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RESEARCH ARTICLE

An assessment of parasite variation in wild populations of roach, *Rutilus rutilus* (L.), in Lithuanian rivers

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Abstract. This study determined the composition of roach, *Rutilus rutilus* (L.), parasites in Lithuanian rivers. A total of 3558 individuals were examined for parasites from 12 rivers in 2005-2009. A total of 27 parasite species belonging to Ciliophora (6), Monogenea (3), Digenea (7), Cestoidea (4), Crustacea (3), Nematoda (1), Acanthocephala (1), Hirudinea (1), and Bivalvia (1) were recorded. Parasitological examinations of the roach showed significant variation in the prevalence of nine parasite species in the rivers studied. These results suggest that parasitological studies of specific parasite species in this freshwater fish can be used as bioindicators to provide information about environmental conditions in rivers.

Keywords: Parasites, roach, *Rutilus rutilus*, rivers, Lithuania

Introduction

Roach, *Rutilus rutilus* (L.), is one of the most common fish in Lithuanian waters, and it is potentially able to structure fish communities in rivers (Virbickas 1998). It is also a host of various parasites which usually infect cyprinids and other freshwater fish (Valtonen et al. 1997, 2003, Knopf et al. 2007, Dzika et al. 2008), and it plays an important role in the cycles of freshwater fish parasites. In Europe, roach has been the subject of numerous parasitological studies that provide broad knowledge of the parasites of this fish species (Valtonen et al. 1997, 2003, Kadlec et al. 2002, Knopf et al. 2007, Dzika et al. 2008). However, roach parasites have recently aroused considerable interest as possible bioindicators of water pollution (Valtonen et al. 1997, 2003).

The investigation of roach parasites in Lithuania began a hundred years ago (Wegener 1909). Most of these studies were conducted in standing waters (Szidat 1926, 1944, Gecevičiutė 1958, 1959). Rauckis (1988) published a book about fish parasites in Lithuania that provides an overview of the various parasites of different freshwater fishes in both lentic and lotic waters. Nevertheless, the current composition of roach parasites might have undergone changes. Quantitative estimates of variation in the prevalence of parasites in wild roach populations in Lithuanian rivers have not been undertaken yet. The need for such information is clear since freshwater parasites can be used as bioindicators that provide information about environmental conditions in rivers (Valtonen et al. 2003, Galli et al. 2001, Blanar et al. 2009). Therefore, variations in the prevalence of parasites in wild roach populations are of great scientific and applied interest.

The aims of this study were to investigate the fauna of roach parasites in Lithuanian rivers; to

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Table 1
Characteristics of the rivers studied (Gailiušis et al. 2001)

River	Mouth	Length (km)	Catchment area (km^2)	Mean discharge ($m^3 s^{-1}$)
Jūra	Nemunas	171.8	3994.4	41.8
Merkys	Nemunas	203.0	4415.7	33.4
Minija	Nemunas	201.0	2942.1	38.7
Nemunas	Curonian Lagoon	937.4	98200.0	540.0
Neris	Nemunas	509.0	24942.3	180.0
Nevėžis	Nemunas	209.0	6140.0	33.2
Šešupė	Nemunas	297.6	6104.8	34.2
Širvinta	Šventoji	246.0	918.1	7.5
Šušvė	Nevėžis	134.6	1165.4	6.2
Šventoji	Neris	509.0	6888.8	55.1
Venta	Baltic Sea	343.0	11800.0	95.0
Žeimena	Neris	79.6	2792.7	27.0

estimate the prevalence and intensity of roach infection with the recorded parasite species; to ascertain whether there are any differences in parasite prevalence, richness, and diversity in the rivers studied; and to investigate seasonal fluctuations in parasite prevalence at study sites.

Material and Methods

Study area and sampling

Fish were sampled from April to November in 2005-2009 by electrofishing. In total, 3558 roach individuals were examined for parasites at 38 study sites in 12 rivers (Fig. 1). The basic characteristics of the rivers studied are presented in Table 1. The investigations were carried out once in 2005 and twice annually from 2006 to 2009 (Table 2). All of the samples came from three seasons according to sampling time: spring (April, May), summer (June, July, August), and autumn (September, October, November). The number of roach specimens investigated for parasites ranged from six to 18 per catch, with 14.3 ± 1.8 as the average number. Not every attempt to catch roach was successful at each sampling site. The total number of fish specimens investigated at each sampling site is presented in Table 2. The mean standard length (SL) and body weight (W) of the roach examined were 15.4 ± 4.4 cm and 49.0 ± 42.1 g, respectively.

