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Fish monogeneans from a shallow, eutrophic Oświn Lake in Poland

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ABSTRACT. Background. A study was carried out in a shallow, eutrophic Oświn Lake, within Seven Islands Reserve (north-eastern Poland), in order to determine the infection of fish with monogeneans as sensitive indicators of water quality. This paper presents comparative analysis of the occurrence of Monogenea in fishes from two, distinctly separated pools of the lake, differing in environmental conditions. The impact of fish size and sampling season on the infection parameters was also analyzed. **Material and methods.** In 1998 and 1999, a total of 1091 fish representing 8 dominant species were examined. Samples were collected four times a year (in May, July, August, and October) simultaneously from the eastern and western parts of the lake. **Results.** 16 species of Monogenea (and some unidentified specimeus) occurred in the fish examined, most of them from the Dactylogyridae family: *Dactylogyrus sphyrna*, *D. auriculatus*, *D. intermedius*, *D. anchoratus*, *D. falcatus*, *D. tincae*, *D. wunderi*, *D. zandti*, *D. difformis*, *D. nanus*, *D. distinguendus*, *D. crucifer*, *D. caballeroi*. Furthermore, *Tetraonchus monenteron* (Tetraonchidae), *Gyrodactylus elegans* (Gyrodactylidae), and *Paradiplozoon megan* (Diplozoidae) were detected. Monogenea occurred abundantly on the gills of pike, roach, rudd, white bream, carp bream and crucian carp, but rather sporadically in tench and perch. The highest species variety and diversity of monogenean guilds were detected in carp bream and roach. It was proved that *D. crucifer* and *D. difformis* were significantly more abundant in the western pool compared to the eastern one. Infection of fish with Dactylogyridae was season-dependent, contrary to the infection of pike with *T. monenteron*. Intensity of infection of white bream with *D. sphyrna* and roach with *D. crucifer* increased with fish body length; such a relationship did not appear for the other monogeneans and their hosts. **Conclusion.** Presence of common Monogenea in the fish examined, lack of rare species, poor diversity of monogenean guilds and relatively low infection rate could be connected with the low stability of the lake environment. Location-dependent occurrence of *D. crucifer* and *D. difformis* indicated that the exchange between fish groups from the eastern and western parts of the lake is limited.

Key words: fish, Monogenea, parasites, Seven Islands Reserve

Introduction

Study on the composition and structure of fish parasite community may supply some information about the stability and health of freshwater ecosystems [1–5]. According to Valtonen et al. [6], parasite communities can be sensitive indicators of the extent of the ecosystem recovery as well. Fish monogeneans, due to their biological properties (ectoparasites with narrow host specificity), can reflect certain disorders in the environment. Increasing rate of the infection with dactylogyrids might be the most convincing evidence of the impaired immune response of fish [7, 8].

The research covered Oświn Lake, an eutrophic and pond-type water body (mean depth 1.7 m, surface area 890 ha). Seven Islands bird sanctuary, located on the lake, is under protection of the Ramsar Convention. Accelerated eutrophication, rapid water level decrease and intoxication with chemical fertilizers had all lead to an ecological disaster which took place before 1983. The water level was raised in 1993 by a dam constructed on the Oświnka River (Fig. 1), which halted the degrada-

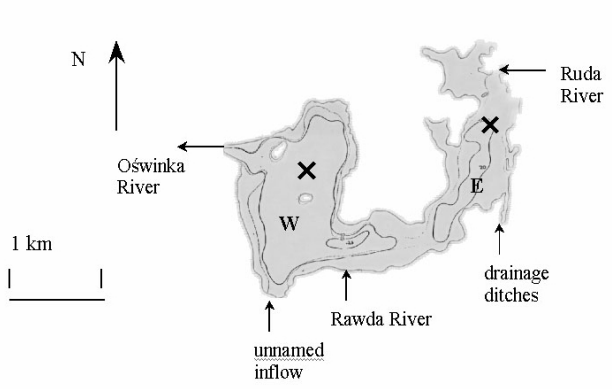

Fig. 1. Location of sampling areas of fish (**X**) in Oświn Lake. E — eastern, W western part of the lake

tion process [9]. The lake area consists of the western and eastern pools differing in environmental conditions and separated by a shoal. Comparative analyzes of the occurrence of digeneans in both pools indicated that the interchange between fish groups from the western and eastern part of the lake is limited [10]. The western part is more overgrown with trees and bushes than the eastern one. The bottom of the eastern basin, unlike in the western part of the lake, is completely covered with hornwort (*Ceratophyllum demersum*). The whole lake is at present a reservoir characterized by moderately advanced eutrophication [9]. However, the current microbiological analysis of the lake water has indicated that the eastern part of the lake is more fertile than the western one [10].

The aim of present paper was: (1) to compare the occurrence of Monogenea in fish from the eastern and western part of Oświn Lake. (2) to detect seasonal changes in the occurrence of monogeneans on the fish studied, and (3) to find the effect of fish body length on the intensity of infection with the parasites.

Material and methods

During two years (1998 and 1999), a total of 1091 individuals belonging to 8 dominant fish species were examined: northern pike (*Esox lucius*), roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), tench (*Tinca tinca*), white bream (*Blicca bjoerkna*), carp bream (*Abramis brama*), crucian carp (*Carassius carassius*), and European perch (*Perca fluviatilis*).

The fish were caught with nets (mesh 30 x 30 mm) in the eastern and western basins four times per year (in May, July, August, and October) (Table 1). Specimens examined were within a broad range of length (Table 2).

