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MOLLUSCS OF THE KRUTYNIA RIVER (MASURIAN LAKELAND)

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ABSTRACT: Studies on molluscs of the Krutynia River (Masurian Lakeland) carried out in 2008-2009 (July) revealed the presence of 38 species (21 species of snails and 17 species of bivalves). The number of species per site ranged from 4 (middle section) to 27 (mouth section of the river). Snails *Bithynia tentaculata*, *Viviparus contectus*, *Radix balthica* and bivalves *Sphaerium corneum*, *Dreissena polymorpha*, *Anodonta anatina*, *Unio pictorum* and *U. tumidus* were found along the whole river course. The highest densities that locally reached 200 indiv./m^2 were noted for *Theodoxus fluviatilis* and the largest biomass of over 2.5 kg/m^2 – for the unionid bivalves, mainly for *Unio tumidus*.

KEY WORDS: river, molluscs, long-term changes

INTRODUCTION

The Krutynia – one of the main rivers in the Masurian Lakeland – was the object of numerous physical, chemical and biological studies (e. g. HILLBRICHT-ILKOWSKA & WIŚNIEWSKI 1996). Previous malacological studies on the river were done fifty to almost a hundred years ago (HILBERT 1913, BERGER 1960) or pertained to only small stretches of the river (LEWANDOWSKI 1996b, JAKUBIK & LEWANDOWSKI 2008), or else considered only a part of the species (BERGER 1962, PIECHOCKI 1989, LEWANDOWSKI 1996a). The aim of this study was to relate the qualitative and quantitative aspects of the malacofauna of the whole Krutynia River to the environmental variability, and to compare the present data with the earlier results.

MATERIAL AND METHODS

The Krutynia is a medium-sized river, about 100 km long. It springs from Lake Warpuny, flows through 17 lakes and ends its course in Lake Bełdany (BAJKIEWICZ-GRABOWSKA 1996). Molluscs were sampled in 2008–2009 (in July) in 10 sites located in the river stretches between the lakes, from the springs to the mouth (Fig. 1). Diversity of lotic stretches of the Krutynia was considered when selecting the sampling sites. The sites, situated at a different distance from the lakes, differed in the width of the river, kind of substratum and plant cover (Table 1). Approximate cover of the river bottom by vegetation was estimated using the three-degree scale of BERNATOWICZ & WOLNY (1974).

In every site the bottom sediments were sampled to determine the content of total phosphorus with the molybdenum blue method and of total nitrogen with the indophenyl blue method (MARCZENKO 1979) after preliminary mineralisation according to the standard Kjeldahl procedure. Quantitative samples of molluscs were taken with a frame of an area of 0.25 m^2 randomly placed on the bottom in four replicates in every sampling site. Biological material was removed from within the frame with a grab and washed on a benthic sieve of 1 mm mesh. Live molluscs and empty shells were collected. Apart from quantitative samples, qualitative samples were also collected in 2009 to estimate the microhabitat species richness.

