

# Age dynamics of roach infestation with metazoic parasites

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**Abstract.** The study of roach for the metazoic parasites' presence allowed to detect *D. crucifer*, *D. chromatophorum*, *P. homoion homoion*, *C. laticeps*, *O. felineus*, *P. ovatus*, *R. campanula*, *I. platycephalus*, *S. bramae*, *P. elongatum*, *R. acus* (l.) *Unionidae* gen. sp *E. sieboldi* *P. geometra* *Protocephalus* sp. The greatest species diversity was observed in fish in groups 2+, 3+, and 4+ (11, 14, and 13 species of parasites, respectively). At the ages of 1+ and 5+, 8 species of parasitic organisms were found, in the group of 0+ - 6 species of parasites. The greatest parasites' species diversity was noted on the gills - 5 species, in the intestines - 3 species, in the muscles and mesentery - 2 species, in the lens, on the fins, in the kidneys and on the body surface - 1 each. Cluster analysis on the invasion extent of roach parasites aged 0+ - 8+ showed groups 1+ - 4+ merging into one cluster; fish aged 0+, 5+ and 6+-8+ are allocated to a separate cluster. The calculated clustering by IE in age groups shows the similarity of parasite fauna and the magnitude of the invasion extensiveness at the ages from 1+ and 4+, and 6+ - 8+. With age, the biotopic distribution and nutrition spectrum of roach changes, which affects its infestation by parasites and the composition of the parasitic community as a whole.

## 1 Introduction

As representatives of vertebrates, fish is characterized by changes in biological and physiological characteristics with age. There may be a change in food characteristics, cross-species interactions, habitat, the nature, and characteristics of metabolism, etc. Consequently, a change in the parasite fauna of animals is expected both in qualitative and quantitative composition (extensiveness and invasion intensity) [1-4]. Discussing the prospects of parasitological research, V.A. Dogel (1948) puts the dependence of parasite fauna on the age of the host in the first place among the general laws of ecological parasitology. In relation to freshwater fish parasites, this paradigm was confirmed in further studies by Yu.I. Polyansky and S.S. Shulbman (1956) [5]. When analyzing the patterns of the parasite fauna of freshwater fish from Karelian lakes, they established the pattern of early infestation with parasites with a direct development cycle or actively penetrating the host. A comparative analysis of age-related changes in the fish parasite fauna thus allows to assert that environmental factors play a leading role in this process. The object of this study was common roach. The common roach *Rutilus rutilus* (Linnaeus, 1758) is a widespread species

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from the carp family living in the waters of Europe, Siberia, and the Aral Sea basin [6]. It is very undemanding; it inhabits rivers, lakes, reservoirs, and ponds. Roach is a euryphagous animal by the nature of nutrition. Adults use various invertebrates and their larvae, mollusks for food; in summer they consume filamentous algae, large roach feeds on larvae and fish fry [6, 7]. In a reservoir where there are no mollusks in the feed, most of the food is allocated to Chironomidae larvae, to a lesser extent - to crustaceans; there is a high proportion of plant food [8, 9]. The objective of this work was to study and analyze changes in metazoic parasites of roach in the Tobol River of the Lower Irtysh basin in 2019-2020 depending on age.

## 2 Materials and methods of research

Roach fishing (n=50) was carried out in the spring-summer period of 2019-2020 in the Tobol River (Karachino village, 58.250 n.lat., 68.635 e.lon., Tobolsk district) (Table 1).

**Table 1.** Some morpho-biological indicators of examined fish

Type of fish	Gender, n			Age group, min.-max.	Weight, min -max., g	Length, min.-max., cm
	females	males	juvenile			
Roach	28	11	11	0+ - 8+	10,0-454,0	10,2-34,2

Fishing was carried out with fixed and drifting multi-size mesh nets of 24-38 mm cell size range out of 5-meter segments; with a cell step of 2 mm, the length of the fixed net - 40 m, the length of the drifting net - 60 m, the height - 2 m. For the study, the fish were delivered live in separate live-fish containers to exclude the movement of parasite fauna. The processing of ichthyological material was carried out by the method of biological analysis [10]. Incomplete parasitological autopsy was performed when examining roach on live material in laboratory conditions according to the method of Bykhovskaya-Pavlovskaya I.E. (1985) [11]. Parasites found in fish were fixed, then temporary and permanent preparations were prepared to determine the species [12-14].