Examination of parasites

Before the parasitological examination, the fish were kept alive in water tanks for no longer than three days. Each fish was killed by severing the spinal cord just before performing a necropsy. To locate parasites, skin, fins, gills, mouth cavity, eyes, and viscera (intestine, mesentery, gall-bladder, gonads, liver, and kidneys) were examined under a stereo-microscope. Roach parasites were studied following conventional methods (Bykhovskaya and Pavlovskaya 1969). Fish parasites were described to the lowest possible taxa according to parasite keys (Bauer 1984, 1985, 1987). The intensity of metazoan parasites was estimated by counting the parasites. Densities of epizootic ciliates, *Apiosoma piscicolum*, *Chilodonella piscicola*, *Tetrahymena pyriformis*, and *Trichodina* spp. were established by estimating the average number of individuals visible in each field of view of skin smear preparations. Densities of *Ichthyophthirius multifiliis* were recorded by estimating the number of specimens per skin smear preparation.

Table 2
River sites studied for the presence of roach parasites. Sampling events in spring, summer and autumn; fish number investigated per site (n) and the mean length and weight of roach examined. Study site numbers are the same as in Figure 1

			Sampling events				Length	Weight
No.	River	Study site	Spring	Summer	Autumn	N	Mean ± SD	Mean ± SD
1	Nemunas	Rusnė (Skirvytė)	-	2	3	74	14.4 ± 3.5	38.9 ± 22.2
2		Jurbarkas	-	3	4	105	13.9 ± 3.5	36.6 ± 27.3
3		Vilkija	-	2	4	90	12.2 ± 3.1	24.9 ± 16.4
4		Kaunas	-	2	4	90	13.0 ± 3.4	30.3 ± 28.7
5		Piliuona	-	3	5	120	12.7 ± 2.5	26.6 ± 13.3
6		Prienai	-	3	4	105	14.5 ± 4.3	50.8 ± 46.9
7		Druskininkai	-	4	4	119	15.0 ± 3.5	39.3 ± 28.9
8	Neris	Kaunas	2	5	-	105	13.4 ± 4.0	34.6 ± 39.3
9		Jonava	3	4	-	99	14.9 ± 4.7	47.1 ± 32.8
10		Vilnius	2	5	-	94	16.9 ± 3.2	58.2 ± 30.3
11		Nemenčinė	3	5	-	119	16.7 ± 5.3	57.8 ± 39.2
12		Buivydžiai	-	1	-	15	19.8 ± 2.0	104.9 ± 47.6
13	Nevėžis	Babtai	2	-	3	70	12.6 ± 1.6	19.3 ± 3.8
14		Kėdainiai	2	-	4	84	16.9 ± 4.0	59.9 ± 46.7
15		Krekenava	4	-	4	115	15.5 ± 4.5	54.1 ± 49.1
16		Panevėžys	4	-	5	130	15.9 ± 4.9	56.4 ± 61.1
17	Šešupė	K. Naumiestis	4	3	-	107	17.4 ± 3.7	59.4 ± 38.8
18		Marijampolė	4	4	-	122	17.0 ± 4.6	65.0 ± 46.9
19		Pilviškiai	3	2	-	76	17.3 ± 4.2	71.2 ± 64.3
20	Širvinta	Širvintai	-	2	4	81	17.5 ± 4.8	85.4 ± 75.6
21	Šušvė	Grinkiškės	-	6	-	91	15.2 ± 3.1	43.1 ± 33.3
22		Josvainiai	-	7	-	104	19.2 ± 2.8	88.2 ± 36.1
23	Šventoji	Anykščiai	4	-	1	66	15.7 ± 4.2	49.8 ± 34.4
24		Kovarskas	4	-	4	117	15.2 ± 3.9	44.1 ± 28.8
25		Ukmergė	3	-	1	58	17.8 ± 5.0	65.9 ± 73.6
26		Užpaliai	4	-	2	85	14.9 ± 4.4	40.6 ± 30.7
27	Jūra	Tauragė	-	4	3	92	13.7 ± 4.5	37.2 ± 36.2
28		Vilkyškiai	-	4	3	102	11.7 ± 4.0	24.6 ± 4.0
29	Merkys	Merkinė	-	4	4	120	14.6 ± 4.6	44.2 ± 37.8
30		Valkininkai	-	4	3	105	16.9 ± 4.6	59.8 ± 46.5
31	Minija	Gargždai	4	-	4	116	16.4 ± 4.1	48.8 ± 25.5
32		Kartena	3	-	4	89	15.2 ± 4.4	43.1 ± 33.8
33		Žarėnai		-	1	15	12.0 ± 3.0	19.6 ± 19.3
34	Venta	Kuršėnai	3	-	4	91	17.8 ± 4.3	70.0 ± 36.6
35		Venta	4	-	4	106	17.8 ± 3.7	80.1 ± 43.5
36		Mažeikiai	4	-	5	126	17.2 ± 3.1	61.5 ± 29.7
37	Žeimena	Pabradė	4	-	4	110	13.6 ± 3.0	30.2 ± 19.3
38		Švenčionėliai	4	-	4	108	14.1 ± 3.2	36.1 ± 26.3
Total			74	79	99	3558	15.4 ± 4.4	49.0 ± 42.1

