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**Gastropods in isolated lakes  
of the Suwalski Landscape Park  
(northeastern Poland)\***

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**Abstract** - Sixteen taxa of Gastropoda were found in nine isolated lakes in the Suwalski Landscape Park. The species composition of snails and the number of species were different in individual lakes, but in this group of lakes were similar to those found in the interconnected lakes in this area. *Bivalvia* were represented by the family Sphaeriidae only.

**Key words**: isolated lakes, Gastropoda, species composition.

## 1. Introduction

From the zoogeographical point of view, isolated lakes are a special group of water bodies. Isolation can affect colonization of lakes similarly as that of small water bodies. On the other hand, surface area, depth and type of littoral can resemble those observed in neighbouring interconnected lakes.

The aim of the present study was to analyse the species composition of gastropods in isolated lakes in the Suwalski Landscape Park and to attempt to explain their specificity.

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## 2. Study area, material, and methods

The material was collected in May and June 1985 and in August 1989, once in eight isolated lakes in the Suwalski Landscape Park, northeastern Poland: Linówek, Wodzilki, Błędne, Cisówek, Boczniel, Jęglóweczek, Purwinek, Kojle, Perty (fig. 1). In each lake the molluscs were collected along 20-50 metres of shoreline, to a depth of 1 m. The sampling stations were located in the most diverse littoral with various types of substratum, usually colonized by gastropods. In each lake the animals were collected from plants, stones, submerged branches and pieces of wood, and also from various kinds of anthropogenic substrata. Live molluscs and empty shells were collected from sediments using a bottom scraper and rinsed through a 1 mm mesh sieve. The material from each lake was collected until no new species were found in several samples.



Fig. 1. Area of the Suwalski Landscape Park

The living snails and empty shells were identified using the key by Piechocki (1979) but according to the shell structure only. Conchological features cannot provide absolutely certain identification of species from some genera and subgenera. As a result, the snails of the subgenera *Radix* Montf., 1810 and *Galba* Schr., 1803 and of the genus *Gyraulus* Charp., 1937 could not be



identified by the species, nor could bivalves of the family Sphaeriidae either. For Lake Purwinek materials by Kamiński (unpubl. data) were used.

Despite the small number (9) of lakes, the frequency of individual taxa was calculated (percentage of lakes with the presence of this taxa). The index of similarity of species composition ( $S$ ), by Marczewski and Steinhäus (1959), for pairs of lakes was also calculated:

$$S = \frac{w}{a + b - w}$$

where:

- $a$  - number of species in lake A,
- $b$  - number of species in lake B,
- $w$  - number of species common to lakes A and B,
- $S$  ranges from 0 to 1.

The surface area of the majority of the lakes was planimetric according to 1:10 000 a map. Data concerning the surface area and depth of some of the lakes were taken from the study by Stangenberg (1936) and Ozimek and Rybak (in press), and those concerning the conductivity of the water, pH, and transparency from the study by Hillbricht-Ilkowska and Wiśniewski (in press).

The isolated lakes in the Suwalski Landscape Park are to a different degree isolated from neighbouring waters (fig. 1). Lakes Linówek, Wodziłki, Błędne, and Cisówek have never been connected with other water bodies. Lake Boczniał at one time had a connection with Lake Hańcza, and sometimes, with high water levels, probably still have it. A periodical, slight connection exists between Lakes Jęglówek and Jęglóweczek. Three lakes, Purwinek, Kojle, and Perty, connected by streams (fig. 1) constitute a detached complex of water bodies.

The investigated lakes have significant differences in surface area and depth (Table I). Data concerning the transparency and pH of the waters are incomplete. The lowest pH was noted in Lake Boczniał (pH = 6.0), and slight alkalinity in Lakes Kojle, Perty, and Cisówek (Table I). Lakes Kojle and Perty are mesotrophic (transparency of the water 5.2 and 4.2 m, respectively), while the remaining ones are eutrophic. Lake Linówek has a pH = 7.1, but its littoral is similar to that in dystrophic water bodies (e.g. *Sphagnum* sp. on the shore line). In all the remaining lakes the littorals are typical of eutrophic lakes or ponds, with a high biomass of different species of macrophytes.

