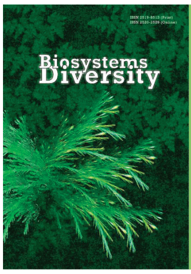


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# Sexual and age characteristics of the parasitofauna of *Abramis brama* (Cypriniformes, Cyprinidae) of the Lower Irtysh (Russia)


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In the present study, an evaluation was made of the dependence between infections by various types of parasites and the sex and age of the host. The parasitic community of *Abramis brama* includes 24 species of parasites. We assessed the degree of infestation by parasites in groups of male, female and juvenile specimens. It was established that only male bream were infested with *Zschokkella nova* (Klokacewa, 1914), *Hysteromorpha triloba* (Rudolphi, 1819), *Allocreadium isoporum* (Looss, 1894), *Ichthyocotylurus platycephalus* (Creplin, 1852). The ciliates of *Trichodina nigra* (Lom, 1960) were noted on the gills and fins of all the examined fish, the extensiveness of infection in the group of juveniles exceeded that of the groups of females and males. Specimens of *Myxobolus rotundus* (Nemeczek, 1911) were found on the gills and in the kidneys, and *M. parviformis* only on the gills of the fish. The level of infection in males was three times the EI in females and juvenile fish. The infestation on the fins by the metacercaria of *Rhipidocotyle campanula* (Dujardin, 1845) in male bream was more than 6 times higher than infection in females and juveniles. An increase in the extensiveness of infection in males by the nematode *Philometra ovata* (Zeder, 1803) was also noted in comparison with groups of females and juvenile fish. Species-specific monogeneans: *Dactylogyrus falcatus* (Wedl, 1857), *D. wunderi* (Bychowsky, 1931), *D. zandti* (Bychowsky, 1933), *Gyrodactylus elegans* (Nordmann, 1832); the trematodes *Sphaerostoma bramae* (Müller, 1776) and *Diplostomum chromatophorum* (Brown, 1931) infested all individuals of bream in approximately the same proportion, whereas an increase in the EI of the *Caryophyllaeus laticeps* (Pallas, 1781) cestode in males was observed. Infection with metacercariae *Metorchis* sp. in males exceeded that in females and juvenile fish. At the same time, only females and juvenile bream were infected by *Chilodonella* sp., metacercariae *Opisthorchis felineus* (Rivolta, 1884) and glochidia Unionidae gen. sp. During the studies in females, the following species of parasite were observed singly : *Proteocephalus* sp., *Azygia lucii* (Miiller, 1776), *Ergasilus sieboldi* (Nordmann, 1832). Parasitization by *Raphidascaris acus* (Bloch, 1779) was recorded only in males and juveniles, whereas in females this parasite was not observed. The dominant parasite in males was *G. elegans*, in females – the representatives of the genus *Dactylogyrus*, in the juvenile individuals the trematode *S. bramae* dominated. Analysis of the parasite fauna in various age groups allowed us to establish that at the age of 5+–6+ bream were infected by 20 species of parasites, in age group 3+–4+ there were 15 species, at the age of 7+–8+ the fish were infected only with 11 parasitic species. The fish in all three groups were infected by *T. nigra*, *Dactylogyrus* spp., *G. elegans*, *D. chromatophorum*, *S. bramae*, *R. acus* almost at the same level and had no sharp differences in extensiveness and abundance of infection. Unionidae gen. sp. were observed only in group 3+–4+. Parasitization by *Proteocephalus* sp., metacercariae *H. triloba* and *I. platycephalus*, *A. isoporum*, and *A. lucii* was found in bream of age group 5+–6+, the species did not occur in bream at other ages. Nematode *P. ovata* and crustacean *E. sieboldi* infested the fish in age groups 3+–4+ and 5+–6+ with a slight increase in the extensiveness of infection at low abundance rates. The same age groups were observed to have decrease in the extensiveness of infection with *Chilodonella* sp. and metacercariae *O. felineus*. Myxozoan *Z. nova* parasitized in age group 5+–6+ and had an increase in extensiveness in age group 7+–8+. In all groups, infection was noted by representatives of the genus *Myxobolus*, *R. campanula* and *Metorchis* sp. with EI increasing with age. The obligate parasite of bream – *C. laticeps* infested fish the most in age group 3+–4+ in comparison with age groups 5+–6+ and 7+–8+. In the younger age group, the dactylogyruses were dominant parasites, in the age group 5+–6+ *Gyrodactylus* dominated, in the older age group – *Metorchis* sp.



*Keywords*: bream; parasites; age; gender; parasitofauna; dominance.


## Introduction

One of the main aspects of the condition of aquatic ecosystems is species introduction. Introduction of alien species of fishes into water bodies causes changes in biocenoses, including the arrival of parasitic organisms not typical for the area. This leads to their mutual adaptation, and therefore change in the composition of parasitic communities in general (Kerr & Grant, 2000; Lymbery et al., 2014; Sheath et al., 2015). During introduction of species to new areas, their usual diet changes, which in turn is reflected in the community of species. Such processes were observed during the introduction of common bream into the Ob-Irtysh basin. Due to its status as a habitat generalist and its high fertility, it has successfully naturalized in the water bodies of Ural, Siberia, Transbaikal and Kazakhstan (Interesova, 2016). This species has distributed itself practically throughout the Ob, Irtysh and many of their tributaries, and also the basin of the Yenisei (Kuderskij, 2001; Popov, 2010). Recently, the interest of scientists to determining presence of dependence between the infestation with different species of parasites and the sex and age of the host has increased (Lizama et al., 2006; Tadiri et al., 2016). The age structure and sex of fish have an effect on change in distribution of parasites in ichthyocenoses, where differences in preferences in feeding and living indicate non-uniformity of trophic behaviour, which significantly contributes to the usually observed aggregation of helminths in hosts in natural conditions (Duneau & Ebert, 2012; Hayatbakhsh et al., 2014; Tadiri et al., 2016). During their research Rahman & Saidin (2011) and Ibrahim (2012) determined the highest number of parasitic species and their intensity in females compared with males. By contrast, Folstad & Karter (1992) found more parasitic species in males, which they associated with high level of testosterone, which causes immunosuppression, making them more susceptible to parasites than females. Also, Ranzani-Paiva et al. (1997) in their study reported that males of *Mugil platanus* had a higher percentage of infection with parasitic species than females. Hayatbakhsh et al. (2014) determined the broadest distribution, average intensity and abundance of parasites in *A. brama orientalis* at the age of 5 years, compared with other age groups. A significant difference was observed in the composition of parasitofauna between males and females, though the authors mentioned that the differences were not statistically significant, male fish were more heavily infested than females (Hayatbakhsh et al., 2014). Anderson (1974) considers that at the age of 2+ the parasitofauna of bream became poorer due to the fact that different age groups feed differently and therefore intensely compete for food resources through which the infestation of fish takes place. Despite numerous studies, there are no definite results on the influence of sex and age of the host on infestation with helminths, not related to the conditions of environment or life cycle of fish.