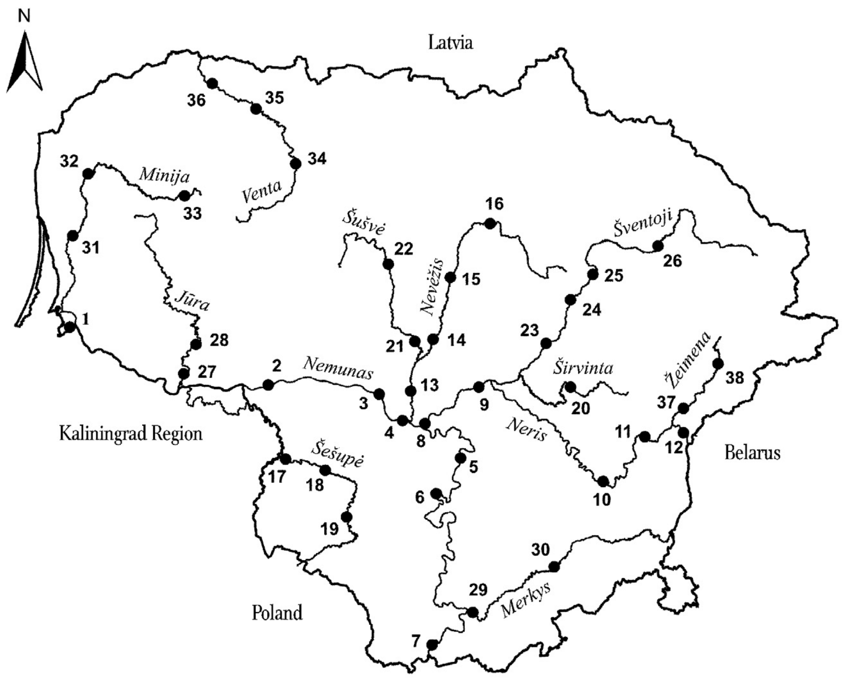

Figure 1. River sites (circles) studied for the presence of roach parasites. Study site numbers are the same as in Table 2.

Densities of *Trypanosoma carassii* were evaluated semi-quantitatively (absent; rare (< 5); frequent (5-20); very frequent (> 20) by estimating the average number of individuals visible in each field of view of kidney squash preparations. The terms prevalence (percentage of hosts infected with a particular parasite species or taxonomic group), density (number of individuals of a parasite species in a sampling unit taken from a host), intensity (number of individuals of a parasite species in/on a single infected host) were used according to Bush et al. (1997).

Data analysis

The communities of roach parasites in rivers were characterized by species richness (total number of taxa per study site). The diversity of parasites was described by the reciprocal of Simpson's index (1/D), with p_i values calculated from prevalence data. This index gives more weight to the more abundant species in a sample, thus it emphasizes the common species (Krebs 1989). The use of prevalence gives higher levels of diversity than when using numbers of parasites (Valtonen et al. 1997). Thus, the current values are comparable within this study, but not necessarily with those of other studies. However, the higher index value indicates lower dominance, and, consequently, greater species diversity.

The river-dependent effect on parasite characteristics was tested with the Kruskal-Wallis ANOVA and Median tests. Differences in parasite characteristics between seasons were tested with the non-parametric Mann-Whitney U test. Statistical significance was accepted when $P < 0.05$. The mean (M) and standard deviation (SD) for roach morphometric parameters and parasite infection intensity are presented.

