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THE TAXONOMIC SURVEY OF THE CERCARIAL FAUNA (PLATYHELMINTHES, TREMATODA) IN THE MOLLUSKS OF UZBEKISTAN

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The Taxonomic Survey of the Cercarial Fauna (Platyhelminthes, Trematoda) in the Mollusks of Uzbekistan. Shakarbaev, U. A., Akramova, F. D., Azimov, D. A. — The article provides a list of trematodes cercariae found in the mollusks of Uzbekistan based on the analysis and generalisation of well-known data published in the period between 1934 and 2019. Currently, the list comprises 50 trematode species belonging to 38 genera, 22 families of trematodes, the adult forms of which parasitise vertebrates (fish, amphibians, birds and mammals), including the human being. The cercariae were discovered in 38 mollusk species belonging to Gastropoda and Bivalvia. The discovered larvae comprised 12 morphotype groups of cercariae.
Key words: cercariae, fauna, trematodes, mollusks, parasites, Uzbekistan.

Introduction

The research into mollusks' participation in the life cycle of trematodes has a long history. The first studies are known to be carried out in the mid-17th century in Europe. Later, the research transferred to other continents. The results of the studies of the cercarial fauna parasitising molluscs in different countries of the world have been generalised in the works of various researchers (Zdun, 1961, 1962; Nasir and Erasmus, 1964; Ito, 1964; Ginetsinskaya, 1968; Yamaguti, 1975; Chernogorenko, 1983; Nasir, 1984; Scholz et al., 2000; Ostrowski de Núñez and Gil de Pertierra, 2004; Bartoli and Gibson, 2007; Mukherjee, 2007; Żbikowska and Nowak, 2009; Cichy et al., 2011; Pinto and Melo, 2013). No doubt, the works mentioned above contributed greatly to the further deeper research into the biodiversity of cercariae in many regions of the world.

Similar research has been accomplished in Uzbekistan. The works of Dogel and Bykhovsky (1934) are often mentioned in relation to cercaria larvae in the fish of the Aral Sea. The authors of this article studied

545 specimens of mollusks, in which they discovered several species of cercariae and metacercariae belonging to the families Bucephalidae, Brachylaimidae, Plagiorchidae, Echinostomatidae and Strigeidae. For over 80 years researchers from Uzbekistan and other countries have been reporting on mollusks in Uzbekistan infected with different kinds of cercarial larvae. The results of their studies have been published in various scientific periodicals and scientific literature. Almost all of them published in Uzbek or Russian, they are practically inaccessible to foreign specialists. Therefore, to make a general survey of the cercarial fauna in the mollusks of Uzbekistan is highly important. We suppose that the publication of the survey in English will contribute to deeper relations between Uzbek scientists and experts from a number of countries around the world, as well as a better exchange of information on the study of trematodes' life cycles.

Material and methods

The material of this work has been composed of the results of numerous studies of freshwater and terrestrial mollusks as trematodes' intermediate hosts in the aquatic and terrestrial ecosystems of Uzbekistan. The studies were begun in 1934 and are still continuing now (2019). At the same time we have worked on published articles dedicated to the cercarial larvae of the mollusks of Uzbekistan kept at different libraries of the former Soviet countries, mainly Russia, Ukraine and Uzbekistan. Besides, through various interviews we have collected data from the publications of specialists from Uzbekistan and other countries of the former USSR we have no access to.

In total we have studied about 100 articles dedicated to research into the cercarial fauna of certain species and groups of trematodes found in freshwater and terrestrial mollusks. The taxonomic diversity of intermediate host mollusks is given in conformity with the following systems (Zhadin, 1952; Starobogatov, 1970; Pazilov, Azimov, 2003; Kruglov, 2005).

The list of cercariae developing in the mollusks of Uzbekistan is presented in conformity with the classification of Lühe (1909) and subsequent additions (Dawes, 1968; Zdun, 1961; Ginetsinskaya, 1968; Chernogorenko, 1983).

It should be noted that the higher taxon system for trematodes from the subclass Digenea Carus, 1863 — its orders and suborders has undergone considerable changes over the last 20 years. It is necessary to pay tribute to those who have done that large amount of work. The most transformed are two orders — Plagiorchiida La Rue, 1957 and Diplostomida Olson, Cribb, Tkach, Bray and Littlewood, 2003 (Gibson et al., 2002; Olson at al., 2003; Jones et al., 2005; Bray et al., 2008; Kostadinova and Pérez-del-Olmo, 2014; Pérez-Ponce de León and Hernández-Mena, 2019), which have considerably grown in size and changed in content. The structure of these orders is highly disputable. According to Taxonomy Browser (2020), the number of orders has grown to 4: Azigiida, Plagiorchiida, Diplostomida and Strigeidida. The higher taxons, orders and suborders of Trematoda Digenea are interpreted in various ways, and there is no uniform opinion on that. The proposed order and suborder systems of Trematoda Digenea are too formal and require amendments.