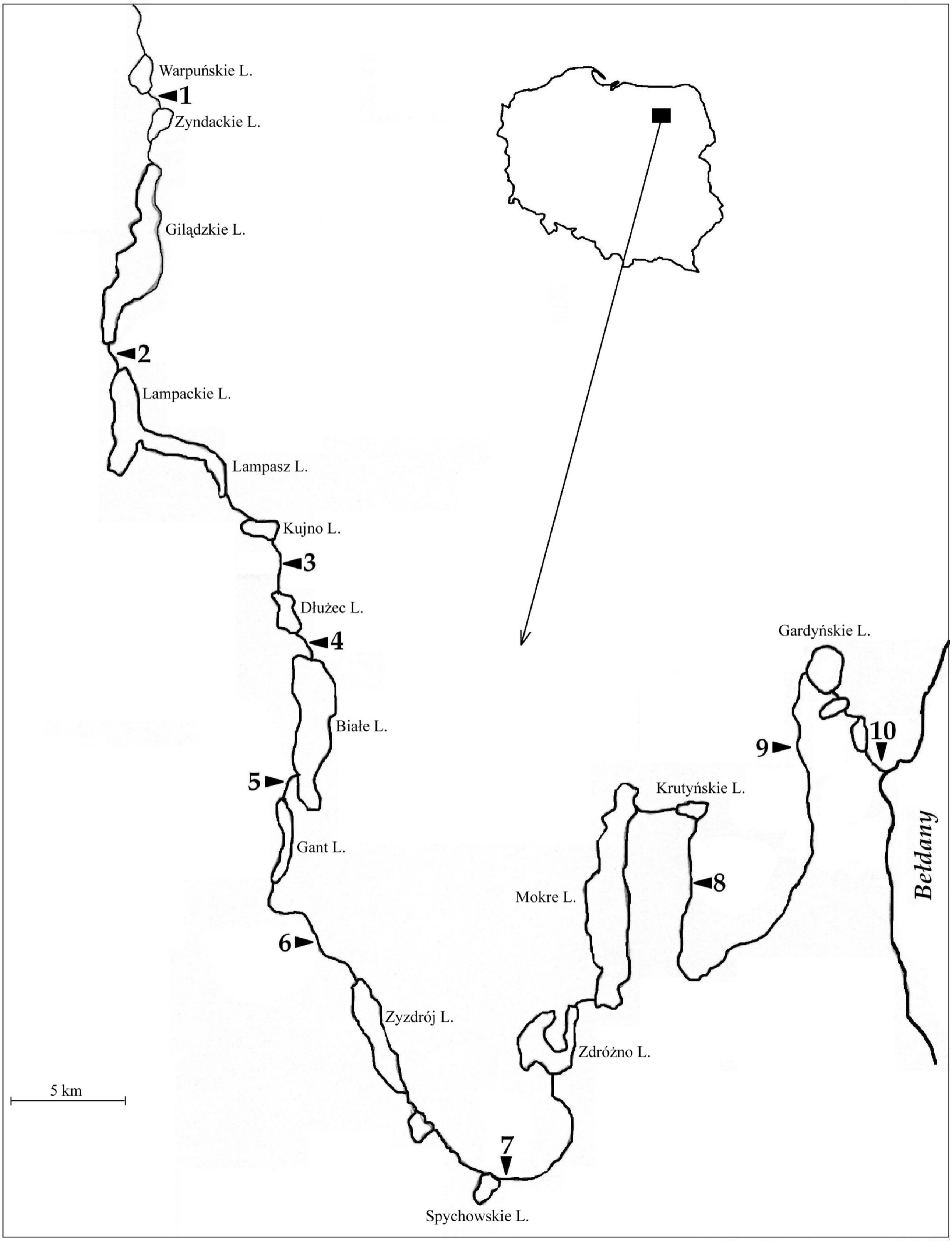

Fig. 1. Distribution of sampling sites (1 – Zyndaki, 2 – Sorkwity, 3 – Borowe, 4 – Dłużec, 5 – Gant, 6 – Machary, 7 – Spychowo, 8 – Wojnowo, 9 – Nowy Most, 10 – Iznota)

Table 1. Characteristics of the study sites; plant coverage estimated according to the scale of BERNATOWICZ & WOLNY (1974), where: 1 – very high density, 2 – medium density, 3 – low density

No.	River width (m)	Maximum depth (m)	Distance from the river outlet from a lake (m)	Type of bottom	Approximate plant cover [%]	Dominant plant species
1	2–3	0.5	50	sand, gravel, stones	40 [2]	*Nuphar lutea, Sparganium ramosum, Potamogeton perfoliatus*
2	8	0.5	100	sand, gravel, stones	20 [2]	*N. lutea, Acorus calamus, Phragmites australis*
3	10–12	0.5	500	sand, gravel	80 [1]	*N. lutea, S. ramosum*
4	12–15	0.5	100	gravel, stones	30 [2]	*Typha latifolia*
5	12	1.0	200	sand, stones	30 [2]	*N. lutea, P. australis*
6	12–15	1.0	2000	sand, gravel	30 [2]	*N. lutea, P. australis*
7	15	0.5	100	gravel	no plants	–
8	20	1.0	2000	sand, stones, mud	30 [2]	*Carex* sp., *Utricularia vulgaris*
9	15	1.0	25000	gravel, stones, mud	80 [1]	*N. lutea, P. australis, A. calamus, Carex* sp., *Sagittaria sagittifolia, Fontinalis antipyretica, Ceratophyllum demersum*
10	12–20	1.0	200	sand, mud	20 [2]	*N. lutea, P. australis*

Bivalves of the family Unionidae were determined to species level, their age was assessed and size was measured in the field, and then live bivalves were released. Other live molluscs were transported to the laboratory, identified and weighed as fast as possible. Most live molluscs were then released into the river. Only a small part of the material was preserved in 50% alcohol. Fresh biomass of unionid bivalves was calculated, considering species composition and size structure based on rich data from 1989 (LEWANDOWSKI 1996a).

The dominance index was calculated according to the formula: $D=100S_a/S$, where S_a – sum of all individuals of a given species in all samples, S – sum of individuals of all species in all samples. Frequency was calculated with the formula: $C=100n_a/N$, where n_a – number of samples with species a, N – number of all samples. Similarity of species composition S (MARCZEWSKI & STEINHAUS 1959) between particular sites was estimated with the equation: $S=w/(a+b–w)$, where a, b – number of species in sites A and B, respectively, w – number of species common to sites A and B. Species diversity was determined from the Shannon-Weaver index (MARGALEF 1958): $H'=-\sum p_i \ln p_i$, where p_i – relative abundance of the i^{th} species.

