

## FEATURES OF THE FORMATION OF FISH HELMINTHIASES UNDER THE INFLUENCE OF ANTHROPOGENIC FACTORS

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### **Abstract**

This article analyzes the influence of anthropogenic factors on the formation and development of the helminth fauna of fish inhabiting freshwater ecosystems. Particular attention is given to the effects of chemical and organic pollution of water bodies, alterations in hydrological regimes, eutrophication processes, intensive exploitation of biological resources, and the introduction of non-native species on host-parasite interactions. The study is based on a comprehensive review of scientific literature and contemporary ecological and parasitological research.

The findings indicate that increasing anthropogenic transformation of aquatic ecosystems leads to a reduction in the species diversity of helminths, changes in the prevalence and intensity of infections, and the predominance of environmentally tolerant helminth species of significant epidemiological and epizootiological importance. Furthermore, anthropogenic disturbances were found to alter the structure and functioning of parasite communities, thereby affecting the stability of aquatic ecosystems.

The obtained results highlight the importance of fish helminth fauna as a valuable bioindicator for ecological monitoring. They also provide a scientific basis for the prevention and control of parasitic diseases in aquaculture and fisheries, as well as for the assessment of the ecological status and environmental quality of freshwater ecosystems.

### **Keywords**

fish helminthiases, anthropogenic factors, helminth fauna, freshwater ecosystems, ecological monitoring, bioindicators, parasite-host relationships, aquatic ecology, aquaculture.

Aquatic ecosystems represent one of the most important components of the biosphere, playing a crucial role in maintaining biodiversity, regulating matter and energy cycles, and supporting human socio-economic needs. In recent decades,

rapid population growth, industrial and agricultural expansion, and increasing urbanization have significantly intensified anthropogenic pressure on natural water bodies. These impacts alter the physicochemical properties of aquatic environments, resulting in substantial ecological changes in hydrobionts, including fish and their parasitic communities.

The helminth fauna of fish constitutes an integral component of aquatic ecosystems. Fish helminths include representatives of parasitic flatworms (Trematoda and Cestoda), roundworms (Nematoda), and thorny-headed worms (Acanthocephala), all of which possess complex life cycles. Within these life cycles, fish may serve as definitive, intermediate, or reservoir hosts. Consequently, the distribution and development of helminths depend not only on the condition of fish populations but also on the ecological characteristics of water bodies, the availability of intermediate hosts, and various environmental factors.

As the ecological status of aquatic ecosystems changes under the influence of anthropogenic factors, significant shifts occur in the species composition, population structure, and host-parasite interactions of helminths. In particular, organic and chemical pollution, alterations of hydrological regimes, construction of reservoirs, land reclamation activities, eutrophication processes, and the introduction of non-native species exert substantial effects on the formation and functioning of parasite-host systems. As a result, ecologically sensitive helminth species tend to decline, whereas species characterized by high ecological plasticity and greater tolerance to anthropogenic disturbances often become dominant.

Parasitic organisms are widely recognized as important bioindicators in ecological monitoring. Changes in their species composition and infection parameters provide valuable information on the ecological condition of aquatic ecosystems, levels of environmental pollution, and the degree of disruption of biological equilibrium. Therefore, investigations of fish helminth fauna are of considerable importance not only for theoretical parasitology but also for fisheries management, veterinary science, ecology, and environmental conservation.

Studies conducted in various regions of the world have demonstrated significant alterations in helminth community structure and infection dynamics within aquatic ecosystems subjected to anthropogenic transformation. However, the formation patterns of fish helminthiases in relation to anthropogenic factors remain insufficiently studied in the inland waters of Central Asia, particularly in Uzbekistan. Given the intensive exploitation of water resources and the ongoing development of agriculture and industry, comprehensive investigations of these processes have become an important and highly relevant scientific challenge.

Accordingly, the objective of the present study is to analyze the influence of anthropogenic factors on the formation and development of fish helminth fauna, to identify ecological patterns in changes of helminth species composition and infection parameters, and to elucidate their significance as bioindicators for assessing the ecological status of aquatic ecosystems. The results of this study are expected to contribute to the development of scientifically grounded recommendations for the prevention of parasitic diseases in aquaculture, the improvement of ecological monitoring systems, and the conservation and sustainable management of aquatic biological resources.

Anthropogenic factors, including chemical pollution of water bodies, the construction of hydraulic engineering structures, climate change, and the introduction of non-native species, significantly alter the life cycles of parasites and affect the population dynamics of their intermediate hosts, such as mollusks and crustaceans.

At present, the increasing impact of human activities on the biosphere has resulted in substantial changes in the hydrological and hydrochemical regimes of natural water bodies. These processes directly influence the ecology and developmental cycles of helminths parasitizing fish. Fish helminthiasis not only cause considerable economic losses in fisheries and aquaculture but also pose potential public health risks, as some species are zoonotic and capable of infecting humans.

