FOLIA MALACOLOGICA
Folia Malacol. 5: 15–24
Cracow, 1993
http://dx.doi.org/10.12657/folmal.005.001

LATE HOLOCENE MOLLUSCAN ASSEMBLAGES FROM CZORSZTYN (PIENINY KLIPPEN BELT, SOUTHERN POLAND)

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ABSTRACT: Rich molluscan assemblages occur in the Upper Holocene sediments of the Pasternik stream at Czorsztyn and in limestone soils on rocks at the castle of Czorsztyn. The older assemblagę found in the muds of the upper terrace comprises a fauna with a big share of forest snails whereas the younger assemblage comes from the sediments of the lower terrace and contains mostly typical species of the open environment. The change of fauna is due to the deforestation of the catchment basin of the stream, which took place in the 13th and 14th centuries. In the initial limestone soil there are very numerous snail shells representing various ecologic groups and the diversification of the assemblages reflects the mosaic pattern of their habitats, which were being slightly changed by human impact.

KEY WORDS: Pieniński National Park, molluscan assemblages, fluvial deposits, ecological groups

Folia Malacologica 5/1993 was originally published as No. 1462 of Scientific Bulletins of University of Mining and Metallurgy, Cracow. This digitalised version was prepared by the Association of Polish Malacologists and first published on-line on December 30th, 2016.

Ministry of Science and Higher Education
Republic of Poland

This digitalised version of Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland under the agreement no. 646/P-DUN/2016 allocated to the activities of disseminating science and by the courtesy of the Rector of the AGH University of Science and Technology, Cracow

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Late Holocene Molluscan Assemblages from Czorsztyn (Pieniny Klippen Belt, Southern Poland)

1. Introduction

In several years, the section of the Dunajec River valley that lies between Niedzica and Czorsztyn will be flooded and transformed into a large, man-made lake. Many interesting localities and geological profiles will then be submerged and never accessible. This concerns a.o. the Holocene outcrops near the castle of Czorsztyn. Two types of sediments that contain snail, slug and bivalve shells can be distinguished there. One of them comprises the muds, sands and gravels that form the terraces of the stream at its outlet to the Dunajec River and the other comprises the limestone soils that occur on limestone rocks, in the crevices, niches, pits and on the irregular surfaces of the rocky slopes. The molluscan assemblages of these sediments have been studied as a part of the Scientific Project CPBP 04.06.01, to be a continuation of the studies on the history of the malacofauna of the Pieniny Mts.

The malacological analysis covered two sampling series that represented the stream sediments and the limestone soils. Out of each series, 6 samples were selected to characterise all the localities studied. All the samples were approximately one size (2.5 - 3 kg) and the tossing, picking up fauna and determining the number of specimens of each taxon were done according to the standard method described by the author (ALEXANDROWICZ 1987). In the lists of the determined species the ecologic groups defined by LOZEK (1964) are considered and the malacological spectra and variability indexes of the assemblages were computed by means of an Amstrad-Schneider 6128 computer using the author's programs Spektrum and Divind.

2. Fauna of fluvial sediments

The Pasternik Stream is a small, left-hand tributary of the Dunajec River. Its catchment basin covers an area of 1.5 sq.km, 30% of which is covered with forest, and its deep, V-shaped valley is 1.5 km long, its gradient being 10‰. In the lower

