ZAKŁAD OCHRONY PRZYRODY I ZASOBÓW NATURALNYCH POLSKIEJ AKADEMII NAUK

1991 OCHRONA PRZYRODY R. 49, cz. I

STEFAN WITOLD ALEXANDROWICZ

MALACOFAUNA OF THE SEDIMENTS OF A DAM LAKE IN THE WETLINA RIVER VALLEY

MALAKOFAUNA OSADÓW JEZIORKA ZAPOROWEGO W DOLINIE WETLINY

Stefan Witold Alexandrowicz: Malacofauna of the sediments of a dam lake in the Wetlina river valley. [Streszczenie]. *Ochr. Przyr.* Ann. 49: 53–64 1991, cz. I, Kraków.

Abstract. The sediments of a dam lake formed in the Wetlina Valley as a result of recent mass movements contain accumulations of mollusc shells. Four thanatocenoses are distinguished, whose composition and diversity reflect the afforestation of the drainage area and the conditions in which the shell material was accumulated. One of the aspects of the case for conservation is the scientific importance of the dam lake. The preservation of the lake in the conditions of its natural evolution would create an opportunity to observe the accumulation of organic remains in its sediments. Such observations are of basic significance for the interpretation of subfossil Quaternary faunas as paleoenvironment indices.

Key words: molluscs, thanatocenoses, dam lakes, Carpathians — Bieszczady Mts.

Stefan Witold Alexandrowicz: Instytut Geologii i Surowców Mineralnych. Akademia Górniczo-Hutnicza. al. Mickiewicza 30, Kraków.

Manuscript received: January 1988
accepted: December 1988

Treść. W osadach jeziorka zaporowego utworzonego w dolinie Wetliny w wyniku współczesnych ruchów masowych, występują nagromadzenia skorupek mięczaków. Wyróżniono cztery tanatocenozy, których skład i zróżnicowanie odzwierciedlają stopień zalesienia zlewni i warunki akumulacji materiału muszlowego. Jednym z aspektów ochrony jeziorka zaporowego w warunkach jego naturalnej ewolucji jest możliwość prowadzenia obserwacji nad gromadzeniem się szczątków organicznych w osadach wypełniających zbiornik. Badania takie są podstawą dla interpretacji czwartorzędowych faun subfosylnych jako wskaźników paleośrodowiska.

I. INTRODUCTION

During the past 12 thousand years, from the close of the Last Glacial up to the present times, numerous landslides have been formed in the Carpathians. Some of these landslides, especially the large ones, as for instance, the rock slide on the northern slope of the Babia Góra Mt., are well pronounced in the landscape and contribute to its diversity (Alexandrowicz 1978). Landslide surfaces bear depressions devoid of outlet which are consecutively being filled by mineral and organic deposits, containing floristic and faunistic remains. The latter may become fossilized, making possible environmental reconstructions of different Holocene phases (Alexandrowicz 1988). A special case is the formation of episodic dam lakes, produced due to damming up of valleys by landslide colluvia. Although the latter become quickly dissected, the episodic lake is filled throughout years by deposits of relatively large thickness. Such deposits may contain numerous fruits and seeds, as well as mollusc shells. Radiocarbon dating of these deposits makes possible a precise age determination which, in turn, provides useful data for reconstructing of floristic and faunistic successions in the catchment area of the dammed stream.

As far as the Polish Carpathians are concerned, only four Holocene dam lakes have been found and dated for 7750 yr BP (the Harcygrund valley near Czorsztyn), 640 yr BP and 250 yr BP (the Ścigocki stream near Krościenko), and 535 yr BP (the Biały stream near Krościenko). Taking into account that in recent times new sites are being found nearly annually, one can expect that such objects are not rare features. A description of sedimentary conditions within these lakes, together with regularities of floristic and faunistic occurrences in their deposits, requires actualistic studies which can be performed exclusively in presently existing reservoirs. Such an opportunity has been provided by a dam lake in the Wetlina river valley, formed in July 1980 due to damming up of the river by colluvia of a large landslide. This landform has first been described by Dziuban (1983), whereas the course of reservoir infilling by sediments and their floristic composition has been studied by Cabaj and Pelc (1991). Malacological analyses carried out by the author are based on two series of samples, one collected by Dr. Cabaj, the other one collected during the author's own field studies.

The author would like to express his thanks to Dr Cabaj for initiating these studies, the passing of sampled material and his help in collecting of samples.

II. DISTRIBUTION OF MALACOFAUNA

Malacofaunistic studies concerned 10 samples collected from the banks of the dam lake, from a sand-gravel bar within the lake, and from the reservoir's bottom (Fig. 1). The samples, 2.5–3.0 kg each, were flushed on sieves of mesh size equal to 0.5 mm and, subsequently, all mollusc shells and shell fragments were collected from the residue. The number of specimens obtained from individual samples ranges from a dozen to several hundred shells, totalling to 1400 specimens

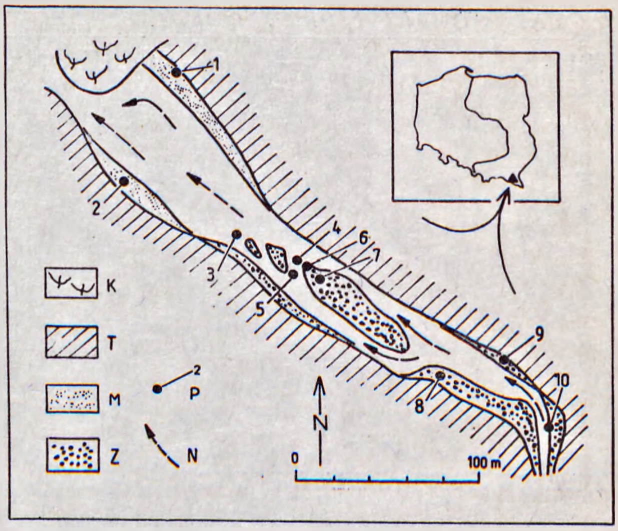


Fig. 1. Dam lake in Wetlina Valley. K — colluvial dam, T — terrace and slope, M — sands and silts, Z — gravels and sands, P — sampling site, 1–10 — sample numbers, N — river current

Ryc. 1. Jeziorko zaporowe w dolinie Wetliny: K — rygiel koluwialny T — terasa i stok, M — piaski i mułki, Z — żwiry i piaski, P — miejsca pobrania próbek, 1–10 numery próbek, N — nurt rzeki

representing 42 taxa. The latter include 5 species of fresh-water snails, 35 species of land snails, 1 bivalve species, as well as calcareous plates of gastropods devoid of shells, conventionally referred to as *Limacidae*.

The sampling pattern reflects the diversity of deposits and zones of accumulation of shell material. Three samples, labelled as G (3, 4, 5), derive from the lake bottom and represent muds and sandy muds. Three other samples, labelled as S (2, 7, 8) have been collected from the reservoir's banks, built up from sandy muds and sands deposited at the time of high water level. Two samples, labelled as T (1, 9), represent bars rich in plant detritus and exposed up to 1.5 m above the water level. These bars are associated either with the incipient stage of the lake development or have been deposited during a flood. The last two samples, labelled as P(6, 10), characterize deposits accumulated immediately above the water level and frequently recycled and enriched in mollusc shells and plant detritus.