Table I. Characteristics of isolated lakes in the Suwalski Landscape Park. - — no data. Other names of lakes: (1) - Muliste; (2) - Pogorzalek; (3) - Boczne, Bocznel; Bocznel Filipowski; (4) - Kociołek, Purwin, Kleszczówek

Lake	Surface area (ha)	Max. depth (m)	Water transparency (m)	pH
Linówek	2.9	6.9	2.3	7.1
Wodzilki	4.5	4.5	—	—
Błędne (1)	2.3	2.0	—	7.4
Cisówek (2)	6.0	—	—	8.0
Bocznel (3)	18.2	4.3	2.0	6.0
Jegłowieczek	1.5	—	—	—
Purwinek(4)	1.2	4.0	2.2	—
Kojle	15.4	33.0	5.2	8.21
Perty	20.0	32.0	4.2	8.16

### 3. Results

Altogether 16 taxa of gastropods were found in the isolated lakes. The numbers of snail taxa in individual lakes (Table II) varied from 1 to 8, and including empty shells from 4 to 12. The smallest number of Gastropoda taxa was found in Lake Linówek (1 and 4) and in Lake Kojle (3 and 4, respectively). In other lakes the numbers of taxa were approximate, from 6 to 8, and including empty shells, from 7 to 13. Bivalves from the family Sphaeriidae were noted in seven lakes; only in Lakes Linówek and Wodzilki were absent.

In the isolated lakes, 11 taxa of Pulmonata and only 5 of Prosobranchia were noted. Among Pulmonata, six taxa had a frequency above 50% (Table III); among Prosobranchia, only two taxa had. *Lymnaea stagnalis* was the species with the highest frequency (100%) and was found in all the investigated lakes. High frequency was also noted for *Bithynia tentaculata* and *Planorbarius corneus*. The species with the lowest frequency were *Marstoniopsis scholtzi*, *Anisus contortus*, and *Segmentina nitida*. *Bithynia leachi*, *M. scholtzi*, and *S. nitida* were found exclusively as empty shells. *Viviparus contectus*, *B. tentaculata*, *Lymnaea (Radix) sp.*, *Anisus vortex*, *Gyraulus sp.*, and *P. corneus* were found as living specimens in some lakes, while in others, exclusively empty shells of these species were noted (Table II).

The numbers of Gastropoda taxa in lakes with a different surface area were compared (fig. 2). No correlation was observed between the area of the lakes and the numbers of taxa. The smallest number of taxa were noted in Lake Linówek (2.9 ha) and in Lake Kojle (15.4 ha); a large number was observed both in small and large lakes.

Table II. Gastrops in isolated lakes of the Suwalski Landscape Park. + - live; • - empty shells only

Taxa	Lakes									
	Linówek	Wodzilki	Błędne	Cisówek	Bocznik	Jegłówek	Purwinek	Kojle	Perty	
<i>Viviparus contectus</i> (Müll.)	•	+		+	+	+	+		•	
<i>Valvata piscinalis</i> (O.F. Müll.)	+	+								
<i>Marstoniopsis scholtzi</i> (Schm.)	•	•	+		+	+	+	+	+	
<i>Bithynia tentaculata</i> (L.)	+	•				•				
<i>Bithynia leachi</i> (Shepp.)		+			+	+				
<i>Physa fontinalis</i> (L.)	+	+	+		+	+		+	+	
<i>Lymnaea stagnalis</i> (L.)		+		+	•			+	+	
<i>Lymnaea (Radix)</i> sp.		+	+	+	+				+	
<i>Lymnaea (Galba)</i> sp.			+	+	+				+	
<i>Planorbis carinatus</i> O.F. Müll.			+	+	+	+			+	
<i>Anisus vortex</i> (L.)		•		+	•	+			+	
<i>Anisus contortus</i> (L.)		•		+		•				
<i>Gyraulus</i> sp.							+	+		
<i>Segmentina nitida</i> (O.F. Müll.)									•	
<i>Planorbis cornuus</i> (L.)	+	+	•	+	+	•			•	
<i>Acroloxus lacustris</i> (L.)		+	+			+			+	



Table III. Frequency of individual Gastropoda taxa in 9 isolated lakes of the Suwalski Landscape Park (live and empty shells). \* – empty shells only