The prevalence and intensity of infection (mean value and range) were calculated following Margolis et al. [11]. Non-parametric statistics were used to find differences in the infection of fish with monogeneans: the Kruskal-Wallis *H*-test to compare the different sampling periods and the Mann-Whitney *U*-test to compare sampling sites. Seasonal changes of infection indices were investigated in details in the case of dominant monogeneans, which appeared abundantly and were present in most samples. To find the relationship between the fish body length (standard length — SL) and intensity of infection with the dominating Monogenea, Pearson's correlation coefficient was calculated (for infected fishes in samples from the entire reservoir). Significant correlations between parameters were illustrated in graphs. The standard length of fish (SL) from the eastern and western parts of the lake was compared by *U*-test to avoid wrong interpretation on location-dependent differences in the infection rate.

Results

Sixteen monogenean species (+ unidentified

Table 1. Number of fish in samples from the eastern (E) and western (W) part of Oświn Lake

Fish species	Samples No E/No W							
	05.98	07.98	08.98	10.98	05.99	07.99	08.99	10.99
Northern pike	10/5	3/3	6/10	10/11	7/10	10/4	10/10	6/10
Roach	15/15	5/10	2/7	10/9	7/8	9/10	10/10	7/10
Rudd	14/9	10/6	9/3	8/5	10/10	10/8	10/10	8/6
Tench	3/1	8/1	10/5	10/10	10/10	10/10	10/10	6/9
White bream	15/13	7/10	0/5	0/10	10/10	10/2	10/10	7/10
Carp bream	14/14	10/10	10/10	10/8	10/10	10/10	10/10	7/10
Crucian carp	3/0	10/5	10/2	6/0	7/6	10/9	10/10	10/8
European perch	13/15	10/10	10/10	9/11	7/10	10/10	10/10	10/10

Table 2. Comparison of the standard length (SL) of fish sampled in the eastern (E) and western (W) part of Oświn Lake. *U* — Mann-Whitney statistics

Fish species	SL [cm] — E ± *s* (range)	SL [cm] — W ± *s* (range)	*U*	*P*
Northern pike	51.17 ± 11.06 (28.5-88.0)	50.17 ± 11.56 (29.0-69.0)	1945.5	> 0.05
Roach	15.75 ± 3.52 (11.0-25.5)	16.87 ± 3.78 (11.5-24.5)	2112.5	> 0.05
Rudd	18.71 ± 4.20 (11.0-26.0)	19.85 ± 3.31 (12.0-25.0)	1886.0	> 0.05
Tench	29.27 ± 4.29 (22.5-41.0)	28.86 ± 3.07 (23.0-34.5)	1864.5	> 0.05
White bream	14.29 ± 3.18 (10.5-21.5)	15.19 ± 3.22 (9.5-21.5)	1706.0	> 0.05
Carp bream	23.44 ± 3.52 (18.0-33.0)	21.77 ± 4.37 (9.0-34.0)	2568.5	< 0.05
Crucian carp	20.17 ± 4.84 (11.5-41.0)	21.99 ± 4.60 (9.0-30.0)	930.5	< 0.05
European perch	19.56 ± 5.68 (11.5-35.5)	19.54 ± 4.5 (11.5-31.5)	2986.0	> 0.05

specimeus) were recorded on the fish examined, mostly from the Dactylogyridae family. These were: *Dactylogyrus sphyrna* Linstow, 1978, *D. auriculatus* (Nordmann,1932), *D. intermedius* Wegener, 1910, *D. anchoratus* (Dujardin, 1945), *D. falcatus* (Wedl, 1957), *D. tincae* Gussev, 1965, *D. wunderi* Bychowsky, 1931, *D. zandti* Bychowsky, 1933, *D. difformis* Wagener, 1957, *D. nanus* Dogiel et Bychowsky, 1934, *D. distinguendus* Nybelin, 1937, *D. crucifer* Wagener, 1957, *D. caballeroi* Prost, 1960, furthermore *Tetraonchus monenteron* (Wagener, 1957) (Tetraonchidea), *Gyrodactylus elegans* Nordmann, 1932 (Gyrodactylidae) and *Paradiplozoon megan* (Bychowsky et Nagibina, 1959) (Diplozoidae). The species identifications was performed according to Gusev [12].

The infection of fish in two pools of the lake

The parameters of monogenean occurrence: prevalence, intensity and abundance in the examined fish samples are presented in the Table 3.

Pike. Two monogenean species were detected. *T. monenteron* occurred numerously in both pools examined, being slightly more numerous in the western one (the values of all three indices were higher in this part of the lake). *D. intermedius* was found only once, in the eastern pool (one specimen in the sample of May 1999).

Roach. Five species were identified. The prevalence of all dactylogyrids was higher in the eastern part of the lake than in the western one. *D. crucifer* markedly dominated in both pools; in spite of lower prevalence in western pool, its abundance was higher in this part of the lake, due to high intensity of fish infection. Mean intensity of *D. nanus* was a little higher in the western pool, while its abundance was significantly higher in the eastern one, due to higher prevalence. This species was represented mainly in sample of May 1999, singular specimens being also present in the samples collected in May 1998, and July of both years. Two remaining species: *D. sphyrna* and *D. caballeroi* occurred sporadically (in samples of May and July of both years), with infection indices comparable in both pools. *Paradiplozoon megan* (one adult specimen and one diporpa) was detected in October 1999 in the western pool only.

Rudd. Only *D. difformis* was identified in this fish species. In the western pool the abundance and prevalence were higher, and main intensity of infection a little lower than in the eastern pool.

Tench was sporadically infected with *D. tincae*; a few specimens were detected in samples of August and October 1999 in the western pool only.

White bream. Two species were detected, with the domination of *D. sphyrna*. The prevalence of this monogenean was higher in the eastern pool, while its main intensity was higher in the western one; the abundance was similar in both pools. *D. distinguendus* occurred mainly in the sample of May 1999, when the maximal intensity of infection reached 11 parasites per fish, moreover a few specimens were detected in July and in August 1999. The prevalence was a little higher in eastern pool, while mean intensity and abundance were there lower.

