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Ecological-Faunistic Analysis of Helminthes of Waterbirds of the Aidar-Arnasay System of Lakes in Uzbekistan

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Abstract

For the first time, the faunal complexes of helminths of waterbirds in the Aidar-Arnasay system of lakes in Uzbekistan were studied. The material for this work was collections of parasitic worms of waterbirds obtained during the hunting seasons of 2020-2023. Using parasitological dissection, 326 bird individuals belonging to 31 species and 6 orders (Grebes, Copepods, Flamingiformes, Anseriformes, Craniformes and Charadariformes) were studied. The features of the distribution and ecology of helminths of the studied groups of birds are considered. In total, 79 species of parasites have been registered in the Aidar-Arnasay lake system. Of these, 29 species belong to the class Cestoda, the class Trematoda is represented by 27 species, the class Acanthocephala – by 3 species

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and the class Nematoda – by 20 species, which are indicated for the study area for the first time. Original data on the structure of the helminth fauna of 6 orders of waterfowl and wading birds are presented. Various routes of transmission of helminths to their hosts, birds, and methods of circulation of the invasion have been elucidated. The life cycles of most species of helminths noted by us involve intermediate (first and second) and reservoir hosts - invertebrate and vertebrate animals. The dietary choices of individual waterbird orders play a significant role in determining the types of parasitic worms that infect them, and are the primary factor in shaping their overall worm population. These processes undeniably take place within a specific timeframe and location, closely regulated by environmental factors.

Keywords:

Waterbirds, helminths, fauna, ecology, distribution, Aidar-Arnasay lake system, uzbekistan.

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Introduction

Currently, there are more than 500 lakes and reservoirs in the territory of Uzbekistan. The largest of them is the Aidar-Arnasay system of lakes with an area of more than 3,500 square meters. km, located between the Jizzakh and Navoi regions. Its length is about 160 km, with a width of 26 km. Depth from 12.5 m to 33.6 m. It is included in the Ramsar list of water bodies of the Convention on Wetlands of International Importance especially as waterfowl habitat (Mishra & Kumar, 2023).

The Aidar-Arnasay system of lakes, located on migration routes, with its vast wetlands and inhabited by numerous and diverse species of birds, including wetlands, remains poorly studied in parasitological terms (Suljić et al., 2018; Hernández et al., 2023). The significance of this research stems from the fact that the waterfowl and wading birds residing in this area are a crucial target for recreational hunting (Robles et al., 2015; Brahmaiah et al., 2021; Sreenivasulu, 2024). Furthermore, many of these birds are protected species listed as rare and endangered in the fauna of Uzbekistan. It is important to remember that birds can transmit various helminthiases. Notably, the trematode fauna holds a significant position, as many members of this systematic group pose a genuine danger to fish, birds, and humans (Hrnjadović et al., 2020; Javvaji et al., 2022; Abdullah, 2020).

In this work, in fact, the first attempt was made to assess the patterns of formation of the species composition of helminths of waterbirds in the Aidar-Arnasay lake system, to characterize the role of different host species, the features of their ecology and nutrition in the formation of the diversity of the fauna of parasitic worms, to identify the range of the most pathogenic species, determining the epizootological status of the study area.

Materials and Methods

The material for this work was collections of parasites of waterbirds caught in the area of the Aydar-Arnasay system of lakes during the hunting seasons of 2020-2023. (Fig. 1). These were trophies of hunters and birds collected by fishermen that died in fishing gear (cages, set nets). Using the method of complete parasitological dissection, 326 birds of 31 species belonging to 6 orders were studied (Table 1).

Autopsy of birds, search and extraction of helminths, their staining and preparation of permanent preparations were carried out according to standard parasitological methods (Dubinina, 1971). Studying,

measuring flukes, photographs and drawings were made using Olympus CK2-TR microscopes, trinocular No. 300 m Ningo Yongkin Optics and MicroCap V2.0 software.

The species identification of helminths was carried out according to well-known monographs and guides (Baruś et al., 1978; Borgarenko, 1981, 1984, 1990; Anderson, 2000).

