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Malacofauna in the watercourses of the Suwalski Landscape Park (northeastern Poland)[x]

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A b s t r a c t - The upper sections of the watercourses were inhabited by small numbers of six taxa of Gastropoda. An increase in the number of taxa were observed in sections in contact with flow-through lakes. In the watercourses there occurred species typical for the lakes of this area. Only *Ancylus fluviatilis* (Gastropoda) and *Unio crassus* (Bivalvia) were found solely in the running waters.

K e y w o r d s : Mollusca, taxonomic composition, watercourses, ecotones.

1. Introduction

The watercourses in the Suwalski Landscape Park flow through an area of young glacial relief of the territory. On their way they find a great number of flow-through lakes with rich and differentiated malacofauna. A comparison of the malacofauna of the flow-through lakes and those without outflow in the Suwalski Landscape Park has shown that the watercourses do not contribute to the displacement of Gastropoda between the water bodies (K o ł o d z i e j c z y k 1989).

The aim of the present work was to identify the malacofauna of a few small lowland rivers remaining in contact with numerous

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lakes and flowing through an area of differentiated landscape and hydrology.

2. Study area, material, and methods

The molluscs were collected in September 1984, May, June, and September 1985 and in September 1986 on the territory of the Suwalski Landscape Park, once at each of the 31 stations (fig. 1, Table I). 6 stations were located above the first flow-through lakes, 7 at places where the rivers entered the lakes, 13 at places of the rivers' outflow, and 5 in between the flow-through lakes. Samples were collected along a section of 10-20 m, to a depth of about 1 m, in most cases from the entire cross-section of the watercourse because of their small depth. The molluscs were collected from aquatic plants, stones, and underwater pieces of wood. From the sediments, collected using a bottom scraper, empty shells were also extracted. At each of the stations the material was collected until the moment when in several successive samples new species ceased to appear.

The collected molluscs and shells were determined using the keys of P i e c h o c k i (1979) and U r b a ń s k i (1957). The snails were

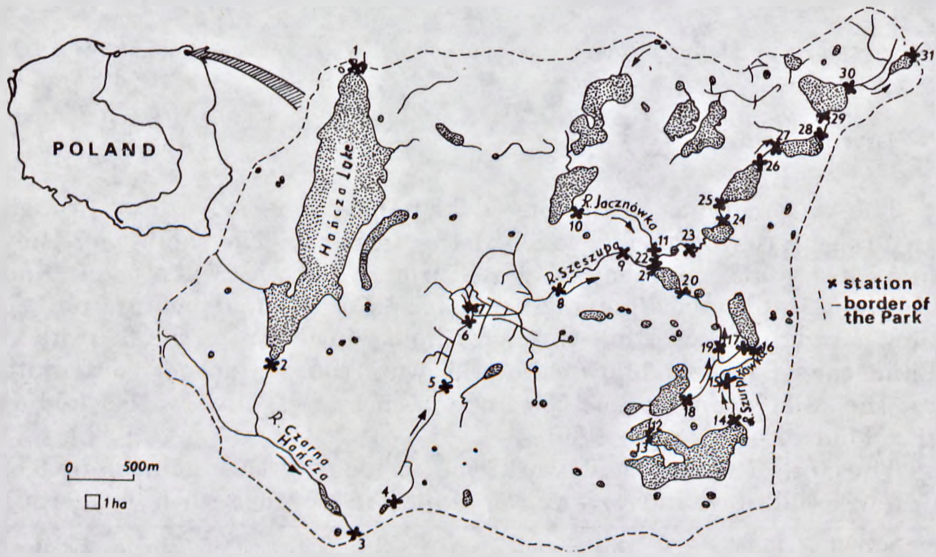

Fig. 1. Map of the Suwalski Landscape Park with sampling stations

Table I. Characteristics of the sampling stations in the watercourses of the Suwalski Landscape Park. Location: P - above the flow-though lakes; D - inflow; W - outflow; M - between the successive flow-through lakes. Current: + - rapid; • - slow. Bottom: + - hard (stones, gravel, sand); • - soft (mud). Macrophytes: + - present; • - absent.

