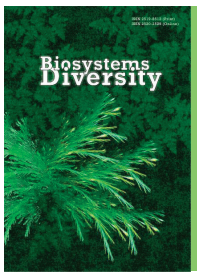

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Parasitofauna of pike *Esox lucius* of the Lower Tobol (Russia)

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One of the predators of the ichthyofauna of the Lower Tobol is *Esox lucius* (Linnaeus, 1758) (Esociformes, Esocidae). The purpose of this work is to study the current state of the *E. lucius* parasite fauna in the lower reaches of the Tobol River. In the present study 47 individuals of the northern pike of different sex aged from 2+ to 8+ years were examined by the method of complete parasitological dissection. As a result of the research, 23 types of parasites were found in the pike. The largest number of species of parasitic organisms – 20 – were found in May, 12 were found in December and 11 in September. Of these, 10 species are specific to northern pike: *Haemogregarina esoci* (Nawrotzky, 1914), *Chloromyxum esocinum* (Dogiel, 1934), *Myxidium lieberkuhni* (Biitschli, 1882), *Myxosoma anurum* (Cohn, 1895), *Henneguya psorospermica* (Thelohan, 1995), *Tetraonchus monenteron* (Wagener, 1857), *Gyrodactylus lucii* (Kulakowskaja, 1951), *Triaenophorus nodulosus* (Pallas, 1781), *Azygia lucii* (Miiller, 1776), *Raphidascaris acus* (Bloch, 1779). For the first time an intraerythrocyte parasite – *H. esoci* – was found in pike in the Lower Tobol, the extensiveness of invasion was 18.7% in December, and 6.2% in May. *Epistylis* sp. and *Trichodinella epizzotica* parasitized on the surface of the body of fish only in May, whereas members of the genus *Trichodina* were found in winter and spring. In all seasons, parasitization by *M. anurum* and *H. psorospermica* was established on the gills. The greatest occurrence of spores of *M. lieberkuhni* and *C. esocinum* was observed in the spring. Myxosporidia parasitized in the kidneys and *T. monenteron* parasitized on the gills during all periods of the study (the latter with an extensivity of invasion of 100.0%). All examined fish are infected with *T. nodulosus* 100.0% of cases. In May, other types of cestodes were found: *P. esocis* and *Dibothriocephalus latus*. Three pike were infected with proteocephalis. The larval stage of diphyllobothriid was found in one fish in the liver and gonads in an amount of 139 individuals. In the pikes' stomach, during all periods of the study, *A. lucii* was found in all the fish examined. In the autumn period of the study immature *R. campanula* were found in in the intestine of 4 fish specimens. The nematode *R. acus* was found in pike only in spring. This nematode was found in fish aged 4+–8+. In May, glochidia with a high intensity of invasion were found on fins, gill covers and gills of fish. *E. sieboldi* copepods were found on the gills; in May, one specimen was found in one pike and in September in 6 with AI of 0.7. *Tetraonchus monenteron* was a dominant species, in May its degree of dominance decreased with the greatest uniformity of species in this study period. Having considered the age dynamics of pike infection by various types of parasites, it was found that in the age group 4+–5+ the number of species of parasites was greatest (20), while in groups 2+–3+ and 6+–8+ it was 14. In the pike, the core parasitic fauna were *M. anurum*, *H. psorospermica*, *T. monenteron*, *T. nodulosus*, *A. lucii*. Seasonality has virtually no effect on the degree of infection with specific parasites. The age of fish largely determines the qualitative and quantitative composition of the parasite fauna.

Keywords: Northern pike; parasitic community; *Haemogregarina esoci*; *Tetraonchus monenteron*; *Triaenophorus nodulosus*; *Azygia lucii*.

Introduction

Northern pike *Esox lucius* (Linnaeus, 1758) is a broadly distributed predatory fish in fresh waters of Eurasia and North America. Also it is found in fresh-water marine areas: in bays of the Baltic and Azov seas. In water bodies where no intensive fishing is done, pike can reach up to 180 cm in length (usually length of caught fish is up to 1 meter) and weigh up to 40 kg (usually up to 8 kg) (Crai, 1996). *E. lucius* lives in areas with slow flow, preferring to keep in thickets of aquatic vegetation. The diet of pike is significantly affected by biotopic, seasonal and size variation (Grunin, 2009). In the Ob river, the basis of diet of adult fish comprises carp, and also whitefish (Coregoninae), European perch, ruffe, burbot, and young pike.

The main factors which determine the qualitative and quantitative composition of parasitofauna are the age of the host and seasonal changes in natural conditions. Over its lifetime, the host undergoes changes in body structure, behaviour and range of food. In turn, extensity and intensity of many species of parasites increase the older the host becomes (Álvarez et al., 2006; Iyaji et al., 2010).