In the basin of the Lower Irtysh *A. brama* is an important link of the ecosystem, its parasitofauna underwent significant changes after acclimatization in the new water body (Tkachev, 1998; Sous' & Rostovcev, 2006; Liberman & Voropaeva, 2018). Numerous studies of parasitic communities in bream, after its introduction into the new aquatic ecosystem have demonstrated impoverishment of the fauna of parasitic organisms compared with the native range; the dynamics of change in its parasitic community in different sex and age groups has not been analyzed by researchers (Agapova, 1958; Agapova, 1966; Kashkovskij et al, 1974; Sous', 1975). Naturally the question rises – how effectively have the specific species parasitic in bream adapted in new habitat over the decades; and whether the sex and age of the host influence the composition of its parasitofauna?

The objective of the study was determining the sex and age peculiarities of the parasitic community of *A. brama* in the Lower Irtysh.

## Materials and methods

Parasitofauna of bream was studied in June–July of 2017–2018. The ichthyological material was obtained in the areas of the Tobol river (Karachino village, 58°02'50" N, 68°06'35" E) and the Irtysh river (Gornoslinkino village 58°43'54" N, 68°41'54" E) within Tobolsky and Uvatsky districts of Tyumen Oblast. A total of 54 bream were examined, aged 3+–8+, with body length (L) of 21.7–44.3 cm and body weight of (M) 214–1,100 g. The fish for the studies were delivered alive in separate containers for live fish in order to avoid transmission of parasitofauna. The analysis of the ichthyological material was performed using the biological analysis method (Pravdin, 1966). Complete parasitological analysis was performed according to the method of Byhovskaya-Pavlovskaya (1985) on living material in laboratory conditions. The parasites found in the fish were fixated, then temporary and constant preparations were prepared for identification of species (Skarlato, 1984, 1985, 1987; Sudarikov et al., 2002; Fiala et al., 2015). We calculated the extensity of infection (percentage of individuals of host in which a species of parasite was found, EI) with standard error, intensity of infection (minimum and maximum number of specimens of parasite per one infected individual, II), abundance index (mean number of specimens of the parasitic species per one examined individual of host, AI) with standard error. To determine the domination of species in the groups, we used the Berger-Parker domination index (d) (Mehgarran, 1992). The data were analyzed in Statistica 10.0 (StatSoft Inc., USA) using the method of descriptive statistics. The results are demonstrated in the tables as x ± SE (x ± standard error). The analysis of significances of differences was performed using ANOVA dispersion analysis method, differences were considered significant at $P < 0.05$. During the analysis of distribution of parasites according to sex and age, the fish were divided into groups of males – 11, females – 27 and juvenile individuals – 16, and also three age groups: 3+–4+ (n = 29), 5+–6+ (n = 21), 7+–8+ (n = 4).

## Results

Peculiarities of parasitofauna of bream in the groups male, female and juvenile fish. In the examined individuals of *A. brama*, 24 species of parasite were found, belonging to different systematic groups: Oligohymenophorea – 1, Phyllopharyngea – 1, Myxosporea – 3, Monogenea – 4, Cestoda – 2, Trematoda – 9, Nematoda – 2, Bivalvia – 1, Copepoda – 1. Only males were observed to have infestation with *Z. nova*, *H. triloba*, *A. isoporum*, *I. platycephalus* (Tables 1, 2). Myxozoan *Z. nova* parasitized the bladder in 27.3% of males. Only 3 individuals were infested with metacercariae of *H. triloba*, EI equaling 9.1%. In the intestine of one bream, immature marita *A. isoporum* were found, with infestation intensity equaling 20 specimens. In one bream, two *I. platycephalus* cysts were found on the surface of the heart.

**Table 1**
Extensity of infection of *A. brama* in the Lower Irtysh by protozoans and myxosporeans in the groups males, females and juveniles (x ± SE, %)

| Species of parasite | Males, n = 11 | Females, n = 27 | Juveniles, n = 16 |
|---|---|---|---|
| *Trichodina nigra* (Lom, 1960) | 45.4 ± 15.0 | 29.6 ± 8.8 | 68.7 ± 11.6 |
| *Chilodonella* sp. | – | 3.7 ± 3.6 | 18.7 ± 9.8 |
| *Zschokkella nova* (Klokacewa, 1914) | 27.3 ± 13.4 | – | – |
| *Myxobolus rotundus* (Nemeczek, 1911) + *M. parviformis* sp. n. | 90.9 ± 8.7 | 29.6 ± 8.8 | 31.2 ± 11.6 |

