms develop in the primary host, they undergo a developmental cycle in an intermediate host through polyembryogenesis or parthenogenesis. In the life cycle of trematodes, the primary intermediate hosts are freshwater molluscs, although in rare cases, mussels (Taskinen et al., 1994; Lajtner et al., 2008; Marszewska & Cichy, 2015) and annelids (Martin, 1952; Oglesby, 1961) have been reported to perform this function.

Today, a lot of detailed materials have been published on the life cycles of trematodes and the fauna of cercariae. This has made it possible to establish a connection between certain species of cercariae

and certain species of mammals (Ginetsinskaya, 1968). Various taxonomies have been proposed by a number of researchers for cercariae (Lühe, 1909; Zdun, 1961; Ginetsinskaya, 1968). The first and simplest morphological classification of cercariae was developed by Lühe. This greatly facilitated the description of cercariae (Lühe, 1909). However, due to their morphological similarities, some cercariae are considered complex species (Fried & Toledo, 2004; Kanev et al., 1993), their identification is carried out on the basis of the location of the tegumentary sensory organs or the identification of these larvae is carried out on the basis of molecular genetic methods.

Freshwater molluscs are widespread in the water bodies of Central Uzbekistan and play an important role in biocenoses. The fauna of freshwater molluscs and their infestation with trematode larvae in the central part of Uzbekistan have been studied in fragmentary form. Separate information about these objects is provided in the works of Nasimov (1967), Shakarbaev et al. (2020).

K. Nasimov conducted studies on the fauna of trematode larvae in the Samarkand and Bukhara regions of Uzbekistan (Nasimov, 1964, 1967). In the study of freshwater molluscs of the Lymnaeidae, Planorbidae and Physidae families, the author noted 21 species of trematode cercariae belonging to the families Notocotylidae, Paramphistomidae, Fasciolidae, Echinostomidae, Cataemassidae, Lecithodendriidae, Plagiorchiidae, Allocreadidae, Sanguinicolidae, Schistosomatidae, Bilharziellidae, Strigeidae, Diplostomidae. In terms of the diversity of cercariae species, he formed a list of: 4 species of echinostomatids, 6 species of stylets and 8 species of diplura. The highest rate of infection with trematode larvae was observed in the mollusca *Lymnaea ovata* (7.8%).

Shakarbayev et al. (2020) presented data on the fauna and species composition of trematode cercariae developing in the molluscs of the Lymnaeidae, Planorbidae and Physidae families in the Kattakurgan

Reservoir of the Samarkand region. During the research, 7,510 specimens of molluscs (Lymnaeidae – 4,116 specimens, Planorbidae – 2,280 specimens and Physidae – 620 specimens) were collected and studied. As a result, five species of freshwater molluscs were recorded in this reservoir: *Lymnaea auricularia*, *L. subdisjuncta*, *Costatelia acuta*, *Planorbis planorbis*, *Anisus covexiusculus*. The fauna of trematode cercariae in the recorded molluscs was represented by 16 species belonging to 15 genera. It was noted that *P. planorbis* mollusca were infected with six species of cercariae and *L. auricularia* was infected with five species of cercariae in the studied region.

Materials and methods

Central Uzbekistan is characterized by semi-desert and desert areas. Irrigated lands, water bodies and biocenoses in areas with developed irrigation systems create favorable conditions for the spread of cercariae. One of the most important water bodies in this region is the Tudakul Reservoir, a valuable water body located in the central part of Uzbekistan. Tens of thousands of birds are found in this region permanently or seasonally, which constitute the main group of hosts for the parasitic worms Digenea (Akramova et al., 2024). This region is distinguished by the specificity of its aquatic environments, which are an important biotope for the occurrence of intermediate hosts – molluscs.

The materials were collected from various types of water bodies in the central part of Uzbekistan during 2024–2025. The study was conducted in spring, summer and autumn. The specimens of molluscs

was collected from May to September at the following coordinate points: 39°48'08.24" N 64°57'10.32" E; 39°47'54.88" N 64°56'59.51" E; 39°48'04.77" N 64°57'07.44" E; 39°48'04.19" N 64°57'07.62" E; 39°48'42.4" N 64°51'59.92" E; 39°48'42.78" N 64°51'58.25" E; 39°48'09.31" N 64°50'48.65" E; 39°55'27.02" N 64°52'46.09" E; 39°49'21.38" N 64°43'21.42" E; 39°49'00.88" N 64°43'18.16" E; 39°49'20.29" N 64°43'21.09" E; 39°49'20.51" N 64°43'20.95" E; 39°47'20.85" N 64°46'30.17" E; 39°47'05.97" N 64°47'15.83" E; 39°55'16.05" N 64°51'24.76" E; 39°54'38.69" N 64°55'04.42" E; 39°51'36.68" N 64°45'58.38" E; 39°53'33.32" N 64°48'28.53" E; 39°55'19.1" N 64°51'12.23" E (Fig. 1).