Results

Parasites

The full roach parasitological examination revealed the presence of 27 parasitic taxa. The prevalence of ectoparasites was higher than that of endoparasites except for the very abundant *Diplostomum* sp. and *Tylodelphys clavata*, which infect fish eyes. Other endoparasites, which parasitize fish intestines, body cavity, or gall-bladder, were rare. The prevalence and mean intensity during the three sampling seasons of all the recorded parasites are presented in Table 3.

Six parasitic taxa from the phylum Ciliophora were identified during this study. The most prevalent among them was *Trichodina* spp. The prevalence of other ciliophorans was comparably lower than that of *Trichodina* spp. (Table 3).

The parasitological examination revealed the presence of three parasitic taxa from the class Monogenea. The highest roach infection prevalence in all seasons was for *Dactylogyrus* spp., followed by *Paradiplozoon homoion homoion* and then *Gyrodactylus prostae* (Table 3). Seven parasitic taxa of the class Digenea were identified during this study. The highest prevalence among these parasites was of *Diplostomum* sp. The prevalence of roach infection with *Posthodiplostomum cuticola* and *Tylodelphys clavata* was also comparably higher than that of other digenean parasites recorded (Table 3). Roach were infected by four parasite species of the class Cestoidea. The prevalence and infection intensity of all cestodes were found to be similarly low (Table 3). Roach were infected with a single nematode species, *Philometra ovata*. Only one parasite species, *Neoechinorhynchus rutili*, was also identified from the phylum Acanthocephala. The prevalence of roach infection with *P. ovata* and *N. rutili* was low (Table 3). This study indicated that roach was infected by three parasite species of the class Crustacea: *Argulus foliaceus, Ergasilus sieboldi, Lamproglena pulchella*. The prevalence of roach infection with all the three crustacean parasites was low (Table 3). Only a single leech species was recorded during this study. The prevalence of roach infection with *Piscicola geometra* was also low. In this study, roach specimens were also found to be infected with glochidia – the juvenile form of mussels. The data on roach infection with glochidia refer only to the 2008 and 2009 seasons.

Parasite variations among rivers

The differences in roach parasite characteristics among the rivers studied were assessed separately for different seasons (spring, summer, autumn). Seven rivers were investigated during the spring season (see Table 2). Before analysis, it was verified if the prevalence of certain parasite species differs significantly among the sampling sites in a given river. Sampling site significantly affected the prevalence of only four parasite species in spring. The prevalence of *A. piscicolum* varied significantly among sampling sites in the Neris River, *S. bramae* in the Nevěžis River, *P. cuticola* in the Šventoji River, and *P. h. homoion* in the Minija River (Kruskal-Wallis ANOVA tests: $P < 0.01$). These rivers were excluded when differences in the prevalence of certain parasite species in rivers were assessed for spring. The variation of parasite species number and richness indexes varied insignificantly among the sampling sites in the rivers studied (Kruskal-Wallis ANOVA tests: $P > 0.05$). Overall, roach parasitological examination revealed significant variation in the prevalence of seven parasite species among different rivers in spring: the ciliophoran *A. piscicolum*; the monogeneans *Dactylogyrus* spp. and *G. prostae*; the digeneans *A. imitans*, *P. cuticola* and *T. clavata*; and the leech *P. geometra* (Table 3). The number of parasite species also varied significantly among rivers in spring, while the diversity index of parasite species did not.

Six rivers were investigated during summer (see Table 2). Sampling site significantly affected the prevalence of only *P. cuticola* in both the Jūra and Šušvė rivers (Kruskal-Wallis ANOVA tests: $P < 0.01$). The variation of species number and diversity index varied insignificantly among sampling sites in the rivers studied in summer (Kruskal-Wallis ANOVA tests: $P > 0.05$). The analysis showed significant variation in the prevalence of four parasite species among different rivers in summer: the monogenean *Dactylogyrus* spp.; the digenean *T. clavata*: the cestode *C. laticeps*; and glochidia (Table 3). Species number and diversity index did not vary significantly among rivers in summer (Kruskal-Wallis ANOVA tests: $P > 0.05$).