**Table 2**
Metozoan parasites in bream in the groups males, females and juveniles (x ± SE)

| Species of parasite | Males, n = 11 | | | Females, n = 27 | | | Juveniles, n = 16 | | |
|---|---|---|---|---|---|---|---|---|---|
| | EI | II | AI | EI | II | AI | EI | II | AI |
| *Dactylogyrus falcatus* (Wedl, 1857), *D. wunderi* (Bychowsky, 1931), *D. zandti* (Bychowsky, 1933) | 100.0 | 5–143 | 45.3 ± 13.1 | 96.3 ± 3.6* | 13–167 | 62.9 ± 7.3 | 100.0 | 9–253 | 85.1 ± 17.4 |
| *Gyrodactylus elegans* (Nordmann, 1832) | 81.8 ± 11.6* | 4–256 | 64.0 ± 23.9 | 81.5 ± 7.5 | 1–258 | 59.4 ± 14.3 | 93.7 ± 6.1 | 4–176 | 70.6 ± 11.9 |
| *Caryophyllaeus laticeps* (Pallas, 1781) | 27.3 ± 13.4 | 1–45 | 4.5 ± 4.1 | 33.3 ± 9.1 | 1–75 | 3.9 ± 2.8 | 50.0 ± 12.5 | 1–13 | 2.9 ± 1.1 |
| *Proteocephalus* sp. | – | – | – | 3.7 ± 3.6 | 1 | 0.04 ± 0.04 | – | – | – |
| *Diplostomum chromatophorum* (Brown, 1931) (mtc) | 81.8 ± 11.6 | 2–21 | 6.0 ± 2.1 | 77.8 ± 8.0 | 1–27 | 6.1 ± 1.5 | 93.7 ± 6.1 | 1–69 | 9.9 ± 4.2 |
| *Hysteromorpha triloba* (Rudolphi, 1819) (mtc) | 9.1 ± 8.7 | 1 | 0.1 ± 0.1 | – | – | – | – | – | – |
| *Rhipidocotyle campanula* (Dujardin, 1845) (mtc) | 45.4 ± 15.0 | 2–8 | 2.5±1.0 | 7.4 ± 5.0 | 4–5 | 0.3 ± 0.2 | 6.2 ± 6.1 | 4 | 0.3 ± 0.3 |
| *Ichthyocotylurus platycephalus* (Creplin, 1852) (mtc) | 9.1 ± 8.7 | 2 | 0.2 ± 0.2 | – | – | – | – | – | – |
| *Metorchis* sp. (mtc) | 54.5 ± 15.0 | 1–10 | 2.3 ± 0.9 | 33.3 ± 9.1 | 1–475 | 18.6 ± 17.6 | 12.5 ± 8.3 | 2–6 | 0.5 ± 0.4 |
| *Opisthorchis felineus* (Rivolta, 1884) (mtc) | – | – | – | 18.5 ± 7.5 | 2–24 | 1.3 ± 0.9 | 31.2 ± 11.6 | 2–5 | 1.1 ± 0.5 |
| *Allocreadium isoporum* (Looss, 1894) | 9.1 ± 8.7 | 20 | 1.8 ± 1.8 | – | – | – | – | – | – |
| *Sphaerostoma bramae* (Müller, 1776) | 90.1 ± 9.0 | 2–79 | 18.5 ± 7.1 | 70.4 ± 8.8 | 1–74 | 13.7 ± 3.8 | 81.2 ± 9.8* | 1–1019 | 98.3 ± 65.4 |
| *Azygia lucii* (Müller, 1776) (juv) | – | – | – | 3.7 ± 3.6 | 2 | 0.1 ± 0.1 | – | – | – |
| *Raphidascaris acus* (Bloch, 1779) (l) | 27.3 ± 13.4 | 3–22 | 2.8 ± 2.0 | 12.5 ± 8.3 | – | 81 ± 6 | 0.4 ± 0.4 | – | – |
| *Philometra ovata* (Zeder, 1803) | 27.3 ± 13.4 | 1–6 | 0.8 ± 0.6 | 14.8 ± 6.8 | 2–6 | 0.7 ± 0.3 | 6.2 ± 6.1 | 1 | 0.1 ± 0.1 |
| *Unionidae* gen. sp. (l) | – | – | – | 7.4 ± 5.0 | 1–3 | 0.1 ± 0.1 | 6.2 ± 6.1 | 5 | 0.3 ± 0.3 |
| *Ergasilus sieboldi* (Nordmann, 1832) | – | – | – | 7.4 ± 5.0 | 1–3 | 0.1 ± 0.1 | – | – | – |
| Berger-Parker index, d | | 0.430 | | | 0.375 | | | 0.315 | |

*Note*: EI – extensity index (%); II – intensity index (min-max); AI – abundance index (spec.); - no parasite was found; mtc – metacercaria; l – larva; juv – juvenile; * – dominating species in the group.

Ciliates of *T. nigra* were recorded on the gills and fins of all examined bream. Extensity of infection equaled 68.7% in juveniles, 45.4% in males, and 29.6% in females. Specimens of *M. rotundus* were found on the gills and in the kidneys, and *M. parviformis* sp. – only on the gills. The level of infestation in males (90.9%) was 3 times higher than EI in females (29.6%) and juvenile fish (31.2%). Infestation of the fins with *R. campanula* metacercariae in male bream was over 6 times higher than infestation in females and juvenile individuals. Also, increase in extensity of infection in males was observed for *P. ovata* nematode (cavity of the body) 27.3%, EI equaled 14.8% in females, and 6.2% in juveniles.

Highly host-specific monogeneans: *D. falcatus*, *D. wunderi*, *D. zandti*, *G. elegans*, *S. bramae* and the trematode *D. chromatophorum* (Table 2) infected the individuals of bream in approximately equal proportions, whereas EI increase was observed for the cestode *C. laticeps*: males → females → juveniles. Infection with metacercariae *Metorchis* sp. equaled 54.5% in males, and 33.3 and 12.5% in females and juveniles respectively. At the same time, only female and juvenile bream were infested with *Chilodonella* sp. with EI measuring 3.7% and 18.7% respectively, *O. felineus* metacercariae (18.5% and 31.2%) and Unionidae gen. sp. glochidia (7.4% and 6.2%) (Tables 1, 2). During the study, the females were found to host singular individuals of the parasites *Proteocephalus* sp., *A. lucii*, *E. sieboldi* (Table 2). Parasitism by *R. acus* was observed only in males and juveniles, EI was 27.3% and 12.5% respectively, and in females this parasite was not found.