Molluscs were collected randomly from a depth of 1.0 m in the coastal part of the water body, by hand and with the help of grab traps and metal sieves. Molluscs belonging to the order Pulmonata (families Lymnaeidae, Planorbidae, Physidae and Thiaridae) were recorded mainly on the surface of aquatic plants (Zhadin, 1952; Kruglov, 2005). The species composition of molluscs was determined based on their morphological characteristics, including shell shape and body color (Beran, 1998; Jackiewicz, 2000; Glöer & Meier-Brook, 2003).

During the study, 2,541 molluscs were collected. The collected molluscs were brought to the laboratory and placed individually in 50 mL beakers with water at a temperature of +18...+22 °C and placed under a light source for up to 4 hours. The emission of cercariae was monitored visually and using an MBS-10 stereomicroscope. The morphology of cercariae released into the water was studied using a mixture of 0.05% neutral red and 0.05% Nile sulfate (Chernogorenko, 1983; Pinto & de Melo, 2010).

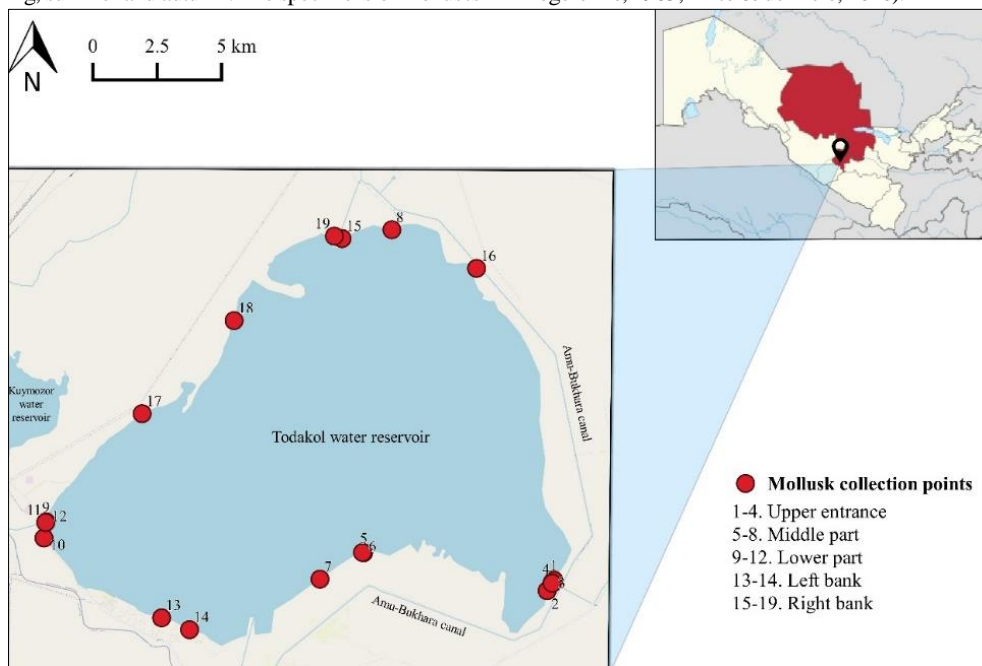


Fig. 1. Areas and coordinates of the research location

Results and discussion

In the water bodies of Central Uzbekistan, molluscs belonging to four families were recorded – Lymnaeidae, Planorbidae, Physidae and Thiaridae – infected with trematode parthenites and cercariae. The identified trematode cercariae amounted to 32 species (Table 1). The data in Table 1 show that the level of trematode larval infection of molluscs and the species composition of trematode cercariae in the studied water bodies of Central Uzbekistan are different. Most species of cercariae were recorded in the water bodies of Navoi and Samarkand regions. The cercariae fauna of molluscs was significantly less recorded in the water bodies of Bukhara region, 16 species of trematode larvae were recorded in this region. The adult forms of these noted trematode larvae have been observed to parasitize vertebrates – fish, amphibians, reptiles, birds, mammals, including humans.

The identification of trematode larvae in molluscs found in various types of water bodies in the studied area deserves special atten-

tion. For information, the species diversity of cercariae is characterized by the widespread distribution and high level of infection of the molluscs *Lymnaea auricularia* and *Planorbis planorbis* (Table 1). 14 and 15 species of trematode cercariae were recorded in these molluscs, respectively. Less than 2 species were recorded in the molluscs *Physa fontinalis* and *Melanooides kainaensis*. Such differences are probably due to biotic and abiotic factors acting in time and space, which is consistent with the results of a number of studies (Ginetsinskaya, 1968; Chernogorenko, 1983; Korobov, 2010; Prokofiev, 2020).