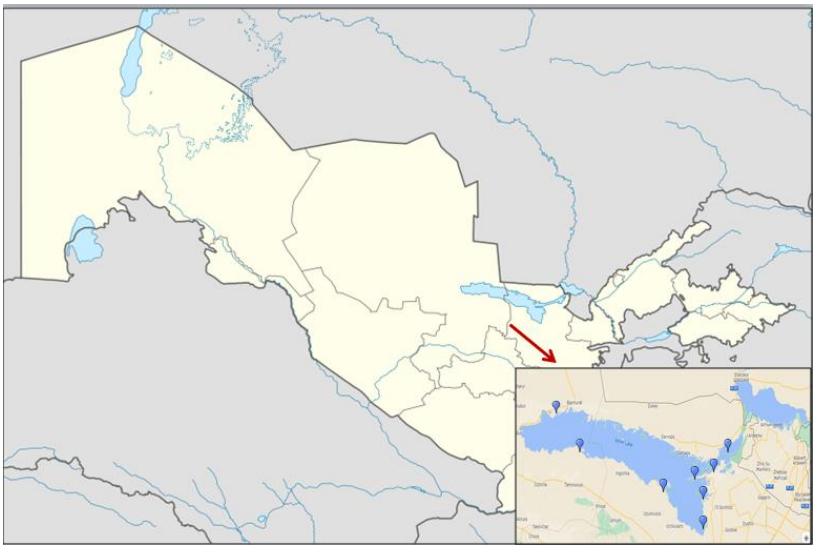

Fig. 1. Place of collection of material

Table 1. Species composition of studied birds

Order and number of species	**Studied, individuals**	**Infected, individuals**
Grebes (2 species)	20	16
Copepods (2 species)	7	6
Flamingiformes (1 species)	1	1
Anseriformes (15 species)	215	195
Crane-like animals (3 species)	39	33
Charadriiformes (8 species)	44	31
Total	326	282

Results and Discussion

We have established that helminths parasitizing waterbirds of the Aydar-Arnasay lake system belong to 4 classes - Cestoda Rudolphi, 1808, Trematoda Rudolphi, 1808, Acanthocephala Rudolphi, 1808 and Nematoda Rudolphi, 1808. The total number of helminth species is now represented by 78 species; of these, 29 species belong to the class Cestoda, 27 species to the class Trematoda, 3 to the class Acanthocephala and 20 to the class Nematoda (Table. 2).

Table 2. Taxonomic composition and species diversity of helminths of waterbirds in the Aydar-Arnasay lake system of Uzbekistan

Family	View
Ligulidae	*Ligula intestinalis* (L., 1758)
	Digramma interrupta (Rud., 1810)
	Schistocephalus solidus (Műller, 1776)
Diphyllobothriidae	*Diphyllobothrium ditremum* (Creplin, 1825)
	Paradilepis scolecina (Rud., 1819)
	Lateriporus clerci (Johnston, 1912)
	Anomotaenia microrhyncha (Krabbe, 1869)
	Anomotaenia microphallos (Krabbe, 1869)
Dilepididae	*Aploparakis furcigera* (Rud., 1819)
	Cloacotaenia megalops (Nitzch, 1829)
	Dicranotaenia coronula (Dujardin, 1845)
	Diorchis brevis (Rybicka, 1957)
	Diorchis flavescens (Krefft, 1871)
	Diorchis inflata (Rud., 1810)
	Diorchis nyrocae (Yamaguti, 1935)
	Diorchis ransomi (Shultz, 1940)
	Diorchis acuminata (Clerc, 1902)
Hymenolepididae	*Diploposthe laevis* (Bloch, 1782)
	Drepanidotaenia lanceolata (Bloch, 1782)
	Drepanidotaenia spinulosa (Dubinina, 1953)
	Fimbriaria fasciolaris (Pallas, 1871)
	Microsomacanthus microsoma (Creplin, 1829)
	Microsomacanthus compressa (Linton, 1892)
	Sobolevicanthus gracilis (Zeder, 1803)
	Sobolevicanthus collaris (Ratsch, 1786)
	Sobolevicanthus fragilis (Krabbe, 1869)
	Flamingolepis tengisi (Gvozdev et Maksimova, 1968)
	Flamingolepis flamingo (Skrjabin, 1914)
	Tschertkovilepis setigera (Fröelich, 1789)
Echinostomatidae	*Echinostoma revolutum* (Fröelich, 1802)
	Echinostoma dietzi (Skrjabin, 1923)
	Echinostoma mygawai (Ishii, 1932)
	Echinostoma transfretanum (Dietz, 1909)
	Echinostoma paraulum (Dietz, 1909)
	Echinostoma robustum (Yamaguti, 1935)
	Echinochasmus coaxatus (Dietz, 1909)
	Echinochasmus spinulosus (Rud. 1809)
	Echinoparyphium recurvatum (Linstow, 1873)
	Echinoparyphium cinctum (Rud., 1803)

