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THE MALACOFAUNA OF LATE HOLOCENE SEDIMENTS OF SROMOWCE (THE PIENINY MOUNTAINS, SOUTHERN POLAND)

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ABSTRACT: Two subfossil mollusc assemblages have been found near Sromowce, occurring in sediments of the Late Holocene. The older assemblage occurs in sediments dated to the V–XII centuries AD, and the younger one is connected with the sediments created in the two most recent centuries. The former comprises numerous species of forest and mesophilous snails and mass agglomerations of *Bythinella austriaca* shells. The presence of such a fauna indicates that in the Early Middle Ages, the southward slopes of the main range of the Pieniny Mountains were almost completely afforested. The dominants in the latter assemblage are typical snails of open habitats. The alteration of the malacofauna, being due to the deforestation of a considerable area, reflects a transformation of the natural environment under human impact.

KEY WORDS: snail assemblages, anthropopression, deforestation, thanatocoenoses, malacofauna

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Two subfossil mollusc assemblages have been found near Sromowce, occurring in sediments of the Late Holocene. The older assemblage occurs in sediments dated to the V – XII centuries AD, and the younger one is connected with the sediments created in the two most recent centuries. The former comprises numerous species of forest and mesophilous snails and mass agglomerations of *Bythinella austriaca* shells. The presence of such a fauna indicates that in the Early Middle Ages, the southward slopes of the main range of the Pieniny Mountains were almost completely afforested. The dominants in the latter assemblage are typical snails of open habitats. The alteration of the malacofauna, being due to the deforestation of a considerable area, reflects a transformation of the natural environment under human impact.

1. Introduction

The malacofauna of the Pieniny Mountains was described by URBAŃSKI (1939), DZIECZKOWSKI (1971), and RIEDEL (1976). It covers more than 100 species of land snails. This means that about 60% of all the snail and slug species known to belong to the Polish fauna occur now in the small area of the Pieniny Mountains National Park and its close vicinity (RIEDEL 1982, 1988). With 15 taxons of freshwater snails and bivalves, it adds up to the real richness of the molluscan fauna, which is due to the very high diversity of habitats and plant communities, the wide distribution of limestone rocks, the favourable climate, and to the fact that the natural environment protected by means of the National Park and nature reserves has only been slightly changed. In the Pieniny, it was not only in the entire Holocene but also in the cold glacial periods, when there were favourable conditions to molluscs to develop. According to URBAŃSKI (1939, 1948) in the said region there were refuges that enabled some species to survive through the periglacial climate phases which repeated several times during the Pleistocene.

The history of the postglacial development of the malacofauna of the Pieniny Mountains and changes in the molluscan assemblages, being due to the natural evolution of the palaeogeographic environment as well as human impact, have not been the subject of a detailed

study so far. Nevertheless, it was as early as in the thirties, when URBAŃSKI (1939) undertook the task and suggested that it had to be continued. The author has been filling the gap, by carrying out studies supported by grants for the research project CPBP 04.06.01 being coordinated by the Institute of Zoology, Polish Academy of Sciences. The studies has covered the fauna of carbonate sediments of the Middle and Late Holocene that was found on several localities in the vicinity of Niedzica, Sromowce, and Kroscienko (ALEXANDROWICZ 1985, 1989), the fauna of slope sediments occurring in a small cave in the Sobczanski Gorge (ALEXANDROWICZ et al. 1985) and a fauna connected with radiocarbon-dated slides (ALEXANDROWICZ 1984, 1986, 1988b). The subject of the following study are molluscan assemblages found in fluvial sediments of the Late Holocene of the areas of Sromowce Wyżne and Sromowce Niżne on the Dunajec River.

2. Material and methods

The analysed fauna was found on six localities of the valleys of the streams Potok Głęboki, Potok Limbargowy, Potok Macelowy, and Potok Sobczański (Fig. 1). A total of 28 samples of silts, sandy silts, and sands, weighting 2...3 kg each, were taken from outcrops of fluvial sediments. The samples were washed so as to pick up all the mollusc shells and shell pieces that could be determined. The material obtained in this way comprised more than 7,700 specimens belonging to 64 taxons (Tab. 1). The methods used to determine the number of shells representing each taxon, to distinguish ecologic groups and to include the corresponding taxons, and to set up malacological spectra and association structure diagrams were ones described by LOŽEK (1964), PUISSEGUR (1976), and ALEXANDROWICZ (1988a). The diversity of assemblages analysed on a basis of sample sets has been expressed as a degree of biotic dispersion, as defined by L.F.KOCH (REYMENT 1971). This value can be conveniently recognized with the use of the association diversity index ADI described by the author (ALEXANDROWICZ 1988a).

