Trematodes of cyprinid fish of the Lower Irtys

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Abstract. The paper presents studies of representatives of cyprinid fish species inhabiting the Lower Irtys was conducted for invasion by multicellular organisms of the Trematoda class. A total of 54 individuals of Abramis brama, 24 individuals of Rutilus rutilus lacustris and 15 Leuciscus idus were studied. Parasiti sm of 13 species of trematodes was found in cyprinid fish.

The first group consisted of 6 species whose entire life cycle is associated with the aquatic environment, where fish are the final hosts (R. campanula, P. elongatum, A. isoporum, S. globiporum, S. bramae, A. lucii). The second group includes 7 species whose marites are parasitic in birds and mammals (D. chromatophorum, Metorchis sp., H. triloba, I. pileatus, I. platycephalus, O. felineus, P. ovatus). Common to bream, roach, and ide are D. chromatophorum, O. felineus, and R. campanula. Metacercaria I. platycephalus are registered in one bream and two ides. Sexually Mature individuals of the trematode of cyprinid - Sphaerostomum bramae, parasitize in the intestines of bream and roach. The greatest similarity of trematode fauna is observed between bream and roach, as well as bream and ide, the least similarity of parasites in ide and roach. The dominant species of parasitic community of fish are the following parasites: bream - Sphaerostom bramae, ide - metacercaria Rhipidocotyle campanula & Metorchis sp., roach - Rhipidocotyle campanula.

1. Introduction
The Trematoda class includes many parasitic organisms whose development cycle includes both fish and land animals (birds, mammals). Some of them, representatives of family Opisthorchiidae, are causative agents of diseases dangerous to humans. The Lower Irtys is rich in its fish resources, most of which are fish of family Cyprinidae, in particular bream, roach and ide [1]. This reservoir is inhabited not only by indigenous species, but also by fish that have been introduced and contributed to the replenishment of the parasitofauna. The study of the parasitic community of cyprinids was carried out by many researchers [2], [3], [4], [5]. All authors note the predominance of representatives of the Trematoda class in the parasitofauna. Current information on the fauna of parasitic species of cyprinids in the Lower Irtys basin is significantly limited and is sporadic in nature, mainly attaching importance to representatives of family Opisthorchiidae [6], [7], [8]. It is known that any watercourse is subject to anthropogenic stress, which makes its own adjustments to the ecological status of the reservoir, thereby influencing the composition of food resources and benthic organisms. In this case, a change in the species composition of benthic organisms, such as mollusks - the first intermediate hosts of trematodes, can also lead to a change in the parasitic community as a whole. To complete the full life cycle of the development of a parasitic organism, the presence of all chain links in the water area is necessary. In this case, when a species new to the reservoir appears, it will have the opportunity to
adapt. When one species is eliminated from the ecosystem, which is part of the trematode development cycle, the parasite will disappear from the habitat over time.

2. Materials and methods

The study was conducted in the summer and autumn periods in the Lower Irtysh basin in 2017-2019. Bream and Siberian roach were caught in the area of the village of Karachino (58.250 N, 68.635 E, Tobolsk district), ide in the area of the city of Tobolsk (58.25904285097162 N, 68.23574066162111 E). A total of 54 Abramis brama (Linnaeus, 1758), 24 Rutilus rutilus lacustris (Pallas) and 15 individuals of Leuciscus idus (Linnaeus, 1758) of various sexes were examined (table 1). Fishing was carried out with fixed and floatable different-mesh nets with a size of mesh of 24-38 mm from 5-meter sections, with a mesh pitch of 2 mm, the length of the fixed net was 40 m, the length of the floatable net was 60 m, and the height was 2 m. Fish for the study were delivered in live form in separate live-fish containers to exclude the movement of parasitofauna. Processing ichthyological material was carried out by the method of biological analysis [9]. Investigation of fish for the composition of the community of the Trematoda class representatives was carried out by the method of incomplete parasitological dissection [10]. The detected parasites were fixed, then temporary and permanent preparations were prepared to determine the species [11, 12].