Water temperature is the main abiotic factor that affects the cycle of the development of ectoparasites – protozoans and monogeneans. Out of them, a large number of species was found to have a clearly manifested spring-summer maximum of the development, and did not have an active state in winter. Kennedy (1975) reported that many endoparasites of fish were observed to have clearly manifested seasonal changes in number over the year. Thus, extensity and intensity of infestation with *Triaenophorus nodulosus* cestode, which parasitizes in pike, remain at a relatively constant level over the year due to dynamic balance between constant replenishment of the population and mortality (death of mature cestodes after breeding). Aspects of seasonal changes in fauna of parasites of fish are broadly studied by many authors (Lamková et al., 2007; Abdel-Aziz et al., 2012; Kondo et al., 2016).

Study of species composition of parasitic organisms in fish has great practical significance for assessment of the epizootic condition of water bodies. Studies on parasitofaunua allow one to find distribution of fish parasites dangerous for humans. In the Ob-Irtysh basin, pike is a source of the dibothriocephalus pathogen.

Detailed study of parasitofauna of *E. lucius* has been conducted by many scientists in our country (Malahova, 1961; Mitenev, 1998; Ieshko & Korosov, 2012; Chugunova et al., 2014), as well as abroad (Watson & Dic, 1980; Çolak, 2013; Fallah et al., 2015). Detailed data on parasites of pikes in the Ob-Irtysh basin have been published in a number of

large studies in the second half of the XX century (Petrushevskij et al., 1948; Titova, 1965; Agapova, 1966; Pugachev, 1984).

The objective of our research was to establish the current condition of species composition of parasites of northern pike in the Lower Tobol.

Materials and methods

Material for our study was collected on 10–21 December of 2017, 14–19 May and 17–22 September of 2018 from the lower flow of the Tobol River (Karachino village, 58°02'50'' N, 68°06'35'' E). Catching was performed using gillnets and fixed gillnets (on stakes) with 24–38 mm cells. The fish were transported to the laboratory alive in special live-fish tanks. Using the method of parasitologic autopsy (Byhovskaya-Pavlovskaya, 1985), a total of 47 individuals of *E. lucius* (L = 31.2–69.2, M = 142.2–1224.0) were examined, 2+ to 8+ year old males, females and juvenile individuals. Biological and morphometric parameters of the fish were determined according to generally accepted methods (Pravdin, 1966). Fixation of found parasitic organisms, and preparing temporary and constant preparations of parasites were made using standard methods (Byhovskaya-Pavlovskaya, 1985). We identified the species of parasites (Skarlato, 1984, 1985, 1987; Fiala et al., 2015), calculated extensity of infestation (percent of individuals of hosts in which a species of parasite was found, EI) with standard mean error, intensity of infestation (minimum and maximum number of specimens of parasite per each infested individual, II), index of abundance (mean number of specimens of a parasite species per one examined individual of host, AI) with standard mean error. For determining the dominance of species in the parasite fauna, we used the Berger-Parker index of dominance (d) (Mehgarran, 1992). Statistical analysis of the results was made using Statistica 10 software (StatSoft Inc., 2011).

Results

As a result of the studies we conducted, in northern pike from the Nyzhny Tobol, 23 species of parasites (Table 1) were determined (Sporozoa – 1, Kinetoplastida – 1, Cnidosporidia – 2, Oligohymenophorea – 4, Myxosporea – 5, Monogenea – 2, Cestoda – 3, Trematoda – 2, Nematoda – 1, Copepoda – 1, Bivalvia – 1). Out of them, 10 species are specific to pike: *H. esoci*, *C. esocinum*, *M. lieberkuhni*, *M. anurus*, *H. psorospermica*, *T. monenteron*, *G. lucii*, *T. nodulosus*, *A. lucii*, *R. acus*. The highest number of species, 20, was determined in May, 12 were found in December, and 11 parasitic species in September (Table 1, 2).

The endoglobular parasite *H. esoci* (Fig. 1*a*) was found in blood smears of 3 specimens (spec.) of fish in December and in 1 fish in May. *Trypanosoma* sp. (Fig. 1*b*) was recorded in the bloodstream of 2 pikes in May and in 10 in September. *Epistylis* sp. and *T. epizzotica* parasitized the body surface of fish only in May, extensity of infestation was 6.2% and 62.5% respectively. *T. esocis* (Fig. 2*a*), *T. rectangle* (Fig. 2*b*) and *T. pediculus* (Fig. 2*c*) were found on the body surface of pikes in the winter and spring period of study, total EI equaled 31.2% in December and 100.0% in May. *M. anurus* (Fig. 3*a*) and *H. psorospermica* (Fig. 3*b*) parasitized the gills of fish during all periods of study with increase in infestation towards autumn (Table 1).