In the molluscan assemblages of the sediments of the Late Holocene of the Sromowce area, the share of aquatic fauna shows much variation. This character makes a palaeoecological interpretation, as one which is chiefly based on the analysis of number of taxons and specimens of terrestrial snails connected with various habitat types, difficult. Hence, the malacological spectra to characterize the assemblages of fauna are so constructed that they cover only the land fauna, proportions between the freshwater snails and the land ones being drawn in the form of simplicised diagrams, the two elements considered only. The structure of the assemblages of the Potok Macelowy (Mt) and Potok Głęboki (Gl) streams has been reconstructed in two steps: for the whole fauna and for the terrestrial one, separately. In this way, it has been possible to determine the ecologic type of both the whole thanatocenosis accumulated by a stream and the thanatocenosis element that comes from the slopes and bottom of the valley, from the surroundings of the sedimentary basin.

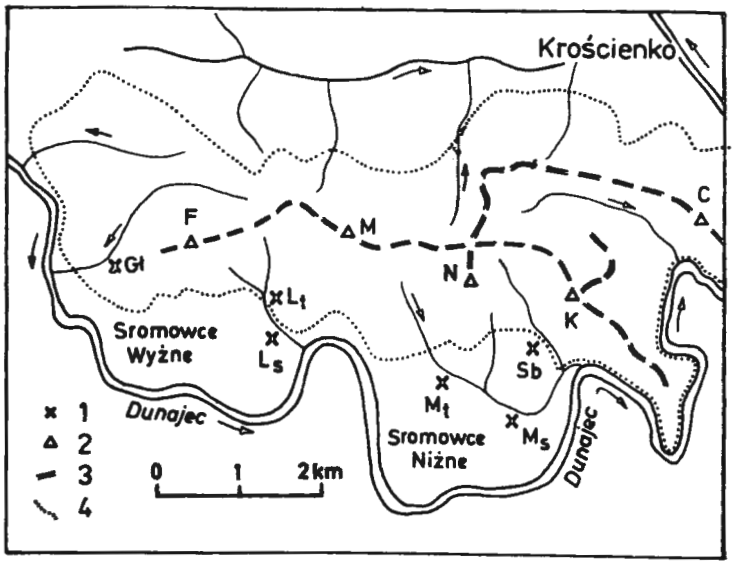


Fig. 1. The situation of outcrops of the Late Holocene at Sromowce. 1 – localities of subfossil malacofauna: Gl – Potok Głęboki, L_t, L_s – Potok Limbargowy, M_t, M_s – Potok Macelowy, S_b – Potok Sobczański; 2 – highest peaks in the Pieniny Mountains: F – the Flaki Mountain, M – the Macelak Mountain, N – the Nowa Góra Mountain, K – the Trzy Korony Mountain, C – the Czertezik Mountain; main ridge of the Pieniny Mountains; 4 – border of the Pieniny Mountains National Park.

3. Profiles and outcrops

The study area is situated on the southward slopes of the main range of the Pieniny Mountains, on the left-hand side of the Dunajec River Valley. The range, consisted of limestone, marl, sandstone and slate of the Jurassic age, is cut by short valleys of several streams. The upper sections of the valleys are narrow and V-shaped, while in the lower sections Holocene terraces and alluvial fans occur. The sediments of the streams are gravel, sand, silt and mud, with intercalations of sand and tufa.

The Stream Potok Głęboki

In the lowest section of the valley, near the mouth opening to the valley of the Dunajec River, a very conspicuous alluvial fan occurs (Fig. 1: Gl). It is cut by the recent bed of the stream bordered with scarps, 0.8...1.6 m high. The fan is composed of gravel intercalated with sand and sandy-silt. In the gravel, fragments of wood may be found, and the silt contains a rich malacofauna and fine

plant debris. In two profiles 50 m far from each other, 8 samples were taken to give more than 600 shell of land and aquatic snails and single shells of bivalves (Fig. 2: Gl).