The material in question includes mainly empty mollusc shells. This applies especially to land snails being represented, most abundantly, by samples collected from the reservoir's banks (S, T). As far as sediments of the lake bottom and sandy bars are concerned (samples G and P) one can find besides empty shells, fairly numerous living specimens, chiefly fresh-water *Ancylus flu-*

viatilis snails. The state of shell preservation is good; in most cases there occur complete shells or their large fragments easy to determine. Fine shell detritus plays a minor role, increasing only in samples labelled as P and T.

The degree of concentration of mollusc shells varies to a great extent. Particularly abundant clusters of shell material have been encountered within bars immediately above the water level (P), whereas much less numerous shells occur on the lake banks at an altitude of 1.5 m (T). The number of taxa distinguished within different types of deposits shows a less distinct differentiation. The share of fresh-water molluscs is the smallest within higher situated bars (T), while the highest one characterizes the lowest bars (P). As far as lake bottom deposits are concerned, fresh-water molluscs constitute tentatively two thirds of all specimens (table I).

TABLE I

Quantitative data of molluscan assemblages
Charakterystyka ilościowa zespołów mięczaków

Prb	1	2	3	4	5	6	7	8	9	10
Tnt	T	S	G	G	G	P	S	S	T	P
Ntx	15	11	14	16	18	17	16	25	19	23
Nsk	28	48	87	76	79	230	74	167	59	583
TDI	.83	80.	.74	.65	.69	.58	.88	.91	.93	.54
% W	25	48	62	73	68	81	51	27	12	86
% L	75	52	38	27	32	19	49	73	88	14

Prb — sample numbers (numery próbek)
Tnt — thanatocenoses — as in Fig. 3 (tanatocenozy — jak na ryc. 3)
Ntx — taxon number (liczba taksonów)
Nsk — specimen number (liczba okazów)
TDI — Association diversity index (współczynnik różnorodności zespołu)
%W — percentage of water molluscs (procentowy udział mięczaków wodnych)
%L — percentage of land molluscs (procentowy udział ślimaków lądowych)

III. THE MOLLUSCAN ASSEMBLAGE

The molluscan assemblage comprises species being typical of different habitats. The composition and structure of the assemblage taken as a whole (for all samples) have been determined by calculating the constancy and domination indices, expressed on a 5-degree scale, as well as by summing up of all identified taxa (table II). Only one gastropod species, *Ancylus fluviatilis*, does reveal the highest 5th class of domination, and its share in the material attains nearly 25%. Another taxon, *Lymnaea peregra peregra*, represents the D-4 class of domination, while the others are represented by infrequent specimens, occupying the two lowest classes (D-1 and D-2).

The distribution of constancy of taxa occurrence within 10 samples is completely different. The highest class, C-5, is represented by four species: *Carychium tridentatum*, *Oxychilus orientalis*, *Vitrea diaphana*, and *Lymnaea truncatula*, whereas the C-4 class embraces: *Cochlicopa lubrira*, *Vitrina pellucida*, *Aegopinella pura*, and *Vitrea crystallina*, alongside with the above mentioned, dominant species — *Ancylus fluviatilis*. Constancy classes C-3 and C-2 contain 15 species, the C-1 class including 18 taxa which also fall into the lowest domination class (D-1).

Such an assemblage structure indicates that nearly 50% of all the taxa represent accessory components and that only a few species occur in the majority of samples (Fig. 2). Characteristic species include land snails: *Carychium tridentatum*, *Oxychilus orientalis* and *Vitrea diaphana*, whilst dominant fresh-water ones are *Ancylus fluviatilis*, *Lymmaea peregra peregra*, and *L. truncatula*.

The MSS malacological spectrum (Fig. 3 — Z) shows that more than half the taxa corresponds to the forest habitat. These are species assigned to ecological groups 1, 2 and 3, labelled according to Lozek's (1964) scheme. Some of these species display high constancy and fall into the second domination class, as do *Oxychilus orientalis*, *Aegopinella pura*, *Vitrea diaphana*, and *V. transsylvanica*. The species preferring partly shadowed habitats (*Vitrea crystallina* and *Arianta arbustorum*) are also numerous, contrary to those which inhabit forests of very moist and swampy substratum. Species typical of open environments (ecological group 5) form a subordinate component of the assemblage, while much more frequent are snails of wide ecological tolerance which may inhabit environments of variegated degree of shadow and of relatively high humidity (ecological groups 7 and 8). A remarkable constancy and the second class of domination display: *Carychium tridentatum*, *Cochlicopa lubrica*, *Punctum pygmaeum*, and *Vitrina pellucida*. Three other taxa, falling into ecological group no. 9, belong to mesophile and hygrophile species which prefer very moist and swampy habitats. One of these, *Succinea putris*, has been encountered at nearly every site.

The amount of fresh-water snails attains 14%. These snails are characterized by a high degree of constancy of occurrence and are represented by numerous specimens. This ecological group (no.10) in-

TABLE II

Composition of molluscan assemblages

Skład zespołów mięczaków

No	Species — Gatunki	Samples — Próbki												
		1	2	3	4	5	6	7	8	9	10	C	D	N
1	*Bythinella austriaca* (Frauenfeld)				+	+	+	+			+	3	1	III
2	*Carychium minimum* Müller						+	+	+	+		2	2	III
3	*Carychium tridentatum* (Risso)	+	+	+	+	+	+	+	+	+	+	5	2	IV
4	*Lymnaea truncatula* (Müller)	+	+	+	+	+	+	+	+		+	5	2	IV
5	*Lymnaea peregra peregra* (Müller)			+		+	+	+		+	+	3	4	V
6	*Anisus leucostomus* (Millet)	+		+		+			+	+	+	3	2	III
7	*Ancylus fluviatilis* Müller	+	+	+	+	+	+	+			+	4	5	VI
8	*Cochlicopa lubrica* (Müller)		+	+	+	+	+		+	+	+	4	2	IV
9	*Cochlicopa lubricella* (Porro)									+		1	1	I
10	*Columella edentula* (Draparnaud)		+						+		+	2	1	I
11	*Vertigo pusilla* Müller					+			+			1	1	I
12	*Vertigo alpestris* Alder							+				1	1	I
13	*Vallonia costata* (Müller)					+			+			1	1	I
14	*Vallonia pulchella* (Müller)				+		+	+	+	+		3	1	II
15	*Acanthinula aculeata* (Müller)	+							+			1	1	I
16	*Ena montana* (Draparnaud)										+	1	1	I
17	*Succinea putris* (Linnaeus)			+	+	+	+		+	+		3	2	IV
18	*Punctum pygmaeum* (Draparnaud)			+		+		+	+	+		3	2	III
19	*Discus perspectivus* (Muhlenfeldt)		+	+	+				+			2	1	II
20	*Vitrina pellucida* (Müller)		+	+	+	+			+	+	+	4	2	III
21	*Eucobresia nivalis* (Dumont-Mort.)				+		+					1	1	I
22	*Nesovitrea hammonis* (Ström)							+		+		1	1	I
23	*Aegopinella pura* (Alder)		+		+	+	+	+	+	+	+	4	2	III
24	*Oxychilus orientalis* (Clessin)	+	+	+	+	+	+	+		+	+	5	2	III
25	*Vitrea diaphana* (Studer)	+	+	+	+		+	+	+	+	+	5	2	IV
26	*Vitrea transsylvanica* Clessin				+		+	+	+	+	+	3	2	IV
27	*Vitrea crystallina* (Müller)	+		+		+		+	+	+	+	4	1	III
28	*Zonitioides nitidus* (Müller)	+										1	1	I
29	*Limacidae*			+								1	1	I
30	*Euconulus fulvus* (Müller)	+							+	+		2	1	II
31	*Iphigena latestriata* (Schmidt)				+				+			1	1	II
32	*Iphigena tumida* (Rossmässler)								+		+	1	1	II
33	*Vesta turgida* (Rossmässler)	+				+						1	1	I
34	*Ruthenica filograna* (Rossmässler)								+			1	1	I
35	*Bradybaena fruticum* (Müller)								+			1	1	I
36	*Monachoides vicina* (Rossmässler)						+				+	1	1	II
37	*Perforatella dibotryon* (Klimakowicz)										+	1	1	I
38	*Trichia bąkowski* (Poliński)	+					+	+	+	+	+	3	1	III
39	*Helicigona faustina* (Rossmässler)	+			+					+	+	2	1	II
40	*Arianta arbustorum* (Linnaeus)	+				+	+		+		+	3	2	III
41	*Helix pomatia* (Linnaeus)										+	1	1	I
42	*Pisidium personatum* Malm	+	+		+	+					+	3	1	II

