A comparative study on the parasite fauna of perch, *Perca fluviatilis* L., collected from a freshwater coastal lake, brackish-water Baltic Sea, and the interconnecting canal

Jadwiga Wierzbicka[1], **Krystyn Wierzbicki**[1], **Wojciech Piasecki**[1], **and Przemysław Śmietana**[2]

[1]Division of Fish Diseases, Agricultural University of Szczecin, ul. Kazimierza Królewicza 4, 71-550 Szczecin, Poland
[2]Division of Animal Ecology and Environment Protection, University of Szczecin, ul. Wąska 13, 71-412 Szczecin, Poland

Corresponding author: Wojciech Piasecki, Division of Fish Diseases, Agricultural University of Szczecin, ul. Kazimierza Królewicza 4, 71-550 Szczecin, Poland; E-mail: piasecki@fish.ar.szczecin.pl

ABSTRACT. Background. Parasitological surveys of freshwater fishes rarely include comparisons between two ecologically different bodies of water. Such studies might help to understand processes of establishment of parasite faunas in estuary areas. The results obtained could also provide useful tools for discriminating various fish populations based on the composition of their parasite faunas. The present authors attempted to study such data from Resko Lake-a freshwater coastal lagoon (6 km^2 surface area), and the adjacent areas of the Baltic Sea. Resko Lake, located 12 km west of the city of Kołobrzeg, is shallow (1.5 m) and is connected to the sea through a small canal (1.3 km long, 30 m wide). **Material and methods.** The material was collected from April 1969 and July 1970. A total of 159 perch were collected, in this number 104 fish from the lake, 43 from the sea, and 12 from the canal. **Results**. A total of 32 parasite species were recovered from the fish necropsied. The parasites represented 7 higher taxa: Protozoa (3 species), Cestoda (4), Digenea (13), Nematoda (5), Acanthocephala (3), Mollusca (1), and Crustacea (3). The parasite fauna of perch from the sea was definitely more abundant (31 species) compared to that of the lake (21), and the canal (12 species). Infection parameters of 13 parasite species demonstrated significant differences between the locations studied. The infection level of 6 parasite species was significantly higher in perch from the sea: *Bothriocephalus scorpii*, *Ligula* sp., *Brachyphallus crenatus*, *Camallanus truncatus*, *Hysterothylacium aduncum*, and *Echinorhynchus gadi*. On the other hand, infection levels of 7 other species were higher at the lake: *Triaenophorus nodulosus*, *Bucephalus polymorphus*, *Azygia lucii*, *Tylodelphys clavata*, *Camallanus lacustris*, *Acanthocephalus lucii*, and *Achtheres percarum*. The infection parameters of the fish from canal were similar to those from the lake. Interesting observations were made on the seasonality of certain parasites of both lake- and Baltic perch. The presently observed differences between parasite faunas of the fish from ecologically different adjacent estuarine locations are certainly caused by diversified environmental conditions that affected the processes of formation of the parasite communities there. Among important factors that could affect compositions of the parasite faunas could have been: availability of the intermediate hosts, exchange of waters (Baltic water influxes to the lake), fish migrations (spawning), and finally the separate identity of the two fish stocks studied.

Key words: Baltic sea, estuary, fish parasites, perch, *Perca fluviatilis*, Resko Lake.

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Introduction

The parasite catalogue (check-list) of Grabda [1] provides detailed data on the parasites of perch, *Perca fluviatilis* L., recorded in Poland up to the year 1970. Within that time period a total of 49 parasite species have been found in perch, mostly freshwater. In the years to follow the majority of surveys on this fish were carried out in freshwater environment [2–12]. Parasites of perch from the Gulf of Gdańsk (Baltic Sea) were studied by

Rokicki [13] and Rolbiecki et al. [14], from the Szczecin Lagoon — by Pilecka-Rapacz [15] and Romuk-Wodoracki [16], and from the Vistula Lagoon — by Rolbiecki et al. [14]. The above-mentioned articles were predominantly surveys or descriptions of individual parasite species. The papers of Pojmańska et al. [17] and Pojmańska [18, 19] take into consideration possible effect of thermal factor on parasite fauna or seasonality of occurrence or reproductive cycles of certain parasites.

Parasites as biological tags have been studied mainly from marine fishes [20–27].