Carp bream. The monogeneans detected on this fish represented 6 species. In the gill guild *D. auriculatus* and *D. zandti* dominated. Both species were more numerous in the eastern pool, the intensity index of *D. zandti* being a little higher in the western pool. Less common was *D. wunderi*, detected mainly in samples of July 1999. All three indices of the occurrence of this species were higher in the western pool. *D. sphyrna* and *D. falcatus* appeared rarely in both pools, only in the sample of July 1999. Single specimen of *Gyrodactylus elegans* was found in July 1998 on the skin of fish from the western pool.

Table 3. Comparison of the fish infection with monogeneans in the eastern (E) and western (W) part of Oświn Lake

Monogenea	Prevalence [%] E/W	Intensity of infection mean E/W	range E/W	Abundance E/W
		Northern pike		
Dactylogyrus intermedius	1.6/0.0	1.0/0.0	1/0	0.02/0.0
Tetraonchus monenteron	33.9/46.0	4.1/4.3	1–14/1–25	1.4/2.0
Roach				
D. sphyrna	3.1/1.3	1.0/1.0	1–1/1	0.03/0.01
D. nanus	10.8/3.8	1.0/1.3	1–1/1–2	0.11/0.05
D. crucifer	32.3/13.9	3.1/9.27	1–10/1–33	1.02/1.29
D. caballeroi	3.1/2.5	1.0/1.0	1–1/1–1	0.03/0.03
Paradiplozoon megan	0.0 2.5	0.0/1.0	0/1–1	0.0/0.03
		Rudd		
D. difformis	31.6/57.9	7.2/6.8	1–27/1–33	2.3/3.9
		Tench		
D. tincae	0.0/3.6	0.0/1.5	0/1–2	0.0/0.05
		White bream		
D. sphyrna	30.5/24.3	8.9/11.4	1–41/1–52	2.7/2.8
D. distinguendus	8.5/7.1	2.6/4.0	1–6/1–11	0.22/0.29
		Carp bream		
D. sphyrna	1.2/2.4	2.0/1.0	2/1–1	0.02/0.02
D. auriculatus	30.9/22.0	2.2/2.1	1–10/1–5	0.69/0.45
D. falcatus	2.5/3.7	1.0/1.3	1–1/1–2	0.02/0.05
D. wunderi	11.1/23.2	2.1/2.5	1–5/1–9	0.23/0.57
D. zandti	30.9/30.5	2.4/3.2	1–8/1–10	0.75/0.98
Gyrodactylus elegans	0.0/1.2	0.0/1.0	0/1	0.0/0.01
		Crucian carp		
D. intermedius	30.3/20.0	4.3/5.4	1–24/1–17	1.3/1.1
D. anchoratus	10.6/5.0	3.9/1.5	1–9/1–2	0.41/0.08
		Perch		
Monogenea indt.	3.8/1.2	1.0/1.0	1–1/1	0.04/0.01

Crucian carp. Two species were present. *D. intermedius* dominated, occurring with much higher prevalence and a little lower mean intensity on fish from the eastern pool. While *D. anchoratus* was distinctly more numerous in the western pool (all three indices achieved distinctly higher values). This parasite was detected mainly in May 1999.

Perch. Few specimens of unidentified dactylogyrids were found in the sample collected in July 1999.

The statistical analysis demonstrated that the infection of roach with *D. crucifer* and rudd with *D. difformis* was significantly higher in the western pool compared to the eastern one (the *U* statistics: 2127.50 and 1672.0 respectively at $p < 0.05$ in both cases; Figs. 3, 4), while the infection of fish with *T. monenteron*, *D. sphyrna*, *D. auriculatus*, *D. zandti* and *D. intermedius* was not location-dependent (Figs. 2, 5, 6, 7, 8).

Seasonality

The seasonality of the monogenean occurrence on fish was analyzed for seven most abundant species.

***Tetraonchus monenteron* in pike** (Fig. 2). Both prevalence and mean intensity of fish infection showed some fluctuations between October 1998 and October 1999, however no clear seasonal peak of these indices in either pool was observed.

***Dactylogyrus crucifer* in roach** (Fig. 3). The prevalence showed clear peak in May or June and fall in July in both parts of the lake, and in both years of the study, while a distinct peak of main

intensity of infection was observed only in May of 1999.

***Dactylogyrus difformis* in roach** (Fig. 4). In both parts of the lake the prevalence was high in spring and summer and decreased towards autumn. The distinct peak was observed in August 1998 and May 1999 in western pool, while in the eastern one was a plateau between May and August 1998, and distinct peak in May 1999. Main intensity was rather low in both pools in 1998, while in 1999 roughly followed the seasonal pattern of the prevalence.

***Dactylogyrus shyrna* in white bream** (Fig. 5). The prevalence in both years, as well as mean intensity in 1999 demonstrated distinct peaks in May 1999 in both pools; these indices markedly dropped as early as in July. Mean intensity was very low in 1998 in both pools, and no seasonal fluctuations were observed, while in 1999 it showed in both pools a distinct peak in May (similar as prevalence).

***Dactylogyrus auriculatus* in carp bream** (Fig. 6). The prevalence of this species reached the highest values in both pools in summer (July in 1998 and May to August in 1999) and seemed to drop towards autumn (it remained quite high in November 1999). The seasonal fluctuations of main intensity were not so distinct, nevertheless they also achieved some peaks in both pools in August 1999.

***Dactylogyrus zandti* in carp bream** (Fig. 7). The prevalence reached the highest values in spring and summer, between May and August (there were small differences in the time of peak between eastern and western pool: July and August in 1998, and May and August in 1999 respectively). Seasonal changes of main intensity of infection were simultaneous in both pools and roughly followed the seasonal pattern of prevalence.

***Dactylogyrus intermedius* in crucian carp** (Fig. 8). The seasonality of the occurrence of this species was very clear. In eastern pool a plateau of the prevalence was observed between July and August in 1998 and a peak in May in 1999, while in western pool there was a peak in July of both years of the study. Main intensity had a highest values in August 1998 in eastern pool, and in July 1999 in both pools.