No — species number, cf. Fig. 2 (numer gatunku — por. ryc. 2)
C — constancy index (wskaźnik stałości)
D — domination index (wskaźnik dominacji)
N — shell number. Number classes I–VI as in Fig. 2 (liczebność skorupek. Symbole liczebności I–VI jak na ryc. 2)

des taxa dominating in respect to the number of shells. The predominance of *Ancylus fluviatilis* and *Lymnaea peregra peregra* influences decisively the assemblage structure, being reflected by proportions among species belonging to certain ecological groups. Such a structure is portrayed by the MSI spectrum (Fig. 3 — Z) showing that fresh-water snails compose 65% of the material analyzed, while forest snails attain only 16%.

The molluscan assemblage of deposits of the dam lake in the Wetlina river valley includes species which at present show a diversified distribution. The zoogeographic structure of the association in question, shown on the spectrum,

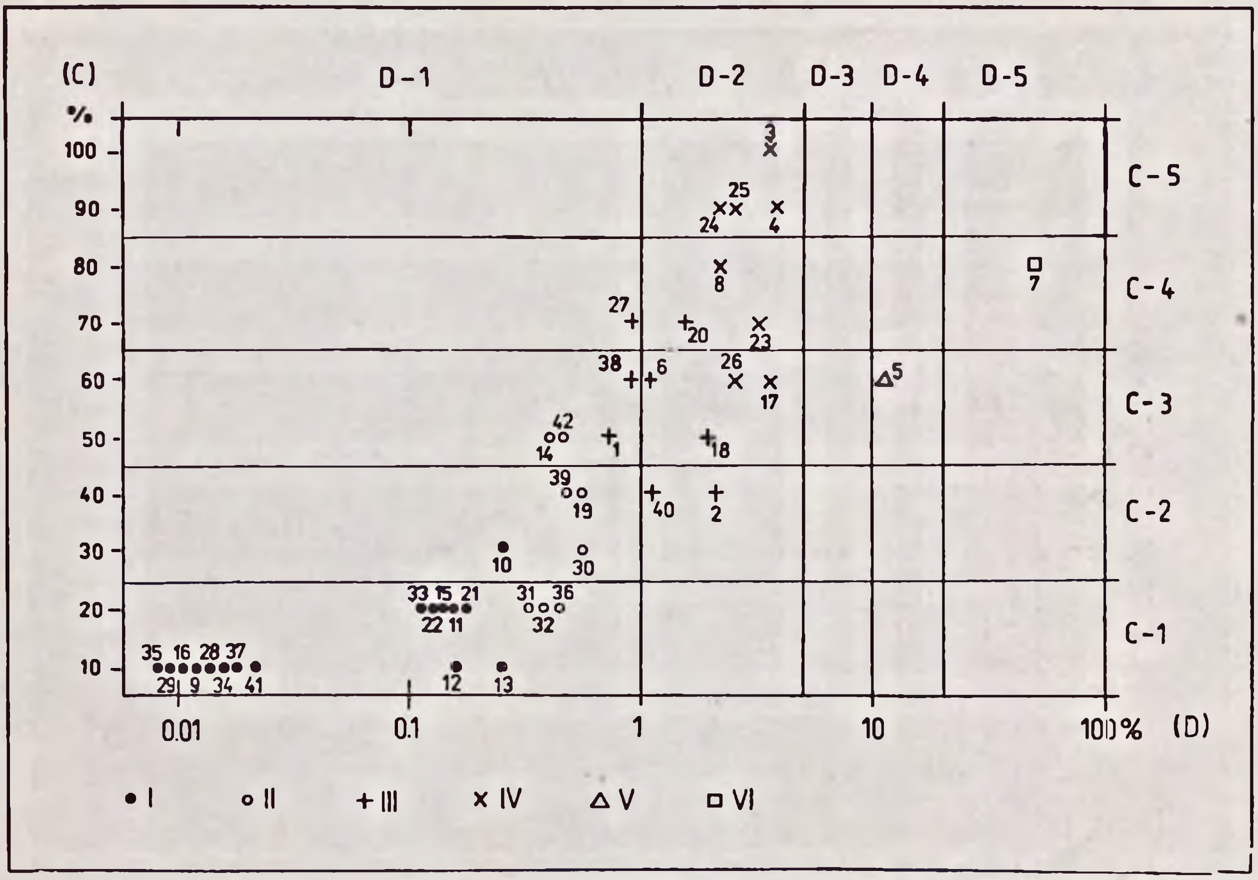


Fig. 2. Structure of molluscan assemblage of dam lake sediments. C — constancy, C-1–C-5 — constancy classes, D — domination, D-1–D-5 — domination classes, 1–42 — mollusc species (according to table II); shell number classes: I–1–3, II — 4–9, III — 10–31, IV — 32–99, V — 100–316, VI — 317–999

Ryc. 2. Struktura zespołu mięczaków z osadów jeziorka zaporowego. C — stałość, C-1–C-5 — klasy stałości, D — dominacja, D-1–D-5 — klasy dominacji 1–42 — gatunki mięczaków (według tabeli II); symbole liczebności skorupek: I — 1–3, II — 4–9, III — 10–31, IV — 32–99, V — 100–316, VI — 317–999

points to a large amount of species of a very wide extent (Fig. 3 — ZG). These are Holarctic, Palaearctic, Eurosiberian and European elements which all together, represent more than 50% of the taxa.