The dominating parasite in the male group was *G. elegans* (d = 0.430), in females – representatives of the *Dactylogyrus* genus (d = 0.375), whereas in juveniles the dominant parasite was the trematode *S. bramae* (d = 0.315) (Table 2).

Extensity of infection in male, female and juvenile bream significantly differed (P < 0.05) for *Z. nova*, *Myxobolus* spp. (*M. parviformis* + *M. rotundus*), and *R. campanula*. In the remaining cases, no significant differences were determined. Extensity of infection by *Z. nova* in males differed from females (P = 0.009) and juveniles (P = 0.009), the same was observed for parasitism by *Myxobolus* spp. (P = 0.006 and P = 0.007, respectively). Significant differences were found in the extent of infestation with *R. campanula* between adult males and females (P = 0.024), and juveniles (P = 0.020).

Dispersion analysis of significance of differences in intensity of infection with metazoan parasites between the male, female and juvenile bream groups revealed significant differences (P < 0.05) only for *R. campanula*, at the same time, II in males reliably differed from that of females (P = 0.017) and juveniles (P = 0.013).

*Peculiarities of parasitofauna of bream of different age groups.* Bream of age 5+–6+ were infected with 20 species of parasites, 15 species were observed for the age group 3+–4+, and only 11 in the age group 7+–8+ (Table 3, 4). All three groups of bream were infected with *T. nigra*, *Dactylogyrus* spp., *G. elegans*, *D. chromatophorum*, *S. bramae* and *R. acus* at practically the same level, with no sharp differences in extensity and abundance of infection. Glochidia Unionidae gen. sp. were observed only in the age group 3+–4+ in 10.3% of the examined fish. Only age group 5+–6+ was observed to be parasitized by *Proteocephalus* sp., metacercariae *H. triloba* and *I. platycephalus*, *A. isoporum* and *A. lucii* in 4.8% of cases each, at the same time these species were not found in the bream of other ages. *Philometra ovata* and *E. sieboldi* infested fish at the age of 3+–4+ and 5+–6+ with insignificant increase in extensity of infection at low parameters of abundance (Table 3). In these age groups, parasitism by *Chilodonella* sp. and metacercariae *O. felineus* was observed with decrease in infection extensity. *Zschokkella nova* parasitized age group 5+–6+ with EI – 4.8%, whereas EI in the group 7+–8+ increased by up to 50.0%. In all age groups, infection by representatives of *Myxobolus* genus, metacercariae *R. campanula* and *Metorchis* sp. was observed with EI increase with increasing age. The obligate parasite of bream – *C. laticeps*, infected fish of age 3+–4+ at 55.2%, in the group 5+–6+ at 14.3%, in 7+–8+ in 25.0% of cases.

In the youngest age group, the dominant parasites were metazoans of the *Dactylogyrus* genus (d = 0.362), in the age group 5+–6+ the dominant were *Gyrodactylus* flatworms (d = 0.454), in the older age group the dominant parasites were metacercariae *Metorchis* sp. (d = 0.603), which, probably, is related to small selection in this group (Table 4).

As a result of ANOVA for extensity of infection in different age groups of bream, reliable differences (P < 0.05) were determined for *Z. nova*, *Dactylogyrus* spp., *C. laticeps*. In the remaining cases no significant differences were found. Infection by *Z. nova* in the 7+–8+ group differed from that of the group 5+–6+ (P = 0.005) and 3+–4+ (P = 0.002), extensity of infection by *Dactylogyrus* spp. in Age 5+–6+ was different from other ages (P < 0.001), and also significant differences in parasitism by *C. laticeps* were determined between the groups 3+–4+ and 5+–6+ (P = 0.014).

Analysis of significance of differences in intensity of infection by metazoan parasites in different age groups of bream revealed differences at infection by *Metorchis* sp. (P < 0.001). Intensity of infection with *Metorchis* sp. of bream at the age of 7+–8+ was different from the groups 3+–4+ (P = 0.015) and 5+–6+ (P = 0.017).

**Table 4**
Extensity of infection of *A. brama* in the Lower Irtysh by protozoans and myxosporeans by different age groups (x ± SE, %)

| Species of parasite | 3+–4+, n = 29 | 5+–6+, n = 21 | 7+–8+, n = 4 |
|---|---|---|---|
| *T. nigra* | 48.3 ± 9.3 | 38.1 ± 10.6 | 50.0 ± 25.0 |
| *Chilodonella* sp. | 10.3 ± 5.6 | 4.8 ± 4.7 | – |
| *Z. nova* | – | 4.8 ± 4.7 | 50.0 ± 25.0 |
| *Myxobolus* spp. | 27.6 ± 8.3 | 61.9 ± 10.6 | 50.0 ± 25.0 |