River system	Station	Location	Ca mg dm^{-3}	Conductivity mS cm^{-1}	Current	Bottom	Macrophytes
Czarna	1	D	60	336	•	•	•
Hańcza	2	W	40	198	+	+	•
	3	W	—	—	+	+	+
Szeszupa,	4	P	—	—	•	+	•
upper	5	P	—	—	+	+	•
section	6	P	—	—	+	+	•
	7	P	—	—	•	+	•
	8	P	—	—	+	+	+
	9	P	—	—	+	+	•
Jacznówka	10	W	45	275	•	•	+
	11	M	—	—	+	+	•
Szurpi-	12	W	45	—	+	+	•
łówka	13	D	45	—	+	+	+
and its	14	W	40	—	+	+	+
tributaries	15	M	—	—	+	+	•
	16	D	42	—	•	•	+
	17	W	46	—	•	+	•
	18	W	42	—	+	+	•
	19	M	—	—	+	+	•
	20	D	45	—	+	+	•
	21	W	42	—	•	•	•
Szeszupa,	22	M	—	—	+	+	•
middle	23	M	58	280	+	+	+
section	24	W	56	290	•	•	+
	25	D	60	290	•	•	+
	26	W	58	280	+	+	+
	27	D	55	280	+	+	+
	28	W	56	280	•	•	+
	29	D	56	290	•	•	+
	30	W	54	287	+	•	+
	31	W	59	295	+	+	+

determined according to the conchological features, hence the species within the subgenus *Radix* Montf., 1810, *Galba* Schr., 1803 and genus *Gyraulus* Charp., 1837 were not determined, nor were those within the family Sphaeriidae. The material was supplemented by data by Lewandowski (1990) concerning the Unionidae from the River Szeszupa.

The frequency of the particular taxa was also calculated, this expressing the ratio between the percentage of stations at which the representatives of a given taxon were found and in relation to the total number of stations. The significance of the differences in the number of species was assessed using the Mann-Whitney U-test and in the frequency of species the Wilcoxon signed ranks test (Sokal, Rohlf 1973).

The data concerning the chemical mechanisms of the water were taken from the study by Hillbricht-Ilkowska and Wiśniewski (1991), and those about the malacofauna of the lakes of this area from a study by Kołodziejczyk (1989).

3. Results

3.1. General characteristics of the malacofauna of the flows

Most of the watercourses of the Suwalski Landscape Park have a similar calcium concentration and elektrolitic conductivity (Table I). pH values were not measured in the watercourses; in the flow-through lakes these values were close to 7. On the other hand, the environmental conditions in the various sections of the flows were different. The upper sections of the River Szeszupa is a narrow stream flowing through meadows. In the next section the velocity of the current distinctly increases and the flow resembles a mountain stream (gravel or stony bottom, typical rheophilic macrofauna). A very rapid current is also characteristic of some sections of the Rivers Szurpiłówka and Czarna Hańcza. The other sections are deeper, the current flowing slowly, and the bottom muddy. The places of outflow from and occasionally also of inflow to the lake were often overgrown with macrophytes (Table I).

In the watercourses of the Suwalski Landscape Park altogether 744 live individuals and 497 empty shells were collected, belonging to 18 taxa of Gastropoda and 7 of Bivalvia (Table II). At five stations no live molluscs were found. At the other stations from 1 to 9 live molluscs were collected and from 1 to 13 taxa, including also empty shells (Table II).

Table II. Molluscs in the watercourses of the Suwalski Landscape Park at Station 1-31. + - live animals; • - empty shells