The highest abundance of spores of *M. lieberkuhni*, which parasitizes the bladder of pike, and *C. esocinum* found in the bladder was observed in the spring period. In September, infestation with spores of these microsporidians decreased, and in December they were not found. In the kidneys, in all studied periods, Myxosporidia was found. In May, highest values of infestation were observed. *Apiosoma* sp. was found on the gills, fins and the body surface of the examined fish only in September with extensity of 37.5%.

The monogenean *T. monenteron* parasitized the gills over all periods of study with high abundance index. In September, AI reached 225.3 spec., and 161 spec. over all periods of study. Another representative of monogeneans – *G. lucii* was found only on the fins of pikes in December and May. Highest infestation with this parasite was observed in spring with EI equaling 68.7%.

In the intestine of the studied pikes, we observed infestation with *T. nodulosus* cestode over all seasons of studies. In spring, we determined high parameters of intensity and abundance. During all periods of study, AI equaled 65.7 spec. of the parasite per one examined fish. In May, we found other species of cestodes: *Proteocephalus* sp. in the intestine and plerocercoid larvae of *D. latus* in the liver and the gonads. Plerocercoid larvae were found in three specimens of pikes. 139 larval specimens of *D. latus* were found in one fish.

Table 1

Extensity of the infestation (%) with protozoans and microsporidians in *Esox lucius* in the Lower Tobol in different seasons of the year

Species of parasite	Period of study		
	December, n = 16	May, n = 16	September, n = 15
Haemogregarina esoci (Nawrotzky, 1914)	18.7 ± 9.7	6.2 ± 6.0	–
Trypanosoma sp.	–	12.5 ± 8.3	66.6 ± 12.2
Epistylis sp.	–	6.2 ± 6.0	–
Trichodina esocis (Lom, 1960), *T. pediculus* (Ehrenberg, 1838), *T. rectangle* (Chen et Hsien, 1964)	31.2 ± 11.6	93.7 ± 6.1	–
Trichodinella epizzotica (Raabe, 1950)	–	62.5 ± 12.1	–
Apiosoma sp.	37.5 ± 12.1	–	–
Myxidium lieberkuhni (Biitschli, 1882)	–	68.7 ± 11.6	26.7 ± 11.4
Myxobolus anurus (Cohn, 1895)	37.5 ± 12.1	37.5 ± 12.1	93.3 ± 6.5
Chloromyxum esocinum (Dogiel, 1934)	–	68.7 ± 11.6	6.7 ± 6.5
Henneguya psorospermica (Thelohan, 1895)	31.2 ± 11.6	31.2 ± 11.6	86.7 ± 8.8
Myxosporidia sp.	25.0 ± 10.8	75.0 ± 10.8	33.3 ± 12.2

Note: n – number of fish in the selection.

Over all seasons of study, pikes were observed to have one more representative of the specific parasites, *A. lucii*, a trematode which parasitizes the stomach. The highest parameters of II and AI were observed in winter; they gradually decreased by autumn. Over the autumn period of studies, in the intestine of 4 individuals of the fish, we found mature specimens of *R. campanula*.

The specific parasite *R. acus* was found in the intestine of pikes only in spring. This nematode was found in fish at the age of 4+–8+. Also, in May, on the fins, gill operculums, and gills, glochidia – parasitic larvae of the Unionidae family of Bivalvia, were found with high intensity of infestation. In the class copepods, *E. sieboldi* crustaceans were found on the gills. One specimen was found in one fish in May, and in September in six fish at AI of 0.7 spec.

Analysis of parasitic component community in the studied population of pike of the lower flow of the Tobol river (Table 2) determined that the dominant species was the monogenean *T. monenteron* (d = 0.556), in May, its level of domination reduced at the highest uniformity of abundance of species in that period of study.

Table 2

Extent of dominance of metazoan parasites in the community of *Esox lucius* in the Lower Tobol

Species in the community	Period of study, N*			
	December	May	September	Total number
T. monenteron	2815	1375	3379	7569
G. lucii	27	160	–	1187
T. nodulosus	862	1355	870	3087
D. latus (pl)	–	139	–	139
Proteocephalus sp.	–	16	–	16
R. campanula	–	–	42	42
A. lucii	688	516	215	1419
R.s acus	–	24	–	24
Unionidae gen. sp. (l)	–	1121	–	1121
E. sieboldi	–	–	11	11
d	0.641	0.292	0.748	0.556
1/d	1.56	3.42	1.34	1.80

Note: N* – total number of parasites in the studied selection; d – Berger-Parker index.