The statistical analyses confirmed that the infection of pike with *T. monenteron* did not differ significantly between seasons (the *H* statistic =7.052260, at $p > 0.05$) (Fig.2), contrary to the season-dependent infection of cyprinids with Dactylogyridae (*H* statistics at $p < 0.05$) (Figs. 3-8).

Intensity of infection and fish body length relationship

Intensity of infection of white bream with *D.*

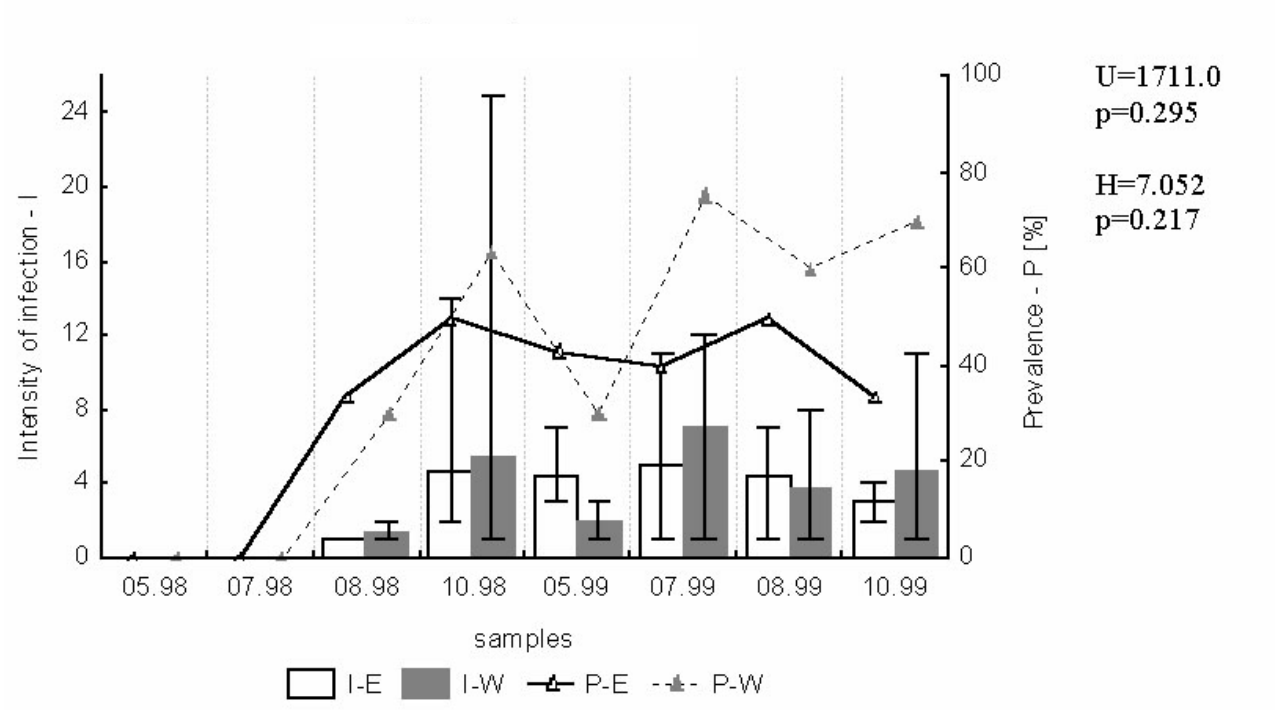

Fig. 2. Prevalence (P) and intensity of infection (I) of pike with *Tetraonchus monenteron* in samples from eastern (E) and western (W) part of Oświn Lake. H — Kruskal-Wallis statistic for seasonal differences. U — Mann-Whitney statistic for location differences

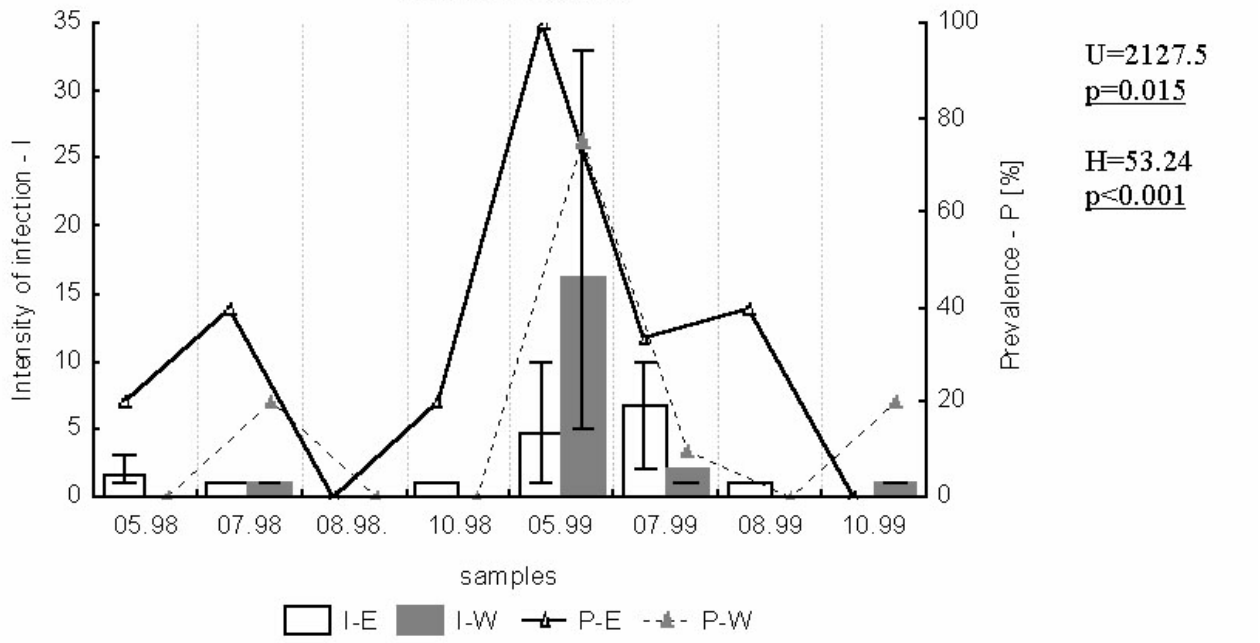

Fig. 3. Prevalence (P) and intensity of infection (I) of roach with *Dactylogyrus crucifer* in samples from eastern (E) and western (W) part of Oświn Lake. Other explanations as in Fig. 2