Table 3

Parasite prevalence (P), mean intensity, and their location within hosts (Site) in roach from rivers in Lithuania, 2005-2009. The prevalence of parasite species that differed significantly (Kruskal-Wallis ANOVA and Median test, P < 0.05) among rivers is indicated by asterisk

Parasites	Spring P (%)	Spring Intensity (Mean ± SD)	Summer P (%)	Summer Intensity (Mean ± SD)	Autumn P (%)	Autumn Intensity (Mean ± SD)	Site
Ciliophora							
Apiosoma piscicolum (Blanchard, 1885)	7.6*	3.7 ± 3.2	0.7	1.9 ± 0.6	0.5	3.3 ± 3.7	skin
Chilodonella piscicola (Zacharias, 1894)	0.3	1.0 ± 0.0	-	-	-	-	skin
Ichthyophthirius multifiliis Fouquet, 1876	6.8	10.1 ± 19.0	4.7	2.0 ± 1.4	4.3	2.4 ± 2.3	skin, gills
Tetrahymena pyriformis (Ehrenberg, 1830)	0.1	1.0	0.1	1.0	0.5	2.5 ± 2.4	skin
Trichodina spp.	46.5	3.4 ± 4.8	5.3	2.0 ± 1.8	2.2	1.6 ± 0.8	skin
Trypanosoma carassii (Mitrophanow, 1883)	4.1	rare-very frequent	2.6	rare-very frequent	7.1	rare-very frequent	blood circulatory system
Monogenea							
Dactylogyrus spp.	43.7*	8.7 ± 10.6	31.7*	7.0 ± 8.9	8.1	3.5 ± 3.3	gills
Gyrodactylus prostae Ergens, 1963	8.4*	2.7 ± 3.9	1.8	1.1 ± 0.2	1.7*	1.1 ± 0.3	skin
Paradiplozoon homoion homoion (Bychowsky & Nagibina, 1959)	15.3	2.1 ± 1.6	14.3	2.1 ± 1.7	8.8	1.8 ± 1.4	gills
Digenea							
Asymphylodora imitans (Mühling, 1898)	0.6*	5.6 ± 4.3	0.2	1.0 ± 0.0	0.3	2.7 ± 2.1	intestine
Diplostomum sp. Nordmann, 1832	76.2	9.0 ± 12.1	77.7	11.2 ± 13.0	79.5	9.5 ± 10.7	lens
Ichthyocotylurus platycephalus (Creplin, 1825)	0.2	3.5 ± 2.1	-	-	0.5	6.6 ± 7.5	internal organs
Palaeorchis incognitus Szidat, 1943	2.4	16.3 ± 28.5	0.5	5.7 ± 7.1	1.8	21.2 ± 24.6	intestine
Posthodiplostomum cuticola (Nordmann, 1832)	29.2*	7.8 ± 12.4	47.4	17.2 ± 45.3	44.5*	13.6 ± 20.8	skin, fins, gills
Sphaerostomum bramae (Müller, 1776)	6.8	8.0 ± 10.2	0.4	21.0 ± 19.2	1.6	8.3 ± 14.7	intestine
Tylodelphys clavata (Nordmann, 1832)	17.7*	7.4 ± 11.3	24.6*	8.2 ± 12.4	14.8	6.9 ± 10.7	vitreous body
Cestoidea							
Caryophyllaeus laticeps (Pallas, 1781)	0.3	1.3 ± 0.6	0.5*	1.0 ± 0.0	0.3	1.0 ± 0.0	intestine
Ligula intestinalis (Linnaeus, 1758)	0.3	2.3 ± 1.2	0.4	1.5 ± 0.7	0.5	3.0 ± 1.3	body cavity
Neogryporhynchus cheilancristrotus (Wedl, 1955)	-	-	0.3	1.3 ± 0.6	0.1	3.0 ± 0.0	intestinal wall
Valipora campylancristrota (Wedl, 1855)	1.0	1.4 ± 0.5	-	-	-	-	gall-bladder
Nematoda							
Philometra ovata (Zeder, 1803)	2.6	5.7 ± 10.3	0.1	1.0	0.1	1.0 ± 0.0	body cavity
Acanthocephala							
Neoechinorhynchus rutili (Müller, 1780)	0.7	1.8 ± 1.0	0.6	7.3 ± 3.7	0.2	4.3 ± 4.9	intestine
Crustacea							
Argulus foliaceus (Linnaeus, 1758)	0.2	1.0 ± 0.0	0.4	1.0 ± 0.0	-	-	skin
Ergasilus sieboldi Nordmann, 1832	0.3	1.0 ± 0.0	0.5	1.8 ± 1.0	0.1	2.0 ± 0.0	gills
Lamproglena pulchella Nordmann, 1832	0.4	2.0 ± 1.4	-	-	-	-	skin, gills
Hirudinea							
Piscicola geometra (Linnaeus, 1761)	7.1*	2.6 ± 2.3	0.3	1.0 ± 0.0	0.3	1.0 ± 0.0	skin
Bivalvia							
Glochidia[1]	6.7	5.2 ± 3.6	6.7*	12.1 ± 17.7	-	-	skin, gills