An interesting example of an ecological approach to parasite fauna of perch was a complex study carried out by Wierzbicki [28] in one of the largest Polish lakes. The results obtained by that author from different sample sites permitted a conclusion that the population of perch, in this particular lake consisted of a number of sub-populations of limited range of occurrence. The present paper constitutes a continuation of Wierzbicki's [28] studies, this time from another type of lake. The body of water selected for this survey was a coastal lake (lagoon) Resko connected with the Baltic Sea by a narrow canal. The present study is likely to describe parasite fauna of perch on the contact zone between two environments — freshwater and marine. The results can be also used for discriminating between the two perch populations based on the composition of their parasite faunas.

Material and methods

The fish for the present study were collected mainly from Resko Lake-a coastal lagoon (Fig. 1) situated 12 km west of the city of Kołobrzeg, from the Baltic Sea off the village of Dźwirzyno and from the interconnecting canal. According to different sources the surface area of the lake, at average water level, was 5.8 km^2, 6.2 km^2 or 6.3 km^2, average depth 1.5 m and 1.9 m, maximum depth 2 m and 2.5 m, respectively [29]. The lake is separated from the sea by a sand-bar (0.3-0.7 km wide) and its connection to the sea is through a canal (1.3 km long and up to 30 m wide). At the time of collecting the material for the present study, the depth of this canal at its lake-end was some 0.6 m, in its middle stretch 0.5-2 m, while at its sea end-not more than 0.3 m. This mouth often used to be obstructed by the sea sand and had to be perpetually dredged. Changes of the water level are substantial and they depend chiefly on the winds. Sea storms from the North can, in a short time, propel great masses of sea water, through the canal to the lake. In such case, the water level can rise some 0.5 m within 24 hours. Very strong and long-lasting storms resulted in water level in the lake rising 1.5 m above the normal value [29].

A total of 159 perch, *Perca fluviatilis*, individuals were collected, in this number 104 fish from the lake and 43 fish from the sea. The fish were purchased from commercial fishermen. In addition, a total of 12 perch were caught on hook and rod from the interconnecting canal, near its mouth to the sea. The material was collected from April 1969 to July 1971. The values of the standard length and weight