We provide the list of trematode cercariae in Uzbekistan in conformity with the system proposed for the subclass Digenea by Key to the Trematoda (2002, 2005, 2008, Vol. 1–3).

That said, we retain a right to interpret the Bilharziellidae (Price, 1929: subfam.) as a sovereign family uniting bilharziae, parasites of birds.

Characterising the species composition of the cercariae of certain taxonomic groups of trematodes, we gave detailed data on the species recorded in the territory of Uzbekistan. This work gives information on the intermediate hosts and groups of vertebrate hosts of each of these species. Each species of cercaria is classified and referred to a certain group of cercariae; each geographic place this or that cercaria species was found in is marked, and for each species references to literary sources are given. Most of the data was obtained through the study of mollusks infected in a natural way, in water or on land. Most of the cercaria species were identified. For some objective reasons a part of the cercariae were not differentiated. In our work they are classified as cercariae with unknown systematic positions.

Results

The bibliographic review is based on the analysis of about 100 scientific articles published between 1934 and 2019 relating to cercarial larvae of trematode found in the freshwater and terrestrial mollusks of Uzbekistan. A large number of mollusks belonging to 2 classes, Gastropoda and Bivalvia, have been studied for the period mentioned, a part of them being trematodes' intermediate hosts. The total number of mollusc species involved in trematodes' life cycles is 38. The mollusks were infected by cercariae of 50 trematode species (see the table below) belonging to 38 genera and 22 families of trematodes, the mature forms of which parasitise fish, amphibians, birds and mammals (Shakarboyev et al, 2012).

Table. The taxonomic composition and species diversity of the cercariae discovered in the molluscs of Uzbekistan (based on works published between 1934 and 2019)

Family	Genus	Number of species
Brachylaimidae	*Brachylaima*	2
Hasstilesiidae	*Hasstilesia*	1
Bucephalidae	*Bucephalus*	1
	Rhipidocotyle	1
Clinostomidae	*Clinostomum*	1
Cyclocoeliidae	*Cyclocoelium*	1
Diplostomidae	*Diplostomum*	3
	Codonocephalus	1
	Neodiplostomum	1
	Tylodelephus	1
Strigeidae	*Strigea*	1
	Cotylurus	1
	Apatemon	1
Schistosomatidae	*Schistosoma*	1
Bilharziellidae	*Bilharziella*	1
	Trichobilharzia	2
	Ornithobilharzia	1
	Dendritobilharzia	2
	Gigantobilharzia	2
Aporocotylidae	*Sanguinicola*	1
Echinostomatidae	*Echinostoma*	1
	Echinoparyphium	2
	Hypoderaeum	1
Fasciolidae	*Fas*ciola	2
Philophthalmidae	*Philophthalmus*	1
Paramphistomidae	*Calicophoron*	2
	Liorchis	1
Gastrothylacidae	*Gastrothylax*	1
Notocotylidae	*Notocotylus*	4
Gorgoderidae	*Gorgodera*	1
Dicrocoeliidae	*Dicrocoelium*	1
	Corrigia	1
	Eurytrema	1
Plagiorchiidae	*Haplometra*	1
Telorchiidae	*Opisthioglyphe*	1
Haematoloechidae	*Haematoloechus*	1
	Skrjabinoeces	1
Pleurogenidae	*Pleurogenes*	1
22	38	50

TREMATODE CERCARIAE FOUND IN THE MOLLUSKS OF UZBEKISTAN

Phylum Platyhelminthes Gegenbaur, 1859
Class Trematoda Rudolphi, 1808
Subclass Digenea Carus, 1863
BRACHYLAIMIDAE TRAVASSOS, 1922

Brachylaima fuscata (Rudolphi, 1819)

Intermediate host: *Oxyloma elegans*, *Deroceras sturanui, Macrochamys sogdiana* (Gastropoda: Succineidae, Agriolimacidae, Ariophantidae).

Cercarial morphotype group: cercariaeum.

Habitat: terrestrial.
Definitive hosts: birds.
Localities: northeastern and southern regions.
References: Davronov (1999), Shakarboyev et al. (2012).

Brachylaima sp.
Intermediate host: *Xeropicta candaharica* (Gastropoda: Hygromiidae).
Cercarial morphotype group: cercariaeum.
Habitat: terrestrial.
Definitive hosts: birds.
Localities: Fergana Valley, northeastern part.
References: Tukhmanyants, Shakhurina (1971), Shakarboyev et al. (2012).