We calculated the extent of invasion (the percentage of hosts that have this type of parasite, EI), the abundance index (the average number of instances of this type of parasite per one studied host, AI). When comparing the biodiversity of the parasitic community of trematodes of fish family Cyprinidae applied the Jacquard coefficient [13]:

\[
C_J = \frac{j}{(a+b+1)}
\]  

(1)

where \(C_J\) is the Jacquard coefficient, \(j\) is the number of common parasite species in hosts in both biotopes, \(a\) is the number of parasite species in hosts in 1 biotope, \(b\) is the number of parasite species in hosts in 2 biotope.

To identify the dominant species in the parasite fauna, the Berger-Parker dominance index (d) was used [13]:

\[
d = \frac{N_{\text{max}}}{N}
\]  

(2)

where \(N_{\text{max}}\) is the number of individuals of the most abundant species, \(N\) is the total number of parasite individuals in the community. The data were analyzed in the Statistics 10.0 program (StatSoft Inc., USA) using descriptive statistics.

### Table 1. Some morphological and biological indicators of the examined fish

| Kind of fish | Number of samples, n | Age, min-max., years | Weight, min-max., g | Length, min-max., cm |
|--------------|----------------------|----------------------|---------------------|----------------------|
| Bream        | 54                   | 3+ - 8+              | 214.0 - 1100.0      | 21.7 - 44.3          |
| Roach        | 24                   | 0+ - 4+              | 10.0 - 454.0        | 10.2 - 34.2          |
| Ide          | 15                   | 1+ - 6+              | 174.0 - 1086.0      | 25.2 - 44.6          |

3. Results

The representatives of family Cyprinidae in the Lower Irtysh established parasitism of 13 species of trematodes: Diplostomum chromatophorum (Brown, 1931), Rhipidocotyle campanula (Dujardin, 1845), Metorchis sp., Opisthorchis felineus (Rivolta, 1884), Paracoenogonimus ovatus (Katsurada, 1914), Hysteromorpha triloba (Rudolphi, 1819), Ichthyocotylurus platycephalus (Creplin, 1825) Odening, 1969, Ichthyocotylurus pileatus (Rud., 1802) Odening, 1969, Phyllodistomum elongatum (Nybelin, 1926), Sphaerostoma globiporum (Rud, 1802), Sphaerostoma bramae (Müller. 1776), Allocreadium isporum (Looss. 1894), Azygia lucii (Müller. 1776) (table 2). For six species of trematodes, fish are the final owners, in other cases, intermediate.
The common parasitic organisms for all fish are metacercaria *D. chromatophorum*, *R. campanula*, and *O. felineus*. In bream, the extent of infection with diplostomes was 83.3%, *R. campanula* - 14.8%, opisthorchids - 18.5%. Roach is invaded by *D. chromatophorum* in 75.0%, *R. campanula* parasitizes with EI - 70.8%, muscles are affected by *O. felineus* with an intensity of 29.2%. In the lens of the eye, the ide showed diplostomes in 60.0% of cases, *R. campanula* & *Metorchis* sp. together parasitize on gills with EI - 46.7% and on fins with EI - 100.0%, infection with the pathogen of opisthorchiasis reaches 100.0%. (figure 1). Metacercaria *I. platycephalus* are registered in one bream (2 specimens of parasites) and two ides (1 specimen each). Mature cyprinid trematodes, *Sphaerostoma bramae*, parasitize in the intestines of bream and roach with EI - 77.8% and 37.5%, respectively (figure 1). Only in bream parasitization of metacercaria *H. triloba* (1.8%), *Metorchis* sp. (31.5%), trematodes *A. isoporum* (1.8%) and juvenile *A. lucii* (1.8%). Asigia cyprinids are infected by ingestion of cercaria floating in the thickness, which allows us to consider this find random. In turn, *L. idus* is infested by *I. pileatus* (mtc) (6.7%), *P. ovatus* (mtc) (40.0%) and trematode of cyprinid fish *S. globiporum* infected 60.0% of the examined ides (figure 1).