	Hypoderaeum conoideum (Bloch, 1782)
	Mesorchis denticulatus (Rud., 1802)
Microphallidae	*Microphallus pygmaeus* (Levinson, 1881)
Psilostomidae	*Psilochasmus oxyurus (Creplin, 1825)*
Phylophthalmidae	*Philophthalmus skrjabini* Efimov,1937
Cyclocaeliidae	*Cyclocoelium halli* (Harrah, 1922)
	Typhlocoelum cucumerinum (Rud., 1809)
Prostogonimidae	*Prosthogonimus cuneatus* (Rud., 1809)
Notocotylidae	*Notocotylus attenuatus* (Rud., 1809)
	Notocotylus chionis (Baylis, 1928)
	Catatropis verrucosa (Frölich, 1789)
Strigeidae	*Cotylurus platycephalis* (Creplin, 1825)
Diplostomidae	*Diplostomum spathaceum* (Rud., 1819)
Bilharziellidae	*Bilharziella palonica* (Kowalewsky, 1895)
	Trichobilharzia ocellata (La Valette, 1854)
	Ornithabilharzia canaliculata (Rud., 1819)
	Dendritabilharzia pulverulenta (Braun, 1901)
Polymorphidae	*Polymorphus magnus* (Skrjabin, 1913)
	Polymorphus minutus (Goeze, 1782)
Filicollidae	*Filicollis anatis* (Schrank, 1788)
Capillariidae	*Capillaria anseris* (Madsen, 1945)
	Thominx anatis (Schrank, 1790)
Dioctophymidae	*Eustrongylides excisus* (Jägerkiöld, 1909)
Amidostomatidae	*Amidostomum anseris* (Zeder, 1800)
	Amidostomum acutum (Lundahl, 1848)
	Amidostomoides monodon (Linstow, 1882)
	Amidostomum skrjabini (Boulenger, 1926)
Trichostrongylidae	*Trichostrongylus tenuis* (Mehlis, 1846)
	Epomidiostomum anatinum (Skrjabin, 1915)
Ascarididae	*Ascaridia galli* (Schrank, 1788)
Anisakidae	*Contracaecum microcephalum* (Rudolphi, 1809)
	Contracaecum spiculigerum (Rud., 1809)
	Porrocaecum crassum (Deslongchamps, 1824)
Heterakidae	*Heterakis gallinae* (Gmelin, 1790)
	Ganguleterakis dispar (Schrank, 1790)
Tetrameridae	*Tetrameres fissispina* (Diesing, 1861)
	Tetrameres gubanovi (Shigin,1957)
	Tetrameres skrjabini (Panova, 1962)
Streptocaridae	*Paracuaria tridentata* (Linstow, 1877)
	Streptocara crassicauda (Creplin, 1829)

The proportion of helminths of individual classes in the helminth fauna of the studied birds is not the same. The most numerous representatives of the class of cestodes (29 species). The second position in terms of species composition is occupied by trematodes (27 species). Nematodes consist of 19 species. Acanthocephalans (3 species) are characterized by the smallest species composition.

Representatives of 31 species of waterbirds (grebes, copepods, flamingiformes, Anseriformes, craneiformes and Charadriiformes) in the studied reservoir were infected with helminths, to a fairly high degree (87.1%). The intensity of infection is low, ranging from single to dozens of specimens.

The helminth fauna of the studied birds, as our studies of these orders have shown, is uneven. The species diversity of helminths is most richly represented in Anseriformes - 53 species. The smallest number of species of avian helminths was observed in representatives of the orders Grebes and Flamingiformes, in which 10 species of parasites were found each. When considering the structures of the helminth fauna at the level of classes of parasitic worms of waterbirds in the studied water area, significant differences were revealed. (Table 3). The class Cestoda is represented by 29 species from four families, among which the richest diversity is found in Hymenolepididae (21 species).

Representatives of the class Trematoda consisted of 27 species belonging to 10 families. The largest number of species was recorded from Echinostomatidae (12 species) and Bilharziellidae (4 species). The remaining 8 families contained from 1 to 3 species of trematodes. From the class Acanthocephala - only 3 species are registered, belonging to two families - Palymorphidae and Filicollidae. Nematodes (20 species), belonging to 9 families, turned out to be quite more diverse (Table 3).

Table 3. Structure of the helminth fauna of waterbirds in the study region

Class	**Family**	**Number**	
		childbirth	**childbirth**
Cestoda	Ligulidae	2	3
	Diphyllobothriidae	1	1
	Dilepididae	7	13
	Hymenolepididae	7	13
Trematoda	Echinostomatidae	5	12
	Microphallidae	1	1
	Psilostomatidae	1	1
	Phylophthalmidae	1	1
	Cyclocaeliidae	2	2
	Prostogonimidae	1	1
	Notocotylidae	2	3
	Strigeidae	1	1
	Diplostomidae	1	1
	Bilharziellidae	4	4
Acanthocephala	Polymorphidae	1	2
	Filicollidae	1	1
Nematoda	Capillariidae	2	2
	Dioctophymidae	1	1
	Amidostomatidae	1	4
	Trichostrongylidae	2	2
	Ascarididae	1	1
	Heterakidae	1	3
	Tetrameridae	1	3
	Streptocaridae	2	2
	Desmidocercidae	1	1
Total		50	79