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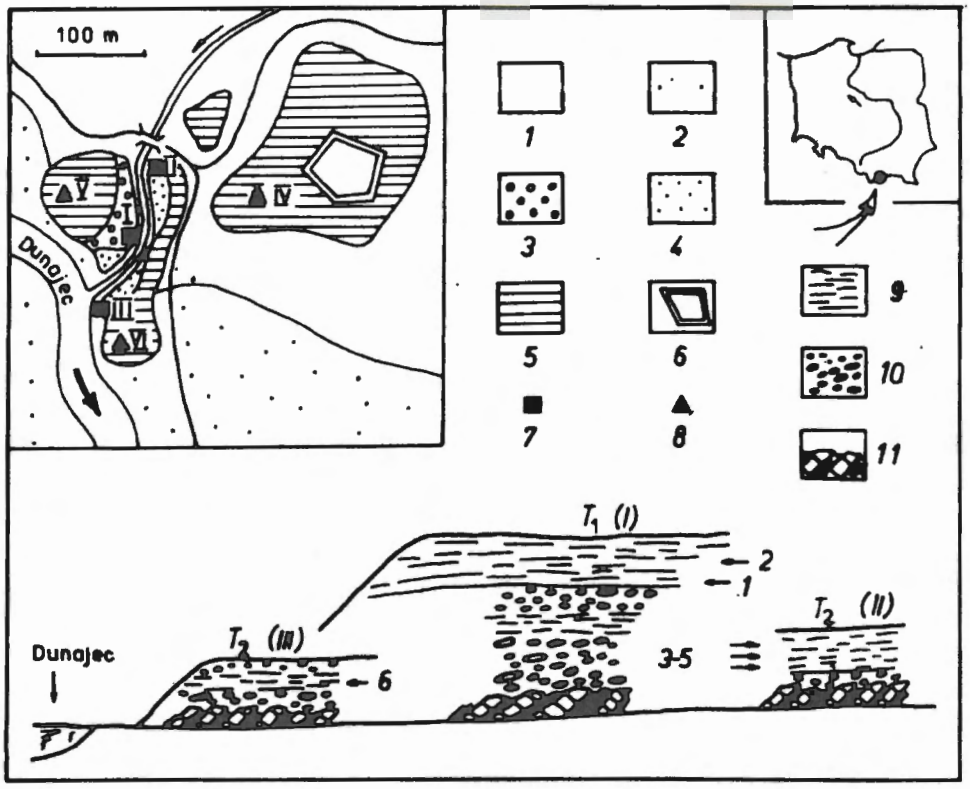

Fig. 1. Holocene sediments of the Pasternik stream at Czorsztyn, 1 - slope, 2 - terrace of the Dunajec river, 3 - upper terrace of the Pasternik stream, 5 - limestone rocks, 6 - ruins of the Czorsztyn castle, 7 - localities of fluvial sediments (I - III), 8 - localities of limestone soils (IV - VI), T1 - upper terrace (1 - 2 - situation of samples), T2 - lower terrace (3 - 6 - situation of samples), 9 - muds, 10 sands and gravels, 11 - rock base

section of the valley, near its mouth, there are two terraces marked by symbols T1 (4 - 5 m) and T2 (1.5 - 2 m). The sediments that form the terraces are visible in the lower part of the valley among the limestone rocks described by BIRKENMAJER (1957). They are gravels, sands with fine gravels, and muds with sand intercalations (Fig. 1). Snail shells were found in the muds of both terraces.

The profile of the upper terrace (T1) is accessible within the left-hand bank of the stream.

The rock base, 0.5 m high, is covered with gravels and coarse-grained sands with limestone and sandstone boulders, which contain thin layers of black sandy silt. Upward, they pass into grey and yellowish grey muds (fen soils) with laminae of fine-grained sands, and in the roof part of the outcrop a recent soil is developed (Fig. 1 - I). The molluscan assemblage that occurs in the lower part of the mud (fen soil) comprises 27 taxons (Tab. 1 - T-1). Its main component are snails of shady habitats - small *Vitrea* shells in particular: *V. diaphana*, *V. transsylvanica*, *V. subrimata*, *V. crystallina*. They are accompanied by, a.o.: *Acicula polita*, *Bradybaena fruticum*, and some species that prefer very humid forests. The snails that are typical

Table 1

Molluscan assemblages of stream sediments.T1-6 - number of samples, E - ecologic groups (as in Fig. 2); symbols of individual number: I - 1...3, II - 4...9, III - 10...31, IV - 32...99, V - 100...316, VI - 317...999