The Stream Potok Limbargowy

In the valley of the stream, the sediments that contain molluscs occur on two localities: within the terrace situated at the junction of the valleys of the streams Limbargowy and Gróbka (Fig. 1: L_t) and in the alluvial fan at the mouth of the valley of the Limbargowy Stream to the Dunajec River Valley. (Fig. 1: L_s). The former locality represents a profile of the sediments of the terrace which is 1.3...2.0 m high and is situated on the left-hand bank of the stream. In the lower part of the outcrop there are visible sands and slates of the Sromowce formation (Upper Cretaceous) tat form the rock-base of the said terrace. The flysch-base is covered by gravels that are chiefly composed of pebbles of limestone, marl, and sandstone with a sandy-silty matrix. A layer of grey silt and sandy muds with remnants of fauna and flora forms an intercalation between the gravels (Fig. 2: L_t). Three samples of the said profile contained more than 300 shells of snails and bivalves.

The alluvial fan situated in the lowest part of the valley is cut by the bed of the stream that flows on flysch formations of the substrate. In several outcrops there are visible gravels and coarse grained sands with gravel, containing one or two thin intercalations of grey sandy-silt (Fig. 2: L_s). In the sands and silts, fragments of wood occur, while in some of the silt-intercalations there is a poor malacofauna. The molluscan assemblage found in two samples comprised 54 specimens.

The Stream Potok Macelowy

The valley of the stream cuts the mountain range of the Macelowa Mountain-Podskalnia Mountain, to create a narrow and deep rocky ravine bordered with steep slopes and limestone walls up to 100 m high (the Wąwóz Gorczyński Ravine). Down the opening of the ravine, the stream flows through a zone that is mainly composed of flysch, a low terrace being developed on the bottom of the valley. In this part of the valley, on two localities, sediments containing assemblages of subfossil molluscs were found. One of the localities was situated about 700 m below the mouth of the ravine, whereas the other was located in the lowest part of the valley (Fig. 1: M_t, M_s).

The former locality is represented by an outcrop in the right-hand side of the stream. It is a scarp 2...3 m high. In the lower part of the outcrop there is a rock-base composed of steep beds of shales and mudstones of the Sromowce formation. Its roof surface shows signs of limonitisation. The sequence of the sediments covering the rock-base is as follows (Fig. 2: M_t):

1. 15 cm, fine-grained gravel intercalated by laminae of coarse-grained sand, containing several fragments of coalified wood;

2. 5 cm, grey calcareous silt with fine grains of tufa;