**Table 5**
Metazoan parasites of bream of different age groups, (x ± SE)

| Species of parasite | 3+–4+, n = 29 | | | 5+–6+, n = 21 | | | 7+–8+, n = 4 | | |
|---|---|---|---|---|---|---|---|---|---|
| | EI | II | AI | EI | II | AI | EI | II | AI |
| *Dactylogyrus* spp. | 100.0* | 9–253 | 75.9 ± 10.2 | 95.2 ± 4.7 | 5–167 | 57.4 ± 10.4 | 100.0 | 17–79 | 37.5 ± 14.0 |
| *G. elegans* | 86.2 ± 6.4 | 1–258 | 58.8 ± 11.4 | 90.5 ± 6.4* | 1–256 | 77.8 ± 17.0 | 75.0 ± 21.6 | 2–63 | 24.3 ± 14.8 |
| *C. laticeps* | 55.2 ± 9.2 | 1–45 | 4.1 ± 1.6 | 14.3 ± 7.6 | 2–75 | 3.8 ± 3.6 | 25.0 ± 21.6 | 1 | 0.3 ± 0.2 |
| *Proteocephalus* sp. | – | – | – | 4.8 ± 4.7 | 1 | 0.05 ± 0.05 | – | – | – |
| *D. chromatophorum* (mtc) | 86.2 ± 6.4 | 1–69 | 8.0 ± 2.5 | 80.9 ± 8.6 | 1–21 | 6.5 ± 1.5 | 75.0 ± 21.6 | 1–17 | 5.3 ± 4.0 |
| *H. triloba* (mtc) | – | – | – | 4.8 ± 4.7 | 1 | 0.05 ± 0.05 | – | – | – |
| *R. campanula* (mtc) | 10.3 ± 5.6 | 4–5 | 0.4 ± 0.3 | 19.0 ± 8.6 | 2–8 | 1.0 ± 0.5 | 25.0 ± 21.6 | 6 | 1.5 ± 1.5 |
| *I. platycephalus* (mtc) | – | – | – | 4.8 ± 4.7 | 2 | 0.1 ± 0.1 | – | – | – |
| *Metorchis* sp. (mtc) | 20.7 ± 7.5 | 1–3 | 0.4 ± 0.2 | 47.6 ± 10.9 | 1–10 | 2.3 ± 0.7 | 25.0 ± 21.6* | 475 | 118.8 ± 118.7 |
| *O. felineus* (mtc) | 24.1 ± 7.9 | 2–5 | 0.8 ± 0.3 | 14.3 ± 7.6 | 2–24 | 1.3 ± 1.1 | – | – | – |
| *A. isoporum* | – | – | – | 4.8 ± 4.7 | 20 | 0.9 ± 1.0 | – | – | – |
| *S. bramae* | 75.9 ± 7.9 | 1–1019 | 59.9 ± 37.8 | 76.2 ± 9.3 | 1–79 | 17.9 ± 4.8 | 100.0 | 5–14 | 8.8 ± 2.1 |
| *A. lucii* (juv) | – | – | – | 4.8 ± 4.7 | 2 | 0.1 ± 0.1 | – | – | – |
| *R. acus* (l) | 6.9 ± 4.7 | 1–6 | 0.2 ± 0.2 | 9.5 ± 6.4 | 6–22 | 1.3 ± 1.1 | 25.0 ± 21.6 | 3 | 0.8 ± 0.8 |
| *P. ovata* | 13.8 ± 6.4 | 1–6 | 0.5 ± 0.3 | 19.0 ± 8.6 | 1–6 | 0.7 ± 0.4 | – | – | – |
| *Unionidae gen.* sp. | 10.3 ± 5.6 | 1–5 | 0.3 ± 0.2 | – | – | – | – | – | – |
| *E. sieboldi* | 3.4 ± 3.4 | 1 | 0.03 ± 0.03 | 4.8 ± 4.7 | 3 | 0.1 ± 0.1 | – | – | – |
| Berger-Parker index, d | | 0.362 | | | 0.454 | | | 0.603 | |

*Note*: see Table 2.

## Discussion

Analysis of distribution of parasites in fish with different habitat or feeding preferences clearly demonstrates how non-uniformity of trophic behaviour significantly contributes to usually observed aggregation of helminths among hosts in natural conditions (Hayatbakhsh et al., 2014). Parasitic organisms, the life cycle of which is not related to the food chain, such as ectoparasites or three-host species, can adapt to the habitat and biological peculiarities of the host. Juvenile individuals were observed to have high, compared with males and females, infection of the surface of the body by protozoans. Therefore, *T. nigra* parasitized 68.7% of the juvenile fish, whereas EI equaled 29.6% in females, and 45.4% in males. However, between the youngest age group and mature individuals no differences in extensity of infection with this trichodinid were observed. By contrast to adults, immature bream prefer shoreline, well heated microbiotopes, which have favourable conditions for the development of trichodinids and other protozoans (Reshetnikov, 2003).

We observed reliable differences in the extensity of infestation with *Dactylogyrus* spp. in the age group 5+–6+ compared with the other age groups and intensity of infection between groups 3+–4+ and 5+–6+ years, which coincides with the life cycle of *Dactylogyrus* metazoans and possible accumulation of parasites in fish with age, when gills enlarge as the fish grow, leading to significant increase in the level of infection (Machado et al., 1994). Another representative of monogeneans, *G. elegans*, was observed to have reduction of intensity of infection in the group 7+–8+ (AI – 24.3 spec.) compared with age group 5+–6+ (AI – 77.8 spec.). Adult *Gyrodactylus* flatworms produce vital larvae which remain on the hosts or attach to plants. Perhaps, reduction in the intensity of infection in the group 7+–8+ was related to preference of fish of older groups for deeper areas in the water bodies, in which, in turn, less vegetation and stronger currents occur (Reshetnikov, 2003). According to Ottová et al. (2005), over the spawning period, male bream are more susceptible to infestation with *Gyrodactylus*, though our studies did not prove this hypothesis.

The three-host parasite – *Rhipidocotyle campanula* in the stage of metacercariae was found on the fins of bream. Extensity and abundance of infection in males was 6–7 times higher than in females and juvenile fish. The parasite develops in mollusks of the *Anodonta* and *Unio* genera, the miricidia infest fish of the Cyprinidae family, and the final hosts of the trematode are predatory fish (Taskinen et al., 1994; Lebedevab, 2005; Rusinek & Kondratistov, 2010). The high rate of infection of males by *R. campanula* was perhaps related to increase in the level of hormones during spawning, which causes immunosuppression, making them more susceptible to parasites (Folstad & Karter, 1992). Helminths *Proteocephalus* sp. and *Azygia lucii* (juv) were found only in females of the age group 5+–6+. Cercariae *A. lucii* develop in mollusks, non-predatory fish become infested after swallowing cercariae swimming in the water column, therefore such findings in bream are considered accidental (Rueckert et al., 2007; Sokolov et al., 2017; Chunchukova et al., 2017). Intermediate hosts for *Proteocephalus* sp. are different crustaceans also included in the diet of bream.