E	Taxon	T -	1	2	3	4	5	6
1	*Acicula polita* (HARTMANN)		II	I				
1	*Argna bielzi* (ROSSMÄSSLER)		I					
1	*Ena montana* (DRAPARNAUD)		I					
1	*Eucobresia nivalis* (DUMONT-MORTILLET)				II	II		
1	*Semilimax semilimax* (FÉRUSSAC)		I					
1	*Oxychilus depressus* (STERKI)		I	I				
1	*O. orientalis* (CLESSIN)		I					
1	*Vitrea diaphana* (STUDER)		III	II	I			
1	*V. transsylvanica* (CLESSIN)		II		I			
1	*V. subrimata* (REINHARDT)		II	I				
1	*Cochlodina laminata* (MONTAGU)				I			
1	*Chilostoma faustinum* (ROSSMÄSSLER)		I					
1	*Isognomostoma isognomostoma* (SCHRÖTER)		II		I			
2	*Discus rotundatus* (FÉRUSSAC)		I	II	I			
2	*Vitrea crystallina* (O.F.MÜLLER)		I	II	I	I		I
2	*Alinda biplicata* (MONTAGU)				I			
2	*Bradybaena fruticum* (O.F.MÜLLER)		II	I			I	
3	*Perforatella bidentata* (GMELIN)		I					I
3	*P. vicina* (ROSSMÄSSLER)		I	I	I		I	
3	*P. umbrosa* (PFEIFFER)		I		II	II	I	
5	*Truncatellina cylindrica* (FÉRUSSAC)		I				I	
5	*Vertigo pygmaea* (DRAPARNAUD)				I	I		
5	*Pupilla muscorum* (LINNAEUS)		I		II	III	II	I
5	*Vallonia pulchella* (O.F.MÜLLER)		I	II	III	III	IV	II
5	*V. costata* (O.F.MÜLLER)		I	I	II	III	II	
6	*Cochlicopa lubricella* (PORRO)						I	
7	*C. lubrica* (O.F.MÜLLER)			I	II	II		I
7	*Vertigo alpestris* ALDER						I	
7	*Punctum pygmaeum* (DRAPARNAUD)		I	I		I		
7	*Vitrea contracta* (WESTERLUND)		I					
7	*Nesovitrea hammonis* (STRÖM)				I	II		
7	*Limacidae*		II	I				I
8	*Carychium tridentatum* (RISSO)		I	II	III	III	II	
8	*Succinea oblonga* DRAPARNAUD						I	
8	*Trichia villosula* (ROSSMÄSSLER)		I					
9	*Succinea putris* (LINNAEUS)				II	III	III	I
9	*Zonitioides nitidus* (O.F.MÜLLER)				II	II		
10	*Lymnaea palustris* (O.F.MÜLLER)		I					
10	*L. truncatula* (O.F.MÜLLER)		I			I		
10	*Pisidium amnicum* (O.F.MÜLLER)						I	

of the open environment and the mesophile ones are represented by single specimens only. The occurrence of freshwater snails that can survive in temporarily desiccated ponds is worth of attention.

In the middle part of the mud profile in question the fauna is very poor and comprises only 13 taxons (Tab. 1 - T-2). The most numerous snails belong to the species that prefer shady habitats: *V. diaphana*, *V. crystallina*, *Discus rotundatus*, but on the other hand, the share of shells of mesophile snails and of the ones that are characteristic of exposed habitats is markedly bigger. There are no aquatic molluscs and the hygrophile species are an accessory element (Fig. 2 - T-1, T-2).