It is noteworthy that in the studied birds, in most cases mixed helminth infestations were noted. We found from two to five types of parasites in infested birds, both domestic and wild. Parasitocenosis was detected in 205 individuals out of 282 infected birds, which is 72.7%. The components of parasitocenosis form various combinations of two to five species associations. Combinations of representatives of all four classes of helminths were noted. In our material, mixed invasions by cestodes, trematodes and nematodes were often observed.

Among the discovered helminths, about 20 species are among the most pathogenic (families Ligulidae, Hymenolepididae, Echinostomatidae, Prostogonimidae, Notocotylidae, Bilharziellidae, Amidostamatidae, Anisakidae, Heterakidae, Tetrameridae, Streptocaridae, Palymorphidae), causing in some cases dangerous helminthiasis of domestic and wild birds, fish and man.

The discovered species and the danger of the diseases they cause indicate the need to expand research into the dynamics of the helminth fauna of waterbirds.

The quantitative distribution of helminths in individual orders of birds in the studied water area of the Aidar-Arnasay system of lakes is extremely uneven. Faunistic analysis of helminths of the studied groups of birds is given below.

Helminthofauna of the order Toadstools – Podicipediformes. Grebes are of moderate to small size and are typically found in aquatic environments (Pokric et al., 2015). The global fauna consists of a total of 22 documented species, with Uzbekistan being home to seven of these species. They inhabit low-lying lakes, reservoirs, and river floods that are covered in dense coastal aquatic vegetation. They are migratory and nesting birds by nature. They live a clandestine lifestyle. Food is acquired through submerging underwater. They consume invertebrates and small fish as their primary source of nutrition (Kreitsberg-Mukhina et al., 2005; Shernazarov et al., 2006). The number is relatively constant. A minority started to reside during the winter months in the southern regions of Uzbekistan. Grebe species serve as hosts for helminths (Khaydarov et al., 2023).

In a study of 20 individuals of two species: the gray-cheeked grebe Podiceps grisigena (Boddaert, 1783) and the great grebe Podiceps cristatus (Linnaeus, 1758) on the territory of the Aydar-Arnasay system of lakes, their infestation with helminths was established. The infestation of the studied grebes was 80%. The intensity of invasion varied from single to dozens of specimens. 10 species of helminths have been identified: Diphyllobothrium ditremum (Creplin, 1825), Ligula intestinalis (L., 1758), Digramma interrupta (Rud., 1810), Schistocephalus solidus (Müller, 1776), Echinochasmus coaxatus (Dietz, 1909), Mesorchis denticulatus (Rud., 1802), Microphallus pygmaeus (Levinson, 1881), Tetrameres gubanovi (Shigin, 1957), Paracuaria tridentata (Linstow, 1877). The noted species of helminths turned out to be representatives of the classes Cestoda, Trematoda and Nematoda. The development cycle of registered species involves numerous species of invertebrates and, in some cases, aquatic vertebrates – fish.

Helminth fauna of the order Copepods – Pelecaniformes. Birds of large and medium size with varied body shapes. All representatives of the order are semi-aquatic. They nest in colonies and also live in flocks outside the breeding season. They feed exclusively on fish. In Uzbekistan they are represented by four species. Habitats: large deep reservoirs rich in aquatic vegetation and fish; lakes, reservoirs, lower reaches and river deltas. By way of life they are nesting migratory birds. They are also found on the territory of the Aydar-Arnasay system of lakes (Kreitsberg-Mukhina et al., 2005; Zhumanov, 2017).

We conducted research on 7 individuals of two bird species: the little cormorant Palacrocorax pygmaeus Pallas, 1773 and the great cormorant Palacrocorax carbo (Linnaeus, 1758) on the territory of the Aydar-Arnasay system of lakes in the North-Eastern region of Uzbekistan. The autopsied birds turned out to be infected with parasites consisting of cestodes, trematodes and nematodes: Ligula intestinalis (L., 1958), Schistocephalus solidus (Müller, 1776), Paradilepis scolecina (Rud., 1819), Cloacotaenia megalops (Nitzch, 1829); Echinostoma revolutum (Fröchlich, 1802), Echinochasmus coaxatus Dietz, 1909, Echinochasmus spinulosus (Rud., 1809), Prosthogonimus cuneatus (Rud., 1809), Cotylurus platycephalus (Creplin, 1825), Eustrongylides excisus Jägerskiold, 190 9, Paracuaria tridentata (Linstow, 1877), Contracaecum spiculigerum (Rudolphi, 1809).