The principal anthropogenic factors affecting fish parasite communities can be classified into the following categories:

1. Chemical Pollution - contamination by heavy metals, petroleum products, pesticides, and mineral fertilizers.
2. Thermal Pollution - increased water temperature caused by the discharge of heated effluents from thermal and nuclear power plants.
3. Hydraulic Engineering Activities - alterations of water flow regimes associated with dam construction and water regulation systems.
4. Eutrophication - excessive enrichment of aquatic ecosystems with organic matter and nutrients, leading to increased biological productivity and ecological imbalance.

Numerous studies have demonstrated that in heavily polluted aquatic ecosystems, the overall species richness of helminths tends to decline. However, certain environmentally tolerant species, particularly those belonging to the genera *Dactylogyrus* and *Diplostomum*, often exhibit a significant increase in both prevalence and intensity of infection. This pattern indicates that anthropogenic disturbances may simplify parasite community structure while simultaneously

promoting the dominance of a limited number of opportunistic and ecologically resilient helminth species. Such changes can serve as valuable indicators of ecosystem degradation and environmental stress.

Parameters	Natural (Unpolluted) Water Bodies	Moderately Polluted Water Bodies	Heavily Polluted (Urbanized) Water Bodies
Number of helminth species	25-30	12-15	4-6
Prevalence of infection (%)	15-20	45-60	85-90
Dominant taxa	Monogeneans, Trematodes	Cestodes, Nematodes	Ectoparasites, Diplostomids
Fish mortality rate	Low (<2%)	Moderate (5-10%)	High (>25%)

**Table 1.** Changes in helminth diversity, infection prevalence, dominant parasite groups, and fish mortality rates under different levels of anthropogenic impact on aquatic ecosystems.

The construction of dams on rivers transforms aquatic ecosystems from a lotic (flowing-water) state into a lentic (standing-water) state. Such hydrological alterations create favorable conditions for the proliferation of intermediate hosts, particularly aquatic mollusks and planktonic crustaceans. Consequently, the abundance and transmission success of helminths with complex life cycles, such as *Ligula intestinalis*, increase significantly. The establishment of stable aquatic habitats enhances the survival of intermediate hosts and facilitates the completion of parasite developmental cycles, thereby promoting the spread of helminth infections among fish populations.

Heavy metals present in aquatic environments, including copper (Cu), lead (Pb), and cadmium (Cd), adversely affect the immune system of fish, reducing their resistance to parasitic infections. As a result, opportunistic parasites are able to invade and establish infections more readily. Statistical data indicate that the prevalence of monogenean infections in fish inhabiting pesticide-contaminated waters is approximately 3.5 times higher than that observed in fish from unpolluted aquatic environments. These findings highlight the significant role of chemical pollution in altering host-parasite relationships and increasing the susceptibility of fish populations to parasitic diseases.

Stage	Hydrological Change	Biological Consequence	Parasitological Outcome
Stage	Reduction in water	Accumulation of sediments and	Rapid increase in mollusk

Stage	Hydrological Change	Biological Consequence	Parasitological Outcome
	Velocity	Organic matter on the bottom substrate	Locations serving as intermediate hosts
Stage	Increased water temperature and eutrophication	Higher density of zooplankton communities (particularly cyclopoids and rotifers)	Enhanced development and transmission of <i>Ligula</i> and <i>Platyhelminth</i> larvae
Stage	Excessive eutrophication of aquatic environment	Aggregation of phytophilous fish and waterfowl	Acceleration of transmission cycles months with complex life histories

**Table 2.** Ecological consequences of hydrological alterations and their influence on the development and transmission of fish helminths.

**The formation of fish helminthiases under anthropogenic influence is an indicator of ecosystem instability and ecological degradation. To address this problem, the following measures are required:**

1. Establishing regular sanitary and parasitological monitoring of aquatic ecosystems;
2. Implementing biological amelioration measures in fish farming enterprises, including the introduction of fish species capable of consuming parasite intermediate hosts;
3. Modernizing wastewater treatment systems to reduce environmental contamination.

#### Chemical Pollution of Aquatic Ecosystems and Parasite Responses

Industrial and agricultural effluents increase the concentrations of nitrogen compounds and heavy metals in aquatic environments. According to our observations, these factors affect different groups of parasites in distinct ways:

**1. Trematodes.**  
Their life cycle is complex and involves mollusks as intermediate hosts. Severe water pollution reduces mollusk abundance, which consequently decreases the occurrence and transmission rate of trematode infections in fish populations.