The larval stage of *R. acus* parasitizes the liver of fish, EI of this species in males was twice as high as infestation in the juveniles. Males, by contrast to juveniles, have their own preferences both in food and habitat, which indicates their more intense infestation. In its development cycle, this nematode has a broad range of reservoir hosts (oligochaetae, mollusks, crustaceans, larvae of insects, alevins, non-predatory fish), which are associated ecologically with one another in trophic networks (Supryaga & Mozgovoj, 1974). The final obligate host for *R. acus* is pike, for which bream, in turn, is food (Sokolov et al., 2017; Platonov et al., 2018). In the Caspian Sea bream were observed to have increase in extensity of infection with *Caryophyllaeus laticeps* at the age 2+ to 5+, at the same time infection in females was 4 times higher than in males (Hayatbakhsh et al., 2011). In our study, contrary data were received, therefore *C. laticeps* infection in bream aged 5+–6+ reliably decreased by 4 times compared with group aged 3+–4+, also no statistically reliable differences in infection rates of males and females were observed. The life cycle of *C. laticeps* takes places with participation of oligochaetae of the following genera: *Tubifex*, *Limnodrillus*, *Psammoryctes* (Cowx, 1983; Kostarev, 2003). Fish of different age are fattened in different parts of the water body, which is related to the spawning time of mature individuals, which choose areas with dense vegetation, due to which their diet range can change, causing these differences (Karasev, 2008; Shatunovskij et al., 2009). A higher parameter of extensity of infection in the younger age group indicates the food preference of bream at this age, i.e. domination of oligochaetae in the diet compared to older fish (Rumyancev, 1975). In turn, the representatives of oligochaetae are intermediate hosts of myxosporeans: *Zschokkella nova* and *Myxobolus* spp. (Tyutyaev, 2008), also these parasites can have a one-host cycle of the development with transmission from fish to fish (Diamont, 1997). In our study, we determined a difference in EI for myxosporeans in males compared with the group of females and juveniles, the percentage of infection in males was three times higher compared to females and juvenile fish. However, infection by *Z. nova* in the groups 7+–8+ years (50.0%) was higher than in fish of the group 5+–6+ (4.8%), and bream aged 3+–4+ were not infected with this parasite. Another situation was observed for infestation with *Myxobolus* spp. in the age groups of fish, extensity of infection was observed with increase in age, which indirectly supports the one-host theory of the life cycle of myxosporeans.

## Conclusions

In the conditions of the Lower Irtysh, no clear borders in distribution of species in the parasitic communities were observed in bream. Significant differences were determined for infection by *Z. nova*, *M. parviformis* and *M. rotundus*, *R. campanula* between the of male, female and juvenile groups, which were related to the biological cycles and the habitat preferences of the fish. In different age groups of bream, differences were noted for infection with *Z. nova*, *Dactylogyrus* spp., *C. laticeps*, the development cycle of which was directly related to the diet range, habitat or process of their accumulation with age. Generalizing the literature data, currently, studies around the world have not yet come to a unanimous opinion on influence of sex and age on the infection of fish by parasitic organisms. More detailed studies should be conducted, for there is no clear picture of whether higher levels of infestation with parasites are conditioned by sex and age of fish, rather than the environment in which they live.

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## References

Agapova, A. I. (1958). Osobennosti parazitofauny ryb, akklimatizirovannyh v vodoemah Kazahstana [Features of the parasite fauna of fish acclimatized in the water bodies of Kazakhstan]. Trudy Instituta Zoologii, Akademii Nauk Kazahskoj SSR, 9, 25–31 (in Russian).

Agapova, A. I. (1966). Parazity ryb vodoemov Kazahstana [Parasites of fishes of reservoirs of Kazakhstan]. Nauka, Alma-Ata (in Russian).

Anderson, R. M. (1974). An analysis of the influence of host morphometric features on the population dynamics of *Diplozoon paradoxum* (Nordmann, 1832). Journal of Animal Ecology, 43(3), 873–887.

Byhovskaya-Pavlovskaya, I. E. (1985). Parazity ryb. Rukovodstvo po izucheniiyu [Fish parasites. Study Guide]. Nauka, Leningrad (in Russian).

Chunchukova, M., Kirin, D., Kuzmanova, D., & Shukerova, S. (2017). Accumulation of lead in *Abramis brama* and its parasite pomphorhynchus tereticollis from Danube river (Vetren area), Bulgaria. Scientific Papers-Series D-Animal Science, 60, 327–332.

Cowx, I. G. (1983). The biology of bream, *Abramis brama* (L), and its natural hybrid with roach, *Rutilus rutilus* (L), in the River Exe. Journal of Fish Biology, 22, 631–646.

Diamont, A. (1997). Fish-to-fish transmission of marine myxosporidians. Diseases of Aquatic Organisms, 30, 99–105.

Duneau, D., & Ebert, D. (2012). Host sexual dimorphism and parasite adaptation. Plos Biology, 10(2), e1001271.

Fiala, I., Bartošová-Sojková, P., & Whipps, C. M. (2015). Classification and phylogenetics of Myxozoa. Myxozoan Evolution, Ecology and Development, 85–110.

Folstad, I., & Karter, A. J. (1992). Parasites, bright males and the immuno competence handicap. The American Naturalist, 139, 603–622.

Hayatbakhsh, M. R., Khara, H., Movahed, R., Sayadborani, M., Rohi, J. D., Ahmadnezhad, M., Rahbar, M., & Rad, A. S. (2014). Haematological characteristics associated with parasitism in bream, *Abramis brama orientalis*. Journal of Parasitic Diseases, 38(4), 383–388.