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Theodoxus fluvialitis (L.)														+																	
Viviparus contectus (L.)										+							+				•			+	+	+	•	+	+	+	+
Valvata cristata O. F. Müll.																•													•		
Valvata piscinalis (O.F. Müll.)																														•	
Bithynia tentaculata (L.)		•	+							+		+			+		•	+			+			+	+	+	+	+	+	+	+
Bithynia leachi (Shepp.)	+																														•
Physa fontinalis Drap.			+					+	+															+	+						
Lymnaea stagnalis (L.)																	+														
Lymnaea (Radix) sp.	+		+							+		+	+										+	•		+	+	+	+	+	+
Lymnaea (Galba) sp.					•		+	+				+	+											+		+			•		
Planorbis carinatus O.F. Müll.										+						+								•				•		•	•
Anisus vortex (L.)					•					+																					•
Anisus contortus (L.)										+																				•	
Gyraulus sp.					•				•																					•	•
Segmentina nitida (O.F. Müll.)																										•					
Planorbarius corneus (L.)										+						+	+														+
Ancylus fluvialitis O.F. Müll.									+															+							
Acroloxus lacustris (L.)								+			+						+					+							+	•	
Dreissena polymorpha (Pall.)		+								+				+			+	+					+			+	+	+		+	+
Unio tumidus Retz.																	•				+					•			+	•	•
Unio pictorum L.										•																+			+		+
Unio crassus Retz.											•											+	+	+			+	+			
Anodonta complanata Rossm.											+										+		+								
Anodonta anatina L.																	•				+	+	+			•			+		•
Sphaeriidae	+	+								+		+	+	+	+		•	+	•		+	•	•	+	+	+	+	+	+	+	+
Total live	3	2	3	0	0	0	1	3	2	9	2	4	3	3	2	2	5	3	0	0	5	3	5	7	4	7	5	6	8	5	6
live + empty shells	3	3	3	0	3	0	1	3	2	10	3	4	3	3	2	3	9	3	1	0	6	4	6	9	4	10	6	7	10	11	13

The frequency of the particular taxa was low (Table III), the highest being that of *Bithynia tentaculata* (50%). Species from the family Sphaeriidae were found at 70% but 8 species only at 5% of the examined stations.

The particular taxa have been ordered according to their preference for running waters (Table III). This is of importance for taxa of considerable frequency at least in one of the environments compared. *Unio crassus* and *Ancylus fluviatilis* were found only in watercourses. *Dreissena polymorpha* and *Unio tumidus* were found slightly more often and Sphaeriidae, *Anodonta anatina*, and *A. complanata* only a little less frequently in watercourses than in standing waters.

Table III. Molluscs in the watercourses of the Suwalski Landscape Park. Ranking according the preference for running waters. F(%) - frequency; F(%) in lakes - after Kolodziejczyk (unpubl. data)

Taxa	F(%) in watercourses / F(%) in lakes	F(%) in watercourses
Unio crassus	only in watercourses	20
Ancylus fluvialitis	only in watercourses	5
Anisus contortus	1.5	5
Dreissena polymorpha	1.2	35
Unio tumidus	1.2	20
Sphaeriidae	0.8	70
Anodonta antina	0.8	25
— *complanata*	0.8	10
Theodoxus fluvialitis	0.7	5
Bithynia tentaculata	0.6	50
Lymnaea (Radix) sp.	0.5	40
Viviparus contectus	0.5	35
Acroloxus lacustris	0.5	20
Unio pictorum	0.5	15
Valvata cristata	0.5	5
Lymnaea (Galba) sp.	0.4	25
Planorbis carinatus	0.4	20
Physa fontinalis	0.4	15
Bithynia leachi	0.3	5
Planorbarius corneus	0.2	15
Gyraulus sp.	0.2	10
Anisus vortex	0.2	10
Segmentina nitida	0.1	5
Valvata piscinalis	0.1	5
Lymnaea stagnalis	< 0.1	5

3.2. Comparison of the malacofauna of the lotic and lenitic environments

The total number of taxa in lotic environments was smaller than in lenitic ones with regard to live individuals, but higher for live individuals and empty shells (Table IV). The mean number of taxa of live individuals an that of live individuals and empty shells together did not differ significantly. Apart from species encountered sporadically at the lenitic stations, the frequency of the following was distinctly higher: *Planorbarius corneus, Planorbis carinatus, Viviparus contectus,* Sphaeriidae, *Unio tumidus, Bithynia tentaculata,* and *Lymnaea (Radix)* sp. (Table V). The lenitic stations were significantly richer ($p < 0.005$) in species.