The invasion extensiveness (percentage of host individuals with this parasite type, IE) was calculated with the standard error of the mean, the intensity of invasion (minimum and maximum number of parasite specimens per contaminated individual, II), the abundance index (average number of specimens of this type of parasite per studied host individual, AI) with the standard error of the mean. The Berger-Parker dominance index (d) was used to identify the dominant species in the parasite fauna [3]:

$$d = \frac{N_{\max}}{N}$$

where  $N_{\max}$  is the number of individuals of the most abundant species, N is the total number of parasite individuals in the community.

The data was analyzed in the Statistica 10.0 program (StatSoft Inc., USA) by the method of descriptive statistics. The results are presented in the tables as  $x \pm SE$  ( $x \pm$  standard error of the mean).

### 3 Results and discussion

Metazoic roach parasites inhabiting the Tobol River are represented by 15 species belonging to 7 systematic groups: Monogenea - 2, Cestoda - 2, Trematoda - 7, Nematoda - 1, Bivalvia - 1, Hirudinea - 1, Copepoda - 1.

Fish aged from 0+ to 8+ were studied in this work (Table 2). Only one specimen was examined from groups 6+ and 8+ each, while 4 and 5 species of parasites were identified, respectively. The greatest species diversity was observed in fish in groups 2+, 3+, and 4+ (11, 14, and 13 species of parasites, respectively). At the ages of 1+ and 5+, 8 species of parasitic organisms were found, in the group of 0+ - 6 species of parasites. The greatest species diversity of parasites was noted on the gills - 5 species, then in the intestine - 3 species, in the muscles and mesentery - 2 species, in the lens, on the fins, in the kidneys and on the body surface - 1 (Table 2).

**Table 2.** Age groups of the examined roach

It. No.	Age group	Number of fish in the sampling, n	Name of the parasite type
1.	0+	4	<i>D. crucifer</i> , <i>Proteocephalus</i> sp., <i>D. chromatophorum</i> , <i>O. felineus</i> , <i>R. acus</i> (l.), <i>E. sieboldi</i>
2.	1+	9	<i>D. crucifer</i> , <i>P. homoion homoion</i> , <i>D. chromatophorum</i> , <i>O. felineus</i> , <i>R. campanula</i> , <i>S. bramae</i> , <i>R. acus</i> (l.), <i>E. sieboldi</i>
3.	2+	6	<i>D. crucifer</i> , <i>P. homoion homoion</i> , <i>Proteocephalus</i> sp., <i>C. laticeps</i> , <i>D. chromatophorum</i> , <i>O. felineus</i> , <i>R. campanula</i> , <i>S. bramae</i> , <i>R. acus</i> (l.), <i>Unionidae</i> gen. sp. (l), <i>E. sieboldi</i>
4.	3+	12	<i>D. crucifer</i> , <i>P. homoion homoion</i> , <i>Proteocephalus</i> sp., <i>D. chromatophorum</i> , <i>O. felineus</i> , <i>P. ovatus</i> , <i>R. campanula</i> , <i>I. platycephalus</i> , <i>S. bramae</i> , <i>P. elongatum</i> , <i>R. acus</i> (l.), <i>Unionidae</i> gen. sp. (l), <i>E. sieboldi</i> , <i>P. geometra</i>
5.	4+	14	<i>D. crucifer</i> , <i>P. homoion homoion</i> , <i>Proteocephalus</i> sp., <i>D. chromatophorum</i> , <i>O. felineus</i> , <i>P. ovatus</i> , <i>R. campanula</i> , <i>S. bramae</i> , <i>P. elongatum</i> , <i>R. acus</i> (l.), <i>Unionidae</i> gen. sp. (l), <i>E. sieboldi</i>
6.	5+	3	<i>D. crucifer</i> , <i>P. homoion homoion</i> , <i>D. chromatophorum</i> , <i>P. ovatus</i> , <i>R. campanula</i> , <i>S. bramae</i> , <i>Unionidae</i> gen. sp. (l), <i>P. geometra</i>
7.	6+	1	<i>D. crucifer</i> , <i>D. chromatophorum</i> , <i>R. campanula</i> , <i>S. bramae</i>
8.	8+	1	<i>D. crucifer</i> , <i>P. homoion homoion</i> , <i>D. chromatophorum</i> , <i>R. campanula</i> , <i>S. bramae</i>