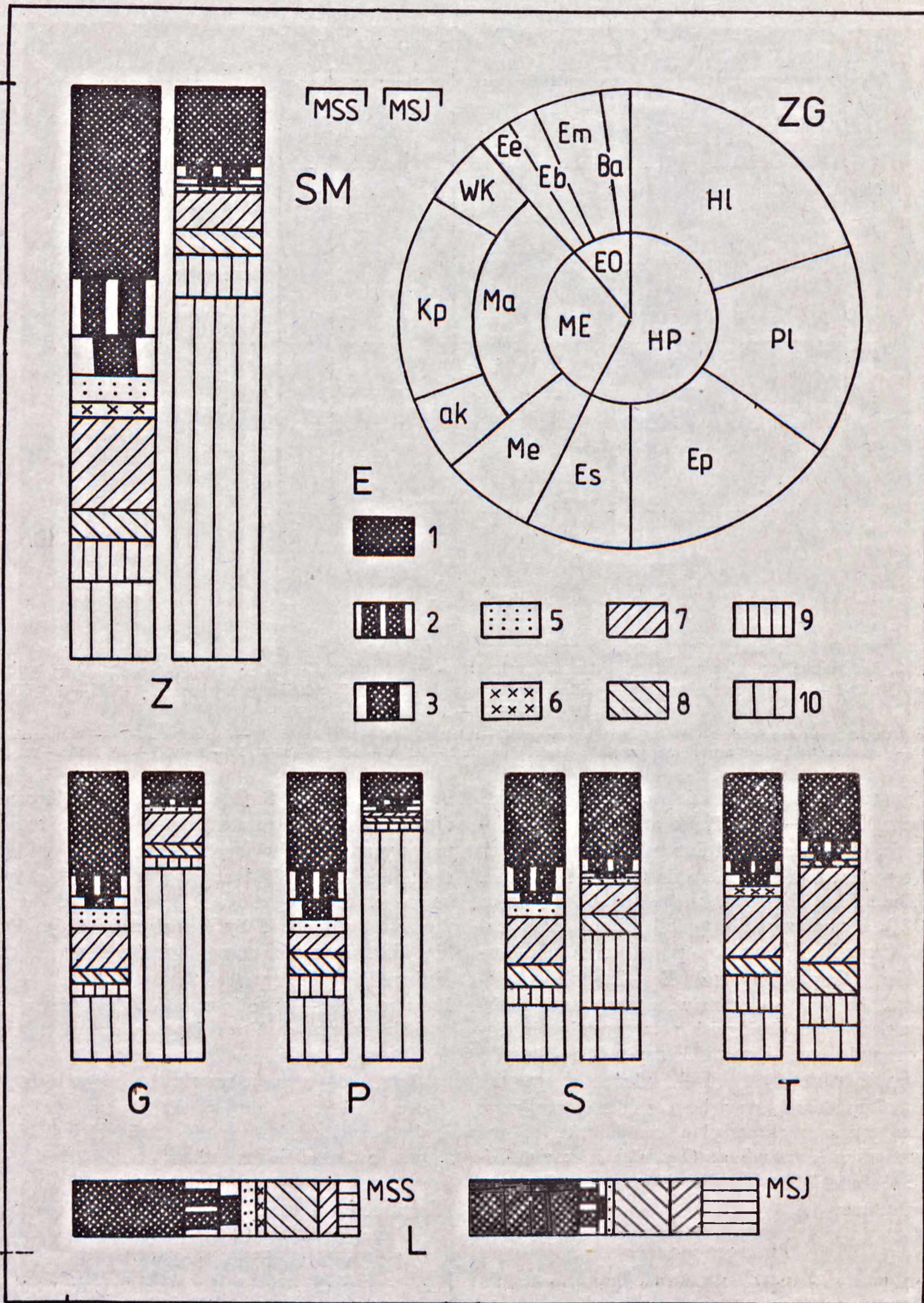
The Middle European species are also numerous (30%), including snails typical of the Alps and the Carpathians, and composed of Alpine-Carpathian, Carpathian, and East-Carpathian elements. Among species showing a reduced spatial extent, one can distinguish taxa occurring in Eastern and South-Eastern Europe. These snails, alongside with those which inhabit chiefly the East Carpathians, may be considered the most characteristic zoogeographic components of the fauna studied, including: *Oxychilus orientalis*, *Trichia bąkowski*, *Perforatella dibotryon*, and *Discus perspectivus*.

Thanatocenoses

Shells of molluscs inhabiting different ecological environments cluster after organisms' death in their habitats. Some of these shells become dissolved or disintegrated, some become buried under younger sediments, while the rest is washed down and redeposited at other places. Accumulations of dead organic remains are called thanatocenoses, as defined by Wasmund (1926). Within different sedimentary environments one can distinguish theree types of thanatocenoses:

1. necrocenose — organic remains laid down in their natural habitats (autochthonous thanatocenose),
2. allocenose — organic remains and organisms redeposited either during the lifetime or after death, and laid down outside their original habitats (parautochthonous thanatocenose), and
3. mixocenose — autochthonous and parautochthonous organic remains deposited together (Alexandrowicz 1988).

Malacofauna occurring within deposits of the dam lake in the Wetlinka river valley forms thanatocenoses of the third type, i.e., mixocenoses.



MSS
MSJ
SM
ZG
Hl
Pl
Ep
Es
Me
ak
Kp
WK
Ee
Em
Eb
Ba
EO
Ma
ME
HP
E
1
2
3
5
6
7
8
9
10
Z
G
P
S
T
MSS
MSJ
L

The molluscan assemblages comprise both bivalves and fresh-water snails, associated with the fluvial environment, as well as land snails derived from habitats spread throughout the valley bottom and the slopes. These assemblages show a distinct differentiation, both in respect to the number of species, and the number of shells representing individual taxa (table I). Such thanatocenoses can characterize molluscan environments only indirectly; they are nevertheless indicative of accumulation processes of organic remains.

In the lake under study, the following four zones of shell accumulation have been distinguished: G — lake bottom deposits, P — bars formed along banks, immediately above the water level, S — deposits laid down during the highest water stand, and T — bars elevated more than 1 m above the water level, abundant in branches, wood fragments, and plant detritus. These zones refer to different environments of thanatocenose formation; hence, they represent four different thanatocenoses (Wasmund 1926, Alexandrowicz 1988).

The assemblage composition analyzed in respect to the occurrence of individual species and irrespectively of the number of shells, is fairly uniform. The taxonomical dendrite displays a simple structure of the set which, owing to the omission of the longest taxonomical distances (0.59, 0.53), does not subdivide into sub-sets. Samples representing thanatocenoses P and G occur side by side in the dendrite; less distinct, however, is the relationship between samples ascribed to the thanatocenose T (Fig. 4).

Malacological spectra and, especially, the MSI diagrams, clearly show differences among assemblages representing the above thanatocenoses (Fig.

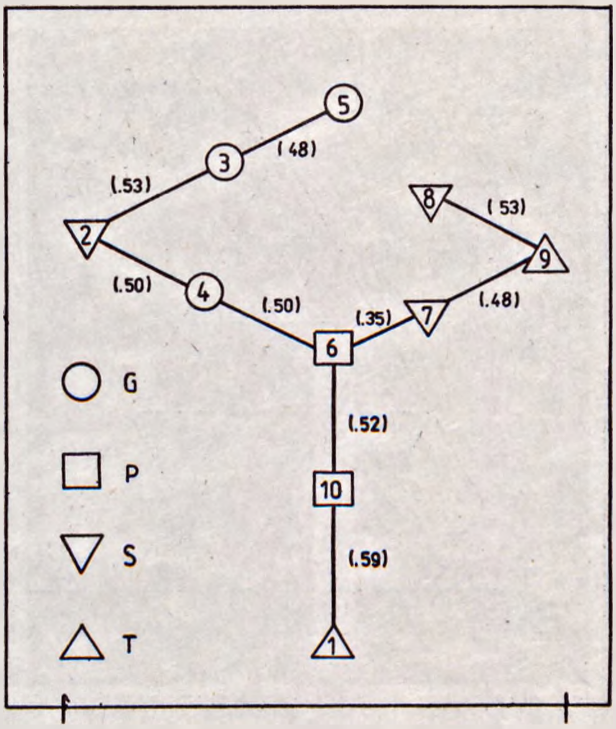


Fig. 4. Taxonomical dendrite of molluscan assemblages. 1–10 — sample numbers, G, P, S, T — thanatocenoses (as *in* Fig. 3), (.59) — taxonomic distances