3.3. Comparison of the malacofauna of stations not overgrown and overgrown by vascular plants

The total number of taxa represented both by live individuals and empty shells was higher at stations with macrophytes (Table IV). The mean number of taxa was significantly higher ($p < 0.001$). Apart from the sporadically occurring taxa, the following were found only at stations with vascular plants: *Planorbis carinatus, Unio pictorum, Valvata cristata,* and *Anisus contortus*. The frequency of most of the remaining taxa was higher at stations with macrophytes (Table V). The abundance of species at these stations was significantly greater ($p < 0.005$)).

Table IV. Number of Mollusca taxa in various environments of the watercourses of the Suwalski Landscape Park

Type of environment	Molluscs					
	live			live + empty shells		
	total taxa	$\bar{x}$	range	total taxa	$\bar{x}$	range
Lotic (n=19)	14	2.9	0 - 7	23	4.2	0 - 13
Lenitic (n=12)	19	4.4	0 - 9	20	5.4	0 - 10
Without macrophytes (n=16)	16	2.0	0 - 5	18	2.5	0 - 9
With macrophytes (n=15)	19	5.1	2 - 9	24	6.7	3 - 13

Table V. Frequency (%) of the particular Mollusca taxa in the various environments of the watercourses of the Suwalski Landscape Park (live and empty shells)

Taxa	Type of environment			
	lotic (n=19)	lenitic (n=12)	without macrophytes (n=16)	with macrophytes (n=15)
Theodoxus fluvialitis	5	0	0	5
Viviparus contectus	20	60	10	60
Valvata cristata	0	15	0	15
— *piscinalis*	5	0	0	5
Bithynia tentaculata	40	65	35	65
— *leachi*	5	10	5	5
Physa fontinalis	15	15	5	25
Lymnaea stagnalis	0	10	5	0
Lymnaea (Radix) sp.	35	50	10	75
Lymnaea (Galba) sp.	25	25	20	35
Planorbis carinatus	10	35	0	40
Anisus vortex	10	10	5	15
— *contortus*	5	10	0	15
Gyraulus sp.	15	0	5	15
Segmentina nitida	5	0	0	5
Planorbarius corneus	5	25	5	20
Ancylus fluvialitis	10	0	5	5
Acroloxus lacustris	20	15	20	20
Dreissena polymorpha	30	40	20	55
Unio tumidus	15	25	10	25
— *pictorum*	10	15	0	25
— *crassus*	20	15	10	25
Anodonta complanata	10	10	10	5
— *anatina*	20	25	20	25
Sphaeriidae	45	100	55	80

3.4. Comparison of the malacofauna at stations of various location with respect to the flow-throught lakes

The total number of taxa was smallest at stations preceding the flow-through lakes and greatest at the places of outflow, though smaller than in lakes (Table VI). The mean number of taxa (live animals) was significantly greater in the outflows than at stations preceding the lakes ($p < 0.001$) and between them ($0.025 > p > 0.01$), but smaller than in the flow-through lakes of this area ($0.05 > p > 0.01$). When taking into consideration also the empty shells, it was found that there were significant differences between the mean number of taxa at stations preceding the lakes and in the inflows ($p = 0.05$), at stations preceding the lakes and in

the outflows ($p < 0.001$), and at stations situated in the outflows and between the lakes ($0.025 > p > 0.01$). In the case of the outflows and lakes the difference was significant at $0.025 > p > 0.01$.

Few individuals of Gastropoda (Pulmonata) were found above the flow-through lakes. The most frequent was *Lymnaea (Galba)* sp.. *Anisus vortex* and *Gyraulus* sp. being found only as empty shells. In the inflows there occurred *Prosobranchia* (4 species), as well as 6 taxa of Bivalvia. The most frequently occurring were *Lymnaea (Radix)* sp., *Viviparus contectus, Bithynia tentaculata,* and representatives of Sphaeriidae. Species often found between the flow-through lakes were Sphaeriidae and *Unio crassus,* less frequent were *Anodonta complanata, A. anatina* and *Acroloxus lacustris,* other Gastropoda encountered appearing only at single stations (Table II). In the outflows (Table VII) the frequency of particular taxa was as high as 90%, the most frequently occurring being *B. tentaculata,* Sphaeriidae, *Dreissena polymorpha, V. contectus*, and *Lymnaea (Radix)* sp.