Normality of distribution was tested with the Shapiro-Wilk test (ŁOMNICKI 1995). To compare temporal changes in the concentration of nitrogen, phosphorus and organic matter, in the number of species, their density and biomass and the species diversity index we used non-parametric Wilcoxon's test (ŁOMNICKI 1995). Spearman linear correlation was used to test the relationship between the species diversity index and the number of species and their biomass. ANOVA was used to test the effect of the concentration of nitrogen, phosphorus and organic matter, of the bottom coverage by vegetation, type of the bottom and the distance from a lake on the number of species.

RESULTS

In both study years the content of total phosphorus in the bottom sediments varied from 0.20 to 0.59 mg/g dry weight and that of total nitrogen – from 0.10 to 1.19 mg/g dry weight. The content of organic matter ranged from 0.57 to 29.70% (Table 2). Statistically significant differences between the study years were observed for the content of phosphorus (Wilcoxon test, N=40, Z=3.03, $p<0.05$) but not for nitrogen (Wilcoxon test, N=40, Z=0.36, p=0.722) or organic matter (Wilcoxon test, N=20, Z=0.84, p=0.401).

A total of 38 mollusc species were recorded (21 species of snails and 17 species of bivalves) (Tables 3 and 4). No significant differences were found in the number of species between the years (Wilcoxon test, N=10, Z=0.49, p=0.624). *Bithynia tentaculata*, *Viviparus contectus, Radix balthica*, *Sphaerium corneum*, *Dreissena polymorpha*, *Anodonta anatina*, *Unio pictorum* and *U. tumidus* were noted along the whole river length. Common species, found only in some river sections, were: *Theodoxus fluviatilis* (not found in the middle

Table 2. Chemical characteristics of bottom sediments in the Krutynia in 2008–2009

Sites	N (mg/g dry wt.)		P (mg/g dry wt.)		Organic matter (% dry wt.)	
	2008	2009	2008	2009	2008	2009
1	0.34–0.66	0.47–0.65	0.22–0.30	0.25–0.31	1.11–1.16	1.25–1.49
2	0.21–1.02	0.27–0.59	0.44–0.55	0.33–0.46	1.01–1.43	1.21–1.50
3	0.18–0.59	0.28–0.40	0.27–0.45	0.20–0.26	0.91–1.02	1.07–1.15
4	0.31–0.53	0.52–0.78	0.39–0.52	0.30–0.34	1.54–1.74	1,47–2.21
5	0.17–0.66	0.24–0.26	0.30–0.57	0.21–0.27	0.60–1.50	0.67–0.83
6	0.23–0.45	0.22–0.24	0.25–0.33	0.23–0.27	1.01–1.07	0.57–0.66
7	0.10–0.23	0.23–0.42	0.32–0.42	0.33–0.44	0.59–0.67	1.12–1.40
8	0.39–1.15	0.30–0.35	0.32–0.38	0.20–0.25	1.63–2.97	0.87–1.03
9	0.53–1.19	0.75–0.92	0.44–0.49	0.35–0.59	3.10–7.00	22.2–29.7
10	0.12–0.39	0.40–0.43	0.28–0.38	0.35–0.47	0.60–0.68	0.29–1.07

section) and *Potamopyrgus antipodarum* (present in the upper and middle sections). The least frequent were *Viviparus viviparus*, *Stagnicola palustris*, *S. corvus*, *Planorbis planorbis*, *P. carinatus*, *Acroloxus lacustris*, *Pseudanodonta complanata*, *Sphaerium rivicola*, *Pisidium crassum* and *Musculium lacustre*. Only empty shells of *Gyraulus albus* were found. Dominant species were: *T. fluviatilis* (c. 26%), *B. tentaculata* (c. 20%) and *U. tumidus* (c. 13%) (Table 3). The number of species in individual sites ranged from 4 to 15 (Fig. 2).