[1]Data only from the 2008-2009 seasons

Nine rivers were investigated during autumn (see Table 2). Sampling site significantly affected the prevalence of *T. carassii* in the Venta River and *P. cuticola* in the Minija River (Kruskal-Wallis ANOVA tests: $P < 0.01$). The range of species number varied significantly among sampling sites in the Minija River, while species richness indexes did so in the Nemunas River (Kruskal-Wallis ANOVA tests: $P < 0.01$). Roach parasitological examination revealed significant variation in the prevalence of only two parasite species among different rivers in autumn: the monogenean *G. prostae*, and the digenean *P. cuticola* (Table 3). Species number and diversity indexes did not vary significantly among rivers in autumn (Kruskal-Wallis ANOVA tests: $P > 0.05$).

Seasonal fluctuation

Seasonal fluctuations in the roach parasite species prevalence, richness, and diversity were assessed. The Neris and Šešupė rivers were investigated in the spring and summer seasons in this study. The prevalence of eight parasite species was significantly higher in spring than in summer. Among all the parasites observed, only the prevalence of *Trichodina* spp. was higher in spring as compared to summer in both rivers (Table 4). Species richness and diversity was also significantly higher in spring, but only in the Šešupė River (Mann-Whitney U test: $P < 0.01$).

Five rivers were investigated in the spring and autumn seasons (Table 2). The prevalence of nine parasite species was significantly higher in spring than in autumn. The prevalence of *Trichodina* spp. and *Dactylogyrus* spp. was higher in summer in comparison to autumn in all the rivers studied except the Minija River (Table 4). Species richness and diversity was also significantly higher in spring in comparison to autumn in all the rivers studied except the Minija River (Mann-Whitney U test: $P < 0.01$).

Three rivers were investigated in the summer and autumn seasons (Table 2). The results showed that the prevalence of three parasite species was significantly higher in summer than in autumn. The prevalence of *Dactylogyrus* spp. was higher in summer in comparison to autumn in all of the rivers studied (Table 4). Species richness was significantly higher in summer in comparison to autumn only in the Nemunas River, while the parasite diversity index was higher in spring only in the Jūra River (Mann-Whitney U test: $P < 0.01$).

Overall, the current results indicate that the prevalence of all parasites exhibiting significant seasonal variation followed a downward trend from spring to autumn, except *T. carassii*, which had higher prevalence in autumn in comparison to spring (Table 4). Notably, the fish parasites *C. piscicola*, *Valipora campyloncristrota*, and *L. pulchella* infected roach only in spring and at a very low prevalence (Table 3).

Discussion

Seasonal fluctuation

A total of 27 parasitic taxa infected roach in the rivers studied. All of the parasites identified are local species that have already been recorded in roach from Lithuania (Rauckis 1988). The roach parasite community was dominated by *Diplostomum* sp., *P. cuticola*, *Dactylogyrus* spp., and *T. clavata*. These findings are consistent with those of other roach parasitological studies in Finland (Valtonen et al. 1997, 2003), Germany (Knopf et al. 2007), Poland (Dzika et al. 2008), and the Czech Republic (Kadlec et al. 2002). The parasitological examination revealed significant seasonal fluctuations in the species richness and diversity of the parasites identified. The highest values of both indexes were in spring. Significant seasonal fluctuations were also noted in the prevalence of 12 parasite species. The prevalence of most of them, especially ciliates and monogeneans, decreased from spring to autumn. These seasonal fluctuation trends of parasite prevalence demonstrate that roach are much more vulnerable to parasites in spring than in summer or autumn, and it explains the highest values of species richness and diversity indexes noted in spring.