**Table 2.** Trematodes of fish of family Cyprinidae of the Lower Irtysh

| Type of parasite                  | Bream                      | Ide                           | Roach                      |
|-----------------------------------|----------------------------|-------------------------------|----------------------------|
| *Diplostomum chromatophorum* (mtc) | lens of the eye            | fin, gills                   | fin, gills                 |
| *Rhipidocotyle campanula* (mtc)   | fin                        | fin, gills                   | fin, gills                 |
| *Metorchis* sp. (mtc)             | gills                      | fin, gills                   | -                          |
| *Hysteromorpha triloba* (mtc)     | muscles                    | -                             | -                          |
| *Ichthyocotylurus pileatus* (mtc) | -                          | liver                         | -                          |
| *Ichthyocotylurus platycephalus* (mtc) | serous membrane of the heart | mesentery                    | -                          |
| *Opisthorchis felineus* (mtc)     | -                          | muscles                      | -                          |
| *Paracoenogonimus ovatus* (mtc)   | -                          | muscles                      | -                          |
| *Phyllodistomum elongatum*        | -                          | ureter                       | -                          |
| *Allocreadium isoporum*           | intestines                 | -                             | -                          |
| *Sphaerostoma globiporum*         | intestines                 | intestines                   | intestines                 |
| *Sphaerostoma bramae*             | intestines                 | intestines                   | intestines                 |
| *Azigia lucii* (juv)              | intestines                 | intestines                   | intestines                 |

Note: mtc - metacercariae, juv - juvenile stage
The lenses of the bream’s eyes with AI are most intensely affected by diplostomes with AI — 7.2 individuals; in ide and roach, the abundance of invasion is at the same level of 3.5 and 3.3 individuals respectively. Roach is infested with *R. campanula* with AI - 26.8 individuals, while bream - 0.74 individuals. Metacercaria infection of opisthorchids at a high level was recorded in the ide, where the AI was 64.5 individuals, while in roach 5.6 individuals, and in bream was not significant - 0.96 individuals. At the same time, a rather high abundance index was observed during the invasion of the ide *R. campanula & Metorchis* sp. - 196.7 individuals, in bream *Al Metorchis* sp. amounted to 9.9 ind. to fish. *I. platycephalus* parasitizes both bream and ide, with a very low degree of invasion, AI - 0.04 and 0.1 individuals, respectively. The *S. bramae* trematode was found in bream with AI - 39.8 ind., while in roach this indicator was only 2.3 ind.. A low level of invasion was observed during examination of bream in the species *H. triloba* (AI - 0.02 individuals), *A. isoporum* (AI - 0.4 ind.) and *A. lucii* (AI - 0.04 ind.). In an ide with parasitization of metacercaria *I. pileatus* and *P. ovatus*, AI 0.1 and 0.7 individuals respectively, in maritum *P. elongatum* and *S. globiporum* — 9.5 and 6.3 individuals (figure 2).
Figure 2. The abundance index (ind.) of trematodose pathogens in fish of family Cyprinidae of the Lower Irtysh: A – A. brama, B – R. rutulus lacustris, C – L. idus

To assess the similarity of species diversity of trematodes in the examined fish of family Cyprinidae applied the Jacquard coefficient. Analyzing the result, we see that the greatest species similarity of the parasitic community of trematodes is observed between bream and roach, as well as bream and ide, the least similarity of parasites in ide and roach (figure 3). Such a difference in the biodiversity of trematodes between an ide and a roach is probably related to the age of the roach participating in the study, young roach individuals have not yet been invaded, since their diet is different at different ages and the transition of young fish to another forage resource contributes to their more intensive infection.

Figure 3. The indicator of the Jacquard index of similarity of the community of trematodoses in fish of family Cyprinidae

The dominant species in the community of parasites of fish are the following have been identified: in the bream, Sphaerostoma bramae, ide - metacercaria Rhipidocotyle campanula & Metorchis sp., roache in Rhipidocotyle campanula (table 3). The Berger-Parker index indicates a decrease in species diversity in the parasite community with the dominance of a particular species.