It should be noted that data on the infection of molluscs found in some water bodies of Central Uzbekistan with trematode parthenites and cercariae are presented in Kh. Nasimov's dissertation "Larvae of freshwater molluscs of the Samarkand and Bukhara regions of the UzSSR". According to him, as a result of the research, 15 species of aquatic molluscs were identified, and the level of infection with trem-

atode larvae was 3.43%. 21 species of cercariae were detected in these molluscs (Nasimov, 1967).

Table 1
Cercariae fauna of mollusc trematodes in water bodies of Central Uzbekistan

Molluscs	Cercariae species	In the cross-section of regions		
		Bukhara	Navoi	Samarkand
Lymnaeidae				
<i>Lymnaea auricularia</i> Linnaeus, 1758	<i>Fasciola gigantica</i> (Cobbold, 1856)	+	+	+
	<i>Notocotylus attenuatus</i> (Rudolphi, 1809)	+	+	+
	<i>Echinostoma revolutum</i> (Frochlich, 1802)	+	+	+
	<i>Echinoparyphium aconiatum</i> Dietz, 1909	–	+	+
	<i>Echinoparyphium recurvatum</i> (Linstow, 1873)	+	+	+
	<i>Hypoderaeum conoideum</i> (Bloch, 1782)	+	+	+
	<i>Haplometra cylindracea</i> (Zeder, 1800)	–	–	+
	<i>Trichobilharzia ocellata</i> (LaValette, 1855)	+	+	+
	<i>Apatemon gracilis</i> (Rudolphi, 1808)	–	–	+
	<i>Cotylurus comutus</i> (Rudolphi, 1808)	+	+	+
	<i>Diplostomum spathaceum</i> (Rudolphi, 1808)	+	+	+
	<i>Diplostomum helveticum</i> (Dubois, 1929)	+	+	+
	<i>Sanguinicola inermis</i> Plehn, 1905	+	+	+
<i>Schistosoma turkestanicum</i> Skrjabin, 1913	–	–	–	
<i>Lymnaea bactriana</i> Hutton, 1849	<i>Notocotylus attenuatus</i> (Rudolphi, 1809)	+	+	+
	<i>Opisthioglyphe ranae</i> (Fröhlich, 1791)	+	–	+
<i>Lymnaea corvus</i> Gmelin, 1791	<i>Notocotylus attenuatus</i> (Rudolphi, 1809)	+	+	–
	<i>Echinostoma revolutum</i> (Frochlich, 1802)	–	–	+
	<i>Echinoparyphium aconiatum</i> Dietz, 1909	–	+	+
	<i>Hypoderaeum conoideum</i> (Bloch, 1782)	+	+	+
<i>Lymnaea peregra</i> O.F. Muller, 1774	<i>Sanguinicola inermis</i> Plehn, 1905	–	–	+
<i>Lymnaea stagnalis</i> Linnaeus, 1758	<i>Haplometra cylindracea</i> (Zeder, 1800)	+	–	+
	<i>Sanguinicola inermis</i> Plehn, 1905	+	+	+
	<i>Echinostoma revolutum</i> (Frochlich, 1802)	+	+	+
	<i>Echinoparyphium aconiatum</i> Dietz, 1909	+	+	+
	<i>Hypoderaeum conoideum</i> (Bloch, 1782)	–	+	–
	<i>Trichobilharzia ocellata</i> (LaValette, 1855)	+	+	–
	<i>Apatemon gracilis</i> (Rudolphi, 1808)	+	+	–
	<i>Cotylurus comutus</i> (Rudolphi, 1808)	–	+	+
<i>Diplostomum helveticum</i> (Dubois, 1929)	+	+	+	
<i>Lymnaea truncatula</i> Muller, 1774	<i>Fasciola hepatica</i> (Linnaeus, 1758)	+	+	+
<i>Lymnaea palustris</i> O.F. Muller, 1774	<i>Apatemon gracilis</i> (Rudolphi, 1808)	+	+	+
Planorbidae				
<i>Planorbis planorbis</i> Linnaeus, 1758	<i>Bilharziella polonica</i> (Kowalewsky, 1895)	+	+	+
	<i>Dendritobilharzia loossi</i> Skrjabin, 1924	–	+	+
	<i>Notocotylus ephemera</i> (Nitzsch, 1817)	–	+	+
	<i>Echinostoma revolutum</i> (Frochlich, 1802)	–	–	+
	<i>Echinoparyphium aconiatum</i> Dietz, 1909	+	+	+
	<i>Calicophoron calicophorum</i> Davydova, 1959	+	+	+
	<i>Calicophoron erschowi</i> Davydova, 1959	–	+	–
	<i>Liorchis scotiae</i> (Willmott, 1950)	+	+	+
	<i>Cyclocoelium</i> sp.	–	–	+
	<i>Skrjabinoeces similis</i> (Looss, 1899)	–	+	+
	<i>Pneumonoeces variatus</i> (Rudolphi, 1819)	+	+	–
	<i>Pleurogenoides claviger</i> (Rudolphi, 1819)	–	+	+
	<i>Gastrothylax crumenifer</i> (Creplin, 1847)	+	+	+
	<i>Strigea falconis</i> Szidat, 1928	+	–	+
<i>Neodiplostomum</i> sp.	–	+	–	
<i>Planorbis sieversi</i> Mousson, 1873	<i>Gastrothylax crumenifer</i> (Creplin, 1847)	–	+	+
<i>Anisus spirorbis</i> Linnaeus, 1758	<i>Echinostoma revolutum</i> (Frochlich, 1802)	+	+	–
	<i>Calicophoron calicophorum</i> Davydova, 1959	–	+	+
	<i>Dendritobilharzia loossi</i> Skrjabin, 1924	+	+	–
	<i>Gigantobilharzia acotylea</i> Odhner, 1910	–	–	–
	<i>Gigantobilharzia</i> sp.	–	+	–
<i>Anisus septemgyratus</i> (Rossmässler, 1835)	<i>Bilharziella polonica</i> (Kowalewsky, 1895)	+	+	–
	<i>Echinostoma revolutum</i> (Frochlich, 1802)	–	+	–
<i>Gyraulus ehrenbergi</i> Beck, 1837	<i>Calicophoron calicophorum</i> Davydova, 1959	+	+	+
	<i>Calicophoron erschowi</i> Davydova, 1959	+	+	–
	<i>Gastrothylax crumenifer</i> (Creplin, 1847)	–	+	+
<i>Gyraulus gredleri</i> Gredler, 1853	<i>Calicophoron erschowi</i> Davydova, 1959	–	+	+
<i>Gyraulus albus</i> O.F. Muller, 1774	<i>Gastrothylax crumenifer</i> (Creplin, 1847)	+	+	+
Physidae				
<i>Physa fontinalis</i> Linnaeus, 1758	<i>Gigantobilharzia acotylea</i> Odhner, 1910	+	–	+
	<i>Gigantobilharzia</i> sp.	–	+	–
Thiaridae				
<i>Melanooides kainarensis</i> Strobogatov et Izzatullaev, 1980	<i>Trichobilharzia ocellata</i> (LaValette, 1855)	–	–	+
	<i>Philophthalmus lucipetus</i> (Rudolphi, 1819)	–	–	+