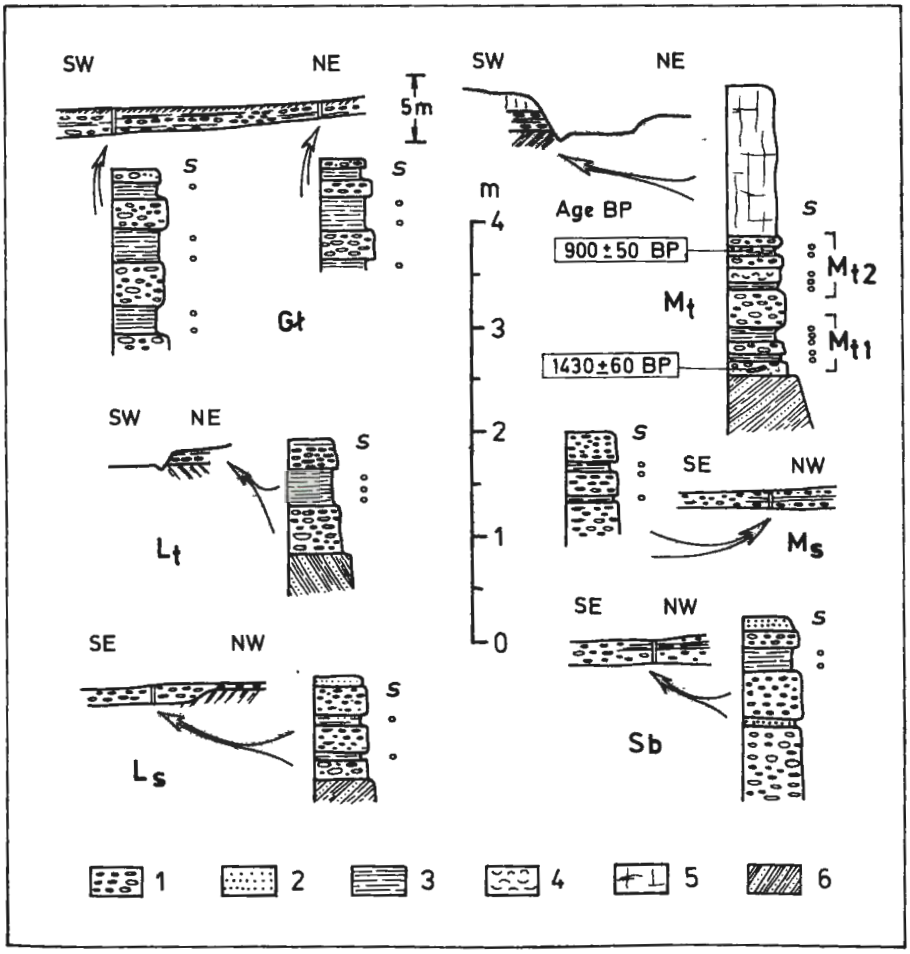


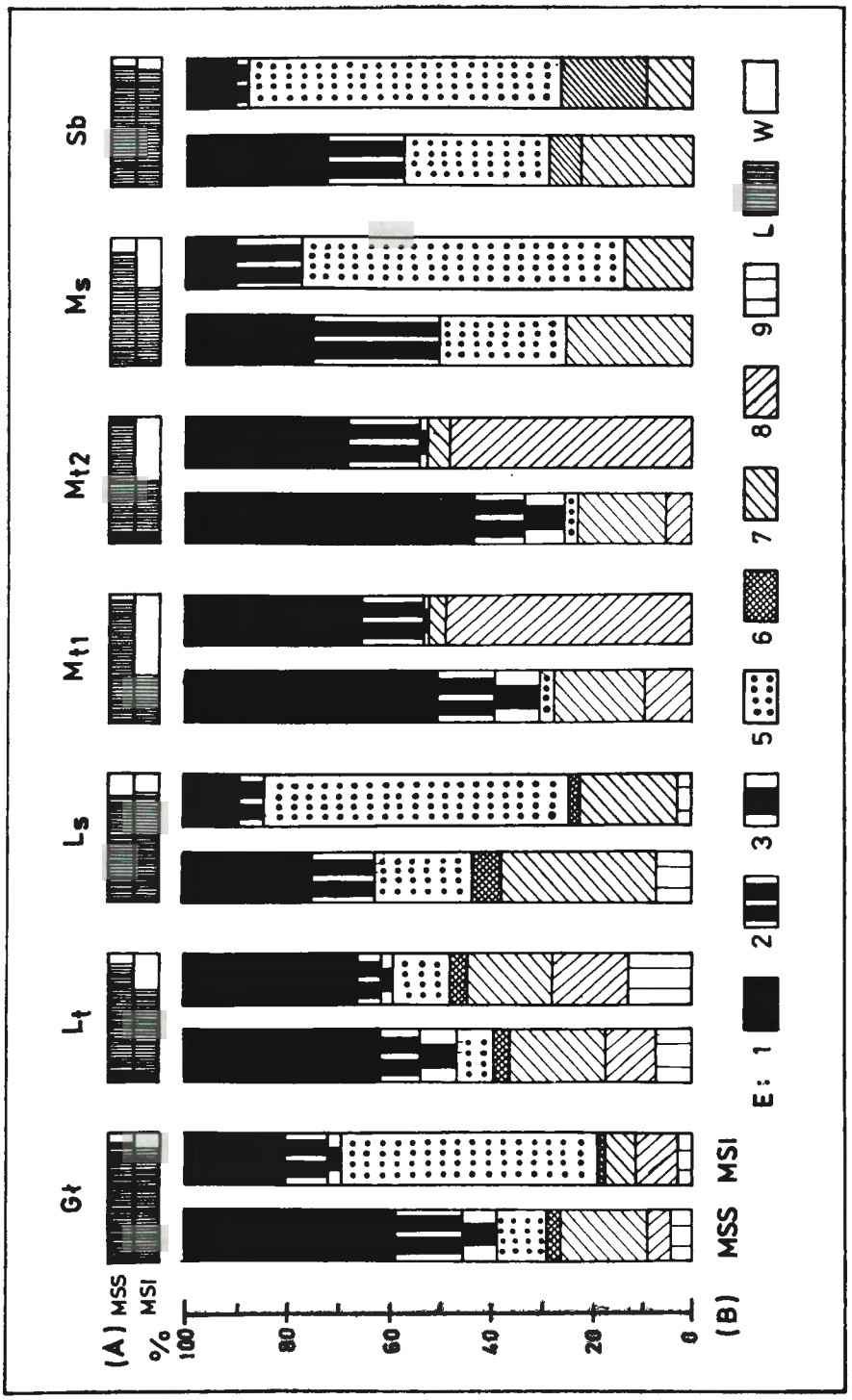
Fig. 2. Profiles of sediments of the Late Holocene. Gl – Potok Głęboki, L_t – terrace in the Potok Limbargowy, L_s – alluvial fan in the Potok Limbargowy, M_t – terrace in the Potok Macelowy, M_s – alluvial fan in the Potok Macelowy, Sb – Potok Sobczański, S – sampling sites; explanations to lithological symbols: 1 – gravels, 2 – sands, 3 – silts, 4 – calcareous tufas, 5 – clays, 6 – rock base (sandstones and shales of the Sromowce formation)