By analyzing the age dynamic of infestation of pike with different species of parasites (Table 4, 5), we observed the highest number of parasitic organisms (20) in the age group 4+–5+, whereas in groups 2+–3+ and 6+–8+ the number was 14, *H. esoci* was found only in pikes of the age group 4+–5+, and *Trypanosoma* sp. parasitized in specimens of all ages. The older the fish, the lower the EI. Also, with age, there was

observed a reduction of infestation with *M. anurus* and *H. psorospermica*. Increase in EI with increase in age was observed for infestation of *M. lieberkuhni*, representatives of *Trichodina* and *T. epizzotica*. For *R. acus*, Unionidae gen. sp. and *G. lucii*, we also observed increase in EI along with increase in age, but at the same time, these parasites were not observed in the age group 2+–3+. We determined that only fish aged 4+–5+ were infested with *Epistylis* sp., *D. latus* and *Proteocephalus* sp. Obligatory parasites of pikes, such as *T. monenteron*, *T. nodulosus* and *A. lucii* infested fish in all age groups with the same high extensity of infestation.

Table 3

Metazoan parasites of *Esox lucius* in the Lower Tobol in different season of the year

Species of parasite	Period of study								
	December, n = 16			May, n = 16			September, n = 15		
	EI	II	AI	EI	II	AI	EI	II	AI
Tetraonchus monenteron (Wagener, 1857)	100.0	9–416	175.9 ± 32.0	87.5 ± 8.3	2–346	85.9 ± 24.5	100.0	94–591	225.3 ± 35.4
Gyrodactylus lucii (Kulakowskaja, 1951)	25.0 ± 10.8	4–9	1.7 ± 0.8	68.7 ± 11.6	2–47	10.0 ± 3.6		–	
Triaenophorus nodulosus (Pallas, 1781)	100.0	7–173	53.9 ± 11.1	100.0	13–344	84.7 ± 20.2	100.0	21–124	58.0 ± 6.9
Dibothriocephalus latus (Linnaeus, 1758) (pl)		–		6.2 ± 6.0	139*	8.7 ± 8.7		–	
Proteocephalus sp.		–		18.8 ± 9.8	2–11	1.0 ± 0.7		–	
Rhipidocotyle campanula (Dujardin, 1845)		–			-		20.0 ± 10.3	1–37	2.8 ± 2.5
Azygia lucii (Miiller, 1776)	100.0	4–120	43.0 ± 10.2	93.7 ± 6.1	1–101	32.2 ± 8.4	100.0	3–33	14.3 ± 2.9
Raphidascaris acus (Bloch, 1779)		–		43.7 ± 12.4	1–8	1.5 ± 0.7		–	
Unionidae gen. sp. (l)		–		50.0 ± 12.5	6–490	70.1 ± 31.4		–	
Ergasilus sieboldi (Nordmann, 1832)		–		6.2 ± 6.0	1*	0.06 ± 0.06	40.0 ± 12.6	1–4	0.7 ± 0.3

Note: EI – extensity of infestation, %; II – intensity of infestation (min–max); AI – abundance index (spec.); n – number of fish in selection; * – in one individual of pike; pl – plerocercoid larvae; l – larva.

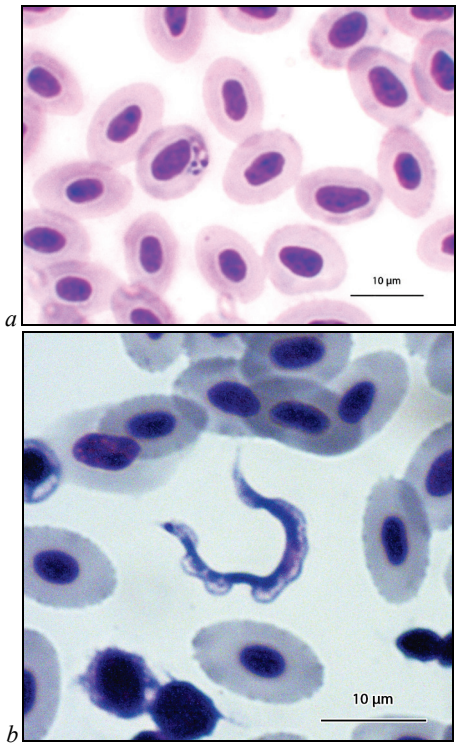

Fig. 1. Endoglobular parasite *Haemogregarina esoci* (*a*) and *Trypanosoma* sp. (*b*) in a blood smear of pike, permanent preparation