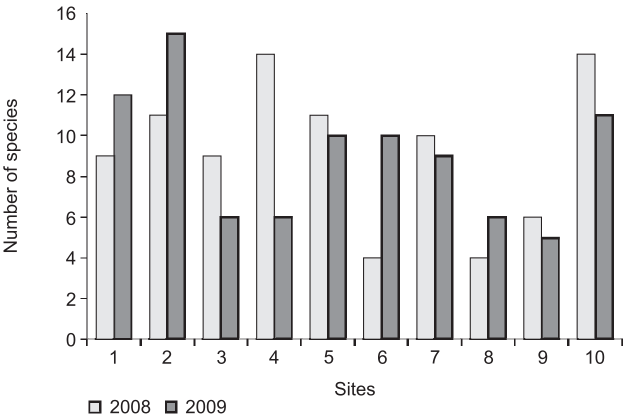

Fig. 2. Number of mollusc species in particular sites of the Krutynia

Theodoxus fluviatilis reached the highest densities, locally exceeding 200 indiv./m^2. From among bivalves *Dreissena polymorpha* formed populations of the density of over 40 indiv./m^2, like *Sphaerium corneum*. Relatively high densities were observed for unionid bivalves. *Unio tumidus* reached the density of several dozen indiv./m^2 (maximum 65 indiv./m^2) in the middle and lower sections of the river. The presence of *Anodonta cygnea* in both lower and upper parts of the river, at a density of 12 indiv./m^2, is noteworthy. Total mollusc densities in particular sites ranged from 25 indiv./m^2 (site 6 in 2008) to ca. 550 indiv./m^2 (site 2 in 2009) (Fig. 3). Biomass varied from c. 13 to over 2,500 g/m^2 (Fig. 4). In the latter case, the large biomass was associated with unionid bivalves which comprised over 99% of the total biomass. Adult individuals of a length between 6 and 7 cm dominated in this group of bivalves, and the age of the oldest individuals was estimated at 7–9 years. No significant differences were found in density (Wilcoxon test, N=10, Z=2.39, p=0.017) and biomass (Wilcoxon test, N=10, Z=0.05, p=0.959) between the two study years.