**2. Monogeneans.**  
In contrast, an increase in organic matter concentrations in aquatic environments suppresses the immune system of fish and creates favorable conditions for the rapid development of ectoparasites, particularly representatives of the genus *Dactylogyrus*.

The introduction of new fish species into aquatic ecosystems may simultaneously introduce helminths that are alien to the native fauna. For example, nematodes associated with invasive species such as *Micropercops cinctus* can be transmitted to indigenous fish species, adversely affecting their physiological

condition. This process contributes to biodiversity loss and disrupts the natural equilibrium of local host–parasite relationships.

Fish helminthiasis represent not only a biological problem but also an important issue in biomedical sciences. Several nematode and cestode infections identified during the study possess zoonotic potential and may pose a risk to both humans and animals by causing parasitic diseases.

From an economic perspective, helminth infections reduce fish growth rates, impair hematological parameters, and diminish the commercial quality of fish products. Consequently, these effects are inconsistent with the principles of food safety and the sustainable utilization of biological resources.

Anthropogenic factors tend to simplify the structure of fish helminth communities: overall species diversity declines, whereas certain highly adaptable species become increasingly abundant and dominant. Therefore, the conservation of aquatic biological resources requires not only the protection of fish populations themselves but also the monitoring and management of their parasitological environment, alongside the development of effective strategies aimed at reducing anthropogenic pollution.

**Anthropogenic factors affecting the formation of fish helminth fauna can be classified into several major groups:**

#### 1. Chemical Pollution of Water Bodies

As a result of industrial activities and agricultural practices, various chemical pollutants are discharged into aquatic ecosystems. Increased concentrations of nitrates, phosphates, pesticides, and heavy metals adversely affect the physiological condition of aquatic organisms.

Chemical pollution results in:

- suppression of the immune system of fish;
- reduced resistance to helminth infections;
- increased abundance of intermediate hosts;
- enhanced survival rates of parasitic organisms.

Numerous studies have reported that trematode and nematode infections are generally more prevalent in aquatic environments characterized by high levels of organic pollution.

#### 2. Alteration of the Hydrological Regime

The construction of reservoirs, regulation of river flow, and expansion of irrigation systems significantly modify the natural hydrological conditions of aquatic ecosystems.

As a consequence:

- water exchange and circulation decrease;

- populations of mollusks serving as intermediate hosts increase;
- the developmental cycles of helminths become accelerated.

Mollusks play a crucial role in the life cycles of many trematode species. Therefore, water stagnation and reduced flow velocity create favorable conditions for their proliferation and, consequently, for the transmission of trematode infections.

### 3. Organic Pollution

Wastewater originating from human settlements and livestock production facilities contains substantial amounts of organic matter.

An increase in organic matter content contributes to:

- the proliferation of benthic organisms;
- an increase in zooplankton biomass;
- enhanced activity and transmission of helminth developmental cycles.

As a result, the occurrence of helminths such as *Diplostomum*, *Ligula*, *Contracaecum*, and *Camallanus* in fish populations tends to increase.

### 4. Introduction of Non-native Fish Species

The introduction of new fish species is often accompanied by the introduction of novel parasites. This process may significantly alter the composition and structure of native parasite communities.

The consequences of species introduction include:

- the formation of new host-parasite systems;
- increased infection levels in native fish species;
- a more complex and potentially unstable epizootiological situation.

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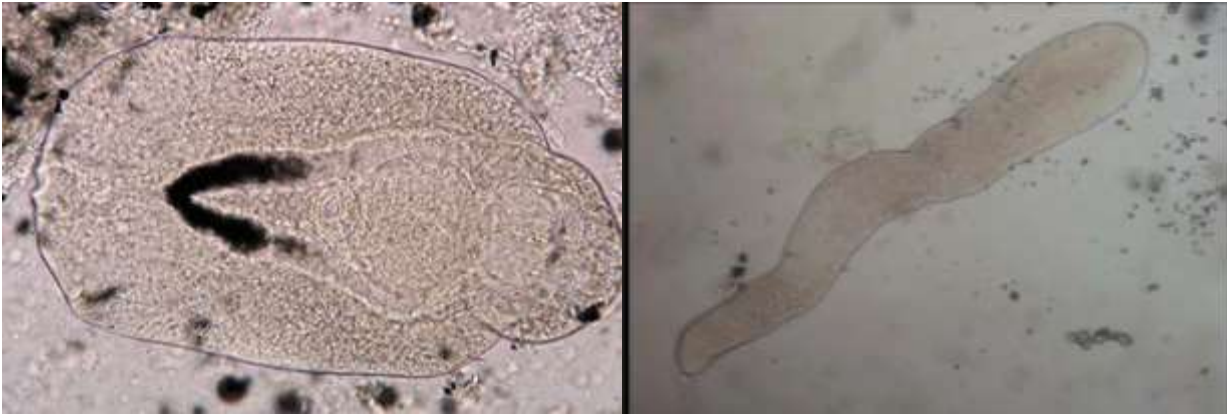
## Changes in Helminth Community Structure under Anthropogenic Transformation

Anthropogenic transformation of aquatic ecosystems leads to significant alterations in the composition and structure of helminth communities. In natural water bodies, ecological equilibrium among parasite species is generally maintained. However, as environmental degradation intensifies, certain environmentally tolerant species become dominant.