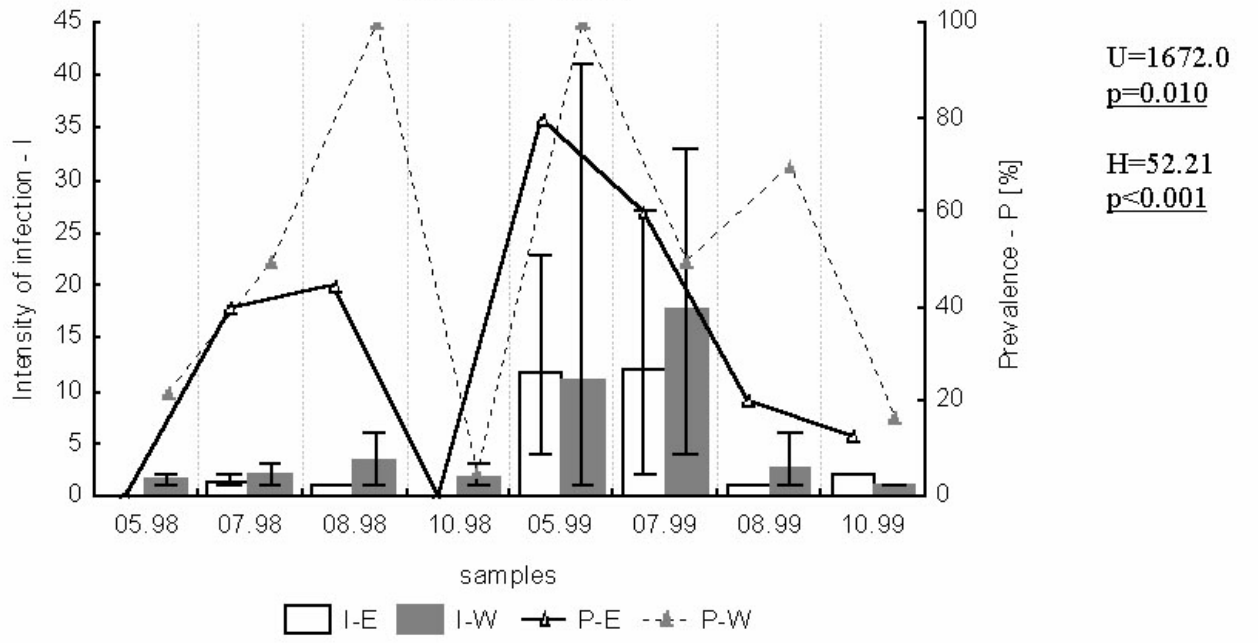

Fig. 4. Prevalence (P) and intensity of infection (I) of rudd with *Dactylogyrus difformis* in samples from eastern (E) and western (W) part of Oświn Lake

sphyrna and roach with *D. crucifer* increased with the fish standard length (SL); Pearson's correlation coefficient reached the values: 0.41 and 0.36 (respectively) at $p < 0.05$ (Fig. 9). Such a relationship was not detected in the case of *T. monenteron*, *D. difformis*, *D. auriculatus*, *D. zandti* or *D. intermedius* (r: 0.05, 0.01, 0.06, 0.02 and -0.10; respectively, at $p < 0.05$).

Discussion

The component guild of monogeneans on fish gills in Oświn Lake consisted of at least 15 species, mainly from Dactylogyridae family, characteristic for cyprinids (Table 3). Only one species was found on the fish skin. *Dactylogyrus difformis* in rudd, *D. crucifer* in roach, *D. sphyrna* in white bream and *D.*