Hayatbakhsh, M., Khara, H., Rahabar, M., & Ahmadnezhad, M. (2011). Parasite infection of bream (*Abramis brama orientalis*) in the Caspian Sea (Bandar Anzali Coast). International conference on chemical, environmental and biological sciences, Pattaya. Pp. 320–323.

Ibrahim, M. M. (2012). Variation in parasite infracommunies of *Tilapia zillii* in relation to some biotic and abiotic factors. International Journal of Zoological Research, 8(2), 59–70.

Interesova, E. A. (2016). Alien fish species in the Ob River basin. Russian Journal of Biological Invasions, 7(2), 156–167.

Karasev, S. G. (2008). Ekologiya ryb nizhnego Tobola i nizhnego Irtysha [Ecology of fishes of lower Tobol and lower Irtysh]. Poligrafist, Tobol'sk (in Russian).

Kashkovskij, V. V., Razmashkin, D. A., & Skripchenko, E. G. (1974). Bolezni i parazity ryb rybovodnyh hozyajstv Sibiri i Urala [Diseases and parasites of fish from fish farms in Siberia and the Urals]. Sredneural'skoe Knizhnoe Izdatel'stvo, Sverdlovsk (in Russian).

Kerr, S. J., & Grant, R. E. (2000). Ecological impacts of fish introductions: Evaluating the risk. Fish and Wildlife Branch. Ontario Ministry of Natural Resources, Peterborough, Ontario.

Kostarev, G. F. (2003). Parazity i bolezni ryb bassejna Srednej Kamy (v usloviyah zagryazneniya) [Parasites and fish diseases in the basin of the Middle Kama (in terms of pollution)]. Izdatel'stvo Permskogo Universiteta, Perm' (in Russian).

Kuderskij, L. A. (2001). Akklimatizaciya ryb v vodoemah Rossii: Sostoyanie i puti razvitiya [Acclimatization of fish in the waters of Russia: Condition and ways of development]. Voprosy Rybolovstva, 2(5), 6–85 (in Russian).

Lebedeva, D. I. (2005). Trematody ryb Ladozhskogo ozera. Biogeografiya Karelii [Trematodes of fishes of the Ladoga Lake. Biogeography of Karelia]. Vol. 7. Ieshko, E. P. (Ed.). Trudy Karel'skogo Nauchnogo Centra RAN. Petrozavodsk (in Russian).

Liberman, E. L., & Voropaeva, E. L. (2018). New data on parasitic fauna of bream *Abramis brama* (Linnaeus, 1758) of the Lower Irtysh (acquired part of the range). Russian Journal of Biological Invasions, 9(3), 232–236.

Lizama, M., De Los, A. P., Takemoto, R. M., & Pavanelli, G. C. (2006). Influence of host sex and age on infracommunities of metazoan parasites of *Prochilodus lineatus* (Valenciennes, 1836) (Prochilodontidae) of the Upper Paraná River floodplain, Brazil. Parasite, 12(4), 299–304.

Lymbery, A. J., Morine, M., Kanani, H. G., Beatty, S. J., & Morgan, D. L. (2014). Co-invaders: The effects of alien parasites on native hosts. International Journal for Parasitology: Parasites and Wildlife, 3(2), 171–177.

Machado, M. H., Pavanelli, G. C., & Takemoto, R. M. (1994). Influence of hosts sex and size on endoparasitic infra populations of *Pseudoplatystoma corruscans* and *Schizodon borelli* (Osteichthyes) of the high Parana river, Brazil. Revista Brasileira Parasitologia Veterinaria, 3, 143–148.

Mehgarran, E. H. (1992). Ehkologicheskoe raznoobrazie i ego izmerenie [Ecological diversity and its measurement]. Mir, Moscow (in Russian).

Ottová, E., Simková, A., Jurajda, P., Dávidová, M., Ondračková, M., Pečínková, M., & Gelnar, M. (2005). Sexual ornamentation and parasite infection in males of common bream (*Abramis brama*): A reflection of immunocompetence status or simple cost of reproduction? Evolutionary Ecology Research, 7, 581–593.

Platonov, T. A., Kuz'mina, N. V., Nyukkanov, A. N., & Protod'yakonova, G. P. (2018). Parazitofauna ryb srednego techeniya reki Leny i ee pritokov v usloviyah vozrastayushchej tekhnogennoj nagruzki [Parazitofauna of fish in the middle course of the Lena River and its tributaries under increasing man-made pressure]. Vestnik Rossijskogo Universiteta Druzhby Narodov, Seriya Ekologiya i Bezopasnost' Zhiznedeyatel'nosti, 26(2), 185–194 (in Russian).

Popov, P. A. (2010). Formirovanie ihtiocenozov i ekologiya promyslovyh ryb vodohranilishch Sibiri [Formation of ichthyocenoses and ecology of commercial fish of Siberian reservoirs]. Geo, Novosibirsk (in Russian).

Pravdin, I. F. (1966). Rukovodstvo po izucheniyu ryb (preimushchestvenno presnovodnyh) [Guidelines for the study of fish (mostly freshwater)]. Pishchevaya Promyshlennost', Moscow (in Russian).

Rahman, W. A., & Saidin, H. (2011). Relationship between sex and parasite intensity in four freshwater fish species from Tasik Merah, Perak, Peninsular Malaysia. World Journal of Zoology, 6(4), 370–374.

Ranzani-Paiva, M. J. T., Ishikawa, C. M., Campos, B. E. S., & Eiras, A. C. (1997). Haematological characteristics associated with parasitism in *Mugil platanus* Gunther, from the estuarine region of Cananela, Sao Paulo, Brazil. Revista Brasileira de Zoologia, 14(2), 329–339.