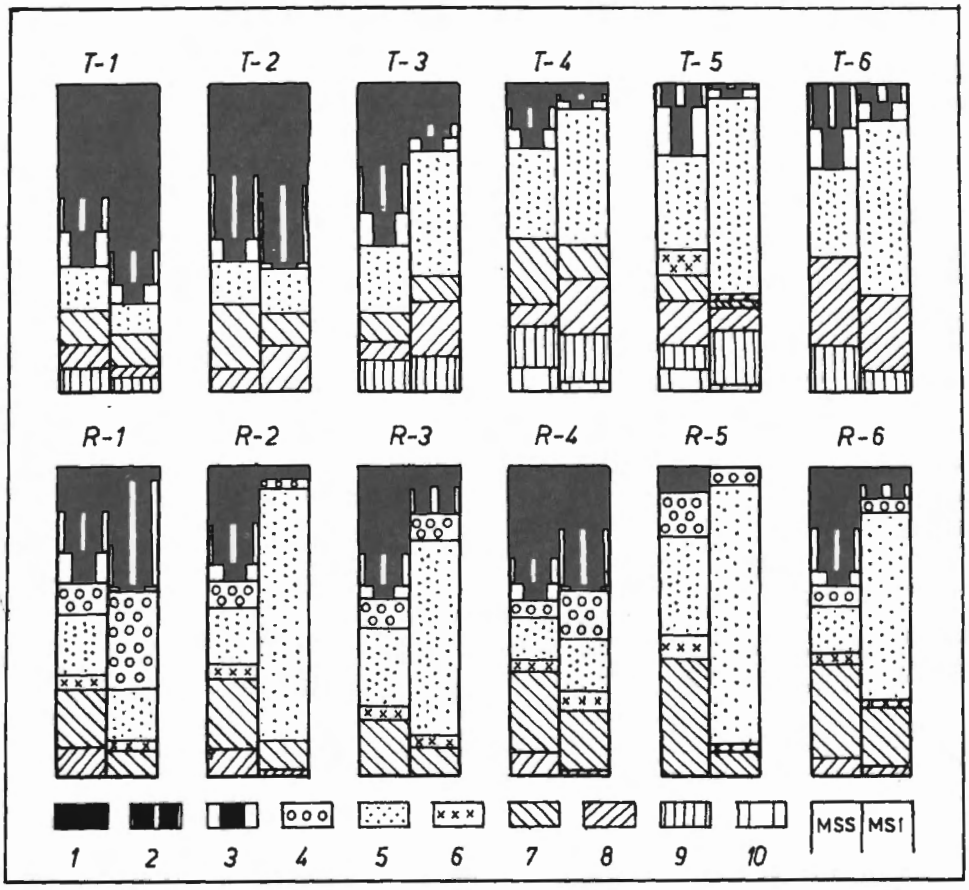

Fig. 2. Malacological spectra of samples of the Holocene sediments of the Czorsztyn area. MSS - species number spectra, MSI - individual number spectra, T-1 - T-6 - samples of fluvial sediments (location as in Fig. 1), R-1 - R-6 - samples of limestone soils; symbols of ecologic groups (E): 1 - forest snails, 2 - snails preferring shady and partly shady habitats, 3 - forest and shade-preferring snails, typical of very humid substrate, 4 - snails of dry and sunny habitats, living also on rocks, 5 - snails of open environment, 6 - mesophilous species of dry habitats, 7 - mesophilous snails of moderately humid habitats, 8 - mesophilous snails of humid habitats, 9 - hygrophilous species, 10 - water molluscs

The profiles of the sediments of the lower terrace (T2) are visible on the left-hand bank of the stream - one of them under the bridge and the other near the outlet. The former comprises grey muds covering a thin layer of gravels and the rock base (Fig. 1 - II). The muds contain numerous mollusc shells. In the lower part of the profile (Tab. 1 - T-3) the assemblage comprises species of various ecologic groups. The snails that prefer shaded and partly shaded habitats are represented by 10 taxons, out of which there are quite numerous specimens of *Eucobresia nivalis* and *Perforatella umbrosa*. It is here that single shells of the *Clausillidae* (*Cochlodina laminata*, *Alinda biplicata*) that are not recorded from other samples of the fluvial sediments, have been found. The main component of the assemblage are open-environment species, (*Vallonia pulchella*, *V. costata*), mesophile snails (*Carychium tridentatum*) and hygrophile ones (Fig. 2 - T-3).

In the middle part of the profile (Tab. 1 - T-4) most of the species that prefer shaded habitats have disappeared and the dominants are snails of the open environment (*V. pulchella*, *V. costata*, *Pupilla muscorum*) along with mesophiles and hygrophiles (*C. tridentatum*, *Succinea putris*). A similar assemblage occurs in the upper part of the profile (Tab. 1 - T-5), in which the predomination of the species that live in exposed habitats is even more conspicuous (Fig. 2 - T-4, T-5).

In the other profile of the sediments of the lower terrace (Fig. 1 - III) the rock base is covered with gravels and sands with an intercalation of sandy mud. The mud contains a poor molluscan assemblage that comprises only 7 taxons, out of which the open-environment snails prevail (Tab. 1 - T-6, Fig. 2 - T-6).

3. Fauna of limestone soils

The group of Czorsztyn Castle rocks is formed of Jurassic and Cretaceous limestones. On the surface of these limestones - especially in small pits, niches and rock shelters - there are inicial soils. These are limestone soils of (A)C-C profile with a thin layer of mull, which abound in small fragments of limestone. In these solis, many subfossil snail shells can be found.