Discussion

In total, in the Ob-Irtysh basin, 82 species of parasitic organisms have been found in pike (Berendeev et al., 2006). Out of them, 20 species were protozoans, 9 – microsporidians, 8 – monogeneans, 8 – cestodes, 23 – trematodes, 5 – nematodes, 2 – acanthocephalans, 2 – leeches, 1 – mollusks, 3 – crustaceans, 4 – acari. The basis of the parasitofauna comprises 15 species of specific parasites – representatives of the boreal plain faunistic complex: *C. esocinum*, *M. lieberkuhni*, *M. anurus*, *H. lobosa*, *H. psorospermica*, *H. schizura*, *H. oviperda*, *T. monenteron*, *G. lucii*, *T. nodulosus*, *T. crassus*, *P. esocis*, *A. lucii*, *R. acus*, *P. obturans*. In most rivers and lakes specific parasites were recorded in pike, but the number of their species significantly varied in separate water bodies (Titova, 1965; Agapova, 1966). Pugachev (1984) observed a notable west to the east decrease in the species richness of both the specific and non-specific parasitofauna of *E. lucius* in the water bodies of the distribution range in the territory of Siberia and North-East of Russia. Thus, 15 specific species of parasites of *E. lucius* were recorded in the Ob, 10 in the Yenisei (Chugunova, 2014), 10 in Baikal (Rusinek, 2007), 7 in the Lena (Platonov et al., 2018), 7 in the Kolyma (Pugachev, 1984), and 3 in the Gizhyga (Pospekhov et al., 2010).

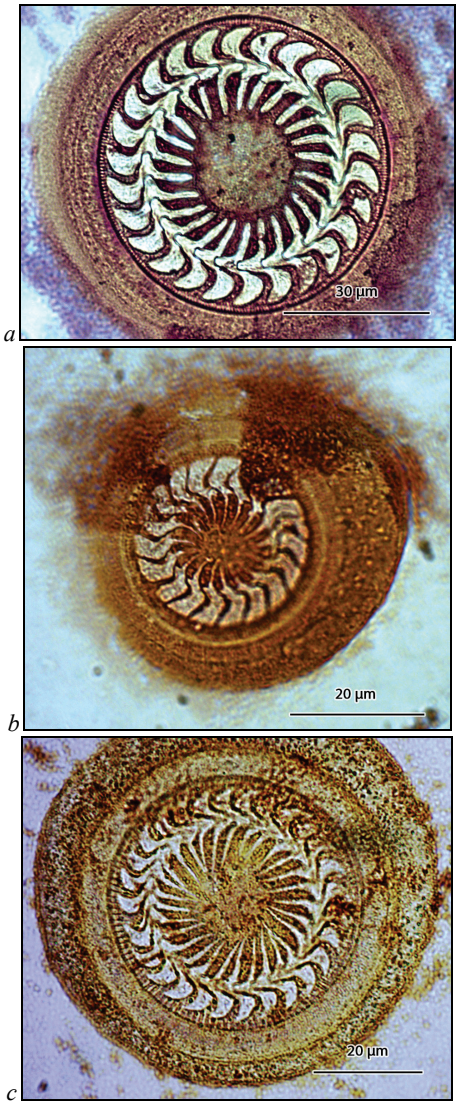

Fig. 2. *Trichodina esoci* (*a*), *T. rectangle* (*b*) and *T. pediculus* (*c*) from the body surface of pike, permanent preparation

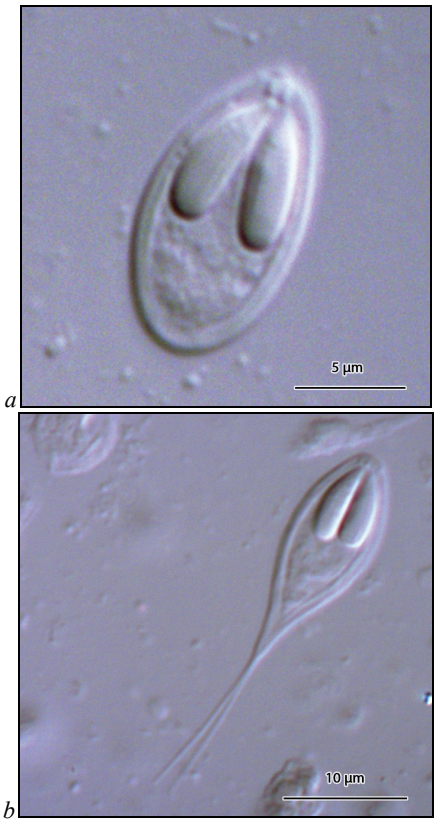

Fig. 3. *Myxobolus anurus* (*a*) and *Henneguya psorospermica* (*b*) from the gills of pike, permanent preparation