Of the total number of helminth species (14) of copepods in the study region, cestodes consist of 4 species, trematodes – 6 species and nematodes – 4 species.

Helminth Fauna of the Order Flamingiformes – Phoenicopteriformes

These are avian creatures characterized by their substantial size and elongated, slender legs. The plumage is predominantly white with a varying intensity of pink tint. The order consists of five species belonging to a single family, with one species, Phoenicopterus roseus Pallas, 1811 (pink flamingo), being found in Uzbekistan.

Certain populations inhabit the exposed shores of expansive water bodies. Lifestyle: This species exhibits migratory behavior, moving from one region to another, and also engages in nesting activities within the region. The organism consumes aquatic invertebrates, particularly small crustaceans and mollusks, dipteran larvae, and seeds of aquatic plants. Status: susceptible, inherently scarce species.

We were able to examine only one adult individual, mortally wounded on the territory of Lake Tuzkan on March 5, 2022, in which cestodes, trematodes and nematodes were found: Sobolevicanthus gracilis (Zeder, 1803), Gryporhynchus Pusillus Nordmann, 1832, Flamingolepis Tengisi Gvozdev et Maksimova, 1968; Flamingolepis flamingo (Skrjabin, 1914); Echinostoma revolutum (Fröchlich, 1802); Psilochasmus oxyurus (Creplin, 1825), Notocotylus attenuatus (Rudolphi, 1809 Philophthalmus skrjabini Efimov, 1937; Tetrameres fissispina (Diesing, 1861), Paracuaria tridentata (Linstow, 1877).

According to the nature of the biological cycle, the noted species (10) belong to heteroxenic forms of helminths. All of them develop with the participation of intermediate hosts, which are numerous species of invertebrates.

Helminth Fauna of the Order Anseriformes – Anseriformes

Anseriform waterfowl of various sizes and colors, with a dense body, a more or less long neck and short legs. The anseriformes of Uzbekistan include representatives of the Anatidae family, diurnal waterfowl, whose biology is closely related to the aquatic environment. They inhabit fresh and salty water bodies and nest on the banks of rivers, lakes, and swamps, mostly solitary, less often in a scattered colony.

By the nature of their diet, species with a mixed animal-vegetable diet predominate. The food of most species is extremely varied. By way of life they are migratory. On the territory of Uzbekistan, there is a seasonal change in population throughout the year.

Distribution: reservoirs of temperate and desert-steppe regions, including the Aydar-Arnasay system of lakes in Uzbekistan. In our republic, Anseriformes are represented by about 35 species, many species of which are known as hosts of helminths (Sultanov, 1963; Yorkulov, 2023; Arepbaev, 2020).

In a study of 215 individuals (15 species) of domestic and wild Anseriformes, parasitic worms were identified in 195, which is 90.7%. Of the collected helminths, 53 species were identified.

We have established that helminths parasitizing domestic and wild anseriformes of the Aydar-Arnasay lake system belong to four classes - Cestoda, Trematoda, Acanthocephala and Nematoda. The total number of helminth species is now represented by 53 species; of which 18 species belong to the class Cestoda, 16 to the class Trematoda and 3 to the class Acanthocephala and 16 to the class Nematoda: *Ligula intestinalis* (Linnaeus, 1758), *Digramma interrupta* (Rudolphi, 1810), *Aploparakis furcigera* (Rudolphi, 1819), *Cloacotaenia megalops* (Nitzch, 1829), *Dicranotaenia coronula* (Dujardin, 1845), *Diorchis flavescens* (Krefft, 1871), *Diorchis nyrocae* (Yamaguti, 1935), *Diorchis acuminata* (Clerc, 1902), *Diploposthe laevis* (Bloch, 1782), *Drepanidotaenia lanceolata* (Bloch, 1782), *Drepanidotaenia spinulosa* (Dubinina, 1953), *Fimbriaria fasciolaris* (Pallas, 1871), *Microsomacanthus microsoma* (Creplin, 1829), *Microsomacanthus compressa* (Linton, 1892), *Sobolevicanthus gracilis* (Zeder, 1803), *Sobolevicanthus collaris* (Ratsch, 1786), *Sobolevicanthus fragilis* (Krabbe, 1869), *Tschertkovilepis setigera* (Fröchlich, 1789), *Echinostoma revolutum* (Fröchlich, 1802), *Echinostoma miyagawai* (Ishii, 1932), *Echinostoma paraulum* Dietz, 1909; *Echinostoma robustum* Yamaguti, 1935; *Echinoparyphium recurvatum* (Linstow, 1873), *Echinoparyphium cinctum* (Rudolphi, 1803), *Hypoderaeum conoideum* (Bloch, 1782), *Cyclocoelium halli* Harrah, 1922; *Typhlocoelium cucumerinum* (Rudolphi, 1809), *Prosthogonimus cuneatus* (Rud., 1809), *Notocotylus attenuatus* (Rudolphi, 1809), *Notocotylus chionis* Baylis, 1928; *Catatropis verrucosa* (Fröchlich, 1789), *Bilharziella polonica* (Kowalewskj, 1895), *Trichobilharzia ceellata* (La Valetti, 1854), *Dendrobilharzia pulverulenta* (Braun, 1901), *Polymorphus magnus* Skrjabin, 1913; *Polymorphus minutus* (Goeze, 1782), *Filicollis anatis* (Schrank, 1788), *Capillaria anseris* (Madsen, 1945); *Thominx anatis* (Schrank, 1790), *Amidostomum anseris* (Zeder, 1800), *Amidostomoides monodon* (Linstow, 1882); *Amidostomum acutum* (Lundahl, 1848), *Trychostrongylus tenuis* (Mehlis, 1846), *Epomidiostomum anatinum* (Skrjabin, 1915), *Ascaridia galli* (Schrank, 1788), *Contracaecum microcephalum* (Rudolphi, 1809), *Porrocaecum crassum* (Deslongchamps,1824), *Heterakis gallinae* (Gmelin, 1790), *Ganguleterakis dispar* (Schrank, 1790), *Tetrameres fissispina* (Diesing, 1861), *Tetrameres skrjabini* Panova, 1962; *Streptocara crassicauda* (Creplin, 1829).