Ryc. 4. Dendryt taksonomiczny zespołów mięczaków: 1–10 — numery próbek; G, P, S, T — tanatocenozy (jak na ryc. 3), (.59) — odległości taksonomiczne

3). Thanatocenoses G and P are dominated by fresh-water molluscs. The former contains also forest and mesophile snails of moderately moist environments, while the latter is composed exclusively of forest snails. The thanatocenose S shows a balanced amount of individual ecological groups and the MSS and MSI diagram structures show a close resemblance to one another. A similar composition does reveal the thanatocenose T, although containing a greater number of meso-

Fig. 3. Malacological and zoogeographic spectra of Wetlina Valley fauna. SM — malacological spectra, Z — cumulative spectra, MSS — specific spectra, MSI — individual spectra, E — symbols of ecologic groups according to Ložek (1964): 1 — forest snails, 2 — predominantly forest snails, 3 — humid forest snails, group 4 is not represented, 5 — open habitat snails, 6 — mesophilous snails of dry habitats, 7 — mesophilous snails of moderately humid habitats, 8 — mesophilous snails of humid habitats, 9 — hygrophilous species, 10 — water molluscs: malacological spectra in thanatocenoses: G — on the reservoir bottom, P — on the water level, S — on a low bank, T — on a high bank; L — cumulative spectra considering only land snails; ZG — zoogeographic spectrum, HP — wide distributed species, Hl — Holarctic, Pl — Palearctic, Ep — European, Es — Eurosiberian, ME — Middle European species, Me — lowland, Ma — mountain, Ak — Alpine-Carpathian, Kp — Carpathian, Wk — East Carpathian, EO — species of limited range, Ee — East European, Eb — Balkan-Pontic, Em — meridional, Ba — Boreal-Alpine

Ryc. 3. Spektra malakologiczne i zoogeograficzne fauny z doliny Wetliny: SM — spektra malakologiczne, Z — spektra zbiorcze, MSS — spektra gatunkowe, MSI — spektra osobnicze, E — symbole grup ekologicznych według Ložka (1964): 1 — ślimaki leśne, 2 — ślimaki żyjące głównie w lasach, 3 — ślimaki wilgotnych lasów, grupa 4 nie jest reprezentowana, 5 — gatunki środowisk otwartych, 6 — ślimaki mezofilne siedlisk suchych, 7 — ślimaki mezofilne siedlisk średnio wilgotnych, 8 — ślimaki mezofilne siedlisk wilgotnych, 9 — gatunki higrofilne, 10 — mięczaki wodne; spektra malakologiczne w tanatocenozach: G — na dnie zbiornika, P — na linii wody, S — na niskim brzegu, T — na wysokim brzegu; L — spektra zbiorcze uwzględniające tylko ślimaki lądowe; ZG — spektrum zoogeograficzne, HP — gatunki szeroko rozprzestrzenione, Hl — holarktyczne, Pl — palearktyczne, Ep — europejskie Es — eurosyberyjskie, ME — gatunki środkowoeuropejskie, Me — niżowe, Ma — górskie, Ak — alpejsko-karpackie, Kp — karpackie, Wk — wschodniokarpackie, EO — gatunki o ograniczonym zasięgu, Ec — wschodnioeuropejskie, Eb — bałkańsko-pontyjskie, Em — meridionalne, Ba — borealno-alpejskie

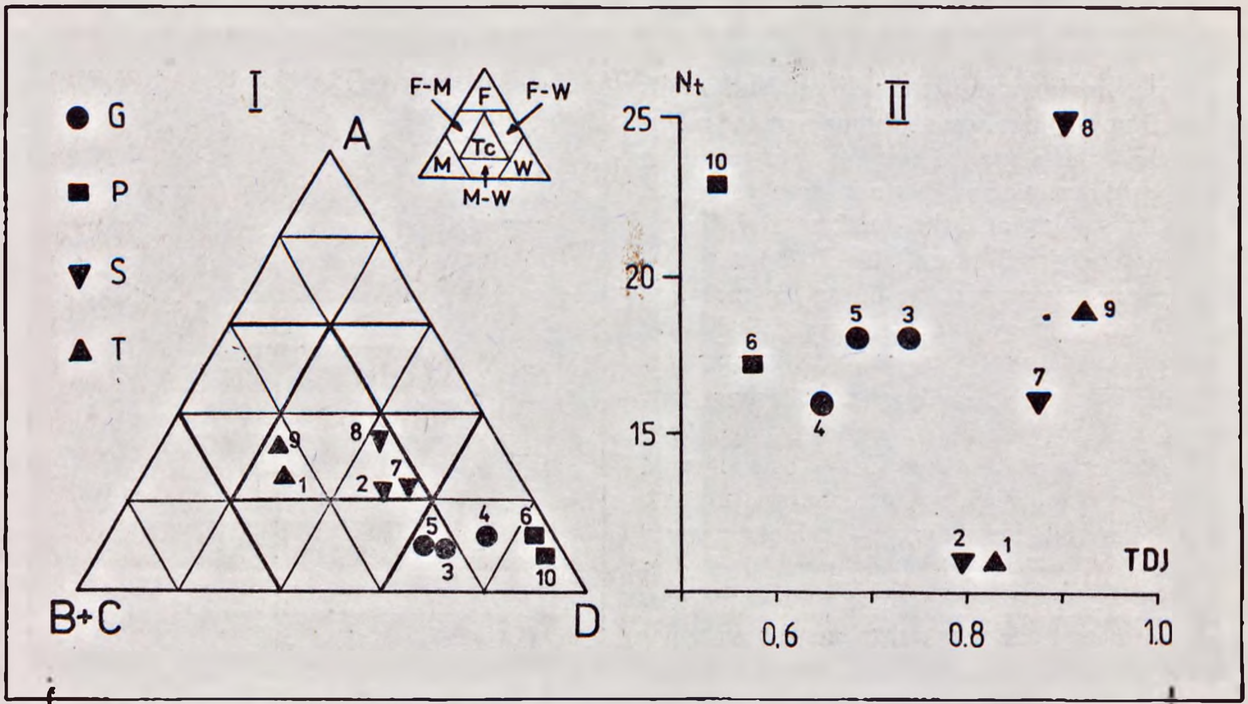


Fig. 5. Diagrams of selected characters of molluscan assemblages. I — triangular projection diagram, G, P, S, T — thanatocenoses (as in Fig. 3), 1–10 — sample numbers, A — forest species, B — open habitat species, C — mesophilous species, D — water species, F — forest associations, M — associations of open and slightly shaded habitats, W — associations of water bodies, F-M, F-W, M-W — associations of two elements, Tc — associations of three elements, II — diagram illustrating relation between value of TDI and number of taxons in samples, Nt — number of taxons, TDI — association diversity index

Ryc. 5. Diagramy wybranych cech zespołów mięczaków: I — diagram w projekcji trójkątnej; G, P, S, T — tanatocenozy (jak na ryc. 3), 1–10 — numery próbek; A — gatunki leśne, B — gatunki stanowisk otwartych, C — gatunki mezofilne, D — gatunki wodne, F — zespoły leśne, M — zespoły siedlisk otwartych i słabo zacienionych, W — zespoły zasiedlające zbiorniki wodne, F-M, F-W, M-W — zespoły dwuskładnikowe, Tc — zespoły trójskładnikowe, II — diagram ilustrujący relację między wartością wskaźnika TDI a ilością taksonów w próbkach, Nt — ilość taksonów, TDI — wskaźnik różnorodności zespołów

phile snails, preferring moderately moist habitats, and a smaller amount of fresh-water molluscs (Fig. 3).