3. 15 cm, medium-grained gravel composed of pebbles of limestone, marl, and sandstone with a clayey-sandy matrix;

4. 10 cm, dark grey calcareous silt, conspicuously bedded, with laminae of fine-grained limestone sand;

5. 35 cm, gravel, conspicuously layered, with scarce big boulders of limestone and marl;

6. 10 cm, grey sandy silt containing single small pebbles of limestone, marl, and radiolarites;


Gt
Lt
Ls
Mt1
Mt2
Ms
Sb
(A) MSS MSI
%
100
80
60
40
20
0
(B) MSS MSI
E: 1 2 3 5 6 7 8 9 L W

7. 12 cm, calcareous silts with intercalations of tufa and fine-grained limestone sand;

8. 10 cm, fine-grained gravel with a clayey-silty matrix;

9. 15 cm, grey sandy silt with thin intercalations of fine-grained sand, containing fragments of coalified wood;

10. 5 cm, fine-grained gravel with a clayey-silty matrix;

11. 1.20...1.50 m, yellow clay with fragments of marls, sandstones and shales.

In the calcareous and sandy silts, mollusc shells occur very numerously. In the lower part of the profile (layers 1 - 4), in 5 samples, 4,800 specimens were found (M_{t1}), while in the upper part (layers 6 - 9) 1,900 specimens were found in next 5 samples (M_{t2}). The fragments of coalified wood, found in the lower and upper parts of the profile, were dated by means of the radiocarbon method, with the following results:

- layer 1 (lower part of the profile) - 1,430 ± 60 B.P. (Gd-5112);
- layer 9 (upper part of the profile) - 900 ± 50 B.P. (Gd-5259).

In the lower section of the valley in question, near its outlet to the Dunajec River Valley, there is a low alluvial fan cut by the recent bed of the stream. In several small outcrops, gravels are visible, their thickness being no more than 1 m. They contain thin intercalations of sandy silts and sands, in which scarce mollusc shells and shell fragments were found (Fig. 2: M_S). The assemblage of fauna, coming from three samples, comprised only 40 specimens.

The Potok Sobczański Stream

The short valley of the stream cuts the mountain range between the Podskalnia and Nowa Góra Mountains, and the Trzy Korony Mountain. It creates a narrow and very deep rocky ravine, the walls of which consist of formations of the Pieniny Limestone Formation. Down the mouth of the ravine (the Wąwóz Sobczanski ravine) the valley becomes wider and on its bottom appear narrow terraces and a conspicuous alluvial fan that passes onto a vast terrace of the Dunajec River (Fig. 1: Sb). In this section of the valley, in several places, the sediments of the stream are cut by its recent bed. In small, outcrops one can observe limestone gravels with scarce, thin intercalations of limestone sands or silts. One of such intercalations was found to contain snail shells and shell fragments. The assemblage of fauna, collected from two samples, comprises 80 specimens (Fig. 2: Sb).