HASSTILESIIDAE HALL, 1916

Hasstilesia ovis (Orloff, Erschoff et Badanin, 1937)
Intermediate host: *Pupilla muscorum, Vallonia costata* (Gastropoda: Pupillidae, Vallonidae).
Cercarial morphotype group: cercariaeum.
Habitat: terrestrial.
Definitive hosts: mammals.
Locality: Fergana Valley.
References: Gvozdev & Soboleva (1972), Shakarboyev et al. (2012).

BUCEPHALIDAE POCHE, 1907

Bucephalus polymorphus Baer, 1827
Intermediate host: *Anodonta cygnea* (Bivalvia: Unionidae).
Cercarial morphotype group: gasterostome.
Habitat: freshwater.
Definitive hosts: fish.
Locality: the Syrdarya river.
Reference: Butenko (1967).

Rhipidocotyle companula (Dujardin, 1845)
Intermediate host: *Anodonta piscinalis* (Bivalvia: Unionidae).
Cercarial morphotype group: gasterostome.
Habitat: freshwater.
Definitive hosts: fish.
Locality: Republic of Karakalpakstan (the Aral Sea).
Reference: Arystanov (1976).

CLINOSTOMIDAE LÜHE, 1901

Clinostomum complanatum (Rudolphi, 1814)
Intermediate host: *Lymnaea stagnalis* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: cercariaeum.
Habitat: freshwater.
Definitive hosts: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

CYCLOCOELIIDAE STOSSICH, 1902

Cyclocoelum sp.
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).

Cercarial morphotype group: cercariaeum.
Habitat: freshwater.
Definitive hosts: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

DIPLOSTOMIDAE POIRIER, 1886

Diplostomum spathaceum (Rudolphi, 1819)
Intermediate host: *Lymnaea auricularia, L. stagnalis, L. subdisjuncta* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Localities: Republic of Karakalpakstan, northeastern and eastern regions.
References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Arystanov (1976), Azimov, Kabilov (1977), Nurullayev (1991), Davronov (1999), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

Diplostomum helveticum (Dubois, 1929)
Intermediate host: *Lymnaea auricularia, L. stagnalis* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Localities: northeastern and central regions.
References: Azimov, Kabilov (1977), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

Diplostomum indisticum (Guberlet, 1923)
Intermediate host: *Lymnaea auricularia* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Codonocephalus urnigerus (Rudolphi, 1899)
Intermediate host: *Lymnaea stagnalis* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Neodiplostomum sp.
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Tylodelphus clavata (von Nordmann, 1832)
Intermediate host: *Lymnaea auricularia* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.

Habitat: freshwater.
Definitive hosts: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

STRIGEIDAE RAILLIET, 1919

Strigea falconis Szidat, 1928
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Locality: Tashkent Province.
Reference: Arystanov (1976).

Cotylurus cornutus (Rudolphi, 1808)
Intermediate host: *Lymnaea auricularia, L. stagnalis, L. truncatula* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Locality: northeastern part.
References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Arystanov (1976), Azimov, Kabilov (1977), Shakarbaev et al. (2013, 2014 a, b).

Apatemon gracilis (Rudolphi, 1808)
Intermediate host: *Lymnaea auricularia, L. stagnalis, L. palustris* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: strigeid.
Habitat: freshwater.
Definitive hosts: birds.
Localities: northeastern and central parts.
References: Nasimov (1967), Azimov, Kabilov (1977), Shakarbaev et al. (2013, 2014 b).

SCHISTOSOMATIDAE STILES ET HASSAL, 1898

Schistosoma turkestanicum Skrjabin, 1913
Intermediate host: *Lymnaea auricularia* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: brevifurcate.
Habitat: freshwater.
Definitive hosts: mammals.
Localities: northeastern and northwestern parts.
References: Azimov (1975, 1978, 1985, 1986), Azimov et al. (2014), Arystanov (1968 a, b, 1969 b, 1976), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

BILHARZIELLIDAE (PRICE, 1929: SUBFAM)

Bilharziella polonica (Kowalewsky, 1895)
Intermediate host: *Pl*anorbis planorbis, Anisus septemgyratus (Gastropoda: Planorbidae).
Cercarial morphotype group: brevifurcate.
Habitat: freshwater.
Definitive hosts: birds.
Localities: Republic of Karakalpakstan, northeastern, central and southern regions.
References: Nasimov (1967), Arystanov (1976), Azimov, Kabilov (1977), Davronov (1999), Akramova, Shakarboyev (2005), Akramova (2011), Shakarboyev et al. (2012),

Shakarbaev et al. (2014 a).