The proportion of helminths of individual classes in the helminth fauna of Anseriformes varies. The most numerous representatives of the class of cestodes (18 species). The second position in species composition is occupied by trematodes and nematodes with 16 species each. The smallest species composition is characterized by acanthocephalans (3 species).

In percentage terms, as already mentioned, the infestation of the studied birds with cestodes was 34%, trematodes and nematodes 30.2% each, and acanthocephalans 5.7%.

Cestodes are represented by species of the families Ligulidae (2 species), Hymenolepididae (16 species). Trematodes turned out to be representatives of 5 families: Echinostomatidae (7 species), Cyclocaelidae (2 species), Prostogonimidae (1 species), Notocotylidae (3 вида), Schistosomatidae (3 вида). Acanthocephalans are represented by 2 families – Palymorphidae (1 species), Filicollidae (1 species). Nematodes are representatives of 8 families: Capillaridae (2 species), Amidostamatidae (5 species), Trichostrongylidae (2 вида), Ascarididae (2 species), Anisakidae (2 вида), Heterakidae (2 species), Tetrameridae (1 species) и Streptocaridae (1 species).

It is noteworthy that in the studied birds, in most cases mixed helminth infestations were noted. In infested Anseriformes species, both domestic and wild, we found from two to five species of parasites. The components of parasitocenosis form various combinations of two to five species associations. Combinations of representatives of all four classes of helminths were noted. In our material, mixed invasions by cestodes, trematodes and nematodes were often observed.

Thus, on the territory of the Aydar-Arnasay lake system, 53 species of parasites of Anseriformes belonging to four classes – Cestoda, Trematoda, Acanthocephala and Nematoda – were identified.

The helminth fauna of Anseriformes, with its diversity, clearly reflects the characteristics of their aquatic lifestyle. They are dominated by parasite species, the development of which is associated with the conditions of the aquatic environment.

Of the discovered helminths of Anseriformes, about 20 species are the most pathogenic, causing dangerous helminthiases in domestic and wild birds, fish and humans. All this requires systematic monitoring of the parasitological situation in wetlands and implementation of preventive measures.

Helminthofauna of the Order Craniformes – Gruiformes

In the avifauna of Uzbekistan, the order Craniformes is represented by 13 species, members of three families - Gruidae, Rallidae and Otididae. The majority are wading birds; they live in densely overgrown, damp places, on overgrown lakes and wet meadows. They feed mainly on plant foods, but can also eat animal food.

By way of life they are migratory. Cranes and shepherds are also found on the territory of the Aidar-Arnasay system of lakes in Uzbekistan. Shepherdesses are objects of sport hunting.

Of the 13 species of rails, cranes and drow fauna of Uzbekistan, 10 are known as hosts of helminths (Sultanov, 1963; Akramova, 2011; Saparov, 2014, 2013; Akramova et al., 2019).