Fig. 3. Malacological spectra of molluscan assemblages. (A) – relationship between the freshwater fauna and land fauna, (B) – composition of land fauna assemblages, MSS – malacological spectra of species, MSI – malacological spectra of individuals, E – symbols of ecologic groups: 1 – typical forest species, 2 – species prefering shaded habitats, mainly forests, 3 – shade-prefering species of very wet habitats, 5 – snails of open environment, 6 – typical species of dry biotopes, 7 – euryecologic snails of medium-humidity habitats, 8 – euryecologic snails of humid habitats, 9 – hygrophilous snail, L – land snails, W – freshwater molluscs

Age of sediments

The sediments described represent the two phases of sedimentation that occurred in the Upper Holocene. The older phase comprises the gravels and sands and silts forming the terraces situated in the valleys of the streams Potok Macelowy and Potok Limbargowy, whereas the younger one covers the gravels of the alluvial fans of the streams Potok Głęboki, Potok Limbargowy, Potok Macelowy, and Potok Sobczański. Results of radiocarbon datings indicate that the age of the older phase is contained within the time-interval 1.500...800 years B.P., which corresponds to the Middle Ages - the Early Middle Ages, in particular. The alluvial fans occur in the beds of the streams cutting the medieval terraces. They were probably created in the last two centuries, this century may have been included, too. Each kind of fauna found in the terraces and alluvial fans is conspicuously different from the others.

4. Malacofauna of older sediments

The richest molluscan assemblage occurs in the sediments of the Young Holocene terrace in the valley of the stream Potok Macelowy (Mt). It comprises 49 species out of which 46 were found in the lower and 42 in the upper part of the profile (Tab. 1). 70% of the species were snails prefering shady habitats, while mesophilous ones covered 25% and aquatic molluscs - 5%. There was only one taxon to represent the open environment snails. As concerns the number of specimens, the dominant element of the assemblage was *Bythinella austriaca* which is a snail that inhabits streams and springs, living in cold water of a constant temperature. The shells of the taxon comprised 60% of the assemblage of the lower part of the profile and 50% of that of the upper part of the profile.

The malacological spectra MSI of the terrestrial fauna were almost the same in both the parts of the profile (Fig. 3). Forest snails of the ecologic group 1 covered 33%...35% of the assemblage. Shells of the five taxons: *Aegopinella pura, Vitrea subrimata, V. transsylvanica, Acicula polita, Acanthinula aculeata,* were found in a large number. Snails of ecologic group 2, prefering shady or partly shady habitats, comprised 13%, their main representative being *Vitrea crystallina.* Shells of snails of ecologic groups 3, 5, and 7 were unnumerous, whereas mesophilous snails being typical of humid habitats (ecologic group B) covered nearly 50% of the total number of specimens. Out of the latter, however, it was only *Carychium tridentatum* (Fig. 3) the shells of which dominated.

The structure of the molluscan assemblage in question has been determined by the value of the constancy index (C) and dominance index (D) of each taxon. The points that correspond to all the species lie on the margins of the diagram (Fig. 4: Mt). It is only *Bythinella austriaca,* a dominant taxon, for which the indices riched a maximum value, while *Carychium tridentatum* and *Vitrea crystallina* are characteristic taxons of the assemblage. From among the species represented by unnumerous specimens, two groups can be distinguished, one of them comprising species of a

Table 1

Molluscan assemblages in the Late Holocene sediments at Sromowce. The number of specimens in samples: I – 1–3 specimens, II – 4–10, III – 11–31, IV – 32–100, V – 101–316, VI – 317–1,000, VII – 1,001–3,162 (ALEXANDROWICZ 1988), E – symbols of ecologic groups (LOŽEK 1964)