The noted cercariae species were determined to belong to the following families: Notocotylidae (1 species), Paramphistomidae (1 species), Fasciolidae (1 species), Echinostomatidae (3 species), Cathaemasiidae (1 species), Lechthodendriidae (1 species), Plagiorchidae (3 species), Allocreadidae (1 species), Sanguinicolidae (2 species), Schistosomatidae (2 species), Strigeidae (2 species), Diplostomidae (1 species) and Cyathocotylidae (1 species). In our research, species, which were determined by the author, such as *Cathaemasia hians* (Rudolphi, 1809), *Dolichosaccus rastellus* (Olson, 1876), *Crepidostomum farionis* (Müller, 1784), *Cercaria vivax* sp. and *Cercaria stylosa* sp. were not observed. At the same time, the trematode cercariae fauna in Central Uzbekistan has been enriched with a number of species: *Fasciola gigantica*, *Diplostomum helveticum*, *Calicophoron calicophorum*, *Liorchis scotiae*, *Gastrothylax crumenifer*, *Notocotylus ephemera*, *Skrjabinocercis similis*, *Strigea falconis*, *Philophthalmus lucipetus*, *Dendritobilharzia loossi*, *Gigantobilharzia acotylea*, *Gigantobilharzia* sp. In total, according to our research results, 32 species of cercariae were identified in molluscs in the water bodies of Central Uzbekistan. The data presented indicate that previous studies are outdated and fragmentary.

The instability of the ecological situation leaves its mark on the structure and functioning of biogeocenoses, primarily on the components of the biodiversity of water bodies. During the study period, monitoring was carried out in the water bodies of the indicated areas. As an example, stationary studies of molluscs were conducted in Tudakul Reservoir. At the same time, we paid attention to the distribution of trematode larvae in this water body. Tudakul Reservoir, like other water bodies, is distinguished by its upper, middle and lower parts. The distribution of trematode cercariae and parthenites in the indicated areas is distinguished by their differences (Table 2, 3).