Reshetnikov, Y. S. (Ed.). (2003). Atlas presnovodnyh ryb Rossii [Atlas of freshwater fish of Russia]. Nauka, Moscow (in Russian).

Rueckert, S., Klimpel, S., & Palm, H. W. (2007). Parasite fauna of bream *Abramis brama* and roach *Rutilus rutilus* from a man-made waterway and a freshwater habitat in Northern Germany. Diseases of Aquatic Organisms, 74(3), 225–233.

Rumyancev, E. A. (1975). Vliyanie nekotoryh faktorov na parazitofaunu ryb pri introdukcii v ozera Karelii [The influence of some factors on the parasitic fauna of fish introduced into lakes of Karelia]. Parazitologiya, 9(4), 305–311 (in Russian).

Rusinek, O. T., & Kondratistov, Y. L. (2010). Izuchenie zarazhennosti karpovyh ryb metacerkariyami trematod v ochage opistorxoza (Tajshetskij rajon, Irkutskaya oblast`, Rossiya) [The study of the infection of carp swarms by trematode metacercariae in the focus of opisthorchiasis (Taishet District, Irkutsk Region, Russia)]. Izvestiya Irkutskogo Gosudarstvennogo Universiteta, Seriya Nauki o Zemle, 3(1), 132–142 (in Russian).

Shatunovskij, M. I., Dgebuadze, Y. Y., Bobyrev, A. E., Sokolova, E. L., Usatyj, M. A., Krepis, O. I., Usatyj, A. M., & Chebanu, A. S. (2009). Nekotorye zakonomernosti izmenchivosti struktury i dinamiki populyacij leshcha *Abramis brama* vodoyomov Vostochnoj Evropy [Some regularities of the variability of the structure and dynamics of the population of bream *Abramis brama* in water bodies of Eastern Europe]. Voprosy Ihtiologii, 49(4), 495–507 (in Russian).

Sheath, D. J., Williams, C. F., Reading, A. J., & Britton, J. R. (2015). Parasites of non-native freshwater fishes introduced into England and Wales suggest enemy release and parasite acquisition. Biological Invasions, 17(8), 2235–2246.

Skarlato, O. A. (Ed.). (1984). Opredelitel' parazitov presnovodnyh ryb fauny SSSR. Paraziticheskie prostejshie [The determinant of parasites of freshwater fish of the USSR. Parasitic Protozoa]. Nauka, Leningrad (in Russian).

Skarlato, O. A. (Ed.). (1985). Opredelitel' parazitov presnovodnyh ryb fauny SSSR. Paraziticheskie mnogokletochnye [The determinant of parasites of freshwater fish of the USSR. Parasitic Metazoa]. Nauka, Leningrad (in Russian).

Skarlato, O. A. (Ed.). (1987). Opredelitel' parazitov presnovodnyh ryb fauny SSSR. Paraziticheskie mnogokletochnye [The determinant of parasites of freshwater fish fauna of the USSR. Parasitic Metazoa]. Nauka, Leningrad (in Russian).

Sokolov, S. G., Reshetnikov, A. N., Protasova, E. N., & Voropaeva, E. L. (2017). New data on alien species of parasites and hosts in the ecosystem of lake Glubokoe (Moscow oblast, Russia). Russian Journal of Biological Invasions, 8(1), 108–114.

Sous', S. M. (1975). Fauna parazitov ryb ozer i prudov yuga Zapadnoj Sibiri [The fauna of parasites of fishes of lakes and ponds of the south of Western Siberia]. In: Ryzhikov, K. M. (Ed.). Parazity v prirodnyh kompleksah Severnoj Kulundy [Parasites in the natural complexes of North Kulunda]. Nauka, Novosibirsk. Pp. 183–196 (in Russian).

Sous', S. M., & Rostovcev, A. A. (2006). Parazity ryb Novosibirskoj oblasti [Parasites of fishes of the Novosibirsk region]. Gosrybcentr, Tyumen' (in Russian).

Sudarikov, V. E., & Shigin, A. A., Kurochkin, Y. V., Lomakin, V. V., Sten'ko, R. P., & Yurlova, N. I. (2002). Metacerkarii trematod – parazity presnovodnyh gidrobiontov Central'noj Rossii [Trematode metacercariae – parasites of freshwater hydrobionts of Central Russia]. Nauka, Moscow (in Russian).

Supryaga, V. G., & Mozgovoj, A. A. (1974). Biologicheskie osobennosti *Raphidascaris acus* (Anisakidae: Ascaridata) – parazita presnovodnyh ryb [Biological features of *Rafidaskaris asus* (Anisakidae: Ascarridat) – freshwater swarm parasite]. Parazitologiya, 8(6), 494–503 (in Russian).

Tadiri, C. P., Scott, M. E., & Fussmann, G. F. (2016). Impact of host sex and group composition on parasite dynamics in experimental populations. Parasitology, 143, 523–531.

Taskinen, J., Valtonen, E. T., & Mäkelä, T. (1994). Quantity of sporocysts and seasonality of two *Rhipidocotyle* species (Digenea: Bucephalidae) in *Anodonta piscinalis* (Mollusca: Bivalvia). International Journal for Parasitology, 24(6), 877–886.

Tkachev, V. A. (1998). K izucheniyu parazitofauny ryb ozera Turgoyak [To study the parazitofauna of the fish of the lake Turgoyak]. Izvestiya Chelyabinskogo Nauchnogo Centra UrO RAN, 1, 161–170 (in Russian).

Tyutyaev, P. Y. (2008). Neorganicheskij sostav obolochki miksosporidij *Henneguya oviperda* (Cohn, 1895) i *Myxobolus pseudodispar* (Gorbunova, 1936) (Myxozoa) [The inorganic composition of the shell of myxospores *Henneguya oviperda* (Cohn, 1895) and *Myxobolus pseudodispar* (Gorbunova, 1936) (Myxozoa)]. Citologiya, 50(1), 83–87 (in Russian).