The first locality studied is situated on the southeast slope of the biggest rock at the castle (Fig. 1 - IV). The limestone beds are here cut by a slit, which is no more than 25 cm wide, partly filled with powdery clay with a considerable admixture of humus. In this material, a rich molluscan assemblage occurs, which comprises 21 taxons. The main components of the assemblage are: *A. biplicata, Chondrina clienta, Pyramidula rupestris, V. costata, Nesovitrea hammonis*. Six other species of the assemblage are also quite numerously represented (Tab. 2 - R-1). The assemblage in question differs from the others in the domination of two ecologic groups: the snails that live in partly shaded habitats and the ones that

Table 2

Molluscan assemblages of limestone soils. R1-6 - numbers of samples. Explanations as to Tab. 1

E	Taxon	R -	1	2	3	4	5	6
1	*Vertigo pusilla* (MÜLLER)		III	IV	II	I	I	III
1	*Argna bielzi* (ROSSMÄSSLER)					I		
1	*Ena montana* (DRAPARNAUD)					I		
1	*Oxychilus depressus* (STERKI)				I	I		
1	*Oxychilus orientalis* (CLESSIN)					II	I	
1	*Vitrea diaphana* (STUDER)				III	IV		
1	*Vitrea transsylvanica* (CLESSIN)				I			
1	*Vitrea subrimata* (REINHARDT)					II		
1	*Cochlodina orthostoma* (MENKE)			I				I
1	*Perforatella incarnata* (MÜLLER)		I	II	I	III		II
1	*Chilostoma faustinum* (ROSSMÄSSLER)		I	II	I	II		II
1	*Isognomostoma isognomostoma* (SHRÖTER)					I		
2	*Vitrea crystallina* (MÜLLER)		I					
2	*Aegopinella minor* (STABILE)			I	II	III		III
2	*Alinda biplicata* (MONTAGU)		V	I	IV	IV		III
2	*Arianta arbustorum* (LINNAEUS)		I	II		II		II
2	*Helix pomatia* LINNAEUS							I
3	*Perforatella vicina* (ROSSMÄSSLER)		II			I		I
3	*Perforatella umbrosa* (PFEIFFER)		I	II	I	II		
4	*Pyramidula rupestris* (DRAPARNAUD)		IV	III	III	IV	II	III
4	*Chondrina clienta* (WESTERLUND)		V	III	III	III	III	III
5	*Truncatellina cylindrica* (FÉRUSSAC)		III	VI	IV	I	V	I
5	*Vertigo pygmaea* (DRAPARNAUD)				I	I		
5	*Pupilla muscorum* (LINNAEUS)		III	II	III	III	III	II
5	*Vallonia pulchella* (MÜLLER)		III	IV	IV	III	IV	IV
5	*Vallonia costata* (MÜLLER)		IV	VI	IV	V	V	V
6	*Cochlicopa lubricella* (PORRO)		III	I	III	III	I	II
7	*Cochlicopa lubrica* (MÜLLER)		II	III		I	I	IV
7	*Vertigo alpestris* ALDER				I	II		II
7	*Punctum pygmaeum* (DRAPARNAUD)			IV	II	III	IV	IV
7	*Vitrina pellucida* (MÜLLER)			IV		II	I	III
7	*Vitrea contracta* (WESTERLUND)		I		I			
7	*Nesovitrea hammonis* (STRÖM)		IV	III		II		III
7	*Euconulus fulvus* (MÜLLER)			II	III	I		I
7	*Clausila dubia* DRAPARNAUD		III		III	III	I	III
7	*Limacidae*					I	I	II
8	*Columnella edentula* (DRAPARNAUD)			II		I		I
8	*Vertigo substriata* (JEFFREYS)					I		
8	*Succinea oblonga* (DRAPARNAUD)		I					
8	*Trichia villosula* (ROSSMÄSSLER)		I	I		I		II

are adapted to living in dry conditions and rocky habitats. On the contrary, the ecologic group of typical species of the open environment covers only less than 20% (Fig. 2 - R-1).

Close to the described slit, in small and shallow pits, there are limestone soils that abound in subfossil snail shells. In the assemblage that contains 22 taxons, 60% of the specimens belong to the two representatives of ecologic group 5. These are *Truncatellina cylindrica* and *V. costata*, accompanied by numerous shells of *V. pulchella, Vertigo pusilla, Punctum pygmaeum* and *Vitrina pellucida* (Tab. 2 - R-2, Fig. 2 - R-2).

On the rock that rises on the right-hand bank of the stream (locality V) the initial limestone soils occur at several spots. One such spot is a shallow pit in the upper part of the rock, which is filled with waste rock covered with a thin layer of humus containing fragments of limestone. In this layer there are very numerous shells of molluscs representing 21 taxons. The main element of the fauna are species that are typical of the open environment - *T. cylindrica, V. costata* and *V. pulchella*, in particular. They total 60% of the fauna. *A. biplicata, Cochlicopa lubricella*, and *C. dubia* shells are also numerous (Tab. 2 - R-3, Fig. 2 - R-3). Another place where an initial soil with a rich, molluscan assemblage occurs is in the lower part of the slope, in a pit under a low overhang. The assemblage is characterised by a relatively high TDA index and contains 35 taxons of various ecologic groups. Some of them are species that prefer shady places and mesophiles, and the others are type species of sunny, dry and rocky places. The main elements of the assemblage in question are as follows: *V. diaphana, A. biplicata, V. costata, P. rupestris, C. clienta, P. incarnata, P. muscorum, A. minor* (Tab. 2 - R-4, Fig. 2 R-4).