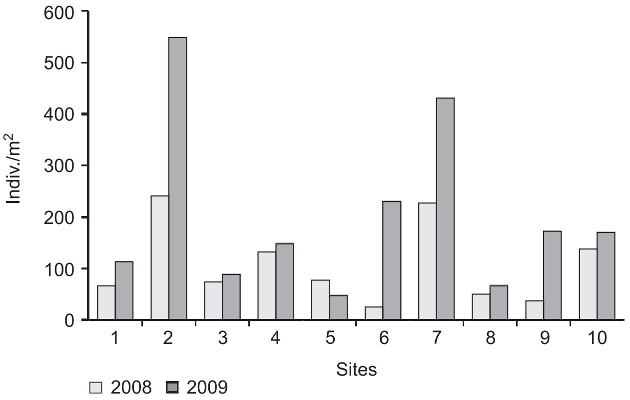

Fig. 3. Density (indiv./m^2) of molluscs in particular sites of the Krutynia

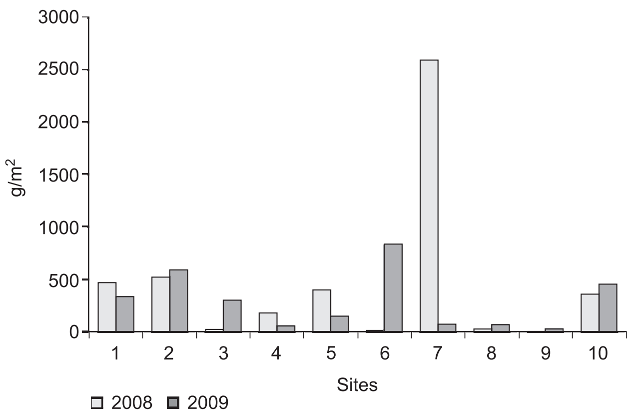

Fig. 4. Biomass (g/m^2) of molluscs in particular sites of the Krutynia

Table 3. Molluscs recorded from the Krutynia in 2008–2009; 0 – empty shells

No.	Species	2008			2009		
		N	Frequency (%)	Dominance (%)	N	Frequency (%)	Dominance (%)
	Gastropoda						
1	*Theodoxus fluviatilis* (Linnaeus, 1758)	278	50	25.8	462	50	26.3
2	*Viviparus viviparus* (Linnaeus, 1758)	–	–	–	6	10	0.3
3	*Viviparus contectus* (Millet, 1813)	44	60	4.1	36	40	2.1
4	*Valvata piscinalis* (O. F. Müller, 1774)	3	20	0.3	38	50	2.2
5	*Potamopyrgus antipodarum* (J. E. Gray, 1843)	83	50	7.7	278	60	15.8
6	*Bithynia tentaculata* (Linnaeus, 1758)	217	90	20.1	300	80	17.1
7	*Galba truncatula* (O. F. Müller, 1774)	–	–	–	2	10	0.1
8	*Stagnicola palustris* (O. F. Müller, 1774)	1	10	0.1	–	–	–
9	*Stagnicola corvus* (Gmelin, 1791)	–	–	–	8	10	0.5
10	*Radix auricularia* (Linnaeus, 1758)	11	30	1.0	14	20	0.8
11	*Radix balthica* (Linnaeus, 1758)	17	60	1.5	12	30	0.7
12	*Lymnaea stagnalis* (Linnaeus, 1758)	6	40	0.5	18	30	1.0
13	*Planorbis planorbis* (Linnaeus, 1758)	1	10	0.1	–	–	–
14	*Planorbis carinatus* O. F. Müller, 1774	2	10	0.2	–	–	–
15	*Anisus leucostomus* (Millet, 1813)	3	30	0.3	–	–	–
16	*Anisus vortex* (Linnaeus, 1758)	–	–	–	12	20	0,7
17	*Bathyomphalus contortus* (Linnaeus, 1758)	2	20	0.2	–	–	–
18	*Gyraulus albus* (O. F. Müller, 1774)	0	–	–	0	–	–
19	*Planorbarius corneus* (Linnaeus, 1758)	20	40	1.8	6	20	0.3
20	*Ancylus fluviatilis* O. F. Müller, 1774	13	20	1.2	–	–	–
21	*Acroloxus lacustris* (Linnaeus, 1758)	–	–	–	4	10	0.2
	Bivalvia						
22	*Unio pictorum* (Linnaeus, 1758)	26	40	2.4	27	60	1.5
23	*Unio tumidus* Philipsson, 1788	138	40	12.8	223	60	12.7
24	*Unio crassus* Philipsson, 1788	–	–	–	6	30	0.3
25	*Anodonta cygnea* (Linnaeus, 1758)	8	20	0.7	14	20	0.8
26	*Anodonta anatina* (Linnaeus, 1758)	62	60	5.8	42	50	2.4
27	*Pseudanodonta complanata* (Rossmässler, 1835)	4	10	0.4	–	–	–
28	*Dreissena polymorpha* (Pallas, 1771)	71	50	6.6	54	40	3.1
29	*Sphaerium corneum* (Linnaeus, 1758)	44	50	4.1	158	80	9.0
30	*Sphaerium rivicola* (Lamarck, 1818)	1	10	0.1	–	–	–
31	*Musculium lacustre* (O. F. Müller, 1774)	–	–	–	2	10	0.1
32	*Pisidium amnicum* (O. F. Müller, 1774)	3	30	0.3	10	10	0.6
33	*Pisidium henslowanum* (Sheppard, 1823)	4	20	0.4	6	30	0.3
34	*Pisidium supinum* A. Schmidt, 1851	2	10	0.2	2	10	0.1
35	*Pisidium subtruncatum* Malm, 1855	1	10	0.1	6	30	0.3
36	*Pisidium nitidum* Jenyns, 1832	4	10	0.4	4	10	0.2
37	*Pisidium crassum* Stelfox, 1918	4	10	0.4	–	–	–
38	*Pisidium casertanum* (Poli, 1791)	4	10	0.4	8	20	0.5

Table 4. Molluscs recorded from particular sites in the Krutynia in 2008–2009; × – live molluscs, o – empty shells

No.	Species	Year	Sites									
			1	2	3	4	5	6	7	8	9	10
							Gastropoda					
1	*Theodoxus fluviatilis*	2008		×					×	×	×	×
		2009		×					×	×	×	×
2	*Viviparus viviparus*	2008							o			o
		2009										×
3	*V. contectus*	2008		×	×	×	×		o	×	o	×
		2009		×	×			×	o	×		
4	*Valvata piscinalis*	2008			×		×					
		2009	×	×	×	×	×					o
5	*Potamopyrgus antipodarum*	2008	×	×		×	×		×			
		2009	×	×		×	×	×	×			
6	*Bithynia tentaculata*	2008	×	×	×	×	×	×		×	×	×
		2009	×	×	×	×	×	×		o	×	×
7	*Galba truncatula*	2008										
		2009		×								
8	*Stagnicola palustris*	2008									×	
		2009										
9	*S. corvus*	2008										
		2009	×			×	×			o		
10	*Radix auricularia*	2008				×	×		×			
		2009			o	×	o	×				o
11	*R. balthica*	2008	×			×		×	×		×	×
		2009	×							×		×
12	*Lymnaea stagnalis*	2008	×	×		×						×
		2009	×					×		×		o
13	*Planorbis planorbis*	2008				×						o
		2009										
14	*P. carinatus*	2008										×
		2009	o	o		o	o					
15	*Anisus leucostomus*	2008			×			×			×	o
		2009										
16	*A. vortex*	2008										
		2009				o				×	×	o
17	*Bathyomphalus contortus*	2008			×	×						
		2009	o	o			o					
18	*Gyraulus albus*	2008		o								
		2009	o	o								
19	*Planorbarius corneus*	2008	×			×		×		o		×
		2009	×				×		o	o		
20	*Ancylus fluviatilis*	2008	×				×					
		2009										
21	*Acroloxus lacustris*	2008										
		2009										×