Trichobilharzia ocellata (La Valette, 1855)

Intermediate host: *Lymnaea auricularia, Melanoides kainarensis* (Gastropoda: Lymnaeidae, Thiaridae).

Cercarial morphotype group: brevifurcate.

Habitat: freshwater.

Definitive hosts: birds.

Localities: northwestern, northeastern, central, eastern and southern regions.

References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Arystanov (1976), Azimov, Kabilov (1977), Nurullayev (1991), Davronov (1999), Akramova (2005, 2008, 2011), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

Trichobilharzia sp.

Intermediate host: *Lymnaea corvus* (Gastropoda: Lymnaeidae).

Cercarial morphotype group: brevifurcate.

Habitat: freshwater.

Definitive hosts: birds.

Locality: northeastern region.

Reference: Akramova (2011).

Ornithobilharzia canaliculata (Rudolphi, 1819)

Intermediate host: *Lymnaea auricularia, L. stagnalis* (Gastropoda: Lymnaeidae).

Cercarial morphotype group: brevifurcate.

Habitat: freshwater.

Definitive hosts: birds.

Locality: northeastern region.

References: Azimov, Kabilov (1977), Akramova, Azimov (2005), Akramova (2011).

Dendritobilharzia loossi Skrjabin, 1924

Intermediate host: *Anisus spirorbis* (Gastropoda: Planorbidae).

Cercarial morphotype group: brevifurcate.

Habitat: freshwater.

Definitive hosts: birds.

Localities: northeastern and northwestern regions.

References: Azimov, Kabilov (1977), Azimov (1986), Akramova (2005, 2011), Akramova et al. (2007, 2009 b, 2011), Shakarboyev et al. (2012), Shakarbaev et al. (2014 a).

Dendritobilharzia purverulenta (Braun, 1901)

Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).

Cercarial morphotype group: brevifurcate.

Habitat: freshwater.

Definitive hosts: birds.

Locality: northeastern region.

References: Azimov, Kabilov (1977), Azimov (1986), Akramova et al., (2009 b), Akramova (2011).

Gigantobilharzia acotylea Odhner, 1910

Intermediate host: *Anisus spirorbis, Physa fontinalis* (Gastropoda: Planorbidae, Physidae).

Cercarial morphotype group: brevifurcate.

Habitat: freshwater.

Definitive hosts: birds.

Locality: northeastern region.

References: Azimov, Kabilov (1977), Akramova (2008, 2011), Akramova et al. (2009 a,

2010), Shakarboyev et al. (2012), Shakarbaev et al. (2014 a).

Gigantobilharzia sp.
Intermediate host: *Physa fontinalis, Anisus spirorbis,* (Gastropoda: Physidae, Planorbidae).
Cercarial morphotype group: brevifurcate.
Habitat: freshwater.
Definitive hosts: birds.
Locality: northeastern part.
References: Azimov, Kabilov (1977), Akramova (2011).

APOROCOTYLIDAE ODHNER, 1912

Sanguinicola inermis Plehn, 1905
Intermediate host: *Lymnaea auricularia, L. peregra* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: furcocercaria.
Habitat: freshwater.
Definitive hosts: fish.
Localities: Republic of Karakalpakstan, northeastern and southern regions.
References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Azimov, Kabilov (1977), Davronov (1999), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

TECHINOSTOMATIDAE LOOSS, 1899

Echinostoma revolutum (Frochlich, 1802)
Intermediate host: *Lymnaea auricularia, L. corvus, L. stagnalis, Pl*anorbis planorbis, Anisus converiusculus, A. spirorbis (Gastropoda: Lymnaeidae, Planorbidae).
Cercarial morphotype group: echinostome.
Habitat: freshwater.
Definitive hosts: birds.
Localities: Republic of Karakalpakstan, Fergana Valley, northeastern regions.
References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Arystanov (1976), Azimov, Kabilov (1977), Davronov (1999), Shakarboyev (2009), Shakarbaev et al. (2013, 2014 a, b).

Echinoparyphium aconiatum Dietz, 1909
Intermediate host: *Lymnaea auricularia, L. corvus, L. stagnalis, Pl*anorbis planorbis (Gastropoda: Lymnaeidae, Planorbidae).
Cercarial morphotype group: echinostome.
Habitat: freshwater.
Definitive hosts: birds.
Localities: northeastern and northwestern regions.
References: Nasimov (1967), Arystanov (1976), Azimov, Kabilov (1977), Shakarboyev (2009), Shakarbaev et al. (2014 a).