Table 4
Prevalence of roach parasites which exhibited significant seasonal variation in the rivers studies (Mann-Whitney U test: P < 0.05)

River	Parasite	Spring	Summer	Autumn
Neris	*Trichodina* spp.	35.3	4.9	-
	V. campylancristrota	4.0	0.0	-
Šešupė	*Trichodina* spp.	59.6	8.9	-
	Dactylogyrus spp.	49.0	18.5	-
	G. prostae	15.6	0.0	-
	S. bramae	12.6	0.0	-
	P. ovata	6.4	0.0	-
	P. geometra	11.3	0.0	-
Nevėžis	*A. piscicolum*	6.7	-	0.0
	Trichodina spp.	45.7	-	0.4
	Dactylogyrus spp.	58.7	-	1.3
Šventoji	*A. piscicolum*	13.3	-	2.5
	Trichodina spp.	54.4	-	10.8
	T. carassii	6.5	-	28.3
	Dactylogyrus spp.	50.9	-	12.1
	G. prostae	12.6	-	1.7
	S. bramae	8.0	-	0.0
Venta	*Trichodina* spp.	59.0	-	0.0
	Dactylogyrus spp.	33.2	-	3.1
	P. h. homoion	21.9	-	9.1
	S. bramae	11.1	-	0.0
	P. ovata	6.9	-	0.0
	P. geometra	15.0	-	0.0
Žeimena	*Trichodina* spp.	51.7	-	0.0
	Dactylogyrus spp.	44.6	-	0.0
Jūra	*I. multifiliis*	-	16.7	0.0
	Dactylogyrus spp.	-	39.2	0.0
Merkys	*Dactylogyrus* spp.	-	50.0	9.5
Nemunas	*Dactylogyrus* spp.	-	36.2	16.7
	Glochidia	-	2.8	0.0

High densities of the ciliates *Trichodina* spp. and *Apiosoma* sp. are commonly found on fish that are stressed, for example, by harsh winter conditions (Lom 1995). According to Knopf (2007), seasonal fluctuations in the number of these ciliates, with a maximum in spring, are typical for warm-adapted fish species such as roach. This general pattern explains the current findings of maximum prevalence of *Trichodina* spp. and *Apiosoma* sp. on roach in spring. This study also indicated a decrease in the prevalence of roach infection with *Dactylogyrus* spp. and *G. prostae* towards autumn, which suggests the greatest parasite pressure is on this host in spring. Water temperature is widely assumed to be an important factor controlling the abundance of monogeneans (Koskivaara et al. 1991a, Šimková et al. 2001). However, the current study suggests water temperature is not the only factor determining the growth of monogenean populations, because high prevalence was observed during the period of increasing water temperatures in spring, but not in autumn when temperature decreases.

The results indicated that Trichodinids often occurred in association with monogeneans with the maximum prevalence in spring in this study. Thus, it seems that both ciliates and monogeneans benefit from similar factors during late winter and spring. According to Knopf (2007), energy depletion during the cold season increases the risk of fish parasitological infection, and this might be the main reason for the observed seasonality in the prevalence of opportunistic ciliates and of monogeneans on roach. Thus, temperature-dependent reduction of activity of the piscine immune system (Watts et al. 2001, Nikoskelainen et al. 2004) facilitated the increased prevalence of the parasites noted in spring. Increased water temperature raise the resistance of roach to parasites, and this could have been a reducing mechanism of the numbers of parasite species observed in summer and autumn. However, the immunological aspect alone is not sufficient to explain the parasite peak observed in spring, but not in autumn. The high prevalence of roach infection with ciliates and monogeneans in April and May could also be related to the roach spawning season.

Parasites variations among rivers

The parasite communities of fish reflect interactions with both the aquatic environment itself and invertebrate communities. All of these are involved in the parasite life cycle. Therefore, parasite assemblages can be used as environmental indicators by tracking decreasing or increasing diversity, species richness, and prevalence as conditions change (Valtonen et al. 1997, 2003, Landsberg et al. 1998, Blanar et al. 2009).

The current roach parasitological examination revealed significant variation in the prevalence of nine parasitic taxa among the rivers studied. Moreover, significant variation was observed in the number of parasite species among the rivers studied in spring. Some of these species could be used as bioindicators of water quality that interfaces with parasite life directly or indirectly by affecting initial, intermediate, or final hosts. Further analysis of parasite prevalence and various water contaminants at the study sites is needed to confirm the suitability of these parasite species as biological indicators of water contamination.