Table 2
Infection with trematode larvae of the mollusc *Lymnaea auricularia* in different areas of Tudakul Reservoir (2024–2025)

Parts of the reservoir	Depth, meter	Checked specimens	Infected	
			specimens	%
Upper part				
Upper passage	0.5–2.0	59	18	30.0
Deep water flow	0.4–1.5	46	10	22.0
Shoreline area	0.5–1.8	48	16	32.6
Total		153	44	28.2
Middle part				
Deep water flow	5.0–7.0	46	0	0.0
Shallow left bank	0.5–1.0	54	6	11.5
Shallow right bank	0.5–1.2	49	5	11.2
Total		149	11	7.6
Lower part				
Lower part	1.0–1.8	54	12	22.4
Coastal area	0.5–1.9	43	11	25.7
Small passage	0.8–1.5	49	6	11.2
Total		146	29	19.8

Table 2
Infection with trematode larvae of the mollusc *Planorbis planorbis* in different areas of Tudakul Reservoir (2024–2025)

Parts of the reservoir	Depth, meter	Checked specimens	Infected	
			specimens	%
Upper part				
Upper passage	0.5–2.0	54	11	21.2
Deep water flow	0.4–1.5	35	4	10.4
Shoreline area	0.5–1.8	62	14	22.8
Total		151	29	18.1
Middle part				
Deep water flow	5.0–7.0	48	0	0.0
Shallow left bank	0.5–1.0	52	5	9.5
Shallow right bank	0.5–1.2	50	4	7.8
Total		150	9	5.8
Lower part				
Lower part	1.0–1.8	45	4	8.0
Shoreline area	0.5–1.9	56	8	13.5
Small passage	0.8–1.5	43	5	10.7

Total	144	17	10.7
-------	-----	----	------

Methodologically, the infection of *L. auricularia* and *P. planorbis* molluscs in the summer season (June, July, August) was carried out on the example of studying 10 or more specimens of molluscs from different parts of the water basins. As shown in Tables 2 and 3, in the studied water basin (Tudakul Reservoir), as well as for other water basins in the central part of Uzbekistan, the infection of molluscs (*L. auricularia* and *P. planorbis*) with the larval stages of trematodes and the distribution of cercariae in the upper, middle and lower parts is different. During the study period in the upper part of the lake, the incidence of accidental infection with trematode parthenites and cercariae in *L. auricularia* molluscs was 22.0–32.6%. In the middle part, the infection rate was 7.6%. In the lower part, this indicator was 11.2–25.7%. A practically similar situation can be observed with the contamination of another species of mollusc *P. planorbis*, the difference from the mollusc *L. auricularia* is that the level of contamination is significantly lower. In the upper part of the water basin, the average contamination of molluscs with *P. planorbis* was 18.1%, while the highest contamination was in the coastal areas – 22.8%. In the middle part, the accidental contamination of molluscs with trematode parthenites and cercariae was 7.8–9.5%, but no contamination of molluscs was observed in the deep water stream. In the lower part, the contamination indicators were 8.0–13.5% (Table 3).

It is characteristic that the highest damage to molluscs in water bodies is observed in shoreline areas with abundant vegetation and shallow depths. Here the density of the mollusc population is also high: during the vegetation period, the number of individuals of *L. auricularia* and *P. planorbis* at a depth of up to 1 m was observed to be from 14 to 23 specimens/m².

It is logical to note that the development and distribution of trematode parthenites and cercariae in water bodies in time and space is determined by the dynamics of the development of freshwater molluscs. In the summer, the increase in the number of molluscs leads to mass infection by trematode larvae. The presence of vertebrates, mainly birds and mammals, is also of great importance for the formation of trematode foci in water bodies.

Aquatic molluscs are important organisms that act as first intermediate hosts in the life cycles of trematodes. They not only create an environment for the development stages of the parasite, but also adapt to the biogeographical conditions in different water environments and determine the distribution areas of the parasites. Species richness of molluscs and their role in ecological niches influence the species composition and distribution dynamics of trematode cercariae.

In Central Uzbekistan in particular, in the Tudakul Reservoir basin, molluscs belonging to the families Lymnaeidae, Planorbidae and Physidae are widespread. Representatives of these families are found in various hydrobiological conditions, ensuring the adaptability and biocenotic connections of trematodes. It is also noted that each mollusc species is associated with a certain trematode species, and their distribution and presence are one of the main factors shaping the fauna of parasites in biotopes.

Climatic factors and the physicochemical characteristics of water bodies play a decisive role in the distribution and successful continuation of the life cycle of cercariae. Factors such as temperature, humidity, water flow rate, stability and oxygen content directly affect the activity of molluscs and the stages of development of trematodes. For example, strong light and high temperature stimulate the emission of cercariae, as well as increase their swimming activity. Under such conditions, the probability of trematode invasion and the level of parasitism may increase. Biological diversity in water sources also shapes trophic relationships and “parasite-host” relationships. Thus, the specific characteristics of the climate and aquatic environment are of strategic importance in the ecology of trematodes and the formation of their fauna. Birds and mammals play an important role as the final (definitive) hosts of trematodes. Their presence and population are decisive factors in the completion of the life cycle of cercariae and their spread to new areas. Birds, especially waterfowl, mainly migratory species, are the main intermediaries that transport trematodes over large geographical areas. During migration, birds can bring

trematode eggs to new water sources. This allows these parasites to come into direct contact with new intermediate hosts – molluscs. At the same time, mammals, especially species active in aquatic ecosystems (e.g. rats, martens, farm animals, etc.), also participate in the spread of trematodes. The ecology, biology, and migratory characteristics of birds and mammals play an important role in shaping the fauna and epidemiology of trematodes. Their presence contributes to the establishment and periodic redistribution of trematode species in biotopes.