An interesting profile of initial limestone soil has been found on the Halka rock, on the left-hand bank of the stream (Fig. 1 - VI). In the lower part of the southwest slope of the rock there is a small niche filled with waste rock that upward passes into an A(C) layer, the thickness of which reaches 15 cm. In the molluscan assemblage of the lower part of the layer there are almost none forest species. More than 80% of the assemblage are the shells of typical species of the open environment: *T. cylindrica, V. costata, V. pulchella, P. muscorum*. They are accompanied with numerous shells of *P. pygmaeum* and *C. clienta* (Tab. 2 - R-5, Fig. 2 - R-5). In the upper part of the A(C) layer the species mentioned above are also the dominant elements of the assemblage, but the more important ones are snails that prefer shady places and mesophiles, as: *V. pusilla, A. biplicata, C. lubrica, V. pellucida, N. hammonis, C. dubia* (Tab. 2 - R-6, Fig. 2 - R-6).

4. Interpretation

The Holocene sediments outcropped at Czorsztyn have not been radiocarbon-dated, but their age can be determined using analogies from the described profiles at Sromowce (ALEXANDROWICZ, NADACHOWSKI, VALDE-NOVAK & WOŁOSZYN 1985, ALEXANDROWICZ 1991). In the valleys of the streams Limbargowy and Macelowy there is a lower terrace formed of sediments of the Sub-Atlantic phase, which were being deposited from the ancient Roman times to the Middle Ages (the fifth to twelfth centuries AD). The terrace corresponds to the T1 terrace of the the Pasternik stream at Czorsztyn. The younger sediments of the T2 terrace are comparable with the sands, gravels and muds of the alluvial fans of the streams that discharge themselves into the Dunajec river at Sromowce Wyżne and at Sromowce Niżne (ALEXANDROWICZ 1991). They represent the historical times and are less than 600 years old. The initial limestone soils that occur on the rocks of the castle of Czorsztyn can be included to the Upper Holocene, too.

The molluscan assemblages that are found in the described two types of sediments are different in several characters. In the limestone soils the fauna is richer and in their individual samples the number of specimens is 5 to 10 times bigger than in the samples of the sediments of the stream. On the other hand, the number of taxons is nearly the same in the two sampling series (Fig. 3 - I). The TDA diversity index of the assemblages is variable within a wide range: in the initial soils TDA = 0.49...0.87, while in the terraces TDA = 0.53...0.85 (Fig. 3 - II).