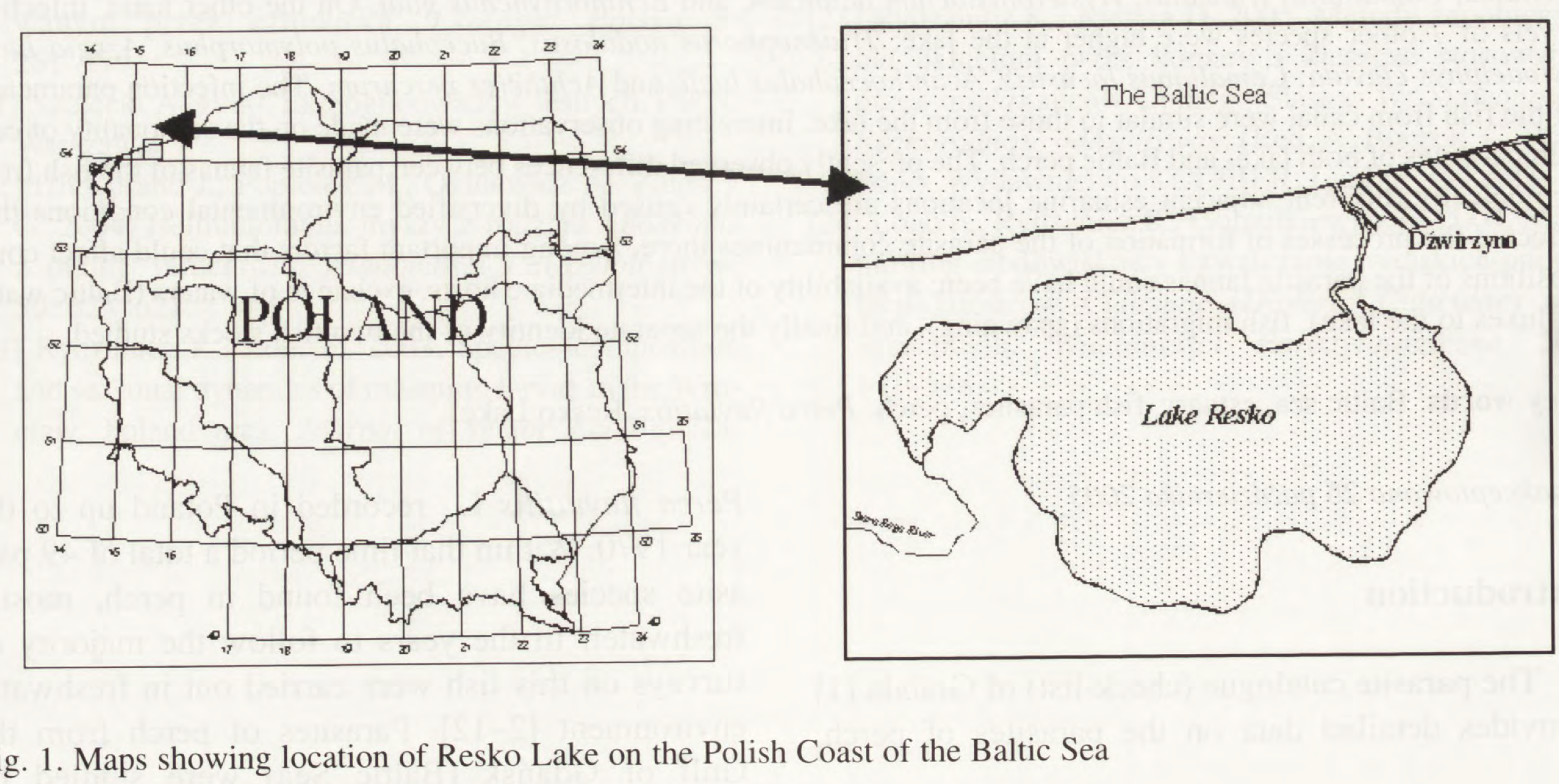

Fig. 1. Maps showing location of Resko Lake on the Polish Coast of the Baltic Sea

Table 1. The number and basic parameters of the examined perch, *Perca fluviatilis*, from the sea, Resko Lake, and the interconnecting canal in respective samples

Date		**Sea**			**Lake**			**Canal**	
	n	Standard length [cm]	Weight [g]	n	Standard length [cm]	Weight [g]	n	Standard length [cm]	Weight [g]
14 Apr 1969	6	24.0–33.5	310–870						
08 May				22	16.5–26.5	80–390			
11 Jun	5	26.5–34.5	415–950						
29 Jul	1	27.5	485						
10 Sep				12	21.0–29.0	220–670			
14 Nov				6	15.0–32.0	60–760			
06 May 1970				14	20.5–30.5	210–440			
21–25 Jun				32	15.0–28.5	50–430	8	26.0–33.0	330–850
7–15 Jul	28	24.0–36.5	330–830	11	21.0–30.0	155–480			
13 Oct				7	19.0–30.5	140–720			
10 Jul 1971	3	28.0–31.0	560–710				4	13.0–17.0	60–110
Total	**43**	24.0–36.5	310–950	**104**	15.0–32.0	50–760	**12**	13.0–33.0	60–850

of the fish are given in Table 1.

The perch collected were subjected to necropsy procedures soon after capture. All organs of the fish body were studied except for the muscles and the blood. Trichodinid protozoans were silvered in 1% solution of $AgNO_3$. Tapeworms, digeneans, and acanthocephalans were fixed in 75% ethyl alcohol and subsequently stained in alum carmine or borax carmine. After dehydration in alcohol series they were mounted on microscopic slides in Canada balsam. The collected nematodes and crustaceans were fixed in 5% formalin on physiological solution and cleared in glycerine. Specific identity of some parasites was determined on the fresh material without making permanent mounts.

Statistical analyses and comparisons between infection parameters of different perch parasites were carried out using Kruskal-Wallis test based only on the fish caught in spring and summer, because in the fall no fish were collected from the sea. Protistan parasites were not analysed statistically.