Echinoparyphium recurvatum (Linstow, 1873)
Intermediate host: *Lymnaea auricularia* (Gastropoda: Lymnaeidae).
Cercarial morphotype group: echinostome.
Habitat: freshwater.
Definitive hosts: birds.
Localities: Republic of Karakalpakstan, northeastern region.
References: Nasimov (1967), Arystanov (1976), Azimov, Kabilov (1977), Shakarbaev et al. (2013, 2014 a, b).

Hypoderaeum conoideum (Bloch, 1782)

Intermediate host: *Lymnaea auricularia, L. corvus, L. stagnalis, L. subdisjuncta* (Gastropoda: Lymnaeidae).

Cercarial morphotype group: echinostome.

Habitat: freshwater.

Definitive hosts: birds.

Localities: Republic of Karakalpakstan, Tashkent and Syrdarya Provinces.

References: Nasimov (1967), Arystanov (1976), Azimov, Kabilov (1977), Davronov (1999), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

FASCIOLIDAE RAILLIET, 1895

*Fas**ciola hepatica*** Linnaeus, 1758

Intermediate host: *Lymnaea truncatula* (Gastropoda: Lymnaeidae).

Cercarial morphotype group: gymnocephalous.

Habitat: freshwater.

Definitive host group: mammals.

Localities: Andizhan, Namangan, Fergana, Tashkent, Syrdarya, Jizakh, Kashkadarya and Surkhandarya Provinces.

References: Salimov (1965, 1989), Nasimov (1967), Tukhmanyants, Shakhurina (1971), Azimov, Kabilov (1977), Nurullayev (1991), Davronov (1999), Azimov et al. (2006), Shakarboyev (2009), Shakarbaev et al. (2013).

Fasciola gigantica (Cobbold, 1856)

Intermediate host: *Lymnaea auricularia, L. bactriana, L. subdisjuncta, L. impure* (Gastropoda: Lymnaeidae).

Cercarian group: gymnocephalous.

Habitat: freshwater.

Definitive host group: mammals.

Localities: Republic of Karakalpakstan, Khorezm, Kashkadarya, Surkhandarya, Syrdarya, Tashkent and Samarkand Provinces.

References: Nasimov (1967), Gekhtin (1967), Arystanov (1976), Azimov, Kabilov (1977), Salimov (1989), Nurullayev (1991), Davronov (1999), Kojabayev (2001), Salimov et al. (1986), Shakarboyev (2009), Shakarbaev et al. (2013, 2014 a, b).

PHILOPHTHALMIDAE LOOSS, 1899

Philophthalmus lucipetus (Rudolphi, 1819)

Intermediate host: *Melanoides kainarensis* (Gastropoda: Melanoididae (= Thiaridae)).

Cercarian group: megalurous.

Habitat: freshwater.

Definitive host group: birds.

Locality: Samarkand Province.

References: Shakarbayev et al. (2016).

PARAMPHISTOMIDAE FISCHOEDER, 1901

Calicophoron calicophorum (Fischoeder, 1901)

Intermediate host: *Pl*anorbis planorbis, Anisus spirorbis, Gyraulus ehrenbergi (Gastropoda: Planorbidae).

Cercarian group: amphistome.

Habitat: freshwater.

Definitive host group: mammals.

Localities: Republic of Karakalpakstan, Khorezm, Surkhandarya, Syrdarya, Tashkent and Samarkand Provinces.

References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Khaydarov (1974), Azimov, Kabilov (1977), Khamrayev (1983), Nikitin (1968), Kojabayev (2001), Shakarboyev

et al. (2012), Shakarbaev et al. (2014 a).

Calicophoron erschowi (Fischoeder, 1901)
Intermediate host: *Pl*anorbis planorbis, Gyraulus ehrenbergi, G. gredleri (Gastropoda: Planorbidae).
Cercarian group: amphistome.
Habitat: freshwater.
Definitive host group: mammals.
Localities: Surkhandarya, Kashkadarya, Samarkand and Tashkent Provinces.
References: Khamrayev (1983), Nikitin (1968), Davronov (1999), Shakarboyev et al. (2012), Shakarbaev et al. (2014 a).

Liorchis scotiae (Willmott, 1950)
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarian group: amphistome.
Habitat: freshwater.
Definitive host group: mammals.
Localities: central, northwestern and northeastern regions.
References: Nikitin (1968), Azimov et al. (1998), Shakarboyev et al. (2012).

GASTROTHYLACIDAE STILES ET GOLDBERGER, 1910

Gastrothylax crumenifer (Creplin, 1847)
Intermediate host: *Pl*anorbis sieversi, Gyraulus ehrenbergi, G. albus (Gastropoda: Planorbidae).
Cercarian group: amphistome.
Habitat: freshwater.
Definitive host group: mammals.
Localities: central, northwestern and northeastern parts of the country.
References: Nikitin (1968), Kojabayev (2001), Shakarboyev et al. (2012).