No.	Species	Year	Sites									
			1	2	3	4	5	6	7	8	9	10
			Bivalvia									
22	*Unio pictorum*	2008	o	×		×			×			×
		2009	o	×		×	×	×	×			×
23	*U. tumidus*	2008				×	×		×	o		×
		2009	×	×	o		×	×	×			×
24	*U. crassus*	2008										
		2009		×			×		×			
25	*Anodonta cygnea*	2008	×	×						o		
		2009	×		×				o			
26	*A. anatina*	2008	×	×	o	×	×		×			×
		2009	×	×	o	o	×	×				×
27	*Pseudanodonta complanata*	2008										×
		2009							o			
28	*Dreissena polymorpha*	2008		×	×	×	×		×			
		2009	×	×				o	×			×
29	*Sphaerium corneum*	2008	×		×				×	×		×
		2009	×	×	×	×	×		×		×	×
30	*S. rivicola*	2008									×	
		2009										
31	*Musculium lacustre*	2008										
		2009	×									
32	*Pisidium amnicum*	2008		×	×		×					
		2009						×				o
33	*P. henslowanum*	2008					×					×
		2009		×			×					×
34	*P. supinum*	2008							×			
		2009							×			
35	*P. subtruncatum*	2008										×
		2009		×				×	×			
36	*P. nitidum*	2008			×							
		2009			×							
37	*P. crassum*	2008				×						
		2009										
38	*P. casertanum*	2008		×								
		2009		×							×	

Species diversity was the greatest in site 2 in 2008 (H'=3.77) and in site 7 in 2009 (H'=4.68). The lowest Shannon-Weaver indices were noted in both years in site 5 (H'=1.19 and 1.74). No statistically significant differences were found in the species diversity between the two study years (N=10, Z=1.68, p=0.093). There was no correlation between the species diversity index and the number of species (2008: r_s=0.38, p=0.278; 2009: r_s=0.31, p=0.387) and their biomass (2008: r_s=0.46, p=0.174; 2009: r_s=–0.16, p=0.651).

Similarity indices calculated for 2008 showed the greatest similarity of species composition between sites 4 and 7 (S=0.50) and the smallest between sites 2 and 6 and between 5 and 6 (S=0.07) (Table 5). In 2009 the greatest similarity was found between sites 2 and 7 (S=0.50) and no similarity – between sites 4 and 8 and 5 and 8 (Table 6).

Concentrations of nitrogen, phosphorus and organic matter in the bottom sediments did not affect the number of species in particular sites (ANOVA; $F_{3,16}$=0.44, p=0.727). The number of species did not

Table 5. Similarity between sites in 2008

	1	2	3	4	5	6	7	8	9	10
1	X	0.33	0.12	0.35	0.25	0.30	0.27	0.18	0.15	0.35
2	0.33	X	0.33	0.47	0.37	0.07	0.31	0.25	0.13	0.31
3	0.12	0.33	X	0.15	0.33	0.18	0.12	0.30	0.15	0.15
4	0.35	0.47	0.15	X	0.39	0.20	0.50	0.12	0.11	0.33
5	0.25	0.37	0.33	0.39	X	0.07	0.23	0.15	0.06	0.25
6	0.30	0.07	0.18	0.20	0.07	X	0.08	0.14	0.43	0.20
7	0.27	0.31	0.12	0.50	0.23	0.08	X	0.17	0.14	0.33
8	0.18	0.25	0.30	0.12	0.15	0.14	0.17	X	0.25	0.28
9	0.15	0.13	0.15	0.11	0.06	0.43	0.14	0.25	X	0.18
10	0.35	0.31	0.15	0.33	0.25	0.20	0.33	0.28	0.18	X

< 0.20	0.20–0.40	> 0.40

Table 6. Similarity between sites in 2009

	1	2	3	4	5	6	7	8	9	10
1	X	0.35	0.28	0.28	0.47	0.29	0.23	0.12	0.13	0.35
2	0.35	X	0.23	0.31	0.35	0.39	0.50	0.10	0.25	0.44
3	0.28	0.23	X	0.33	0.23	0.14	0.07	0.09	0.22	0.13
4	0.28	0.31	0.33	X	0.45	0.33	0.25	0	0.22	0.21
5	0.47	0.35	0.23	0.45	X	0.33	0.36	0	0.15	0.31
6	0.29	0.39	0.14	0.33	0.33	X	0.27	0.17	0.07	0.17
7	0.23	0.50	0.07	0.25	0.36	0.27	X	0.07	0.17	0.33
8	0.12	0.10	0.09	0	0	0.17	0.07	X	0.22	0.13
9	0.13	0.25	0.22	0.22	0.15	0.07	0.17	0.22	X	0.23
10	0.35	0.44	0.13	0.21	0.31	0.17	0.33	0.13	0.23	X