Results

A total of 32 parasite species were recovered from the fish necropsied. The parasites represented 7 higher taxa: Protozoa (3 species), Cestoda (4), Digenea (13), Nematoda (5), Acanthocephala (3), Mollusca (1), and Crustacea (3). The infection parameters of all parasites and their location in the host are given in Table 2. The parasite fauna of perch from the sea was definitely more abundant (31 species) compared to that of the lake (21), and the canal (12 species). Perch from the coastal zone of the Baltic Sea yielded no protistan parasites, whereas the "lake" perch was infected by three species (representing order Mobilina) often quite abundant: *Trichodina urinaria*, *Trichodina epizootica* and *Trichodina* sp. (Table 2).

Statistical analyses revealed significant differences in the infection of perch with 13 parasite species. Among them six species (*Bothriocephalus scorpii*, *Ligula* sp., *Brachyphallus crenatus*, *Camallanus truncatus*, *Hysterothylacium aduncum*, and *Echinorhynchus gadi*) demonstrated statistically significantly higher levels of infections in perch collected from the sea. On the other hand, seven other species (*Triaenophorus nodulosus*, *Bucephalus polymorphus*, *Azygia lucii*, *Tylodelphys clavata*, *Camallanus lacustris*, *Acanthocephalus lucii*, and *Achtheres percarum*) demonstrated significantly higher infection levels in perch from the lake. Two other species, the tapeworm, *Proteocephalus percae* and digenetic fluke, *Bunodera luciopercae*, were more numerous in fish from the lake.

A survey of the 12 perch individuals from the interconnecting canal yielded 12 parasite species. The prevalence and intensity of infection of those parasites were, in most cases, similar to those from the lake perch.

Discussion

The observed differences in the infection levels between perch collected from the lake and from the sea are probably related to the different environmental conditions, which affect the process of formation of the parasite faunas, for example through

Table 2. Infection parameters of perch, *Perca fluviatilis*, from Resko Lake and adjacent area of the Baltic Sea

Parasite species		Sea n = 43	Lake n = 104	Canal n = 12	Infection site	Remarks
Trichodina urinaria, Dogiel, 1940	P	0	27.9	0	Ub	
	I		f-v			
	mI					
	A					
Trichodina sp.	P	0	1.9	8.3	G	
	I		f	f		
	mI					
	A					
Trichodinella epizootica (Raabe, 1950)	P	0	9.6		G	
	I		1-a			
	mI					
	A					
Triaenophorus nodulosus (Pallas, 1781) p*	P	37.2	63.5	66.7	L	
	I	1–14	1–11	1–7		
	mI	3.69	1.98	2.62		
	A	1.37	1.26	1.75		
Bothriocephalus scorpii (Müller, 1776)	P	53.5	15.4	0	B, S (f)	Scolex & juv.
	I	1–32	1–6			
	mI	5.74	1.81			
	A	3.07	0.28			
Ligula sp. p*	P	9.3	0	0	S, B	1 ind.
	I	1–2				
	mI	1.50				
	A	0.14				
Proteocephalus percae (Müller, 1780)	P	9.3	28.8	8.3	B	Juv. & ad.
	I	1–4	1–13			
	mI	2.50	2.23	1.00		
	A	0.23	0.64	0.08		
Bucephalus polymorphus Baer, 1827	P	0	17.3	0	B	
	I		1–160			
	mI		14.05			
	A		2.43			
Rhipidocotyle campanula (Dujardin, 1845)	P	9.3	15.4	8.3	B	
	I	1–4	1–9	3		
	mI	2.50	2.75	3.00		
	A	0.23	0.42	0.25		
Brachyphallus crenatus (Rudolphi, 1802)	P	65.1	2.9	0	B, B(f)	
	I	1–41	1–3			
	mI	11.18	2.33			
	A	7.28	0.07	0.25		
Bunodera luciopercae (Müller, 1776)	P	53.5	49.0	0	B	
	I	1–51	1–67			
	mI	5.56	13.98			
	A	2.98	6.85			
Phyllodistomum pseudofolium Nybelin, 1926	P	0	0.96	0	Ub	
	I		1			
	mI		1.00			
	A		0.01			
Azygia lucii (Müller, 1776)	P	0	12.5	0	S	
	I		1–2			
	mI		1.08			
	A		0.13			

Table 2 (continued)