Thus, the nature of the distribution of trematode cercariae in the horizons of water bodies is diverse: the first place in terms of the frequency and localization of cercariae is occupied by the shoreline, shallow areas of the upper and lower parts, characterized by an abundance of aquatic vegetation. In the thickets formed by aquatic grasses and aquatic plants, intermediate and other types of hosts (aquatic insects, fish, amphibians) are widespread. The presence of these areas creates the opportunity for the main hosts of trematodes – waterfowl and mammals – to assemble in high concentrations and become infected with trematode larvae. Trematodes are widespread and ecologically plastic. A distinctive feature of trematodes is their unique life cycle, which, depending on the species, can be complexly heterogeneous and have one, two, three, and even four hosts. At the same time, the hosts of trematodes include representatives of almost all the most important animal taxa (primarily molluscs, arthropods, and vertebrates). Finally, trematodes serve as pathogens of many dangerous helminthiases in humans and economically important animals. Therefore, representatives of the trematode class attract the attention of both medical and veterinary medicine, as well as zoologists, parasitologists, ecologists, and other biological sciences (Prokofev, 2006). In most cases, the object of research is the helminths that parasitize the main host. Sporocysts and redia, miracidia, and cercariae have been studied to a much lesser extent. The main morphophysiological and biological adaptations of miracidia and cercariae were considered in the scientific works of a number of scientists (Ginetsinskaya, 1968; Ginetsinskaya & Dobrovolsky, 1983; Galaktionov & Dobrovolsky, 1998; Prokofev, 2006). Among these, we can see the development of specialized movement organs (cilia around the body in miracidia and fin membranes and loops on the body and tail of cercariae), many sensors and taxis that serve to analyze environmental signals, and the formation of complex direction and behavioral reactions. Larvae being “in the right place” and “at the right time” is the main task of the free-living stage – to successfully infect the next hosts.

Miracidia is the first free-living larval stage in the life cycle of trematodes. Its main functional feature is to infect the first intermediate host – molluscs, from which the development of parthenogenetic generations (sporocyst and redia) occurs. In sporocysts or redia, cercariae are formed, depending on the taxonomic group of trematodes. After entering the body of the first intermediate host – molluscs, miracidia undergo metamorphosis and turn into a mother sporocyst (Ginetsinskaya, 1968). The mother sporocyst is formed in the body of the molluscs on a parasitic basis and the development of the first parthenogenetic generation of trematodes begins. The ontogenesis of parthenogenetic generations (sporocyst, redia) and their morpho-biological characteristics have been described in detail and do not require additional explanations (Ginetsinskaya & Dobrovolsky, 1983; Galaktionov & Dobrovolsky, 1998). It is noteworthy that from the moment the miracidia enter the tissues of the host organism, the “trematoda-mollusc” parasitic system begins to function. The formation of cercariae occurs in aquatic molluscs. This is also confirmed by the results of our studies on the development of a number of trematode cercariae in the corresponding intermediate hosts – Lymnaeidae, Planorbidae, Physidae, Thiariidae molluscs. As a result of parasitological examination of molluscs in various water bodies in the central part of Uzbekistan, it was noted that the species composition of cercariae consists of 32 species, the larvae of which parasitize almost all classes of vertebrates, mainly waterfowl and mammals (Fig. 2).

Thus, the study of the cercariae fauna of molluscs shows the richness of the cercariae fauna in the central water bodies of Uzbekistan.

The formation of the cercariae fauna of trematodes depends on many factors and corresponds to the general scheme of the formation

of the fauna complexes of sexually mature mammals, with the only difference being that cercariae, as noted above, develop in the body of molluscs. These processes are directly dependent on abiotic and biotic factors. According to our observations, the leading place in the number of detected larval forms is occupied by the molluscs *Lymnaea auricularia* and *Planorbis planorbis*, in which more than 50% of cercariae species were recorded, which indicates the stability of the functioning of the “parasite-host” system in the studied water bodies. The development of cercariae and their distribution in the studied water bodies are very similar. The general trend of the water bodies is high density of molluscs in the shallow areas of the water, limited species composition of larvae is observed in the deep areas of the water.