The possibility of distinguishing of two types of molluscan assembleges is provided by the projection triangular diagram, constructed according to the author's scheme (Alexandrowicz 1988). The thanatocenoses S and T fall into the area occupied by three-component associations (T), whereas thanatocenoses G and P cluster within the area of fresh-water associations (W). The distribution of projection points referring to individual samples also reflects secondary differences observed among the described association types (Fig. 5 — I).

The degree of assemblage diversity has been determined by the TDI index, defined by the author (Alexandrowicz 1988). This index provides results fairly similar to formular expressing the so-called equitability index (J'), or the relative diversity index (H×). Both these indices are based on the Shannon-Weaver formula (Kasprzak, Niedbała 1981), frequently quoted in ecological literature. As far as the material described is concerned, the TDI index changes from 0.54 to 0.91, although individual thanatocenoses display more narrow variability ranges. The lowest figures (0.50–0.60) are confined to the thanatocenose P which can be described as a relatively uniform one. This results from a distinct domination of numerous fresh-water snailand, especially, from the mass occurrence of *Ancylus fluviatilis*, being the dominant component. Higher figures of the TDI index can be observed in the thanatocenose G (0.60–0.75), showing a more equal distribution of the number of taxa. Thanatocenoses T and S, in turn, do not differ from each other in respect of the characteristics in question. The TDI index is here 0.80–0.90, pointing to a very high malacological diversity.

A characteristic feature of the described assemblages is the lack of correlation between the number of taxa, denoted by N_t, and TDI values (Fig. 5 — II). Such relationship, confirmed by linear correlation coefficients, has been found to exist among assemblages of these molluscs which inhabit environments preferring species of a given ecological valence. It has also been found among autochthonous thanatocenses (necrocenoses), both in land and in fresh-water assemblages. As far as mixocenoses are concerned, this relationship occurs much less frequently.

The diversity of composition of molluscan assemblages forming thanatocenoses relates mainly to the mode of transport and deposition of mineral and organic material within individual zones of the dam lake. Shells of snails and bivalves transported by the river during floods are sorted in respect to their size and weight. They concentrate close to the water surface, alongside with plant remains, and are deposited at those places where the river transporting capacity becomes reduced. Light organic remains are deposited chiefly during the periods of low water level, and cluster within river bends, small embayments, along breaks of the shoreline, at the mouth of the stream into the basin, as well as on shores and close to the colluvial dam. Shell banks accumulated due to agents showing diversified intensity differ from each other by size and degree of shell disintegration. As a result, individual thanatocenoses display a given faunistic composition and the state of fauna preservation (Fig. 6 — I). The basin bottom deposits contain the poorest molluscan assemblage, both in respect to the number of taxa and specimens (thanatocenose G). On the bank, immediately above the water level, the bars contain most numerous species and specimens (thanatocenose P), while shell accumulations formed during high water stands (thanatocenoses S and T) occupy a transitional position, containing a large proportion of land snails. A similar differentiation can be observed within accumulations of plant remains, mainly fruits and seed occurring commonly in dam lake deposits. Basing on detailed analyses of distribution of plant remains in this basin, Cabaj and Pelc (1991) have distinguished two facies of deposits: the deltaic and the lacustrine ones (Fig. 6 — II). The former is confined to a distal part of the lake, situated at the mouth of the Wetlina river. This facies represents medium- to coarse-grained deposits, containing abundant concentrations of fruits and seeds of relatively large size. The latter facies is represented by fine-grained sediments, accumulated in a proximal part of the lake, and

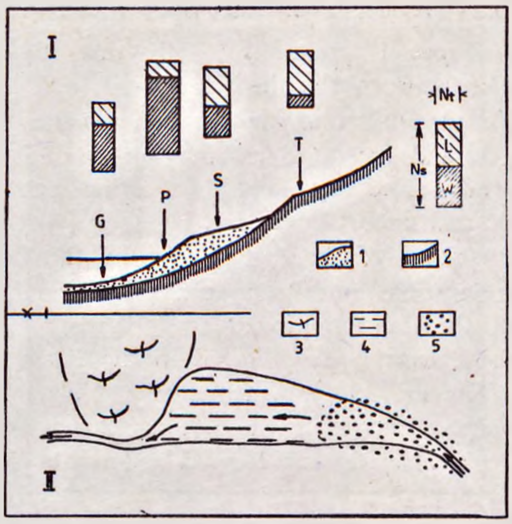


Fig. 6. Scheme of facies distribution and thanatocenose types in dam lake. I — schematic profile, G, P, S, T — thanatocenoses (as in Fig. 3), proportions of land and water species in associations: Ns — specimen number, Nt — taxon number, L — land snails, W — water molluscs, II — map of facies distribution, 1 — dam lake sediments, 2 — substrate, 3 — colluvial dam, 4 — lake facies, 5 — delta facies

Ryc. 6. Schemat rozmieszczenia facji i typów tanatocenozy w zbiorniku zaporowym: I — przekrój schematyczny, G, P, S, T — tanatocenozy (jak na ryc. 3), proporcje gatuunków lądowych i wodnych w zespołach: Ns — ilość okazów, Nt — ilość taksonów, L — ślimaki lądowe, W — mięczaki wodne, II — mapka rozkładu facji, 1 — osady zbiornika zaporowego, 2 — podłoże, 3 — rygiel koluwialny, 4 — facja jeziorowa, 5 — facja deltowa

containing fruits and seeds of smaller dimensions.

These two facies (Cabaj and Pelc, 1991) bear clusters of mollusc shells, differing from each other by the degree of shell concentration. Within deltaic deposits, the number of shells is several times greater than in lacustrine ones. A similar regularity has been documented for the Holocene dammed up basins in the Harcygrund and Ścigocki streams in the Pieniny Mts. (Alexandrowicz 1984, 1986). Both these sites represent deposits preserved in distal parts of the basins, containing numerous taxa and specimens. In the Ścigocki stream valley, deposits of a proximal part of the lake, bearing infrequent mollusc shells, have also been found.

IV. CONCLUSIONS

The results of studies on molluscan assemblages in the dam lake deposits in the Wetlina river valley make it possible to draw a number of conclusions, concerning both the recent malacofauna of the Bieszczady Mts., and the role of thanatocenoses in palaeogeographic reconstructions of individual Holocene phases. The latter aspect requires special attention, mainly due to clear analogies between the described basin and similar lake basins occurring throughout the Carpathians, and preserved as more or less distinct landforms, filled by deposits bearing subfossil floristic and faunistic remains.

Malacofauna of the eastern part of the Polish Carpathians has not been studied in detail, although abundant molluscan assemblages, not yet described, have been collected in the Bieszczady Mts. (Riedel 1981). The most complete lists of species, occurring in the San and Strwiąż drainage basins, have been presented by Kotula (1882) who distinguished taxons occurring mainly in the foothills, those occupying lower and higher situated sites, and those confined to high mountains. Assemblages described by Kotula are more abundant than that found in lake deposits in the Wetlina valley, although containing the same characteristic elements.