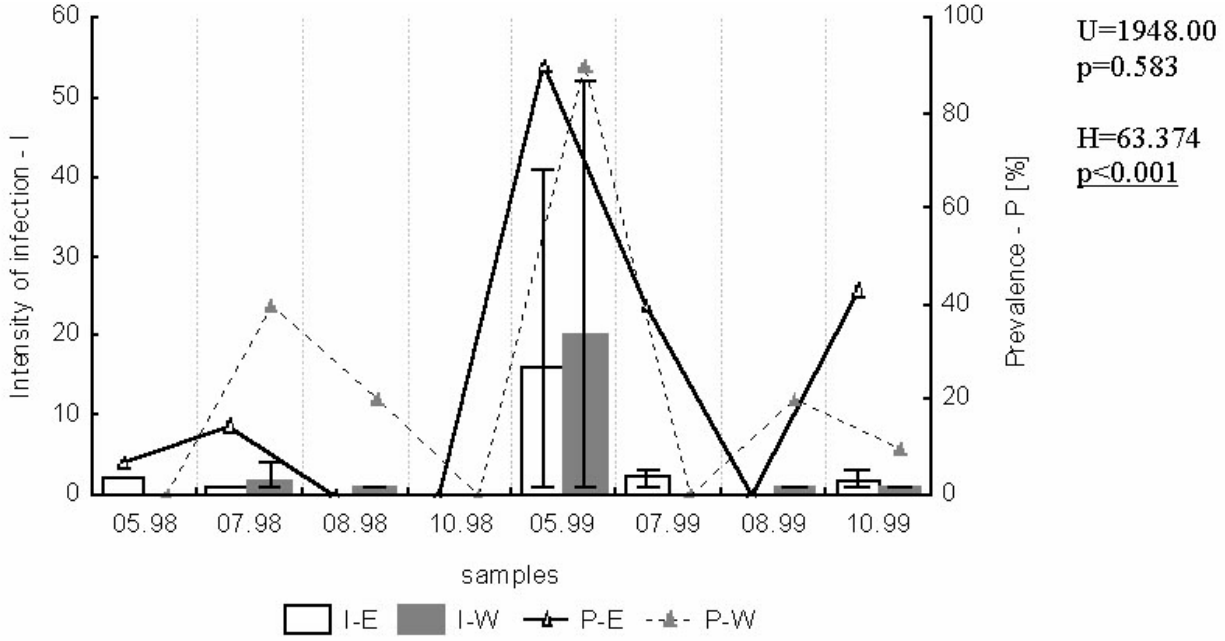

Fig. 5. Prevalence (P) and intensity of infection (I) of white bream with *Dactylogyrus sphyrna* in samples from eastern (E) and western (W) part of Oświn Lake

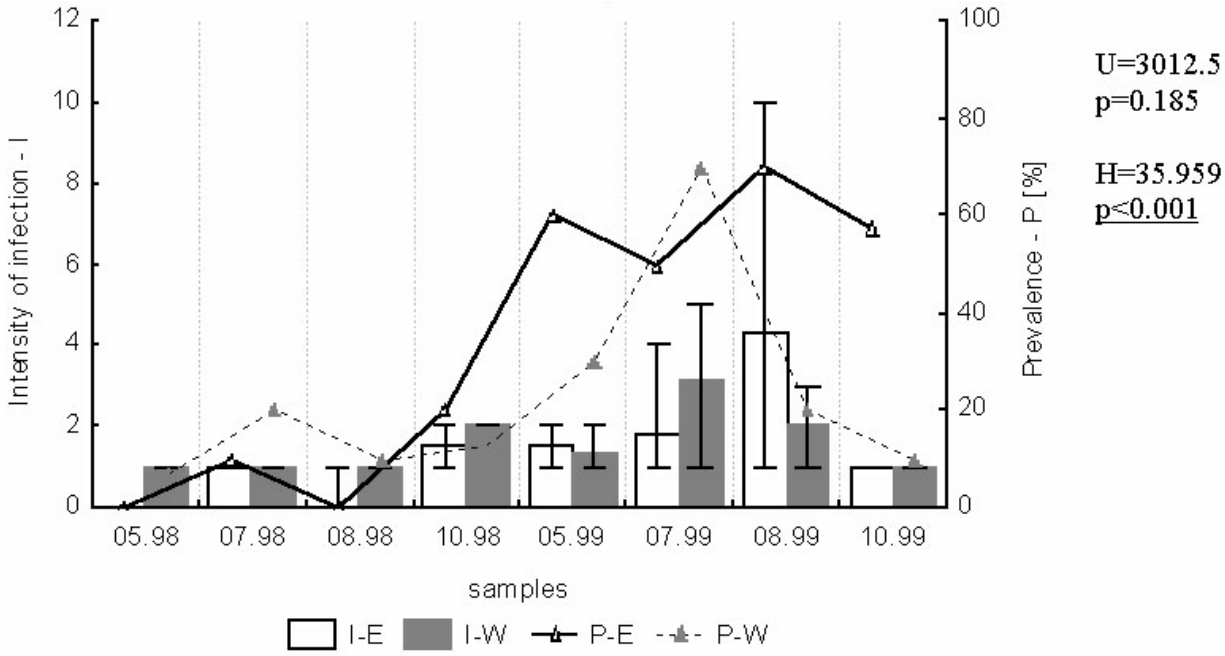

Fig. 6. Prevalence (P) and intensity of infection (I) of carp bream with *Dactylogyrus auriculatus* in samples from eastern (E) and western (W) part of Oświn Lake

zandti in carp bream reached the highest values of the infection indices, as well as *Tetraonchus monenteron* in pike did (Table 3). The most of species occurred commonly in their main hosts (especially at a time when populations of parasites grew), except perch and tench, which were sporadically infected. Every species of Monogenea exhibited narrow host specificity; in the case of colonizing more than one fish species they appeared to infect abundantly one host and incidentally the others (*D. sphyrna* two-, *D. intermedius* one additional host) (Table 3).

Compared to the other reservoirs [5, 13-15] the species richness of monogenean guilds in all the fish examined was relatively low (Table 3). Those of carp bream and roach were richer than in the other