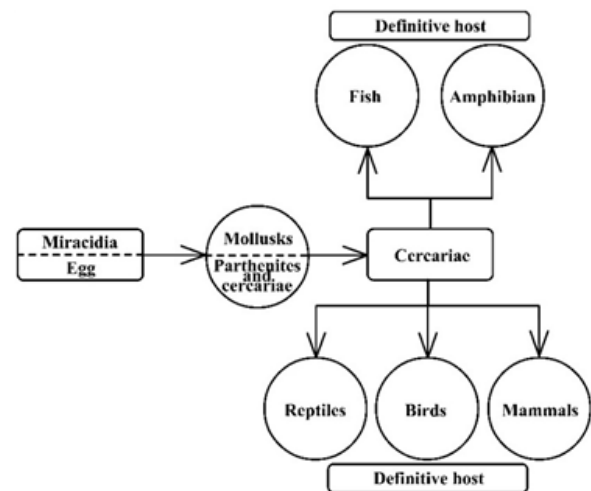


Fig. 2. Scheme of development of cercariae in water bodies

Conclusions

The formation of the cercarial fauna of trematodes is a complex process that occurs in accordance with the combination of a whole set of factors. The main factors in this process are the presence of molluscs, the presence of eggs and larvae (miracidia) of trematodes, the regime of the water body, the corresponding physicochemical and biological characteristics of hydrobiological objects, the relationship of vertebrates – hosts – with water bodies, the temperature regime and the environment. The mentioned processes contribute to the formation of biocenoses and parasitocenoses in certain areas. Among the factors affecting the formation of the cercarial fauna of trematodes, intermediate hosts – molluscs – occupy a special place. Cercariae emerging from sporocysts and rediae have specific adaptations, i.e. their morphofunctional and behavioral features are aimed at ensuring the infection of the second intermediate or primary hosts. Based on the factors noted above, it can be noted that the modern fauna of trematode cercariae developing in aquatic molluscs of Central Uzbekistan is formed.

This research work was carried out within the framework of the research program of the Institute of Zoology of the Academy of Sciences of the Republic of Uzbekistan for 2025–2029 ‘1.2. Creation of a digital information system of the animal world of the Bukhara and Navoi regions’, financed from the state budget.

References

- Akramova, F. D., Shakarbaev, U. A., Mirzaeva, A. U., Saidova, S. O., Yorkulov, Z. M., Ubbiniyazova, J. K., Paluaniyazova, D. A., Safarov, A. A., Saparov, K. A., Toremuratov, M. S., & Azimov, D. A. (2024). Larvae of helminths of molluscs and insects in Karakalpakstan. *Biosystems Diversity*, 32(1), 83–98.
- Beran, L. (1998). Vodní Měkkýši ČR. Metodika Českého svazu ochránců přírody [Aquatic molluscs of the Czech Republic. Methodology of the Czech Union of Nature Conservation]. Vlašim (in Czech).