A comparison of the occurrence of individual taxa in the different sections of the watercourses (Table II) may aid in determining their environmental preferences. *Ancylus fluviatilis* did not occur at stations adjoining the lakes, while *Viviparus contectus, Bithynia tentaculata, Lymnaea (Radix)* sp., *Planorbis carinatus* and *Planorbarius corneus* seem to prefer such sections. *Unio crassus* and *Anodonta complanata* are more likely to be found between the lakes, and *B. tentaculata, P. carinatus, P. corneus, Dreissena polymorpha*, and *U. tumidus* in the outflows.

A comparison of the frequency in the watercourses taken as a whole with that in the outflows (Table VII) revealed that this environment is preferred by a great number of the molluscs taxa.

Table VI. Number of Mollusca taxa in environments of various location with respect to the flow-through lakes and in the flow-through lakes of the Suwalski

Stations	Molluscs					
	live			live + empty shells		
	total taxa	$\bar{x}$	range	total taxa	$\bar{x}$	range
Precedings lakes (n=6)	4	1.0	0 - 3	6	1.5	0 - 3
Inflows (n=7)	15	3.4	0 - 7	16	4.1	0 - 10
Outflows (n=13)	19	5.0	3 - 9	23	7.0	3 - 13
Between lakes (n=5)	8	2.4	0 - 5	8	3.2	1 - 6
Lakes connected by watercourses (n=16)	24	7.5	2 - 14	26	11.0	3 - 21

Table VII. Molluscs in the watercourses of the Suwalski Landscape Park. Ranking according to the preference for outflow environments. F(%) - frequency

Taxa	F(%) in outflows / F(%) in watercourses	F(%) in outflows
Anisus contortus	3.0	15
Segmentina nitida	3.0	15
Dreissena polymorpha	2.1	75
Planorbis carinatus	2.0	40
Unio tumidus	2.0	40
Theodoxus fluvialitis	2.0	10
Valvata piscinalis	2.0	10
Bithynia leachi	2.0	10
Lymnaea stasnalis	2.0	10
Bithynia tentaculata	1.8	90
Viviparus contectus	1.7	60
Planorbarius corneus	1.7	25
Unio pictorum	1.7	25
Lymnaea (Radix) sp.	1.5	60
Anisus vortex	1.5	15
Gyraulus sp.	1.5	15
Sphaeriidae	1.3	90
Anodonta anatina	1.2	30
Lymnaea (Galba) sp.	1.0	25
Physa fontinalis	1.0	15
Anodonta complanata	1.0	10
Acroloxus lacustris	0.7	15
Unio crassus	0.7	15
Valvata cristata	0.0	0
Ancylus fluvialitis	0.0	0

4. Discussion

In the watercourses of the Suwalski Landscape Park the number of taxa and the taxonomic composition of the molluscs were similar to those reported for the lakes of this area (Kołodziejczyk 1989), only *Valvata pulchella* Stud., *Marstoniopsis scholtzi* (Schm.), *Lymnaea glutinosa* (O. F. Müll.) and *Anodonta cygnea* Schrot. being absent. Only two species were found to occur exclusively in the watercourses. However, the frequency of the particular taxa was in most cases lower than in the lakes. Because of the lack of species determination in the Sphaeridae family a comparison of the number of taxa with the data obtained by other authors can be made only for Gastropoda. In Pasłęka

Piechocki (1972) discovered the presence of 23, and in Grabia (Piechocki 1969) of 29 species of snails against the presence of 18 taxa established on the studied area. Accurate determination of *Lymnaea (Radix)* sp., *Lymnaea (Galba)* sp., and *Gyraulus* sp., however, might increase the number of the identified species.