All age groups were invaded by the specific monogenea *Dactylogyrus crucifer* (Wagener, 1857) and metacercariae *Diplostomum chromatophorum* (Brown, 1931) Shigin, 1986 (Table 2). The invasion extensiveness of *D. crucifer* is observed from 66.7% in group 5+ to 100.0% in groups 2+, 6+ and 8+; the abundance of infestation varies from 5.0 to 123.0 specimens per one examined fish (Table 3). *Dactylogyrus* have a direct development type and infest their hosts through free-floating larvae. Roach is infested with *D. chromatophorum* with low intensity, but high invasion extensiveness. So, in the group of 5+ IE - 33.3% with AI - 0.7

spec., at the age of 2+, 6+ and 8+ IE amounted to 100.0% with AI - 2.2; 2.0 and 8.0 spec., accordingly. In group 1+, the infestation extensiveness was 55.6% with an intensity of 3.2 spec., in group 3+ EI - 66.7% and AI - 2.5 spec. At the ages of 0+ and 4+, the level of diplostoma invasion was above average and amounted to 75.0 and 78.6% (AI 5.5 and 3.4 spec.), respectively. The first intermediate hosts of *D. chromatophorum* are mollusks of the Lymnaea genus. Infestation of roach as the second intermediate host occurs by means of free-floating cercariae; in this regard, there is no pattern in the invasion of fish of different ages. However, it may depend on the water level in the river as a factor affecting the number of mollusks in the reservoir [15].

The following species also belong to the specific parasites of cyprinid fish: *Paradiplozoon homoion homoion* (Bychowsky et Nagibina, 1959), *Caryophyllaeus laticeps* (Pallas, 1781), *Opisthorchis felineus* (Rivolta, 1884), *Paracoenogonimus ovatus* (Katsurada, 1914), *Rhipidocotyle campanula* (Dujardin, 1845), *Ichthyocotylurus platycephalus* (Creplin, 1852), *Sphaerostoma brauae* (Müller. 1776), *Phyllodistomum elongatum* (Nybelin, 1926).

Monogenea *P. homoion homoion* is found in groups 1+ - 5+ and roach aged 8+ (table 2). There is an increase in the infestation extensiveness with the age of fish, while the invasion intensity in different age groups remains at the same low level (AI - 0.1 - 1.3 spec.).

*C. laticeps* is found in the intestines of the examined roach at the ages of 2+ and 4+ with an IE of 33.3 and 7.1%, respectively; the infestation intensity is quite low, IE - 1.3 and 0.4 spec. (table 3). This type of cestode is most often found in bream. The specimens of Caryophyllidae found in roach were not of reproductive age. The intermediate Cestoda hosts are Oligochaeta of Tubifex and Limnodrillus genera [16]. This year's brood and young roach feed on microplankton, insect larvae, and greens [7]. With age, the proportion of planktonic and benthonic organisms in the roach diet increases; the chance of *C. laticeps* invasion also increases due to the expansion of the nutrition spectrum [2].