NOTOCOTYLIDAE LÜHE, 1901

Notocotylus attenuatus (Rudolphi, 1809)
Intermediate host: *Lymnaea auricularia, L. bactriana, L. corvus* (Gastropoda: Lymnaeidae).
Cercarian group: monostome.
Habitat: freshwater.
Definitive host group: birds.
Localities: northwestern and northeastern parts of Uzbekistan.
References: Nasimov (1967), Arystanov (1969 a, b, 1970, 1976, 1980), Azimov, Kabilov (1977), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 a, b).

Notocotylus ephemera (Nitzsch, 1817)
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarian group: monostome.
Habitat: freshwater.
Definitive host group: birds.
Localities: Republic of Karakalpakstan, Fergana Valley, northeastern part.
References: Nasimov (1967), Arystanov (1969 a, 1976, 1980), Azimov, Kabilov (1977), Shakarboyev et al. (2012).

Notocotylus sp. 1
Intermediate host: *Bithynia caeurlans* (Gastropoda: Bulinidae).
Cercarian group: monostome.

Habitat: freshwater.
Definitive host group: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Notocotylus sp. 2
Intermediate host: *Theodoxus pallasi* (Gastropoda: Neretidae).
Cercarian group: monostome.
Habitat: freshwater.
Definitive host group: birds.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

GORGODERIDAE LOOSS, 1901

Gorgodera pagenstecheri (Ssinitzin, 1905)
Intermediate host: *Sphaerium corneum, Pisidium abtusale* (Bivalvia: Pisidiidae).
Cercarian group: amphistome.
Habitat: freshwater.
Definitive host group: amphibians.
Locality: Fergana Valley.
Reference: Tukhmanyants, Shakhurina (1971).

DICROCOELIIDAE LOOSS, 1889

Dicrocoelium dendriticum (Rudolphi, 1819)
Intermediate host: *Leucozonella rufispira, Xeropicta candaharica, Bradybaena phaezona, Ponsadenia semenovi, Subzebrinus labieleus, Pseudonapaeus sogdianus* (Gastropoda: Hygromiidae, Bradybaenidae, Buliminidae).
Cercarian group: microcercous.
Habitat: terrestrial.
Definitive host group: mammals.
Localities: eastern, northeastern, central and southern regions of Uzbekistan.
References: Salimov (1965, 1974, 1989, 1991), Ernazarov (1972), Tukhmanyants, Shakhurina (1971), Sultanov et al. (1975), Shakarboyev et al. (2012).

Corrigia corrigia (Braun, 1901)
Intermediate host: *Candaharia rutellum, Bradybaena phaezona* (Gastropoda: Parmacellidae, Bradybaenidae).
Cercarian group: cercariaeum.
Habitat: terrestrial.
Definitive host group: birds.
Locality: southern regions.
Reference: Davronov (1999).

Eurytrema pancreaticum (Giard et Billet, 1892)
Intermediate host: *Bradybaena phaezona* (Gastropoda: Bradybaenidae).
Cercarian group: microcercous.
Habitat: terrestrial.
Definitive host group: mammals.
Locality: Fergana Valley.
References: Sultanov et al. (1975), Shakarboyev et al. (2012).

PLAGIORCHIIDAE LÜHE, 1901

Haplometra cylindracea (Zeder, 1800)
Intermediate host: *Lymnaea stagnalis* (Gastropoda: Lymnaeidae).
Cercarian group: xiphidiocercaria.
Habitat: freshwater.
Definitive host group: amphibians.
Localities: central and northeastern regions.
References: Nasimov (1967), Shakarbaev et al. (2013, 2014 b).

HAEMATOLOECHIDAE FREITAS & LENT, 1939

Haematoloechus variegatus (Rudolphi, 1819)
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarian group: xiphidiocercaria.
Habitat: freshwater.
Definitive host group: amphibians.
Localities: Republic of Karakalpakstan, Fergana Valley.
References: Tukhmanyants, Shakhurina (1971), Arystanov (1976).

Skrjabinoeces similis (Looss, 1899)
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarian group: xiphidiocercaria.
Habitat: freshwater.
Definitive host group: amphibians.
Localities: Fergana Valley, central and northeastern parts of Uzbekistan.
References: Nasimov (1967), Tukhmanyants, Shakhurina (1971), Shakarbaev et al. (2013, 2014 a).