In the Lower Tobol, the highest number of parasites in pike was observed in spring (20 species). Over that period, along with increase in water temperature, infestation of fish with ectoparasitic protozoans steeply increases. Maximum value of *T. epizzotica* infestation occurred in spring and early summer, and in winter the parasite was not found (Shul'man et al., 1974). Young pike become infested with this parasite from the age of two weeks (11.0–56.8%) (Polyanskij & Shul'man, 1956; Lyubarskaya, 1968). We determined that pike were infested with representatives of the *Trichodina* genus in winter (31.2%) with increase in the extensity in spring (93.7%); in September, no trichodinids were found. *T. epizzotica* parasitized only over the spring period, EI was 62.5%. Endoparasitic protozoans Haemogregarina and *Trypanosoma* were also observed in pike of the Lower Tobol. In Staruha Lake (Ukraine), in the blood flow of pike, there was observed a low level of EI (73.0%) *Trypanosoma* sp. (Grybchuk-Ieremenko et al., 2014). According to Gusejnov (2008), infestation of pike with *Trypanosoma carassii* and *T. schulmani* reached a peak by the early summer (76.9% and 15.4% respectively), gradually reducing in autumn (50.0% and 28.6% respectively). In our study, infestation of pike with trepanosoms was observed in May (12.5%) and September (66.6%), but parasitism of leaches, transmitters of the parasite, was not observed in any of the study periods. An opposite result was observed for *H. esoci*: it was recorded in December (18.7%) and May (6.2%). These are first published data on infestation of pike with Haemogregarina in the basin of the Lower Irtysh.

Table 4
Extensity of infestation (%) of protozoans and microsporidians in *Esox lucius* in the Lower Tobol in different age groups

Species of parasite	Age of the pike		
	2+–3+, n = 15	4+–5+, n = 23	6+–8+, n = 9
H. esoci	–	17.4 ± 7.9	–
Trypanosoma sp.	53.3 ± 12.9	13.0 ± 7.0	11.1 ± 10.5
Epistylis sp.	–	4.3 ± 4.2	–
Trichodina esocis, T. pediculus, T. rectangle	20.0 ± 10.3	52.2 ± 10.4	66.7 ± 15.7
T. epizzotica	6.7 ± 6.5	26.1 ± 9.2	33.3 ± 15.7
Apiosoma sp.	20.0 ± 10.3	17.4 ± 7.9	–
M. lieberkuhni	26.7 ± 11.4	30.4 ± 9.6	44.4 ± 16.6
M. anurus	86.7 ± 8.8	47.8 ± 10.4	33.3 ± 15.7
C. esocinum	13.3 ± 8.8	34.8 ± 9.9	22.2 ± 13.9
H. psorospermica	66.7 ± 12.2	39.1 ± 10.2	44.4 ± 16.6
Myxosporidia sp.	46.7 ± 12.9	47.8 ± 10.4	33.3 ± 15.7

Note: n – number of fish in a selection.

Table 5
Age dynamic of infestation of pike with parasitic organisms

Age group	2+–3+, n = 15			4+–5+, n = 23			6+–8+, n = 9		
Species of parasite	EI	II	AI	EI	II	AI	EI	II	AI
T. monenteron	93.3 ± 6.5	94–394	183.0 ± 25.0	100.0	9–591	163.9 ± 31.6	88.9 ± 10.5	2–416	117.1 ± 45.2
G. lucii		–		43.5 ± 10.3	2–18	3.7 ± 1.2	55.6 ± 16.6	4–47	11.4 ± 6.1
T. nodulosus	100.0	21–115	63.7 ± 7.7	100.0	13–344	73.7 ± 15.5	100.0	7–100	48.4 ± 10.5
D. latus (pl)		–		4.3 ± 4.2	139*	6.0 ± 6.0		–	
Proteocephalus sp.		–		13.0 ± 7.0	2–11	0.7 ± 0.5		–	
R. campanula	20.0 ± 10.3	1–37	2.8 ± 2.6		–			–	
A. lucii	93.3 ± 6.5	5–46	15.6 ± 3.3	100.0	2–120	35.7 ± 7.8	100.0	1–96	40.6 ± 13.0
R. acus		–		17.4 ± 7.9	1–7	0.4 ± 0.3	33.3 ± 15.7	1–8	1.6 ± 1.0
Unionidae gen. sp. (l)		–		17.4 ± 7.9	6–490	28.1 ± 21.5	44.4 ± 16.6	70–186	52.7 ± 23.1
E. sieboldi	33.3 ± 12.2	1–4	0.7 ± 0.3	8.7 ± 5.9	1*	0.1 ± 0.06		–	

Note: see Table 2.