Table 3. The Berger-Parker dominance index (d) in the parasite community of fish of family Cyprinidae

| Type of parasite                          | Bream | Ide   | Roach |
|------------------------------------------|-------|-------|-------|
| Diplostomum chromatophorum (mtc)         | 390   | 53    | 78    |
| Rhipidocotyle campanula (mtc)            | 40    | 2950* | 644*  |

*Significant difference compared to other species.
\begin{tabular}{lccc}
Metorchis sp. (mtc) & 536 & - & - \\
Hysteromorpha triloba (mtc) & 1 & - & - \\
Ichtyocotylurus pileatus (mtc) & - & 1 & - \\
Ichthyocotylurus platycephalus (mtc) & 2 & 2 & - \\
Opisthorchis felineus (mtc) & 52 & 967 & 135 \\
Paracoenogonimus ovatus (mtc) & - & 11 & - \\
Phyllodistomum elongatum & - & 143 & - \\
Allococadium isoporum & 20 & - & - \\
Sphaerostoma globiporum & - & 94 & - \\
Sphaerostoma bramae & 2147* & - & 56 \\
Azygia lucii (juv) & 2 & - & - \\
d & 0.673 & 0.699 & 0.705 \\
1/d & 1.5 & 1.4 & 1.4 \\
\end{tabular}

Note: * - the dominant parasite in the group

4. Discussion

Parasitofauna of fish of family Cyprinidae is rich in representatives of the Trematoda class [14]. Such plasticity for parasitic organisms is associated with their resettlement through the introduction of various representatives of cyprinids into new reservoirs for them. In the Lower Irtysh basin, bream is an invasive species, while ide and Siberian roach are indigenous species. The community of trematodes of cyprinid fish of the Lower Irtysh is represented by parasitic species with a complex development cycle. All of them use mollusks of various genera as the first intermediate hosts, however, by their belonging to the definitive host, the detected parasites can be divided into two groups. The first includes 6 species in which the entire life cycle is associated with the aquatic environment, where the fish act as the final hosts (R. campanula, P. elongatum, A. isoporum, S. globiporum, S. bramae, A. lucii). The second group includes 7 species whose marites parasitize in birds and mammals (D. chromatophorum, Metorchis sp., H. triloba, I. pileatus, I. platycephalus, O. felineus, P. ovatus).

In our study, D. chromatophorum, O. felineus, and R. campanula are common for bream, roach, and ide. Metacercariae diplostomids invade a wide range of fish [15], [16], [17]. Infection of fish with diplostomids is noted at a fairly high level, which corresponds to their invasion in other water bodies. Thus, in Galich Lake, diplostomes in the lenses of the eyes were recorded in 56% of bream, in Lake Chukhloma in 68% of roach [18]. In the Belgorod and Starosokolsky reservoir EI of bream with diplostomes was 84.4% and 83.3%, respectively, roach in these reservoirs was invaded in 100% and 42.8% of cases [19]. In the lake Senezh observed 100% infection of roach D. chromatophorum [20]. In Lake Ladoga, the ide is invaded by D. chromatophorum with EI - 60.0% [21]. At the ide in the lake Dâbie recorded diplostome invasion in 73.6% of the fish examined [22].

Rhipidocotyle campanula - is a widespread fish parasite, metacercariae are mainly recorded in cyprinid species, and predatory fish are the definitive hosts [23], [24]. In the Ladoga lake, bream was found to have parasitism of R. campanula metacercariae up to 81.3%, roach was infested in 91.3% of cases, ide-48.0% [21]. In the Irtysh river E Petrouchuk et al. (2013) recorded infection of the bream with this parasite with EI - 26.6% [25]. In roach, R. campanula is recorded on the gills, muscles and fins in various areas of its habitat, both in our country and abroad [5] [26], [27]. In the Irtysh basin, in the Ishim and Alabuga rivers, roach is invaded by R. campanula with EI - 26.0% and 16.9%, respectively [28]. In the Lower Ob, the ide is invaded by R. campanula with an extensiveness of 50.0% [7].