In our study of 39 individuals of three species – the coot Fulica atra, the railer Rallus aquaticus and the moorhen Gallinula chloropus, we found helminths in 33, which is 84.6%. The collected helminths turned out to be representatives of cestodes, trematodes and nematodes: Diorchis brevis Rybicka, 1957; Diorchis inflata (Rud, 1810), Diorchis ransomi Schultz, 1940; Fimbriaria fasciolaris (Pallas, 1781); Echinostoma dietzi Skrjabin, 1923; Echinostoma transfretanum Dietz, 1909; Notocotylus attenuatus (Rud., 1809); Dendritobilharzia pulverulenta (Braun, 1901); Streptocara crassicauda (Creplin, 1829).

The helminth fauna consists of 9 species, of which cestodes are 4 species, trematodes are 4 species and nematodes are 1 species.

Helminth fauna of the Order Charadriiformes - Charadriiformes

The birds of this order are small and medium-sized and have a wide variety of appearances. The vast majority lead an aquatic or semi-aquatic lifestyle, but among them there are species that live in desert and arid landscapes. Representatives of 7 families are found in Uzbekistan. More than 70 species have been recorded.

Wetland representatives of the families - plovers Charadriidae, avocets Recurvirostridae, snipe Scolopacidae and gulls Laridae are also found on the territory of the Aydar-Arnasay system of lakes. Many species of Charadriiformes are hosts of helminths in the conditions of Uzbekistan (Sultanov, 1963; Akramova, 2011; Saparov, 2016; Akramova et al., 2020).

In a study of 44 individuals, 8 species (Charadris dubins Scopoli, 1786, Vanellus vanellus (Linnaeus, 1758), Tringa glareola Linnaeus, 1758, Gallinago gallinago (Linnaeus, 1758), Larus cachinnaus Linnaeus, 1758, Larus ridibundus Linnaeus, 1758 and Laurus hyperboreus Gunnerus, 1767) caught during autumn hunting in the wetlands of the Aidar-Arnasay lakes of Uzbekistan, infection was detected in 31 individuals (70.4%). From the collected gelmine collections, 13 species belonging to cestodes, trematodes and nematodes are identified: Ligula Intestinalis (Linnaeus, 1758), Schistocephalus Solidus (Müller, 1776), Anomotaenia Microrhyncha (Krabbe, 186 9), Anomotaenia microphallos (Krabbe, 1869), Lateriporus Clerci (Johnston, 1912), Aploparaksis furcigera (Rud., 1819), Diplostomum spathaceum (Rudolphi, 1819), Bilharziella pulonica (Kowalewsky, 1895), Ornithabilharzia canaliculata (Rudolphi, 1819); Paracuaria tridentata (Linstow, 1877), Streptocara crassicauda (Creplin, 1829).

Of the total number of species of Charadriiformes helminths, cestodes are the most richly represented (8 species), the second position is occupied by trematodes - 3 species. Nematodes consist of 2 types.

In the waters of the Aydar-Arnasay lake system, helminths were found in 31 species of water birds. Of the total number of 326 birds, 282 birds (86.5%) were infected with helminths. The identified parasites belonged to the classes Cestoda, Trematoda, Acanthocephala and Nematoda.

The helminth fauna of the studied orders of birds is unequal. The species diversity of parasites is most richly represented in Anseriformes (53 species), Craniformes (15 species), Copepods (14 species), Grebes and Flamingiformes (10 species each).

The evident resemblance in the helminth fauna among various bird orders, excluding falconiformes, flamingiformes, and loons due to insufficient research, can be attributed to the considerable adaptability of waterbirds and the prevailing climatic conditions. It is well-established that waterbirds have a diverse diet that includes a substantial amount of intermediate and reservoir hosts of helminths. These hosts consist of various groups of invertebrates and vertebrates, such as fish.

The examination of the origins of helminth infection in specific waterbird populations revealed that the overwhelming majority of identified helminth species are of heteroxenic nature, meaning their development takes place through intermediate and reservoir hosts. This encompasses all categories of cestodes, trematodes, and acanthocephalans.

Monoxenic forms of helminths were found only among nematodes – Trychostrongylus tenius, Epomidiostomum anatinum, Ascaridia galli, Heterakis gallinae and Ganguleterakis dispar. Of the 79 discovered species of helminths, 74 species have life cycles that involve intermediate and reservoir hosts.

Upon investigating the origins of waterbird infections, it was discovered that the development of numerous helminth species remains unstudied. Consequently, we relied on available information about the life cycles of specific groups of helminths, using similar species of parasites as a reference and considering the feeding habits of host birds.

Research revealed that the majority of identified helminth species infiltrate the avian body through diverse means, with intermediate, additional, and reservoir hosts acting as infection sources. This is supported by a multitude of publications, which are condensed in foundational monographs. They are recognized by experts. The primary hosts for representatives of the class Cestoda were predominantly crustaceans, which are inhabitants of diverse aquatic environments. Additionally, oligochaetes served as secondary or reservoir hosts.