- Chernogorenko, M. I. (1983). Lichinki trematod v molliuskakh Dnepra i yego vodokhranilishch [Larvae of trematodes in the molluscs of the Dnieper and its bodies of water]. Naukova Dumka, Kiev (in Russian).
- Esch, G. W., Barger, M. A., & Fellis, K. J. (2002). The transmission of digenetic trematodes: Style, elegance, complexity. *Integrative and Comparative Biology*, 42(2), 304–312.
- Fried, B., & Toledo, R. (2004). Criteria for species determination in the 'revolution' group of *Echinostoma*. *Journal of Parasitology*, 90(4), 917–917.
- Galaktionov, K. V., & Dobrovolskiy, A. A. (1998). Proiskhozhdeniye i evolyutsiya zhiznennykh tsiklov trematod [Origin and evolution of life cycles of trematodes]. Nauka, Saint Petersburg (in Russian).
- Ginetsinskaya, T. A. (1968). Trematody, ikh zhiznennyye tsikly, biologiya i evolyutsiya [Trematodes, their life cycles, biology and evolution]. Nauka, Leningrad (in Russian).
- Ginetsinskaya, T. A., & Dobrovolskiy, A. A. (1983). Zhiznennyy tsikl trematod kak sistema adaptatsiy [Life cycle of trematodes as a system of adaptations]. *Proceedings of the Biological Research Institute of Leningrad State University*, 34, 112–157 (in Russian).
- Glöer, P., & Meier-Brook, C. (2003). Süßwassermollusc en: Ein Bestimmungsschlüssel für die Bundesrepublik Deutschland [Freshwater molluscs: A key to identification for the Federal Republic of Germany]. Deutscher Jugendbund für Naturbeobachtung, Deutschland (in German).
- Jackiewicz, M. (2000). Błotniarki Europy (Gastropoda, Pulmonata, Lymnaeidae) [European marsh moths (Gastropoda, Pulmonata, Lymnaeidae)]. Wydawnictwo Kontekst, Poznań (in Polish).
- Jadin, V. I. (1952). Molliuski presnykh i solonovatykh vod SSSR. Opredeliteli po faune SSSR [Molluscs of fresh and brackish waters of the USSR. Identification guides to the fauna of the USSR]. Academy of Sciences of the USSR, Moscow (in Russian).
- Kanev, I., Nollen, P. M., Vassilev, I., Radev, V., & Dimitrov, V. (1993). Redescription of *Philophthalmus lucipenus* (Rudolphi, 1819) (Trematoda: Philophthalmidae) with a discussion of its identity and characteristics. *Annalen des Naturhistorisches Museum Wien*, 94/95B, 11–34.
- Khalil, L. F. (2002). Family Schistosomatidae Stiles & Hassall, 1898. In: Gibson, D. I., Jones, A., & Bray, R. A. (Eds.). *Keys to the Trematoda*. CABI. Vol. 1. Pp. 419–432.
- Korobov, O. I. (2005). Fauna i ekologo-biologicheskie osobennosti lichinok trematod molliuskov roda *Lymnaea* vodoyemov Omskoy oblasti [Fauna and ecological-biological features of larvae of trematodes of molluscs of the genus *Lymnaea* of reservoirs of the Omsk region]. Vitebsk State Medical University, Vitebsk (in Russian).
- Kruglov, N. D., (2005). Mollyuski semeystva prudovikov (Lymnaeidae, Gastropoda, Pulmonata) Evropy i Severnoy Azii [Molluscs of the family (Lymnaeidae, Gastropoda, Pulmonata) of Europe and North Asia]. Smolensk State Pedagogical University, Smolensk (in Russian).
- Lajtner, J., Lucić, A., Marušić, M., & Erben, R. (2008). The effects of the trematode *Bucephalus polymorphus* on the reproductive cycle of the zebra mussel *Dreissena polymorpha* in the Drava River. *Acta Parasitologica*, 53(1), 85–92.
- Littlewood, D. T. J., & Bray, R. A. (Eds.). (2014). *Interrelationships of the Platyhelminthes*. CRC Press, London.
- Lühe, M. (1909). Parasitische Plattwürmer. I. Trematods [Parasitic flatworms. I. Trematodes]. Brauer, A. (Ed.). *Die Süßwasserfauna Deutschlands*. Verlag von Gustav Fischer, Jena, Heft (in German).
- Marszewska, A., & Cichy, A. (2015). Unionid clams and the zebra mussels on their shells (Bivalvia: Unionidae, Dreissenidae) as hosts for trematodes in lakes of the Polish Lowland. *Folia Malacologica*, 23(2), 149–154.
- Martin, W. E. (1952). Another annelid first intermediate host of a digenetic trematode. *The Journal of Parasitology*, 38(4), 356–359.
- Nasimov, K. (1967). Lichinki trematod presnovodnykh molliuskov Samarkandskoy i Bukharskoy oblastey UzSSR [Trematode larvae of freshwater molluscs of Samarkand and Bukhara regions of the Uzbek SSR]. Samarkand State University, Samarkand (in Russian).
- Nasimov, K. N. (1964). K izucheniyu lichinok trematod v presnovodnykh molliuskakh Samarkandskoy oblasti [On the study of trematode larvae in freshwater molluscs of Samarkand region]. *Works of Samarkand University*, 151, 62–64 (in Russian).
- Oglesby, L. C. (1961). A new cercaria from an annelid. *The Journal of Parasitology*, 47(2), 233–236.
- Pinto, H. A., & de Melo, A. L. (2010). *Melanoides tuberculata* as intermediate host of *Philophthalmus gralli* in Brazil. *Revista do Instituto de Medicina Tropical de São Paulo*, 52(6), 323–327.
- Pozdnyakov, S. E., & Gibson, D. I. (2008). Family Didymozoidae Monticelli, 1888. In: Bray, R. A., Gibson, D. I., & Jones, A. (Eds.). *Keys to the Trematoda*. CABI. Volume 3. Pp. 631–734.
- Prokofyev, V. V. (2006). Strategiya zarazheniya zhivotnykh – khozyayev tserkariyami trematod: Opyt analiza v ekosistemakh pribrezh'ya morey i ozer severo-zapada Rossii [Strategy of infection of host animals with trematode cercariae: Experience of analysis in coastal ecosystems of seas and lakes of Northwestern Russia]. Zoological Institute of the Russian Academy of Sciences, Saint Petersburg (in Russian).
- Shakarbaev, U. A., Akramova, F. D., Esonboyev, J. R., & Shodieva, F. O. (2020). Trematode fauna of molluscs of the Kattakurgan Reservoir of the Samarkand Region. *Theory and Practice of Parasitic Disease Control*, 21, 502–508.
- Taskinen, J., Valtonen, E. T., & Mäkelä, T. (1994). Quantity of sporocysts and seasonality of two *Rhipidocotyle* species (Digenea: Bucephalidae) in *Anodonta piscinalis* (Mollusca: Bivalvia). *International Journal for Parasitology*, 24(6), 877–886.
- Zdun, B. I. (1961). Lychnyky trematod u prsnovodnykh molliuskakh Ukrainy [Trematode larvae in freshwater molluscs of Ukraine]. Publishing House of the Academy of Sciences of the Ukrainian SSR, Kyiv (in Ukrainian).