E	Species	Outcrops						
		Gl	Lt	Ls	Mt1	Mt2	Ms	Sb
1	*Acicula polita* (Hartmann)	I	I		IV	IV		
1	*Vertigo pusilla* O.F.Müller	I	I		I	II		
1	*Argna bielzi* (Rossmässler)	I			III	I		
1	*Acanthinula aculeata* (O.F.Müller)	I			IV	III		
1	*Ena montana* (Draparnaud)	II	I	I	II	II		I
1	*Ena obscura* (O.F.Müller)	I						
1	*Discus ruderatus* (Ferussac)					I		
1	*Discus perspectivus* (Mühlenfeldt)	I	I		III	II	I	
1	*Eucobresia nivalis* (Dumont, Mortillet)				III	III		
1	*Semilimax semilimax* (Ferussac)		I		II	I		
1	*Aegopinella pura* (Alder)	III	III		V	IV		
1	*Oxychilus orientalis* (Clessin)				I	I		
1	*Daudebardia rufa* (Draparnaud)	I	I		III	II		
1	*Vitrea diaphana* (Studer)	I	I		III	II	I	I
1	*Vitrea transsylvanica* Clessin	III	III	I	IV	IV		II
1	*Vitrea subrimata* (Reinhardt)	II	III	I	V	IV		
1	*Cochlodina orthostoma* (Menke)		I		II	I		
1	*Cochlodina laminata* (Montagu)		I		I			
1	*Clausilia cruciata* Studer	I						
1	*Iphigena latestriata* (Schmidt					I		
1	*Iphigena plicatula* (Draparnaud)	I			II	I		
1	*Lacinaria cana* (Held)				II	I		
1	*Ruthenica filograna* (Rossmässler)	II	I		III	III		
1	*Monachoides incarnata* (O.F.Müller)	III	I		II	II		
1	*Helicigona faustina* (Rossmässler)	I	I	I	II	II		I
1	*Isognomostoma isognomostoma* (Schröter)	II	II		III	III		
2	*Discus rotundatus* (O.F.Müller)	II	I		I	II		
2	*Aegopinella minor* (Stabile)				III	III		
2	*Oxychilus glaber* (Rossmässler)	I		I				
2	*Vitrea crystallina* (O.F.Müller)	III	II	I	V	V	I	I
2	*Laciniaria biplicata* (Montagu)	I						
2	*Arianta arbustorum* (Linnaeus)	II	I	I	II	II		I
2	*Helix pomatia* (Linnaeus)	I			I			
3	*Iphigena ventricosa* (Draparnaud)	II	I		I			
3	*Iphigena tumida* (Rossmässler)				I	I		
3	*Vestia gulo* (Bielz)	II	I		II	II		
3	*Monachoides vicina* (Rossmässler)	II	I		I			
3	*Perforatella bidentata* (Gmelin)					I		
5	*Truncatellina cylindrica* (Ferussac)	I						
5	*Vertigo pygmaea* (Draparnaud)							I
5	*Pupilla muscorum* (Linnaeus)	III	I	II			I	I
5	*Vallonia costata* (O.F.Müller)	IV	II	II				II
5	*Vallonia pulchella* (O.F.Müller)	V	III	III	I	I	II	IV
6	*Cochlicopa lubricella* (Porro)	II	II	I				III
7	*Cochlicopa lubrica* (O.F.Müller)	III	I		I		I	
7	*Vertigo alpestris* Alder	II	II	I	I	I		II
7	*Punctum pygmaeum* (Draparnaud)	I	I	I	III	II		
7	*Vitrina pellucida* (O.F.Müller)		II					I
7	*Nesovitrea hammonis* (Ström)	I	I			I		
7	*Vitrea contracta* (Westerlund)	II	II	I	III	II		
7	*Limacidae*		III	II	I	I	I	I
7	*Euconulus fulvus* (O.F.Müller)		I		II	III		
7	*Clausilia dubia* Draparnaud	I			II	I		
8	*Carychium tridentatum* (Risso)	III	III		VI	VI		
8	*Vertigo angustior* Jeffreys		I		I			
8	*Vertigo substriata* (Jeffreys)		I		III	III		
8	*Succinea oblonga* Draparnaud	III	I		I			
9	*Vertigo antivertigo* (Draparnaud)		I					
9	*Succinea putris* (Linnaeus)	III	III	I				
9	*Zonitoides nitidus* (O.F.Müller)	I	I					
10	*Bythinella austriaca* (Frauenfeld)	IV	IV	I	VII	VI		II
10	*Lymnaea truncatula* (O.F.Müller)	II	III	I			III	
10	*Pisidium personatum* Malm		II		III	II		
10	*Pisidium casertanum* (Poli)	I		I				