*O. felineus* metacercariae have been recorded in roaches from the age of 0+ to 4+ (Table 3). The infestation extensiveness varies from 22.2% in group 1+ to 75.0% at the age of 0+; in groups 2+, 3+, and 4+ it is approximately at the same level (33.3%, 41.7% and 35.7%, respectively), while AI varies from 1.3 spec. (1+) up to 23.0 spec. (4+).

*R. campanula* parasitizes the fins and gills of fish in groups 1+ - 8+ with high infestation rates. At the ages of 1+, 5+, 6+ and 8+, there is 100.0% invasion with AI 10.4; 112.7; 86.0 and 7.0 specimens, respectively. In group 3+ and 4+, IE 91.7 and 92.6% with AI - 52.6 and 69.4 specimens is noted; in group 2+ IE - 66.7% with AI - 10.0 specimens.

*P. ovatus* is found in the roach muscles aged 3+ - 5+ (IE - 33,3%, 28,6%, 33,3%), the infestation intensity is not significant from 0.3 to 2.9 specimens per examined fish (Table 3). The invasion by this parasite is probably associated with the roach feeding by mollusks of the Viviparus genus [17].

In this study, only one roach aged 3+ had *I. platycephalus* metacercariae found on the mesentery.

*P. elongatum* was registered in the renal tubules of two fish; three immature trematodes were found at the age of 3+, one mature - at 4+ (Table 2). The intermediate hosts of the parasite are mollusks of the Pisidium genus, the final one is fish of the Cyprinidae family.

Analysis of the roach infestation distribution with *O. felineus*, *P. ovatus*, *R. campanula*, *I. platycephalus* and *P. elongatum* in various age categories shows a direct correlation between the parasite's entry into fish and its nutritional priorities. Roach fry are more often invaded by ingestion of free-floating cercariae; also, when they are introduced directly into the fish body, nutrition is added to these infestation routes at older ages, where the proportion of mollusks in the food lump increases [8, 18,19].

*S. brauae* - a trematode parasitizing in the intestines of roach; detected in groups 1+ - 8+. The first intermediate host of this parasite is the mollusks of the Bithynia genus; the second intermediate host is the Herpobdella leech. Definitive hosts are mainly cyprinid fish;

predatory fish - perch, pike, grayling, and eel [20]. It is worth noting that in the age groups 5+, 6+ and 8+, parasites of this species were found only in one roach specimen. The maximum rate of invasion intensity was noted in roach 5+ with 233 specimens found, 6+ - 1 specimen, 8+ - 8 specimens of parasites. The minimum infestation extensiveness was noted in the 4+ group (35.7%) at an intensity of 1.3 spec., at the age of 1+ IE it amounted to 44.4% (AI - 0.6 spec.), in 2+ IE - 50.0% (IO - 14.7 spec.), 3+ IE - 83.3% (AI - 23.3 spec.) (Table 2). Found trematodes were both mature and immature specimens.

*Proteocephalus* sp., *R. acus*, *Unionidae* gen. sp., *E. sieboldi*, *P. geometra* are parasites common to a wide range of fish that do not have strict species specificity.

Plerocercoids *Proteocephalus* sp. were fixed in group 0+, 2+ - 4+. At the age of 0+, the parasite was found in two fish with 2 specimens each, in groups 2+ and 4+ - only one specimen in one fish, in 3+ 3 fish were invaded with AI - 0.4 specimens (table 2). The development of cestodes takes place in the copepods Cyclops, Eucyclops, Macrocyclus, which are included in the diet of mainly roach fry [21].

The larval form of *R. acus* was found in roach's mesentery at the age of 0+ - 4+ (table 2). The invasion extensiveness varies from 16.7% to 25.0% at low intensity from 0.2 to 0.8 spec. per examined fish. The first intermediate hosts of nematodes are many different organisms: Oligochaeta, mollusks, planktonic and benthonic crustaceans, larvae of aquatic insects. As the second intermediate hosts, the fish invasion occurs during feeding, predatory fish act as definitive hosts. A wide variety of the first intermediate hosts of *R. acus* causes fish infestation at all ages; however, along with various animal organisms, the roach diet includes aquatic vegetation [22,23]. Therefore, there is a low invasion intensity by this parasite.