High infestation of pike with spores of *M. lieberkuhni* and *C. esocinum* in spring is related to spawning. Increase in water temperature contributes to infestation of Oligochaeta, intermediate hosts in littoral parts of water body, which creates favourable conditions for infestation of young fish. Therefore, by age of three-months up to 85.0% of young pike become infested with *M. lieberkuhni* (Lyubarskaya, 1968). Burdukovskaya et al. (2017) determined high sensitivity of this parasite to anthropogenic contamination of water bodies, which has an effect on its number. Spores of microsporidians of *M. anurus* and *H. psorospermica* in pike in water bodies of Karelia occur in all seasons of the year (Malahova, 1961; Shul'man et al., 1974). In Konchezero Lake, the highest parameters of contamination with these parasites were observed in autumn (Malahova, 1961). In her studies, Gorbunova (1936) found no dependence between infestation of pike with *M. anurum* and the age of the fish. In the Lower Tobol, *M. anurus* and *H. psorospermica* are common species parasitizing northern pike, but the older the fish, the lower the infestation of fish with these parasites. Many authors observed ubiquitous infestation of pike, regardless of conditions of the hydrological regime of the water body, with such obligatory parasites as *T. monenteron*, *T. nodulosus*, *A. lucii*, *R. acus*. The monogenean *T. monenteron* infests pike with high extensivity and intensity of invasion, and has a dominating position in its parasitofauna (Mitenev, 1998; Rusinek, 2007; Burdukovskaya et al., 2017; Ozturk et al., 2000). Young fish became infested with Tetraonchidae already at age of two weeks with EI up to 26.0% (Lyubarskaya, 1968). The older the pike, the higher the EI and II of *T. monenteron* (Gorbunova, 1936; Ozturk et al., 2000). High II of adult individuals of *E. lucius* (up to 800 spec.) with monogeneans of *T. monenteron*, according to Gorbunova (1936), is related to increase in area of the gills with age of fish, as the place of localization of parasites. Over the year, *T. monenteron* produces several generations both in north and south latitudes. Ac-

cording to Malahova (1961), in Konchezer, infestation of pike with *T. monenteron* in the spring-summer months increases up to 97.0%, and decreases in winter to 4.5%. In a study of the seasonal dynamic of *T. monenteron* in pikes in Dzhapana Lake (Georgia), Chernova (1975) observed 100.0% infestation in the spring-summer period at AI of 77.2 spec., decrease in infestation in autumn to 38.5% at AI of 2.9 spec., and increase in infestation in the winter period to 86.7% at AI of 21.8 spec. According to the author, reduction in infestation of pike with this parasite in autumn is conditioned not by the temperature factor, but by some other factors. Ozturk et al. (2000) also found high infestation of the gills of pike (100.0%) in the autumn-winter and summer periods, and decrease in extensivity of infestation to 65.0% in spring. In the winter period, AI significantly decreased (25 spec.) and in spring it steeply increased (146 spec.) (Ozturk et al., 2000). Analysis of the conducted studies has revealed that intensity of infestation of pike with *T. monenteron* in the Lower Tobol has no clearly manifested seasonal dynamic, there was observed an insignificant decrease in EI and AI in May. A different picture was observed for infestation of pike with the specific monogenea *G. lucii*. This species occurs more rarely and with low intensity of infestation (Titova, 1965; Mitenev, 1998; Burdukovskaya et al., 2017). We recorded parasitism of *Gyrodactylus* with low AI in the winter and spring periods of study in fish aged from 4+–8+.

Pike is an obligatory terminal host for *T. nodulosus*, *R. acus* and *A. lucii*. It becomes infested with the abovementioned species by consuming fish, intermediate or reservoir hosts of the parasites. It should be mentioned that according to literature data, pike begin feeding on fish at 10–15 days after hatching at body length of 20–23 mm; at the age of 2.0–2.5 months, its diet mostly comprises fish, and also larvae of dragonflies, mayflies and pupae of chironomids (Ivanova & Svirskaya, 2009). High parameters of infestation with *T. nodulosus* have been observed throughout the distribution range of *E. lucius*. The cestode parasitizes pikes both in the stage of plerocercoid larva (rarer) and in their mature form. Pikes become infested with *T. nodulosus* early in the second year and with age, EI increases from 40.0% (1+) to 100.0% (8+–10+) (Gorbunova, 1936). In the Lower Tobol, pike were infested with *T. nodulosus* in all periods of study in 100.0% of cases, but highest intensity and abundance of parasite was observed in spring. In many water bodies, *T. nodulosus* is dominant and is significant in formation of the parasitofauna of pike. Shabunov & Radchenko (2012) report that at high level of infestation with *T. nodulosus* in the intestine of pikes, there were no acanthocephalans, trematodes, and nematodes had low EI. A peculiarity of the relation between pike and *T. nodulosus* in the system parasite-host is that even at high II, pathogenity of the parasite for the host is minimum, indicating dependency of this system on long mutual evolution, and also maintenance of total homeostasis of the system (Izvekova, 2001; Vysockaya et al., 2015). At the same time, plerocercoid larvae of *T. nodulosus* have high pathogenity for fish and can cause mass death of young fish (Pronina & Pronin, 1988). The obligatory parasite of pike – *A. lucii* – infests also facultative hosts: perch, zander, burbot, trout, and ruffe. Lung flukes, in which cercaria develop, are intermediate hosts for it, and fish are terminal hosts. Plantophagous fish become para-definite host, in which the parasite undergoes the first stages of morphogenesis of adult individual, but does not reach maturity. Large predators become infested with Azygia after swallowing fish which are para-definitive and definitive hosts of lower trophic level. Infestation of pike with *A. lucii* occurs in the autumn-winter period, therefore in spring, large mature, as well as small immature individuals, occur. For the first time it becomes infested with Azygia in the beginning of the second year of life and extensity and intensity increase with age (Gorbunova, 1936). According to our and literature data, seasonal changes of infestation of pike with this parasite were not determined (Shul'man et al., 1974). In the data on infra-communities, there are observed clear borders of trophic relations between parasite and host, and trophic niches, between such parasitic organisms as *T. nodulosus* and *A. lucii*, expressed in differentiated selection of location, which reduces their interspecies competition.