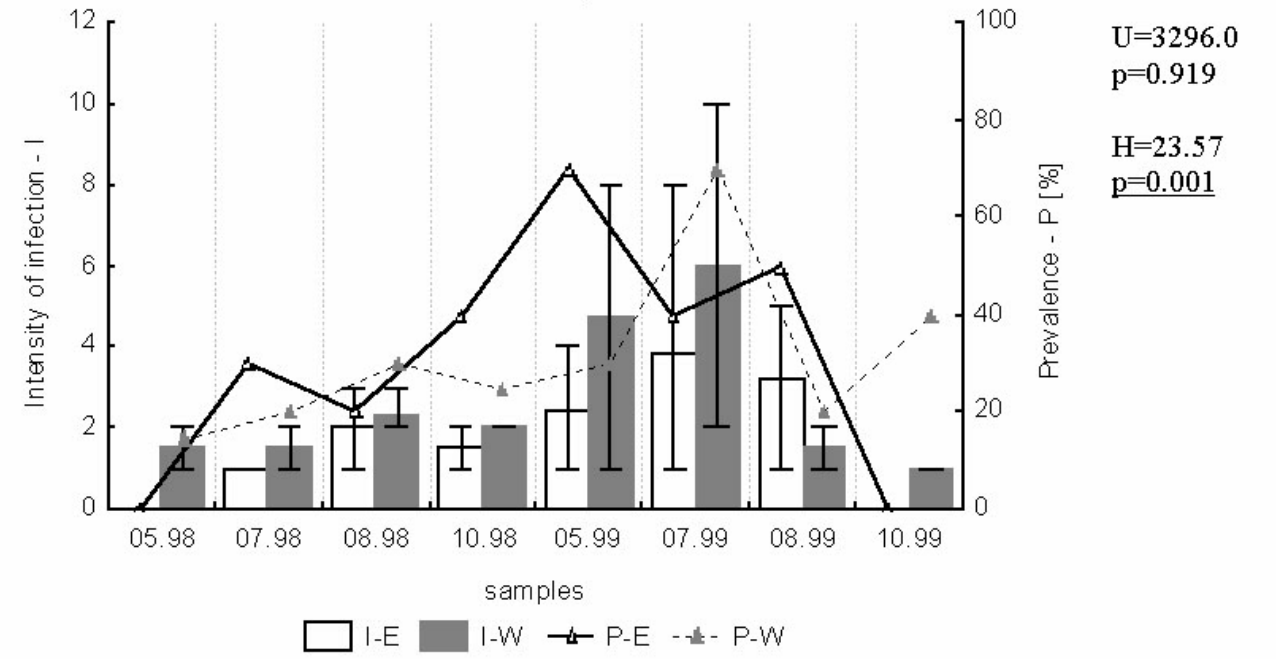

Fig. 7. Prevalence (P) and intensity of infection (I) of carp bream with *Dactylogyrus zandti* in samples from eastern (E) and western (W) part of Oświn Lake

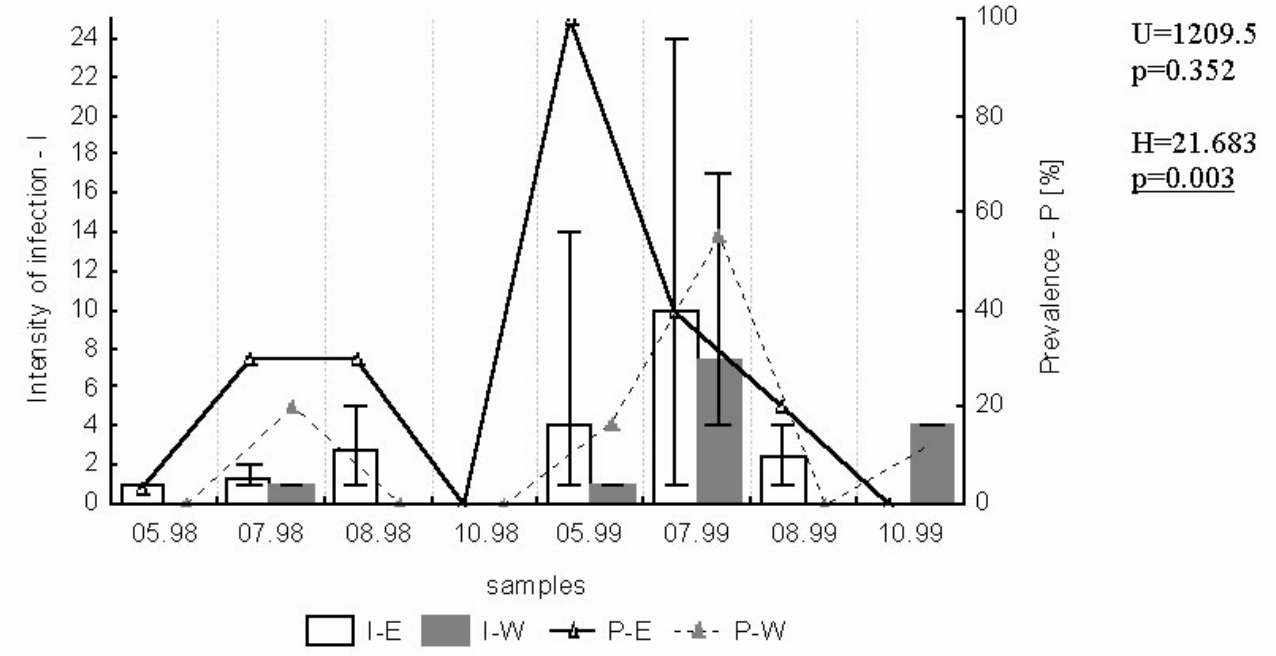

Fig. 8. Prevalence (P) and intensity of infection (I) of crucian carp with *Dactylogyrus intermedius* in samples from eastern (E) and western (W) part of Oświn Lake

fish studied (Table 3). All the species detected were common and widely spread in the region [5, 16]; the species occurring rarely were not found in the lake under study. Such composition of the monogenean guilds was probably connected with the low stability of the lake environment (accelerated eutrophication, degradation, intoxication and renovation at last) [9]. Environmental degradation is believed to transform heterogeneity of parasitic communities to simple assemblages dominated by a few species [3]. On the other hand, lack of monogeneans typical for polluted water bodies (such as *D. micracanthus*, *D. fallax*, *D. similis* and *D. suecicus* in roach) [1, 2, 5], in conjunction with the relatively low infection rates