TELORCHIIDAE LOOSS, 1899

Opisthioglyphe ranae (Froelich, 1791)
Intermediate host: *Lymnaea auricularia, L. bactriana, L. stagnalis* (Gastropoda: Lymnaeidae).
Cercarian group: xiphidiocercaria.
Habitat: freshwater.
Definitive host group: amphibians.
Localities: Republic of Karakalpakstan, central and northeastern regions.
References: Nasimov (1967), Arystanov (1976), Shakarboyev et al. (2012), Shakarbaev et al. (2013, 2014 b).

PLEUROGENIDAE LOOSS, 1899

Pleurogenes claviger (Rudolphi, 1819)
Intermediate host: *Pl*anorbis planorbis (Gastropoda: Planorbidae).
Cercarian group: xiphidiocercaria.
Habitat: freshwater.
Definitive host group: amphibians.
Locality: Fergana Valley.
Reference: Tukhmanyants, Shakhurina (1971).

CERCARIAN GROUPS OF UNIDENTIFIED SPECIES
(species inquirendae)

Amphistome
Intermediate host: *Lymnaea auricularia*.

Habitat: freshwater.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Xiphidiocercaria
Intermediate host: *Lymnaea auricularia, L. stagnalis*.
Habitat: freshwater.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Xiphidiocercaria
Intermediate host: *Lymnaea auricularia*.
Habitat: freshwater.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Xiphidiocercaria
Intermediate host: *Lymnaea stagnalis*.
Locality: Republic of Karakalpakstan.
Reference: Butenko (1967).

Brevifurcate
Intermediate host: *Lymnaea auricularia*.
Locality: Republic of Karakalpakstan.
Reference: Arystanov (1976).

Brevifurcate
Intermediate host: *Pl*anorbis planorbis.
Locality: the Syrdarya River.
Reference: Butenko (1967).

Discussion

Trematodes are common in the biocoenoses of Uzbekistan, where they are represented by about 200 species. They are entirely parasitic organisms. Trematodes' definitive hosts are various vertebrates, such as fish, amphibians, birds and mammals (Shakarboyev et al., 2012). They concentrate in various organs in the definitive host's body. Some species and groups cause serious helminthiases in domestic and game animals and the human.

The class Trematoda is divided into two subclasses — Aspidogastrea Faust and Tang, 1936 and Digenea Carus, 1863 (Gibson et al., 2002). All the trematode cercarial larvae covered by this work belong to the subclass Digenea.

The enormous research made into of the cercarial fauna developing in the mollusks of Uzbekistan's aquatic and terrestrial biocenoses has a long history. For the first time mollusks as trematodes' intermediate hosts were studied in the biocenoses of this region in the 30s of the 20th century (Dogel & Bykhovsky, 1934).

In the years that followed the research was continued and spread to the aquatic and terrestrial biocenoses of the adjoining territories. The results were presented in numerous articles published in Russian, which, therefore, proved inaccessible to foreign parasitologists.

Currently, after 80 years of research (1934–2019), there are about 100 scientific articles dedicated to the fauna of trematodes living in the aquatic and terrestrial mollusks of Uzbekistan. These publications demonstrate that the trematode cercariae of mollusks have been studied quite properly in the water bodies of the lower course of the Amu River (Arystanov, 1967, 1968 a, b, 1969 a, b, 1970, 1971, 1976), where 41 cercaria species have been recorded. The infection rate among mollusks ranged between 0.02 % and 37.2 %, depending on the season and type of a water body.

There have been 21 cercaria species discovered in mollusks of the classes Gastropoda and Bivalvia inhabiting the water bodies of the Syrdarya and Zarafshan Rivers. The average infection rate among the studied mollusks was 3.43 % (Nasimov, 1967).

The freshwater and terrestrial mollusks of the Fergana Valley (Andizhan, Namangan and Fergana Provinces) were recorded to be the hosts of 28 cercaria species. The infection rate among the freshwater mollusks was 4.3 %, among the terrestrial ones — 1.0 % (Tukhmanyants, Shakhurina, 1971). There were 12 cercaria species recorded in the south of Uzbekistan (Davronov, 1999).

There were also a number of scientists who carried out comprehensive research into the life cycles of trematode groups most pathogenic for animals and the human being. The experts determined the rate of infection with fluke cercariae among freshwater and terrestrial mollusks (Salimov, 1965, 1974, 1989, 1991; Salimov et al., 1986; Ernazarov, 1972; Azimov et al., 2014; Akramova, 2011; Shakarboyev et al., 2012; Shakarbaev et al., 2013, 2014 a, b).