Blanar et al. (2009) concluded that both Digenea and Monogenea would be excellent indicators of metal pollution, but that digeneans would be more reliable indicators of eutrophication. In the current study, three parasite species of the class Digenea (*A. imitans*, *P. cuticola*, *T. clavata*) and two species of the class Monogenea (*Dactylogyrus* spp., *G. prostae*) exhibited significant variation in prevalence in the rivers studied. Furthermore, Mierzejewska and Własow (2005) determined that the eye flukes *Diplostomum* sp. and *T. clavata* as well as *P. cuticola* are sensitive indicators of environmental changes as they reflect spatial differences and long-term changes in ecological conditions. In the present study, *T. clavata* and *P. cuticola* also showed significant variation in prevalence in the rivers studied. In addition, Valtonen et al. (2003) reported that in roach, dactylogyrids were the main positive indicator of the adverse effects of pollution resulting in impaired immune response. They concluded that monitoring dactylogyrids might be an inexpensive way to monitor the status of roach immune response. The prevalence of dactylogyrids also varied significantly in the present study. *Dactylogyrus* spp. exhibited significant prevalence variation in the rivers studied in the spring and summer seasons. Differences of *Dactylogyrus* spp. prevalence in the rivers studied can be explained by different water temperatures. Water temperature is recognized as an important factor controlling the occurrence of monogeneans (Chubb 1997, Koskivaara et al. 1991b, Šimkova et al. 2001). However, it is evident from other field studies (Chubb 1977, Koskivaara et al. 1991a, 1991b) that temperature is not the only factor determining the growth of monogenean populations, and that other abiotic (light, pH, oxygen) and biotic (fish spawning) factors might mask the effect of temperature (Chubb 1977, Gonzalez-Lanza and Alvarez-Pellitero 1982).

Importance of fish parasite monitoring

River ecosystems are changing rapidly, mainly under anthropogenic impacts. Fish are exposed to numerous pathogenic factors (e.g., atmospheric pollution, influx of rain waters from cultivated fields and urban areas containing potentially toxic substances), which make them more susceptible to parasitic infections. Thus, it is important to follow the dynamics of parasite prevalence in dominant fish species annually and to try to forecast future trends. The parasitological examination of roach is interesting not only from the viewpoint of parasitology, but also from that of environmental protection. Therefore, using parasites as pollution indicators has aroused considerable interest recently. Valtonen et al. (1997) demonstrated that extensive parasite communities in freshwater fishes such as roach and perch are good indicators of pollution.

In conclusion, fish parasites are adapted to the specific conditions of both their abiotic aquatic environment and their hosts (Pietrock et al. 2001). This makes them potentially useful as important determinants of host health and excellent biological indicators of water contamination (Poulin 1992). Thus, parasitological studies of certain parasite species in roach can be used as an alternative monitoring system of environmental quality in rivers alongside more common approaches. This would provide a more comprehensive and multidisciplinary evaluation of ecosystem health.

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Streszczenie

Ocena zmienności występowania pasożytów u płoci, *Rutilus rutilus* (L.) w litewskich rzekach

W pracy przedstawiono wyniki badań składu taksonomicznego, częstości występowania i intensywności zarażenia pasożytami płoci z 12 litewskich rzek. Badania parazytologiczne prowadzono na 38 stanowiskach, od wiosny do jesieni, dwukrotnie w latach 2006-2009 i jednokrotnie w 2005 roku. Łącznie zbadano 3558 osobników płoci i stwierdzono 27 gatunków pasożytów. Reprezentowały one 9 wyższych taksonów: Ciliophora (6 gatunków), Monogenea (3), Digenea (7), Cestoidea (4), Crustacea (3), Nematoda (1), Acanthocephala (1), Hirudinea (1) i Bivalvia (1). Wszystkie stwierdzone gatunki pasożytów były wcześniej odnotowane w badaniach parazytologicznych płoci prowadzonych na Litwie. Wśród odnotowanych gatunków pasożytów najczęściej występowały: *Diplostomum* sp., *Posthodiplostomum cuticola, Tylodelphys clavata*, *Dactylogyrus* spp. i *Trichodina* spp. Stwierdzono istotną zmienność intensywności zarażenia pasożytami w zależności od rzeki i pory roku. W stosunku do 9 gatunków pasożytów stwierdzono znaczne różnice w intensywności zarażenia pomiędzy rybami pochodzacymi z różnych rzek, natomiast 12 gatunków wykazywało istotne zróżnicowanie sezonowe. Większość z nich, szczególnie przywry i orzęski, wykazywały spadek intensywności zarażenia w okresie od wiosny do jesieni.