The most commonly found species was *R. acus*. Adults of this nematode parasitize the intestine of predatory fish, mostly pike. The larval stage develops in a broad range of intermediary hosts (fish) and reservoir (crustaceans, Oligochaeta, larvae of chironomids and aquatic insects, mollusks) hosts (Moravec, 1970). The peak of seasonal infestation of pike with *R. acus* occurs in the winter and spring period (Akkent & Ozturk, 2017). By the end of summer, this nematode leaves the gastrointernal tract of fish. Infestation of young pike with *R. acus* depends on the temperature regime of the water body and can reach 30.0% in warm years (Lyubarskaya, 1968). With age, infestation with *R. acus* increases, maximum values were recorded in the group aged from 5+–11+ (Gorbunova, 1936). Infestation of pike in the Ob-Irtysh basin ranges from 6.2–80.0% (Titova, 1965), 6.6–38.2% in lakes of Karelia, 13.3–93.3% in water bodies of the North Kola (Mitenev, 1998), and 2.7–29.0% in the basin of the Northern Dvina River (Shabunov & Radchenko, 2012).

Parasitism of *R. campanula* in pike is related to its predation. The first intermediary hosts are mollusks of *Unio* and *Anodonta* genera, the second are various fish, mostly from the Cyprinidae family. According to the literature data, in the lakes of Karelia, infestation of pike with mature stages of *R. campanula* is significantly lower (4.8–20%) than infestation of non-predatory fish with metacercariae of this parasite (*Rutilus rutilus* – 20.0–80.0%, *Leuciscus leuciscus* – 40.0–85.7%; Shul'man et al., 1974). A similar picture of infestation of fish with *R. campanula* was observed in our study as well. Therefore, total infestation of pike with this parasite was 6.4% at abundance index of 0.9 spec. per examined fish. We have agreed with the authors that perhaps it is related to the fact that species of fish heavily infested with metacercariae have no significant role in the diet of pike in these water bodies.

Infestation of fish with glochidia occurs in spring. In spring, in pike in the Lower Tobol, II reached 490 spec. per fish, whereas in winter and autumn, this parasite was not found. By contrast, parasitism of *E. sieboldi* began with increase in water temperature; in May 1 crustacean was found in 1 pike, and in September, EI equaled 40.0% with AI of 0.7 spec.

Among the parasites dangerous for humans and animals, in the lower flow of the Tobol river, we found *D. latus* plerocercoid larvae only in one pike, but with high intensity of infestation. Examination of different predatory fish (306 individuals) of the lower flow of the Irtysh in 2002–2009, Pel'gunov (2012) revealled no *D. latus* plerocercoid larvae. These data indicate improvement of sanitary-epizootic condition of water bodies of the Lower Tobol as a result of improvement of culture of the population and reduction of release of unfiltered drainage water to the water bodies.

It should be mentioned that the species composition of non-specific parasites of pike depends on the local ecological conditions. Thus, in pike, Agapova (1966) found *Dactylogyrus* monogeneans, which are characteristic for carp. Pike in the Gizhyga River become infested with both fresh-water and marine parasites to the same extent. They become infested with the latter presumably by consuming migratory and semi-migratory fish (Pospekhov et al., 2010). According to Ieshko & Korosov (2012), the main factor which determines the diversity of the parasitic community of pike is the age composition of the population. The authors have proved that the highest infestation is among fish of average age: 4+–6+ year-old fish, which play the main role in maintaining the population of parasites. This correlates with our studies.

Conclusion

Thus, for the northern pike which inhabit the Lower Tobol, the core parasitofauna is composed of *M. anurus*, *H. psorospermica*, *T. monenteron*, *T. nodulosus*, and *A. lucii*. Seasonality has practically no effect on the extent of infestation with specific parasites. The dominant species was a monogenetic fluke *T. monenteron*. The age of the fish to a large extent determines the qualitative and quantitative composition of the parasitofauna. Pike are most heavily infested at the age of 4+–5+, when the food range of the predator increases. Seasonal and age change in the species composition of parasites of pike is often related not only to its selection of food objects, activity, temperature regime of water body, but to also the life cycles of the parasitic organisms.

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