Trematodes undergo development with the involvement of aquatic mollusks, serving as the initial intermediate host. Noted among the second group are various species of insects, fish, amphibians, reptiles, and small mammals. Nematodes utilize a broader spectrum of intermediate hosts, including oligochaetes, crustaceans, and both aquatic and terrestrial insects. Nematodes have been documented to utilize fish and amphibians as secondary hosts and reservoirs.

In the helminth fauna of waterfowl and wading birds of the Aydar-Arnasay system of lakes in Uzbekistan, parasites associated with hosts through trophic relationships predominate. This includes cestodes - 100%, trematodes - 73%, acanthacephali - 100% and nematodes - 76.1%. Infection of 23.7% of helminth species occurs through a topical route: this includes five species of nematodes - T. tenuis, E. anatinum, A. galli, H. gallinae and G. dispar; infection of birds occurs through ingestion of invasive elements (eggs or larvae). Topical also includes bilharziellid cercariae of 4 genera - Bilharziella, Trichobilharzia, Ornithobilharzia, Dendrobilharzia, the larvae of which enter the body of birds only by the parenteral route.

The dietary habits of the waterbird orders under study play a significant role in determining the types of parasitic worms that infect them, and are the primary factor in shaping their helminth population. These processes undoubtedly take place within a specific timeframe and location, under the precise regulation of environmental factors. The interplay of the aforementioned factors influenced the emergence of the contemporary helminth fauna of aquatic birds in the investigated region of Uzbekistan.

Discussion

Helminths are undoubtedly one of the most popular objects of research on the fauna of Uzbekistan (Sultanov, 1963; Akramova et al., 2023). However, information about the helminth fauna of birds, in particular, the wetlands of the Aydar-Arnasay lake system of Uzbekistan, is completely absent.

The results of the study of helminth fauna, distribution features and ecology are a significant addition to the community of parasites of waterbirds, inhabitants of a large reservoir - the Aydar-Arnasay system of lakes of modern Uzbekistan. We identified 80 species of helminths, consisting of representatives of cestodes, trematodes, acanthocephalans and nematodes, which are widespread among the studied birds in the waters of the Aidar-Arnasay lake system.

Waterbirds are recognized for their significant ecological and trophic adaptability. Birds primarily become infected through their consumption of food items that are linked to intermediate and reservoir hosts, a common characteristic of helminths with heteroxenic life cycles. This is supported by a multitude of publications from both national and international authors (Shultz & Gvozdev, 1970; Ryzhikov et al., 1973, 1974; Anderson, 2000).

Various classes of animals, including oligochaetes, aquatic and terrestrial mollusks, crustaceans, insects, fish, amphibians, and reptiles, contribute to the spread of invasive bird helminths. They have the ability to function as intermediate or reservoir hosts, as documented, (Panin, 1957; Karmanova 1968; Smogorzhevskaya, 1976; Krasnolobova, 1987; Anderson, 2000).

Hence, our data align with the existing literature on the helminth fauna of waterbirds in the reservoirs of Karakalpakstan (Sultanov, 1963; Turemuratov, 1964; Akramova et al., 2019) and neighboring regions of Tajikistan (Borgarenko, 1981, 1984, 1990). The comparison of the current helminth fauna of waterfowl and wading birds in the studied region with the data from the aforementioned authors reveals a noticeable alteration

in the species diversity of parasites, likely attributed to the ecological characteristics of the Aydar-Arnasay lake system.

Conclusion

The helminth fauna found in the waterbirds of the Aydar-Arnasay lake system exhibits a significant level of species diversity. The helminth fauna of birds living in aquatic ecosystems is characterized by the presence of four classes of helminths: Cestoda, Trematoda, Acanthocephala, and Nematoda. This combination of helminth classes is what makes the faunal complexes of these birds unique. The diversity and abundance of parasite species in this region are influenced by the historical development of reservoirs and the distribution of helminths among the primary hosts. Anseriformes, with 53 species, exhibit the most extensive and varied helminth fauna among bird species.

Flatworms are the most prevalent and abundant type of helminths in the studied region. This reservoir exhibits a wide range of faunal complexes consisting of helminths, along with their biocenotic connections. Consequently, it creates favorable conditions for the transmission of trematodes and cestodes with diverse life cycles.

Overall, the data collected on the helminth fauna of waterbirds in the Aydar-Arnasay lake system has allowed for the addition of new information to the existing fauna and the identification of the overall pattern of changes in parasite species diversity in current environmental conditions.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

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