We specified the life cycles of a number of trematode species in Uzbekistan: *Brachylaima fuscata, Diplostomum spathaceum, Schistosoma turkestanicum, Bilharziella polonica, Trichobilharzia ocellata, Dendritobilharzia loossi, Gigantobilharzia acotylea, Sanguinicola inermis, Fas*ciola hepatica, Fasciola gigantica, Calicophoron calicophorum, Calicophoron erschowi, Gastrothylax crumenifer, Notocotylus attenuates, Dicrocoelium dendriticum, Eurytrema pancreaticum. We were the first to provide the descriptions of life cycles and biology of three species — *Calicophoron erschowi, Dendritobilharzia loossi, Gigantobilharzia acotylea* (Khamrayev, 1983; Akramova et al., 2007, 2010, 2011, 2017).

Thus, the research into the fauna of cercariae and the larval stage of trematodes that has been so far carried out in the territory of Uzbekistan is absolutely insufficient. The total number of cercaria species established in the course of the research both in freshwater and terrestrial mollusks is 50. The cercarial fauna of freshwater mollusks comprises 44 species, while only 6 species of cercarial from the families Dicrocoeliidae and Brachylaimidae have been recorded in terrestrial mollusks. It should be noted that by the present time 187 species of adult forms of trematodes have been recorded to parasitise the vertebrates of Uzbekistan (Sultanov et al., 1975; Shakarboyev et al., 2012; Azimov et al., 2014). The species diversity of cercariae discovered in the studied mollusks was much poorer, amounting to 26.7 % of the total number of adult forms of trematodes. Moreover, the same situation can be observed in the natural rate of infection with cercariae of different groups of trematodes among mollusks. According to the malacologists of Uzbekistan, the country's mollusc fauna comprises 386 species (Zhadin, 1952; Starobogatov, 1970; Izzatullayev, 1987; Pazilov, 2005; Pazilov, Azimov, 2003), of which 214 are freshwater and 172 — terrestrial. Only 38 species of the total number have been recorded to be infected with cercariae, which is 9.8 %. According to this data, only a small portion of the mollusc species were infected with cercarial larvae, which makes us think about the necessity of deeper research into the relations between mollusks and trematodes on a vast area of Uzbekistan with the use of the molecular genetic methods in order to specify the cercariae's species diversity. Nevertheless, analysing the existing materials we can distinguish two types of cercaria communities: the ones inhabiting acquatic biocenoses and those living in terrestrial ones. There are at least four strategies cercariae use to infect definitive hosts. The first strategy is utilised by cercaria species of the families Fasciolidae, Paramphistomidae, Gastrothylacidae and Notocotylidae, which encyst on underwater substrates. Adolescariae enter the organism of a definitive host with food. The second strategy is characteristic of most of cercariae, which use vertebrate and invertebrate animals as the second intermediate hosts to turn into metacercariae (the Echinostomatidae, Cyclocoeliidae, Clinostomidae, Plagiorchiidae, Telorchiidae, Dicrocoeliidae, Strigeidae, Diplostomidae, Brachylaimidae and Bucephalidae). Definitive hosts become infected through eating the second intermediate host with metacercariae inside. The third group of cercarial are quite active penetrating into their definitive host

through its skin (the Schistosomatidae, Bilharziellidae and Aporocotylidae). The fourth strategy is rather passive, when floating cercariae get into their definitive host with water through the mouth or infraorbitally, or when the host eats substrate with an adolescaria (metacercaria) in it (the Philophthalmidae).

As for the last strategy, it should be noted that earlier a number of experts discovered the possibility for a definitive host to be infected with cercariae or adolescariae of the Philophthalmidae (Galaktionov, Dobrovolsky, 1998; Pinto and Melo, 2013). This strategy should be defined as a mixed-type strategy, as it combines two strategies described above (Prokofyev, 2006; Prokofyev and Galaktionov, 2009).

The above described strategies used by certain groups of cercariae are accomplished through a number of responses, mainly photo-, geo- and chemotropism developed in the course of the evolution of parasite-host relations contributing to the concentration of larvae in the area with the best opportunities to meet hosts.

Conclusion

The territory of Uzbekistan is a habitat for 50 trematode species cercarial larvae species from 22 families. They infect certain species of freshwater and terrestrial mollusks. The core of the fauna of cercariae is formed of cercarial larvae developing in freshwater mollusks (44 species).

The definitive hosts of the mentioned cercariae are vertebrates — fish, amphibians, birds and mammals.

It should be noted that the groups of cercariae described above are common for the biogeocenoses of Uzbekistan, and the trematode-mollusk relations are quite stable. The risk of infection with certain trematodes is very high for animals. In this connection mollusks infected with trematode cercariae should be constantly monitored, which may allow us to understand parasite-host relations better and to study the life cycles, ecology and taxonomy of these parasites, on the one hand, and to develop the methods of preventing trematodoses in animals and the human being, on the other hand.

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