The Ob-Irtysh basin is a natural focus of opisthorchiasis, which leads to infection not only of mammals, but also of humans when eating non-disinfected fish products. In our study, a high invasion of the ide (100.0%) by metacercariae of opisthorchids was found, bream was infected by 18.5%, roach in 29.2% of cases. It was noted that the invasion of fish by metacerciae O. felineus begins at the age of 0+, which negatively affects the physiological and biochemical state of the body, reduces growth
rates, an increase in infection rate with increasing age leads to a decrease in the biological and nutritional quality of meat [29], [30]. Pisces of family Cyprinidae in all habitats are invaded by metacercariae *O. felineus*, which suggests their joint evolutionary development [6], [22], [32], [33], [34].

A species common to the bream and ide has been established, the metacercariae of which parasitize on fins and gills - *Metorchis* sp. In the Novosibirsk reservoir, the invasion of ide by *M. bilis*, *M. xanthosomus* and *M. intermedius* with EI was recorded - 7.7% each, while this parasite was not found in the bream in the same reservoir, in the Karakan river, the infection of the ide *M. bilis* was 33%, in the Ob floodplain - 80.6%, in the Sosnovka and Milyush rivers *M. xanthosomus* was invaded with EI of 16.7% and 50.0%, respectively [35].

In the conditions of the Lower Irtysh, bream and roach were found to have parasites of *S. bramae*, and for ide *S. globiporum*. Representatives of the genus *Sphaerostoma* are permanent parasites of cyprinid fish species, are widespread in their habitats, parasites have an annual development cycle, therefore, fish infection is timed to the season of the year [32], [36], [37], [38].

In bream and ide there was no significant invasion of *I. platycephalus* and *I. pileatus*. These species are parasites of birds, using many fish as intermediate hosts. *I. platycephalus* invades the ide of the Dâbie Lake (Poland) 23.6% [22]. *I. platycephalus* and *I. pileatus* were found at an ide in the Pra river with EI - 85.7% and AI - 1.3 individuals [33].

Invasion of *P. ovatus* was recorded only in the ide. Paracoegonimus at the metacercaria stage parasitizes in many fish species, mainly cyprinids, definitive hosts are daytime birds of prey [6], [22], [33], [39], [40], [41].

In our study, *P. elongatum* was detected in the ureters of two individuals of ide. This trematode is recorded in various reservoirs in many species of cyprinids, has a complex development cycle associated with the eutrophication of the reservoir, as well as a change in the abundance and biomass of zooplankton and increasing its role in the diet of fish [33], [42], [43].

5. Conclusion

Fauna of the trematode fish population of the Lower Irtysh of family Cyprinidae (bream, roach, ide), in the summer-autumn period of the study, is represented by 13 species. For six of them, fish are definitive hosts, which allows the parasite to go through the entire development cycle in the aquatic environment, due to which cyclicality and shorter development times from egg to marita are observed. Seven species use fish as second intermediate hosts, parasitizing at the metacercariae stage, and the final hosts are birds and mammals, that is, the development cycle ends in the air. In the process of evolutionary development, parasitic organisms have mastered many adaptive functions in order to occupy as many ecological niches as possible. It has been established that common for cyprinids are: *D. chromatophorum* (mtc), *R. campanula* (mtc), *Metorchis* sp. (mtc), *I. platycephalus* (mtc), *O. felineus* (mtc), *S. bramae*. Detection of *A. lucii* (juv) in bream is an accidental find. The greatest similarity of biodiversity was observed in bream and roach. The dominant species in the bream fauna are *S. bramae*, roach - *R. campanula*, ide - *D. chromatophorum* & *R. campanula*. It is necessary to continue the study of parasitofauna in other periods of the year to obtain a more complete picture of the composition of the parasitic community of fish.

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