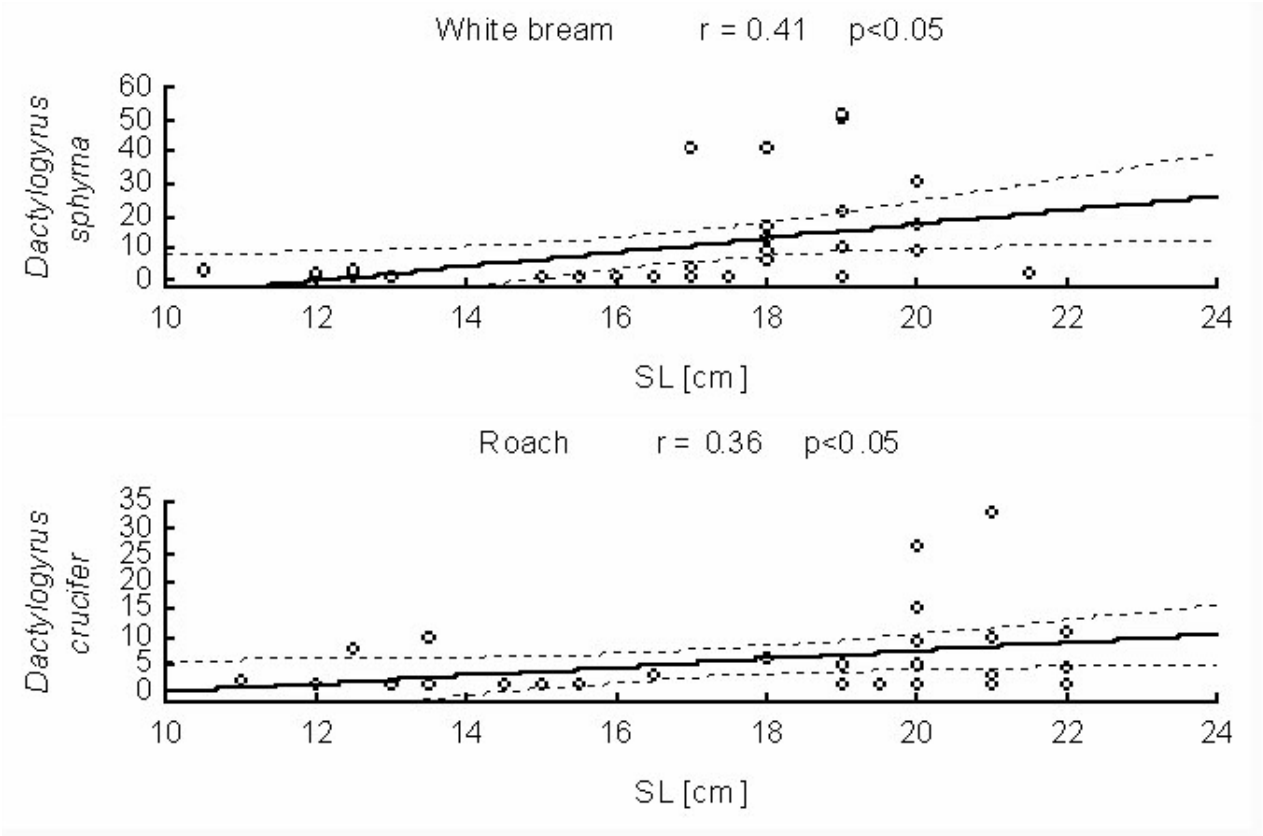

Fig. 9. Relationship between the number of Monogenea and the standard length (SL) of fish from Oświn Lake

with the other species indicated that there were no environmental disorder which would impair the fish defence responses. This might be an evidence that the lake recovery is in progress. Dominance of *D. crucifer* in roach, typical for unpolluted eutrophic and oligotrophic reservoirs [1, 2, 5], also supports this opinion.

The infection of roach with *D. crucifer* and rudd with *D. difformis* (both abundant and dominant in the guilds) was significantly higher in the western pool compared to the eastern one (Table 3; Figs. 3, 4). The study on the digeneans performed in this lake at the same time, proved that the interchange between fish groups from the western and eastern parts of the lake was limited [17]. It seems that the quantitative differences in the monogenean occurrence could be an effect of spatial differences in environmental conditions within the lake. The question was — what the factor impaired the immune response against some species of Monogenea, or — most certainly — what the factor supported the population grow of those parasites in the western pool (less fertile than the eastern one)? It is difficult to recognize the proper cause, but the higher abundance of *D. crucifer* in roach and *D. difformis* in rudd might be indirectly connected with significantly higher infection rate of those fishes with *Posthodiplostomum cuticola* in the western pool compared to the eastern one [17]. In any case, the results indicated that the transfer of some monogeneans — the parasites of a direct life cycle — was impeded. It supports the previous observations of limited fish interchange between the two pools of the lake [17].

The infection of white bream with *D. sphyrna* and of roach with *D. crucifer* increased with the fish body length (Fig. 9). Such a relationship is usually linked with rising space of gills in older fish and indicated that hosts do not acquire permanent immunity against the parasites [1].

In this study a seasonality of the occurrence of dactylogyrids was observed. Some species as *D. crucifer*, *D. difformis* and *D. shyrna* occurred with the prevalence of the maximal values at the beginning of a vegetation season (sample of May 1999), decreasing markedly in further samples. The intensity of infection with the parasites reached a high level as early as in May 1999 and distinctly decreased in July (*D. sphyrna*) or in August (*D. crucifer* and *D. difformis*). In the case of *D. intermedius* the highest prevalence in May 1999 visibly preceded the highest values of the intensity of infection in

July that year. Prevalence of *D. auriculatus* and *D. zandti* remains relatively high from May to August 1999, while the intensity of infection reached the highest values in July or in August. Fluctuations in the infection indices for *T. monenteron* was not seasonal in character. It is natural for big monogeneans such as *T. monenteron* because the life span of the parasite is longer than one year and new generations could join older specimens [19].

It is worth to point out, that the level of the occurrence of almost all dactylogyrid species was much lower, and seasonal fluctuations expressed much feebly in 1998 than in 1999. It is difficult to explain these differences, as the sizes of fish samples being examined were similar. Perhaps some climatic conditions should be taken into account.

Conclusions

(1) The composition of monogenean guilds on fish gills, comprising mainly common species, their poverty, lack of rare species, and relatively low infection rate could be connected with the low stability of the lake environment.

(2) Location-dependent occurrence of *D. crucifer* and *D. difformis* indicated that the interchange between groups of rudd and roach from the eastern and western part of Oświn Lake is limited.

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