Among the most characteristic dominant species are:

- *Diplostomum spathaceum*;
- *Ligula intestinalis*;
- *Camallanus lacustris*;
- *Contracaecum* spp.;
- *Neoechinorhynchus rutili*.

These species are distinguished by their high ecological plasticity and their ability to adapt successfully to changing environmental conditions. Their increasing dominance is often regarded as an indicator of anthropogenic disturbance and ecological imbalance within aquatic ecosystems.



a

b

Figure 1. a-*Diplostomum spathaceum*, b-*Ligula intestinalis*

#### Ecological Significance of Fish Helminths as Bioindicators

The results of parasitological investigations indicate that helminths serve as important bioindicators for assessing the ecological status of aquatic ecosystems.

As environmental conditions deteriorate:

- the prevalence of infection increases;
- the intensity of infection rises;
- the proportion of pathogenic species becomes higher;
- the physiological condition of fish worsens.

Therefore, monitoring the composition and structure of helminth communities is of considerable importance for evaluating the ecological condition of aquatic ecosystems.

Analyses have demonstrated that anthropogenic factors participate both directly and indirectly in the formation and spread of fish helminthiases.

#### Direct impacts include:

- water pollution;
- alterations in temperature regimes;
- reduction in dissolved oxygen concentration.

#### Indirect impacts include:

- an increase in the abundance of intermediate hosts;
- modifications of food-web relationships;
- restrictions on fish migration.

As a consequence, the biological cycles of parasites become more stable and efficient, resulting in an increase in the prevalence and transmission of helminth infections.

## Main Findings

1. Anthropogenic factors represent important ecological drivers in the formation of fish helminth fauna.
2. Chemical and organic pollution of water bodies contribute to increased levels of helminth infections in fish populations.
3. Alterations in hydrological regimes create favorable conditions for the development and transmission of helminths.
4. The introduction of non-native fish species facilitates the spread of new parasite species.
5. Ecologically tolerant helminth species become dominant in areas subjected to high anthropogenic pressure.
6. Fish helminth fauna serves as an effective bioindicator for assessing the ecological status of aquatic ecosystems.
7. Monitoring of helminthiasis is essential for the conservation of aquatic ecosystems and for controlling epizootiological conditions in aquaculture and fisheries.

The conducted studies revealed that anthropogenic factors exert a significant influence on the formation, species composition, and distribution of fish helminth fauna. Alterations in hydrological regimes, pollution from agricultural and industrial wastewater, expansion of aquaculture activities, introduction of non-native fish species, and transformation of aquatic ecosystems were identified as the principal anthropogenic factors directly affecting the developmental cycles of helminths and the epizootiological status of fish populations.

The findings demonstrated that water bodies exposed to high anthropogenic pressure exhibit substantial changes in helminth community structure and infection dynamics. In particular, an increase in the proportion of biohelminths was observed, which can be explained by the greater abundance of intermediate and supplementary hosts and by the increasing complexity of ecological interactions within altered ecosystems. Disturbances of ecological equilibrium create favorable conditions for the spread of pathogenic and epidemiologically significant helminth species.

The level of helminth infection in fish was found to be closely associated with the ecological condition of water bodies, water quality, trophic relationships, host population density, and the degree of anthropogenic disturbance. Representatives of the classes **Trematoda**, **Cestoda**, and **Nematoda** occupied dominant positions within the helminth fauna and were identified as the most sensitive groups responding to ecological changes in aquatic ecosystems.

Thus, the formation of fish helminthiasis results from the complex interaction between natural and anthropogenic factors. Under conditions of intensified anthropogenic impact, significant changes occur in both the species composition and transmission dynamics of helminths. Consequently, improving ecological monitoring programs, strengthening veterinary and parasitological surveillance in aquaculture, and implementing preventive measures against helminth infections are essential for the conservation of fish resources and the maintenance of their biological safety.

The results of this study provide an important scientific basis for understanding the patterns of transformation of fish helminth fauna under anthropogenic influence, assessing the parasitological status of aquatic ecosystems, and predicting epizootiological risks in fisheries and aquaculture systems. Furthermore, they contribute to the development of scientifically based strategies for environmental protection, sustainable fisheries management, and biodiversity conservation in freshwater ecosystems.

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