< 0.20	0.20–0.40	> 0.40

depend on the degree of bottom coverage by vegetation (ANOVA; $F_{3,9}$=1.27, p=0.423) despite the fact that two extreme situations were represented (bottom almost wholly plant-covered as opposed to vegetation-free substratum), or on the type of substratum (ANOVA; $F_{2,9}$=0.36, p=0.723). The only factor significantly affecting the number of species was the distance of the sampling site from a lake (ANOVA; $F_{1,9}$=10.89, p=0.046).

DISCUSSION

The species richness (38) and species composition of the malacofauna in the Krutynia recorded in 2008–2009 did not differ much from the earlier data. Fifty years previously, BERGER (1960, 1962) found five species more, i. e. 24 species of snails and 19 species of bivalves. A similar number of species (44) was reported for the beginning of the 20th century by HILBERT (1913). In his list HILBERT (1913) included as separate species what is now regarded as forms or synonyms: *Paludina diluvianiformis* (a form of *Viviparus contectus*), *Valvata antiqua* (a form of *Valvata piscinalis*), *Limnaea ovata* (or *L. peregra* – *Radix balthica*), *Anodonta piscinalis* (a synonym of *A. anatina* also recorded by that author), *Sphärium mamillanum* (a form of *Sphaerium corneum*). The actual number of species recorded by that author was thus only 39 (Table 7).

As many as 23 species were recorded in all three compared study periods, and another 11 found in 2008–2009 were also recorded in one of the earlier papers. It can be thus assumed that 33 mollusc species

Table 7. Species composition of molluscs in the Krutynia according to various sources

No.	Species	Hilbert 1913	Berger 1960, 1962	Own study
		Gastropoda		
1	*Theodoxus fluviatilis* (Linnaeus, 1758)	×	×	×
2	*Viviparus viviparus* (Linnaeus, 1758)	×	×	×
3	*Viviparus contectus* (Millet, 1813)	×	×	×
4	*Valvata piscinalis* (O. F. Müller, 1774)	×	×	×
5	*Valvata cristata* O. F. Müller, 1774	×	×	
6	*Valvata macrostoma* Mörch, 1864	×		
7	*Potamopyrgus antipodarum* (J. E. Gray, 1843)			×
8	*Marstoniopsis scholtzi* (A. Schmidt, 1856)	×	×	
9	*Bithynia tentaculata* (Linnaeus, 1758)	×	×	×
10	*Bithynia leachii* (Sheppard, 1823)	×	×	
11	*Physa fontinalis* (Linnaeus, 1758)	×	×	
12	*Galba truncatula* (O. F. Müller, 1774)	×		×
13	*Stagnicola palustris* (O. F. Müller, 1774)	×		×
14	*Stagnicola corvus* (Gmelin, 1791)			×
15	*Radix auricularia* (Linnaeus, 1758)	×	×	×
16	*Radix balthica* (Linnaeus, 1758)	×	×	×
17	*Radix ampla* (W. Hartmann, 1821)	×		
18	*Myxas glutinosa* (O. F. Müller, 1774)		×	
19	*Lymnaea stagnalis* (Linnaeus, 1758)	×	×	×
20	*Planorbis planorbis* (Linnaeus, 1758)	×	×	×
21	*Planorbis carinatus* O. F. Müller, 1774	×	×	×
22	*Anisus leucostomus* (Millet, 1813)	×		×
23	*Anisus vortex* (Linnaeus, 1758)	×	×	×
24	*Anisus vorticulus* (Troschel, 1834)		×	
25	*Anisus spirorbis* (Linnaeus, 1758)	×		
26	*Anisus septemgyratus* (Rossmässler, 1835)	×		
27	*Bathyomphalus contortus* (Linnaeus, 1758)	×		×
28	*Segmentina nitida* (O. F. Müller, 1774)	×		
29	*Gyraulus albus* (O. F. Müller, 1774)		×	×
30	*Gyraulus laevis* (Alder, 1838)		×	
31	*Gyraulus crista* (Linnaeus, 1758)	×	×	
32	*Hippeutis complanatus* (Linnaeus, 1758)	×	×	
33	*Planorbarius corneus* (Linnaeus, 1758)	×	×	×
34	*Ancylus fluviatilis* O. F. Müller, 1774	×	×	×
35	*Acroloxus lacustris* (Linnaeus, 1758)		×	×
		Bivalvia		
36	*Unio pictorum* (Linnaeus, 1758)	×	×	×
37	*Unio tumidus* Philipsson, 1788	×	×	×
38	*Unio crassus* Philipsson, 1788	×	×	×
39	*Anodonta cygnea* (Linnaeus, 1758)	×	×	×
40	*Anodonta anatina* (Linnaeus, 1758)	×	×	×
41	*Pseudanodonta complanata* (Rossmässler, 1835)	×	×	×
42	*Dreissena polymorpha* (Pallas, 1771)	×	×	×