Nicolla skrjabini (Iwanitzky, 1928)	P	4.65	9.6	8.3	B	
	I	1	1–6	1		
	mI	1.00	1.90	1.00		
	A	0.05	0.18	0.08		
Diplostomum sp. met**	P	11.6	8.65	8.3	EL	
	I	1–2	1–3	1		
	mI	1.60	1.33	1.00		
	A	0.19	0.11	0.08		
Tylodelphys clavata (Nordmann, 1832) met**	P	58.1	90.4	83.3	Ev	
	I	1–100	1–250	1–250		
	mI	19.92	60.71	49.40		
	A	11.58	54.87	41.17		
Ichthyocotylurus platycephalus (Creplin, 1825) met**	P	0	0.96	0	B	eaten
	I				F	
	mI					
	A					
Ichthyocotylurus variegatus (Creplin, 1825) met**	P	2.3	9.6	25.0	Pc, P, B	eaten
	I				f	f-a
	mI					
	A					
Posthodiplostomum cuticola (Nordmann, 1832) met**	P	0.3	0.96	0	S	eaten
	I	1				
	mI	1.00				
	A	0.01				
Apatemon annuligerum (Nordmann, 1832) met**	P	18.6	20.2	25.0	S	eaten
	I	1–4	1–7	2–10		
	mI	1.62	2.00	4.67		
	A	0.30	0.40	1.17		
Eustrongylides excisus Jägerskiöld, 1909 l***	P	0	0.96	0	B	encysted
	I	1				
	mI	1.00				
	A	0.01				
Camallanus lacustris (Zoega, 1776)	P	65.1	91.3	100	B	
	I	1–40	1–65	2–33		
	mI	5.82	16.21	16.00		
	A	3.79	14.81	16.00		
Camallanus truncatus (Rudolphi, 1814)	P	60.5	21.15	0	B	
	I	1–18	1–11			
	mI	3.54	3.09			
	A	2.14	0.65			
Cucullanus sp.	P	2.3	0.96	0	B	
	I	1	2			
	mI	1.00	2.00			
	A	0.02	0.02			
Hysterothyllacium aduncum (Rudolphi, 1802)	P	30.2	8.65	0	B	
	I	1–9	1–30			
	mI	3.00	8.89			
	A	0.91	0.7	7		
Neoechinorhynchs rutili (Müller, 1780)	P	0	2.9	0	B	
	I	1–9				
	mI	3.67				
	A	0.11				

Table 2 (continued)

Echinorhynchus gadi (Müller, 1776)	P	23.25	0.96	0	B
	I	1–6	1		
	mI	1.60	1.00		
	A	0.37	0.01		
Acanthocephalus lucii (Müller, 1776)	P	11.6	48.1	66.7	B
	I	2–7	1–36	1–15	
	mI	4.80	4.80	6.75	
	A	0.56	2.31	4.50	
Unionidae gen. sp. gloch****	P	11.6	18.3	0	G
	I	f	f		
	mI				
	A				
Ergasilus sp.	P	7.0	3.8	0	G
	I	1–2	1–2		
	mI	1.33	1.25		
	A	0.09	0.05		
Achtheres percarum Nordmann, 1832	P	7.0	32.7	58.3	G, M
	I	1	1–11	1–9	
	mI	1.00	2.41	3.00	
	A	0.07	0.79	1.75	
Argulus foliaceus (Linnaeus, 1758)	P	0	1.9	0	
	I		1		
	mI		1.00		
	A		0.02		
Number of species		21	31	12	

p* – plerocercoid, met** – metacercaria, l*** – larva, gloch**** – glochidium; a – abundant; f – few; v – very abundant; B – intestine; El – eye, lens; Ev – eye, vitreous humour; G – gills; L – liver; M – buccal cavity; P – peritoneum; Pc – peritoneal cavity; S – stomach; Ub – urinary bladder; P – prevalence; I – infection intensity (range); mI – mean intensity of infection; A – abundance