Taxa	Frequency %
<i>Lymnaea stagnalis</i>	100
<i>Bithynia tentaculata</i>	90
<i>Planorbarius corneus</i>	90
<i>Viviparus contectus</i>	65
<i>Anisus vortex</i>	65
<i>Lymnaea (Radix) sp.</i>	55
<i>Lymnaea (Galba) sp.</i>	55
<i>Planorbis carinatus</i>	55
<i>Gyraulus sp.</i>	45
<i>Physa fontinalis</i>	35
<i>Acroloxus lacustris</i>	35
<i>Valvata piscinalis</i>	20
<i>Bithynia leachi</i> *	20
<i>Marstoniopsis scholtzi</i> *	10
<i>Anisus contortus</i>	10
<i>Segmentina nitida</i> *	10

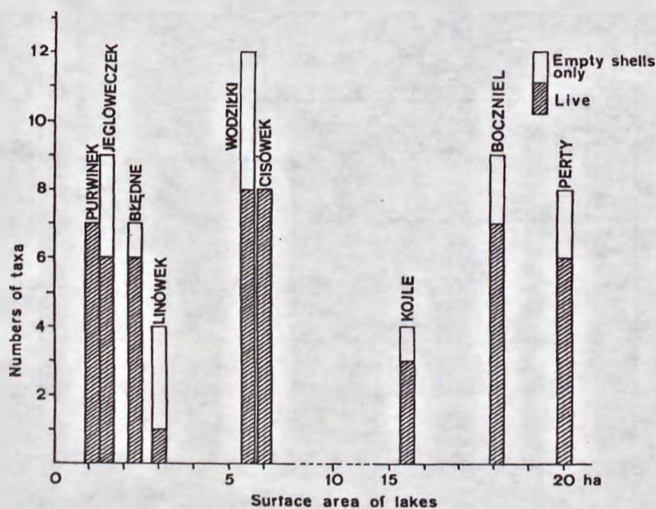


Fig. 2. Number of Gastropoda taxa in isolated lakes of the Suwalski Landscape Park

The similarity index of species composition of gastropods between pairs of isolated lakes is not high (fig. 3), i.e. from 0.20 (Cisówek-Kojle) to 0.80 (Perty-Boczniel) - the average value being 0.43. High values of this index ( $> 0.60$ ) were noted for 4 (11%) pairs of lakes only. There was no correlation between the distance from lake to lake and the values of the index of species composition similarity (fig. 4). Three lakes connected by small streams (Purwinek, Kojle, and Perty) had low values of the similarity index. Its value between periodically connected lakes, i.e. Boczniel and the interconnected Lake Hańcza (0.55) and Jęglóweczek and the interconnected Lake Jęglówek (0.18) is also not high.

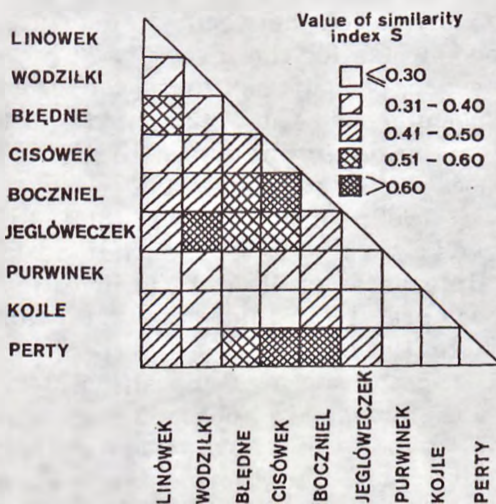


Fig. 3. Similarity in species composition of the Gastropoda community within isolated lakes in the Suwalski Landscape Park

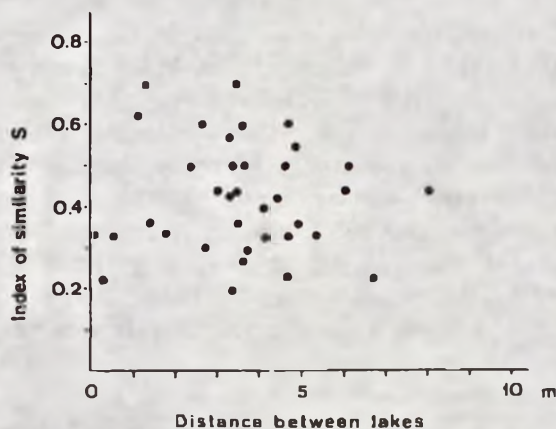


Fig. 4. Distance between isolated lakes and similarity in species composition of Gastropoda

#### 4. Discussion

The differences in pH and conductivity in the water of the investigated lakes were small, as well as those in the trophic structure (Hillbricht-Ilkowska, Wiśniewski in press). The littoral zones of the lakes (with the exception of Lake Linówek) are similar, with a large biomass of different macrophyte species. The differences which were observed in the occurrence of gastropods probably have other causes.