No.	Species	Hilbert 1913	Berger 1960, 1962	Own study
43	*Sphaerium corneum* (Linnaeus, 1758)	×	×	×
44	*Sphaerium rivicola* (Lamarck, 1818)			×
45	*Musculium lacustre* (O. F. Müller, 1774)			×
46	*Pisidium amnicum* (O. F. Müller, 1774)	×	×	×
47	*Pisidium henslowanum* (Sheppard, 1823)		×	×
48	*Pisidium supinum* A. Schmidt, 1851		×	×
49	*Pisidium milium* Held, 1838		×	
50	*Pisidium subtruncatum* Malm, 1855		×	×
51	*Pisidium nitidum* Jenyns, 1832		×	×
52	*Pisidium crassum* Stelfox, 1918		×	×
53	*Pisidium obtusale* (Lamarck, 1818)	×		
54	*Pisidium casertanum* (Poli, 1791)	×	×	×
55	*Pisidium hibernicum* Westerlund, 1894		×	
56	*Pisidium pulchellum* Jenyns, 1832		×	
57	*Pisidium moitessierianum* Paladilhe, 1866		×	
	total	39	43	38

have been present in the Krutynia permanently for at least several dozen years.

Six of the species listed in the two earlier papers were not recorded in this study. These included *Valvata cristata*, *Marstoniopsis scholtzi*, *Bithynia leachii*, *Physa fontinalis*, *Gyraulus crista* and *Hippeutis complanatus*. Most of them were described by BERGER (1960) as infrequent (only empty shells of *H. complanatus* were found in the Krutynia). Four other species (*Potamopyrgus antipodarum*, *Stagnicola corvus*, *Sphaerium rivicola* and *Musculium lacustre*) were recorded only in this study.

Neither HILBERT (1913) nor BERGER (1960) specified in which part of the river they collected their material. Detailed information on the studies in the lower section of the Krutynia was given by BERGER (1962) in his paper on the occurrence of bivalves of the family Sphaeriidae.

The malacofauna of the Krutynia is rich, though some rivers in Poland hold more species, for example the Grabia with its 50 species (PIECHOCKI 1969) or the Pasłęka with 43 species (PIECHOCKI 1972). The high species richness in the former case may result from the fact that the studies involved not only the river but also the stagnant water bodies in its floodplain. We analysed only the proper river, without the lakes it flows through. Differences in species richness between rivers of similar length may result from their water quality.

The content of nitrogen, phosphorus and organic matter in bottom sediments of the Krutynia was relatively small and similar to that in other lowland rivers (e.g. SVEDESEN et al. 1993, CLARKE & WHARTON 2001, KORYCIŃSKA & KRÓLAK 2007). Slightly higher content of nitrogen and organic matter in sites 8 and 9 resulted from the character of substratum, which, apart from sand, stones and gravel, contained large amounts of mud accumulating in stagnant river coves.

The correlation between the content of nitrogen, phosphorus, and organic matter in bottom sediments and the number of species was not statistically significant. Chemical parameters do not always affect significantly the qualitative and quantitative composition of the malacofauna. This was confirmed by the studies of STRZELEC (1993) carried out in several dozen anthropogenic water bodies in Silesia. From among many analysed physical and chemical parameters of the water (pH, total hardness Ca^{2+}, Cl^{-}, Fe^{2+}, N-NH_4, N-NO_3, BOD_5) only the content of Mg^{2+} and SO_4^{2-} seemed to affect the number of species (STRZELEC 1993).

Individual sites in the Krutynia River differed, apart from chemical properties of bottom sediments, also in the type of substratum, plant cover and the distance from the nearby lake. Only the distance from the lake outlet appeared to be significant for species richness. The sites located close to lakes were characterised by higher richness and diversity than those situated far from lakes. A maximum of 10 species was noted in the sites situated far from lakes. The sites closer to lakes had a much richer malacofauna, with the number of species often exceeding 10. These sites may be regarded as ecotone habitats where both riverine and lacustrine species co-exist (e.g. WOTTON 1988, RICHARDSON & MACKAY 1991, LEWANDOWSKI 1996b).

To obtain a comprehensive picture of the malacofauna of the Krutynia, also the lakes should be studied. The river flows through 17 lakes and this may undoubtedly modify species composition of molluscs in the river itself.

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