The list of species occurring in the East Carpathians has been given by Urbański (1948) in his critical review of the Polish malacofauna. This list includes nearly all the taxa found in the Wetlinka river valley, except for *Carychium tridentatum*, whose presence in that part of the Carpathians has been confirmed somewhat later (Berger 1963, Ložek 1964). Special attention should be given, however, to the presence of such species, as *Trichia bąkowski*, *Oxychilus orientalis*, and *Perforatella dibotryon*. The first species has been reported in Poland exclusively from the East Carpathians (Urbański 1948, 1956), whereas in Slovakia it extends further to the west and has been described from the Nizne Tatry Mts. (Ložek 1949, 1964). The two subsequent taxa show a similar geographic extent, and are considered East Carpathian elements. Slightly more widespread are *Discus perspectivus*, *Vitrea diaphana*, and *V. transsylvanica*, occurring throughout the Carpathians and, partly, in the Małopolska Upland. These species are confined to the Ponto-Mediterranean zoogeographic centre (Baba 1982) and, particularly, to the East Balkan and East Carpathian zones.

The above comparison indicates that the molluscan assemblage found in dam lake deposits in the Wetlina river valley is typical for the Bieszczady Mts. One can expect that future systematic studies on the present-day malacofauna inhibiting the closest surroundings of this lake would help in supplementing the list of taxa by adding species which have not been found within fluvial deposits.

Thanatocenoses composed of mollusc shells, formed in the fluvial environment, comprise fresh--water species being indicative of aquatic environment, as well as land species characterizing habitats distributed throughout the catchment area, situated upstream of the place of sediment deposition. In the course of malacological analyses concerning Quaternary faunas, these two elements should be interpreted separately, whereas their mutual quantitative relationships reflect, to a large extent, the environment of shell material accumulation. Such a conclusion results from the diversity observed in molluscan assemblages of the dam lake deposits. The distinguished associations differ from each other mainly by proportions among those taxa and specimens which represent fresh-water and land molluscs (Fig. 6 — I).

Fresh-water molluscs represent several types of environments. Dominant elements are rheophile and euryecological species, inhabiting mountaineous rivers and streams; the snails preferring episodic water reservoirs and spring zones form subordinate admixtures. Such a faunistic composition, dominated by *Ancylus fluviatilis*, reflects well conditions of aquatic environment in the Wetlinka stream, its tributaries, and reservoirs occupying the valley bottom.

The assemblage of land molluscs can be characterized by comparing of malacological MSS and MSI spectra, excluding fresh-water species (Fig. 3 — L). Both these spectra show a similar structure indicating that no one taxon dominates decisively. The amount of shadow-preferring species (ecological groups 1, 2, 3) attains 50%, that of mesophile snails, typical of moderately humid and humid environments (ecological groups 7 and 8) being around 30%.

Species characteristic of open environments (ecological groups 4 and 5) are accessory elements, whereas hygrophile species (ecological group 9) are represented mainly by *Succinea putris*.

The above presented thanatocenose composition reflects approximately the distribution of individual types of habitats in the Wetlina drainage basin. 80% of this area is covered by forests, providing habitats suitable for the development of species of groups 1, 2, and 3 and, partly, to species of groups 7 and 8. An enrichment of the thanatocenose into shells of hygrophile snails, occupying chiefly the valley bottom, as well as a large amount of mesophile snails, inhabiting bushes and different types of shadowed habitats, relates to the rate of supply of shell material into the stream. This phenomenon depends mainly on the intensity of ablation and downwash. Forested slopes are characterized by much slower and less effective transport of the material, as compared with slopes occupied by meadows and bushes. This results in a relative impoverishment of the thanatocenose into shells of snails belonging to ecological groups 1–3, in comparison with those of groups 4–8. The dam lake deposits, comprising the described molluscan thanatocenoses, are also rich in accumulations of plant remains which document very well the course of processes active in the bottom of a deeply cut valley, dammed up by a landslide. These remains are subject to actualistic studies, the results of which are essential for proper interpretations of Quaternary deposits laid down under similar conditions. Some of these deposits may be preserved on lake banks, even when the lake itself vanishes due to dissection of the colluvial dam.

The dam lake in the Wetlina river valley should be considered an exceptional object of inanimate nature. Besides its landscape and floristic properties, described by Michalik and Mazur (1991), special attention should be given to its scientific and didactic values in the field of geology and geomorphology. The first detailed description of the landslide and related dam lake was published three years after these landforms were formed (Dziuban 1983), and systematic studies on erosional and accumulational processes were initiated nearly at the same time (Cabaj and Pelc, 1991). The initiation of actualistic studies, concerning the occurrence and distribution of plant remains and mollusc shells within various types of deposits, introduced a new valuable element, consisting in a possibility of continuing of similar studies during successive stages of dissection of the colluvial dam and the related lowering of the lake level. The importance of such studies for comparative purposes is also underlain by the fact that natural environment of the Wetlina drainage basin is relatively slightly altered and does not show any distinct traces of anthropogenic influence. Hence, it may serve as a benchmark for the studies on the Holocene palaeogeography of the Carpathians. The high degree of forestation of that drainage basin provides especially favourable conditions for locking for analogies between Holocene and fairly recent geological processes. This assumption is particularly important for the poorly advanced as yet studies on thanatocenoses.

Translated into English by Witold Zuchiewicz

REFERENCES

Alexandrowicz S. W. 1978. The northern slope of Babia Góra Mt. as a huge rock slump. *Studia geomorphol. Carp.-Balk.* 12: 133–148.

Alexandrowicz S. W. 1984. Środkowoholoceńska malakofauna z Harcygrundu koło Czorsztyna (Pieniński Pas Skałkowy). *Studia geol. pol.* 83: 95–115.

Alexandrowicz S. W. 1986. Datowane osuwiska w dolinie Potoku Ścigockiego. Przewodnik LVII-go Zjazdu Pol. Tow. Geol., 229–232.

Alexandrowicz S. W. 1988. Analiza malakologiczna w badaniach osadów czwartorzędowych. *Geologia*, Zesz. Nauk. AGH, 13, 1–2: 1–216.

Baba K. 1982. Eine neue zoogeographische gruppierung der ungarischen Landmollusken und die Wertung des Faunenbildes. *Malacologia* 22, 1–2: 441–454, New York.

Cabaj W., Pelc S. 1991. Seeds and fruits from sediments of a recent landslide lake in the Wetlinka river valley (Sine Wiry reserve) (Nasiona i owoce z osadów współczesnego jeziorka osuwiskowego w dolinie Wetliny (rezerwat Sine Wiry). *Ochr. Przyr.* 49: 31–52.

Dziuban J. 1983. Osuwisko Połoma. *Czas geogr.* 54, 3: 369–376.

Kasprzak K., Niedbała W. 1981. Wskaźniki biocenotyczne stosowane przy porządkowaniu i analizie danych w badaniach ilościowych. W: Metody stosowane w zoologii gleby. Państw. Wydawn. Nauk. Warszawa.

Kotula B. 1882. Wykaz mięczaków zebranych w okolicach Przemyśla, tudzież w dorzeczu górnego Strwiąża i Sanu. *Spraw. Komis. Fizj. PAU*, A-16: 100-129.

Ložek V. 1949. Kriticky přěhled ceskoslovenskych měkkyšu. *Sborn. Narod. Musea v Praze* 5, B-3: 1–43.

Ložek V. 1964. Quartärmollusken der Tschechoslowakei. *Rozpr. Ustr. Ust. Geol.* 31: 1–374.

Michalik S., Mazur W. 1991. Roślinność rezerwatu leśno-krajobrazowego Sine Wiry w Bieszczadach Zachodnich. (The vegetation of the Sine Wiry forest-landscape reserve, West Bieszczady). *Ochr. Przyr.* 49: 3–21.