determination of availability of the intermediate hosts. Among the parasites found, the typically marine ones were: *Bothriocephalus scorpii*, *Brachyphallus crenatus*, *Hysterothylacium aduncum*, and *Echinorhynchus gadi*. The above-mentioned four species occurred predominantly in the perch from the sea and they demonstrated substantially higher values of the prevalence and infection intensity. Those parasites had been found also in other hosts in the Gulf of Gdańsk (Baltic Sea) and two of them *B. scorpii* (larva) and *H. aduncum* (adult), similarly as in the present study were found among others, also in perch [13]. The second intermediate hosts for *B. scorpii* tapeworms are fishes (e.g. *Pomatoschistus minutus*), while the final host can be *Psetta maxima* (L.) [30]. As much as 98.5% *P. maxima* surveyed from the same sea area and at the same time as perch harboured adult forms of *B. scorpii* and the intensity of infection reached 346 parasites in a single 20.5-cm-long fish (Wierzbicka, unpublished). Larvae of this tapeworm were found in 46.1% of *Pomatoschistus minutus* from the Polish coastal waters [31]. *P. minutus* is a food component of perch feeding in the Baltic Sea [32] and therefore the larvae and juveniles of *B. scorpii* were more frequent in the alimentary tract of "sea" perch than "lake" perch.

Acanthocephalan, *Echinorhynchus gadi* is a common Baltic Sea parasite infecting many fish species. In the Gulf of Gdańsk it has been frequently found in cod, *Gadus morhua* L. The prevalence reached 100% [13, 33]. The fact of finding this parasite solely in the "sea" perch has been associated with the availability of intermediate hosts (mainly Amphipoda) [34].

The nematode, *Camallanus truncatus* was also a parasite characteristic for "sea" perch and it assumed infection parameters much higher than those from the lake. This parasite was recorded in the Gulf of Gdańsk from 8 fish species, in this number one marine, four migratory species, three freshwater ones [13] and in eels, *Anguilla anguilla* (L.), from the Szczecin Lagoon [35] and the south-eastern Baltic Sea [36].

Another related species, namely *C. lacustris*, infects perch in freshwater lakes [3, 4, 6, 10, 18, 37] and in the Gulf of Gdańsk [13]. This species was distinctly more abundant in perch from Resko Lake. It is therefore evident from the above that *C. truncatus* can thrive also in waters of low salinity.

An interesting fact has been detection of *Ligula* sp. plerocercoids solely in perch from the sea. It is possible that this parasite's life cycle is linked to the marine environment. This phenomenon requires further studies.

Parasite fauna of perch from Resko Lake was similar to those from other Polish freshwater lakes [3, 4, 10, 18]. It is particularly evident in the case of species, which exhibited significantly higher infection parameters in Resko Lake. The occurrence of four marine parasite species and *C. truncatus* in perch from Resko Lake can be associated with strong influxes of Baltic Sea waters during storms, enabling transfer of the intermediate hosts to this environment.

The infection of "sea" perch with freshwater parasites can take place during "visits" to the lake for example during spawning migrations in the spring when the water temperature reaches 7°C [32].

Analysing the seasonality of parasites' occurrence in the material studied we observed statistically significantly lower infection rate with nematode *H. aduncum* and with acanthocephalan *E. gadi* in the summer compared to spring. Similarly Sulgostowska et al. [36] noted in the area of Hel peninsula (south-eastern Baltic) a summer- and autumn decline in the prevalence of *E. gadi* in *Myoxocephalus scorpius* (L.) and with *H. aduncum* (adult) in Zoarces *viviparus* (L.).

Seasonality of *B. luciopercae* infection in Resko Lake was clearly visible. In the "sea" perch the ovigerous individuals were present as late as in July, whereas those parasites were absent in the „lake" perch in June and July. Most probably it was related to the lower water temperature in the sea. According to Pojmańska [18], the temperature can be a stimulus causing rejection of the adult flukes by fish. The shift in the timing of removal of subpopulations of this parasite had its effect on relatively high infection parameters of this parasite in the marine environment. The study on perch parasites from Dargin Lake demonstrated that the distribution of parasites in this relatively large body of water was uneven [28]. Each of the lacustrine zones (littoral, mid-lake shoal, and deep pelagial) had their characteristic dominant species, which was closely associated with the relevant ecological conditions and availability of the intermediate hosts, as well as with the mode of perch feeding. The results obtained by Wierzbicki [28] enabled him to conclude that the perch population in Dargin Lake consists of a number of subpopulations. The present follow-up study covering two distinct environments: a more uniform Resko Lake and the Baltic Sea also provided significant differences in the parasite fauna of perch. The presently found differences confirm the observations of Wierzbicki [28] and permit a conclusion that the perch in the areas presently studied belong to distinct schools (subpopulations or even populations?) inhabiting these separate environments.

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