Ancylus fluviatilis, which is typical for streams and common, e.g., in Grabia (Piechocki 1969) and Pasłęka (Piechocki 1972), was here reported sporadically. *Theodoxus fluviatilis* characteristic of rivers, dominating, e.g., in Pasłęka (Piechocki 1972), was in the present investigations found only in the outflow of the River Szurpiłowka from Lake Szurpiły. In the watercourses of the Suwalski Landscape Park, similarly as in the lakes of this area (Kołodziejczyk 1989) the typically stagnicolous *Viviparus contectus* is found, whereas *V. viviparus* (L.) is absent. *Dreissena polymorpha*, common in the watercourses here, was reported only from sections connected with the flow-through lakes and from these lakes (Kołodziejczyk 1989). It is probable that in the small, fast flowing streams the planktonic larvae of this bivalve did not find favourable conditions. On the other hand, in the outflows with a rapidly current (e.g., in the outflow of the River Czarna Hańcza from Lake Hańcza) *D. polymorpha* may be very numerous. Such a phenomenon was also observed with respect to the other groups of the filtrator organisms, Spongia, and the larvae of Simulidae. This might be due to the abundance of food in these environments. Hynes (1970) cites data concerning the positive effect on the numbers and biomass of the passively feeding benthos of food carried out from the lake.

In the sections of the watercourses situated under the direct influence of the lakes the malacofauna was richest and its composition was similar to that of the lakes. This might be an indication that ecotones were not formed here. It is more probable that species typical of the lakes found their way into the flows to an extent determined by the environmental conditions. The durability of this settling is an open problem, and the process of its occupation most probably passive. The possibility of active movement of molluscs upstream has rarely been reported in the literature in comparison with data for other groups of the macrofauna (Söderström 1987). It may be one of the reasons for the greater abundance of malacofauna in the outflows than in the inflows.

At stations overgrown with macrophytes the number of molluscs was higher than at those without vegetation. This was observed in various types of waters (Stańczykowska 1960, Soszka

1968, Ökland 1969, Kołodziejczyk 1984a, Brönmark 1985a). Live macrophytes do not constitute good food for the snails (Soszka 1975, Kołodziejczyk, Martynuska 1980, Kołodziejczyk 1984b) but are a convenient substratum for laying egg coccons (Piechocki 1979), a shelter against the predatory vertebrates (Brönmark 1985b), a substratum for periphyton, the principal food of snails (Pieczyńska 1970, Soszka 1975) and for the larvae of *Dreissena polymorpha* (Lewandowski 1982). The simultaneous occurrence of several factors: plants, muddy bottom, and slow current, may also be an advantage. On the other hand, the velocity of the current itself does not seem to be the essential factor determining the occurrence of the molluscs on the examined area. This may be due to the great diversification of the environment and even the presence of plants in the current which are a substratum for the molluscs and locally reduce the current.

Piechocki (1969, 1972, 1979) emphasized the greater differentiation of the species of Mollusca in the upper sections of small lowland rivers in comparison with the monotonous environment of their further course. Contrary to this statement, the upper section of the River Szeszupa was extremely poor. It was perhaps due to the absence in this area of various types of water body near the river banks, which are the habitat for many species of snail. The recurrence of sections with a fast current as a result of the unusually diversified configuration of the territory may also be a barrier hindering the spread of the stagnicolous species.

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5. Polish summary

Malakofauna cieków Suwalskiego Parku Krajobrazowego (północno-wschodnia Polska)

Badano malakofaunę cieków Suwalskiego Parku Krajobrazowego (ryc. 1, tabela I). W górnym biegu Szeszupy znaleziono przedstawicieli sześciu taksonów Gastropoda (tabele II, VI). W odcinkach cieków związanych z jeziorami malakofauna była bogatsza, zwłaszcza w wypływach.

Skład taksonomiczny malakofauny cieków był podobny jak w jeziorach przepływowych. Wyłącznie w wodach płynących znaleziono tylko *Unio crassus* i *Ancylus fluviatilis* (tabela III). Bogactwo taksonomiczne malakofauny było w niewielkim stopniu zależne od szybkości prądu, bardziej od obecności makrofitów (tabele IV, V), a głównie od położenia względem jezior przepływowych (tabele VI, VII).

Najbogatsze w gatunki środowiska wypływów są prawdopodobnie strefami przenikania mięczaków jeziornych do sąsiadujących odcinków cieków, a nie ekotonami.

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