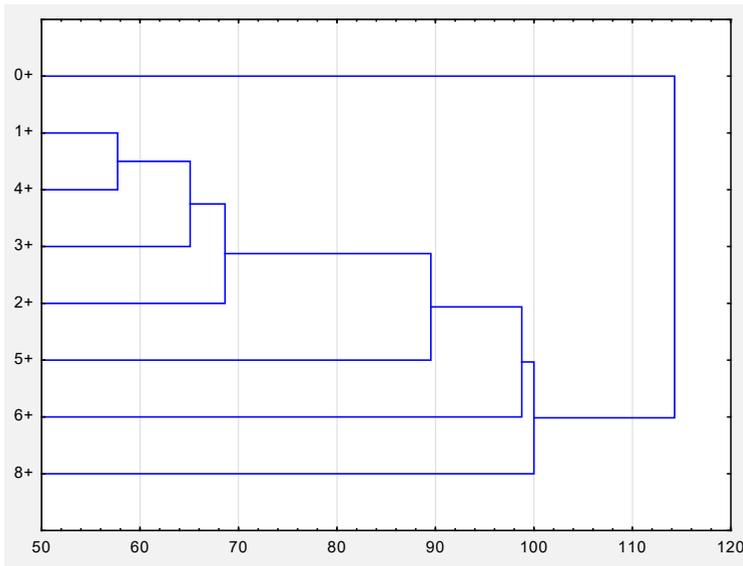
Glochidia *Unionidae* gen. sp. have been found on roach gills in groups 2+ - 5+ (table 3). The invasion extensiveness has no clear dependence on the fish age. So, at the age of 2+ IE - 16.7% (AI - 0.2 spec.), at 3+ - 50.0% (AI - 12.7 spec.), at 4+ IE - 28.6% (AI - 6.0 spec.), at 5+ IE - 66.7% (AI - 7.3 spec.).

*E. sieboldi* parasitizes the roach gills from the age of 0+ to 4+ (Table 2). The greatest infestation is observed in fish aged 2+ IE - 66.7% with AI - 3.7 specimens.

*P. geometra* was found on the body surface of fish 3+ and 5+, while only one fish was invaded with only one parasite.

At the age of 0+, the dominant species is *O. felineus* ( $d=0.539$ ), 1+ two species *D. crucifer* and *R. campanula* ( $d=0.361$ ) dominate, in groups 2+ and 8+, *D. crucifer* dominates ( $d=0.502$  and  $0.837$ , respectively), in categories 3+ - 6+ years - *R. campanula* ( $d=0.356$ ;  $0.395$ ;  $0.459$ ;  $0.915$ ).

Cluster analysis on the invasion extensiveness of roach parasites age 0+ - 8+ showed the group 1+ - 4+ merging into one cluster; fish aged 0+, 5+ and 6+-8+ are allocated to a separate cluster (Figure 1). The calculated clustering by IE in age groups shows the similarity of parasite fauna and the magnitude of the invasion extensiveness at the ages from 1+ and 4+, and 6+ - 8+. With age, the biotopic distribution and nutrition spectrum of the roach changes [24,25], which affects its parasite infestation and the composition of the parasitic community as a whole.



**Fig. 1.** Cluster analysis of the metazoic roach parasites' distribution in different age groups

## 4 Conclusion

The dynamics of roach infestation with parasitic organisms is not stable and may depend on various environmental factors, which affects the indicators of fish invasion in various age categories. Depending on the fish age, there are changes in food priorities and consequent changes in the composition of the parasite fauna, but some parasitic organisms have a cumulative effect. The ecology of the habitat reservoir itself introduces its own adjustments through the vital activity of the first intermediate hosts. As a result of many factors' combination, the greatest species diversity of parasite fauna in roach is observed at the age of 2+ - 4+.

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