There was no correlation between the surface area and the number of Gastropoda taxa for the investigated lakes. The area has an indirect significance, perhaps as a basis for differentiation of the littoral, and especially of the macrophyte composition. The correlation between the differentiation of the environment and the number of molluscs or Gastropoda taxa were shown by many authors (Økland 1969, Piechocki 1969, 1972, Harman 1972, Kołodziejczyk 1983, Brönmark 1985). It is possible that the differences in area of the investigated lakes (from 1.22 to 20.0 ha) are too small to significantly affect the environmental differentiation.

Great differences in the species composition of molluscs between individual lakes in the Suwalski Landscape Park were demonstrated in the previous paper (Kołodziejczyk 1989). These differences were not related to the existence or non-existence of connections between them. There are no significant differences in the number of taxa (Table IV) or in the species composition of Gastropoda ( $S = 0.80$ ) between isolated and interconnected lakes. On the other hand, Unionidae and *Dreissena polymorpha* (Pall.), common in the interconnected lakes and in the streams and rivers in this area (Kołodziejczyk 1989, 1992, Lewandowski 1990), were not found in the isolated lakes. The surface area and depth of isolated lakes are similar to those in the majority of interconnected lakes (Kołodziejczyk 1992). The absence of Unionidae and *Dreissena polymorpha* in the isolated lakes may suggest that this is due to the possibility of migration and not to the environmental conditions. It may be that for these bivalves, water courses are only the means of colonizing new lakes in the investigated area. It may also suggest stability of the isolation of these lakes.

Table IV. Number of Gastropoda taxa in two groups of lakes in the Suwalski Landscape Park (after Kołodziejczyk 1989 and unpubl. data)

Type of lakes	Gastropods					
	live			live + empty shells		
	total taxa	x	range	total taxa	x	range
Isolated (n=9)	13	5.9	1 - 8	16	7.7	4 - 12
Connected by streams (n=16)	17	5.0	2 - 8	20	8.2	3 - 16



In the investigated area, the lakes are often far away from each other, in deep reentrants. The great differences in the species composition of gastropods in individual lakes may suggest randomness of colonization. For snails, especially Pulmonata, dominating in isolated lakes, and for bivalves Sphaeriidae, migration on birds (Roscoe 1965, Boag 1986) and on some insects (Lansbury 1955) has been described. The small values of the similarity index for the periodically connected lakes and for the complex of three lakes could be the effect of "limiting character" of these water courses, similar to the case of the interconnected lakes in this area (Kołodziejczyk 1989).

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## 5. Polish summary

### Gastropoda jezior bezodpływowych Suwalskiego Parku Krajobrazowego (północno-wschodnia Polska)

W dziewięciu bezodpływowych, izolowanych jeziorach (tabela I, ryc. 1) znaleziono 16 taksonów Gastropoda (tabela II). Najwyższą frekwencją charakteryzowały się *Lymnaea stagnalis* i *Bithynia tentaculata* (tabela III). Liczba taksonów w poszczególnych jeziorach nie była związana z wielkością ich powierzchni (ryc. 2). Całkowita liczba taksonów (tabela IV) oraz lista rodzajów i gatunków nie odbiegały od notowanych w grupie sąsiednich jezior przepływowych. Natomiast, pomimo zbliżonych w poszczególnych jeziorach warunków środowiskowych, zaobserwowano duże, nie związane z odległością pomiędzy zbiornikami (ryc. 4), różnice w składzie gatunkowym pomiędzy poszczególnymi jeziorami (ryc. 3). To, oraz proporcjonalnie większa liczba taksonów Pulmonata niż Prosobranchia wskazywać mogą na kolonizację tych jezior przez ślimaki głównie drogą powietrzną, oraz potwierdzać pełną i trwałą izolację badanych zbiorników.

Spośród Bivalvia w litoralu badanych zbiorników obecni byli tylko przedstawiciele Sphaeriidae. Nie znaleziono Unionidae i *Dreissena polymorpha*, pospolitych w sąsiednich jeziorach przepływowych. Wskazywać to może na to, że dla rozprzestrzeniania się tych małży decydujące znaczenie na badanym obszarze miały drogi wodne.

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