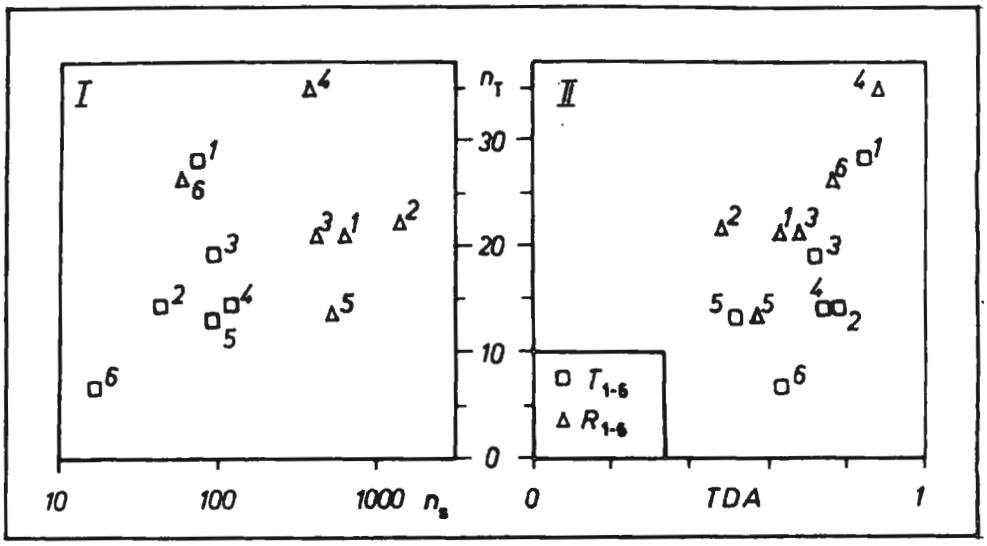

Fig. 3 - Structural characters of fauna assemblages. nT - number of taxons, nS - number of individuals, TDA - diversity index of assemblages, (antilogarithm of TDI index), I - nT-nS relation, II - NT-TDA relation, T1-2 - samples of the Pasternik stream sediments, R1-6 - samples of limestone soils

The highest diversity and biggest number of taxons were found for a sample of the lower part of the mud of the upper terrace (T-1) and samples of the initial soil of a rock shelter and a rock niche (R-4 and R-6). In the sediments of the lower terrace shells of hygrophilous and aquatic snails occur (ecologic groups 9 and 10) while the occurrence of snails that prefer living in dry places, on rocks, and represent ecologic group 4, is characteristic of the soils (Fig. 2).

A high percentage of snails that prefer to live in shady places, some of the species being typical forest ones, is characteristic of the mud of the upper terrace. The proportion between the number of specimens that belong to ecologic groups 1 - 3 and to ecologic group 5 is 7 : 1 for sample T-1 and 4 : 2 for sample T-2. This is indicative of the distinct afforestation of the catchment area of the stream at the time when the mud sedimented. In the molluscan assemblages of the sediments of the lower terrace the proportions between the ecologic groups are the opposite. The main element are the shells of open-environment snails and the said proportion is 1 : 2 to 1 : 6, and even less than 1 : 10 (sample R-5). These sediments were deposited after the time when a large part of the catchment area of the Pasternik stream was deforested, and the assemblages reflect the impoverishment of the malacocoenosis that lived in the then habitats.

The main component of the fauna of the limestone soils are the shells of open-environment snails. In some samples, also a distinct percentage of snails that live on rock walls or in partly shaded places has been observed. The assemblages of particular samples are recognizably different from each other and their composition is mainly due to the respective local conditions. The fauna of the sediments that fill crevices consists of three elements. They are snails of ecologic groups 2, 4, and 5 (sample R-1). In the upper parts of rocks, in shallow pits, there are assemblages , in which typical open-environment snails prevail (samples R-2 and R-3). In the lower part of the slope there are soils, the fauna of which contains many taxons, including the shells of snails of various ecologic groups. These assemblages belong to the mixocoenosis type and consist of species that live in various habitats in the upper part of the rock (sample R-4). The succession that characterizes the profile of the limestone soil accumulated in a hollow on a rock comprises two assemblages. In the lower part, the fauna contains mainly the shells of typical open-environment snails while in the upper one there is an admixture of mesophilous and shade-preferring species (samples R-5 and R-6).

The Holocene sediments of the Czorsztyn area contain a malacofauna of a total of 49 species of terrestrial snails and two species of aquatic snails, one bivalve species, and slug shells. When compared with the Recent fauna of the Pieniny Mts., as described by URBAŃSKI (1939), DZIĘCZKOWSKI (1972) and RIEDEL (1976, 1982, 1988), there are only 50% of the number of the Recent taxons, so much less then in the Holocene sediments of the Sromowce area (ALEXANDROWICZ 1991). The difference is due to the small diversification of habitats in the

catchment area of the Pasternik stream, whereas the catchment basins of the streams Limbargowy and Macelowy cover the main range of the Pieniny Mts. and the area of the Pieniny Mts. National Park that has a very varied relief and flora and fauna. The succession of assemblages that is observed within the terraces reflects the human impact on the environment. The observed changes in the environment are due to the development of colonization in the XIIIth and XIVth centuries and also in the next ones (KOŁODZIEJSKI, PARCZEWSKI, RYDLEWSKI & VALDE-NOWAK 1982). The older fauna corresponds to the time before the deforestation of the catchment area of the stream, so it characterizes the Sub-Atlantic phase till the Early Middle Ages. The younger fauna was being accumulated after the deforestation, probably in the last two centuries.

The molluscan assemblages found in limestone soils on rocks were only slightly changing as the human impact increased, because the steep, rocky slopes were almost uncultivated by man. The assemblages have maintained much of their natural character and reflect the original mosaic of habitats.

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