Riedel A. 1981. Stan zbadania fauny Polski — mięczaki (*Mollusca*). *Przegl. zool.* 25, 2: 251–257.

Urbański J. 1947. Krytyczny przegląd mięczaków (*Mollusca*) Polski. *Ann. UMCS*, ser. C 2: 1–35.

Urbański J. 1957. Krajowe ślimaki i małże. Państw. Zakl. Wydawn. Szkol. Warszawa.

Wasmund E. 1926. Biocenose und Thanatocenose. *Arch. hydrobiol.* 17: 1–116, Stuttgart.

STRESZCZENIE

Jeziorko w dolinie rzeki Wetliny w Bieszczadach utworzyło się w roku 1980-tym w wyniku zatamowania rzeki przez masy koluwialne dużego osuwiska. Osady akumulowane

na dnie zbiornika oraz na jego brzegach zawierają liczne szczątki roślin oraz skorupki mięczaków. Badania malakologiczne zostały przeprowadzone na podstawie 10-ciu próbek, z których uzyskano ponad 1400 skorupek ślimaków i małżów, reprezentujących 42 taksony (ryc. 1, tab. I, II). Próbki zostały pobrane w następujących strefach jeziorka: 3 próbki (G) z dna zbiornika, 3 próbki (S) z brzegów jeziorka, 2 próbki (T) z odsypu występującego około 1,5 m ponad poziomem wody, 2 próbki (P) z materiałem akumulowanego tuż przy poziomie wody. Największa koncentracja skorupek jest notowana w próbkach P, a najmniejsza — w próbkach T. Ilość taksonów występujących w wymienionych strefach sedymentacji jest mało zróżnicowana. Udział mięczaków wodnych jest najwyższy w osadach tworzących się tuż nad poziomem wody, a najniższy w odsypach położonych wysoko, natomiast w osadach dennych wynosi on około 70% (tab. I).

Zespół mięczaków obejmuje gatunki typowe dla różnych środowisk (tab. II). Gatunkami dominującymi są *Ancylus fluviatilis* i *Lymnaea peregra peregra*. Wysokie klasy stałości (C-4 i C-5) wykazuje tylko 9 gatunków ślimaków podczas gdy w najniższych klasach stałości i dominacji mieści się 18 gatunków. W konsekwencji ponad połowę taksonów można określić jako składniki akcesoryczne asocjacji (ryc. 2). Za gatunki charakterystyczne można uznać ślimaki lądowe: *Carychium tridentatum*, *Oxychilus orientalis* i *Vitrea diaphana* oraz ślimaki wodne — *Ancylus fluviatilis*, *Lymnaea peregra peregra* i *L. truncatula*.

Spektrum malakologiczne MSS wskazuje, że ponad połowa taksonów odpowiada faunie związanej ze środowiskiem leśnym, natomiast na spektrum MSI wyraźnie zaznacza się liczne występowanie skorupek ślimaków wodnych. Zwraca uwagę bardzo mały udział ślimaków typowych dla środowiska otwartego (ryc. 3-Z). Struktura zoogeograficzna asocjacji ukazuje dużą liczebność gatunków o szerokim rozprzestrzenieniu a także gatunków środkowoeuropejskich, w tym — typowych dla Alp i Karpat (ryc. 3 — ZG). Taksony występujące w Europie wschodniej i południowo-wschodniej, w tym również w Karpatach wschodnich, są reprezentowane przez: *Oxychilus orientalis*, *Trichia bąkowski*, *Perforatella dibotryon* i *Discus perspectivus*. Są to gatunki charakterystyczne dla opisywanego zespołu.

Malakofauna występująca w osadach jeziorka zaporowego tworzy tanatocenozy autochtoniczne i parautochtoniczne czyli mixocenozy. Strefy sedymentacyjne, z których pochodzą próbki reprezentują cztery tanatotopy, określone symbolami G, P, S i T. Rozmieszczenie poszczególnych gatunków mięczaków w tych tanatotopach jest dość jednolite. Wynika to z dendrytu taksonomicznego, na którym analizowany zbiór zespołów nie rozdziela się na jednorodne podzbiory (ryc. 4). Różnice między zespołami związanymi z tanatotopami zaznaczają się natomiast na spektrach malakologicznych MSI (ryc. 3). Tanatocenozy P i G odznaczają się dominującym udziałem mięczaków wodnych podczas gdy tanatocenozy S i T mają skład bardziej wyrównany (ryc. 5 — I). Wskaźnik różnorodności asocjacji TDI osiąga najwyższe wartości w tanatocenozach T i S (zespoły generalizowane) a najniższe — w tanatocenozach P i G (zespoły specjalizowane). Wartości tego wskaźnika nie są skorelowane z ilością taksonów, co jest cechą typową dla tanatocenoz mieszanych (ryc. 5 — II).

Skorupki mięczaków transportowane przez rzekę głównie podczas powodzi są sortowane według ich wielkości i ciężaru. Są one osadzane w czasie obniżania się poziomu wody i gromadzą się w dystalnej części jeziorka, wzdłuż jego brzegów, w zatoczkach i na dnie zbiornika w pobliżu zapory koluwialnej. Tanatocenozy powstające pod wpływem czynników działających z różnym nasileniem odznaczają się określonym składem fauny i stanem jej zachowania (ryc. 6 — I). Podobne zróżnicowanie wykazują nagromadzenia szczątków roślinnych opisane przez Cabaja i Pelca (1991). Autorzy Ci wyróżnili fację deltową i jeziorną (ryc. 6 — II). Analiza malakologiczna potwierdza możliwość wydzielenia takich facji zarówno w jeziorku w dolinie Wetliny jak też w osadach kopalnych jeziorek zaporowych opisanych z Pienin (Alexandrowicz, 1984).

Opisany zespół mięczaków zawiera gatunki żyjące w Bieszczadach (Kotula 1882, Urbański 1948). Tanatocenozy obejmują faunę lądową, która odpowiada różnym typom środowisk rozprzestrzenionych na obszarze zlewni Wetliny oraz faunę wodną, charakteryzującą środowisko rzeczne i zbiorniki na terasie zalewowej. Wśród mięczaków wodnych dominują gatunki reofilne i euryekologiczne, spotykane w górskich potokach i w pobliżu źródeł. Spektra malakologiczne MSS i MSI, uwzględniające tylko mięczaki lądowe mają strukturę bardzo podobną do siebie (ryc. 3 — L). Udział ślimaków lądowych wynosi około 50%, ślimaków mezofilnych — około 30%, a ślimaki typowe dla siedlisk podmokłych i otwartych osiągają kilka do kilkunastu procent. Taki skład tanatocenozy odzwierciedla w przybliżeniu udział powierzchni zajętych przez poszczególne typy środowisk, bowiem około 80% zlewni Wetliny zajmują lasy.

Opisane jeziorko zaporowe należy uznać za unikalny zabytek przyrody nieożywionej. Obok jego walorów krajobrazowych i florystycznych na podkreślenie zasługują wartości naukowe i dydaktyczne z zakresu geologii i geomorfologii jak też możliwości prowadzenia obserwacji nad gromadzeniem się w osadach szczątków roślin i skorupek mięczaków. Studia takie mogą być kontynuowane w kolejnych etapach rozcinania rygla koluwialnego i obniżania się poziomu jeziorka. Wyniki badań aktualistycznych mogą być pomocne przy interpretowaniu ewolucji koplanych zbiorników zaporowych, które istniały na obszarze Karpat w różnych fazach holocenu.