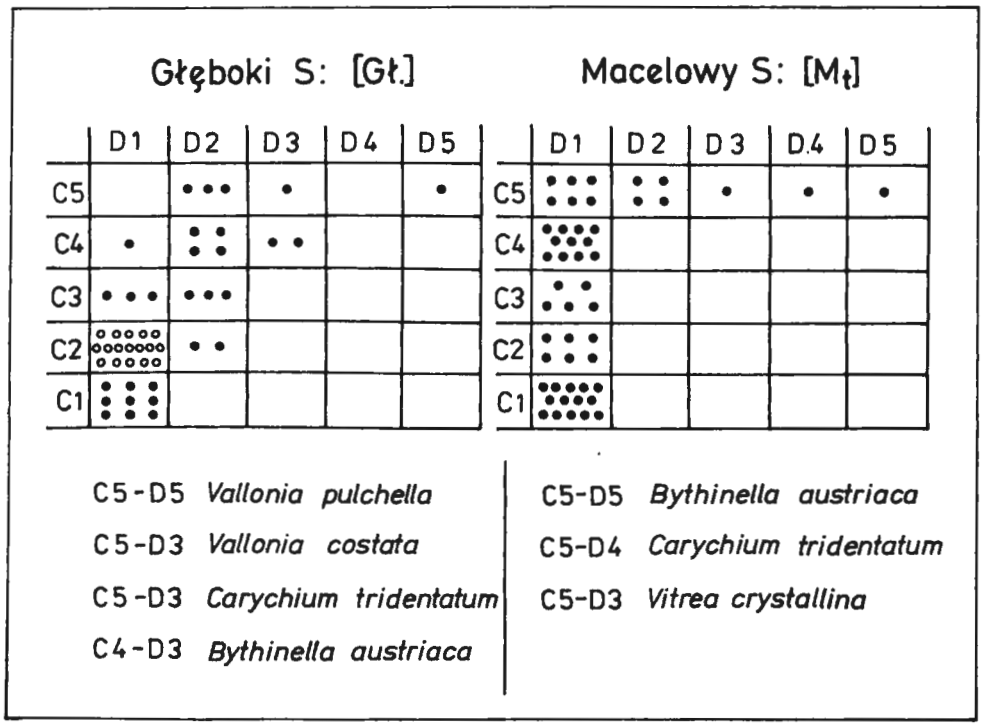


Fig. 4. Structures of molluscan assemblages. Gł – Potok Głęboki, younger malacofauna, Mł – Potok Macelowy (terrace), older malacofauna. C1–C5 – constancy degrees of taxons, D1–D5 – domination degrees of taxons

high constancy (C5–D1, C4–D1) and the other comprising accessory species (C1–D1). The former group is represented by *Ena montana, Discus perspectivus, Eucobresia nivalis, Ruthenica filograna, Monachoides incarnata, Helicigona faustina, Isognomostoma isognomostoma, Arianta arbustorum, Vestia gulo, Vitrea contracta,* and *Euconulus fulvus.*

The described malacofauna can be interpreted as a thanatocenosis consisted of two different but synchronous elements (a mixocenosis – ALEXANDROWICZ 1988a). On of the elements is the assemblage of freshwater molluscs with *Bythinella austriaca.* This is a typical fauna of the upper course of streams and of areas rich in springs of water of a constant, low temperature (HASSLEIN 1960, 1966). Such a fauna is characteristic of the sedimentary environment of the sediments forming the terrace of the Potok Macelowy and can be regarded as an autochthonous component, that is, a necrocenosis. The other element covers land snail shells coming from the closest vicinity of the locality and, part of them, from the upper section of the valley (allocenosis). In the structure of the element, the species of the hihgest constancy and dominance is *Carychium tridentatum* (C5–D5) followed by *Vitrea crystallina* (C5–D4), *Aegopinella pura* and *Vitrea*

subrimata (C5–D3). A similar type of assemblage was described by FUHRMANN (1973) from sediments of the Middle and Upper Holocene of Saxony (a *Carychium–crystallina*-fauna). This is typical of natural forest habitats.

The fauna of the Late Holocene terrace of the stream Potok Macelowy is all the same throughout the studied profile. The value of the association diversity index ADI, calculated for all the ten samples of the lower and upper parts of the profile altogether, is low: ADI = 0.478. This reflects a considerable stability of the conditions of the sedimentary environment throughout the formation of the terrace. The gravels, sands, and silts were accumulated at overflows of the stream. Part of the bottom of the valley was covered by either a forest or humid habitats shaded to a various degree, whereas the slopes were covered by a deciduous or mixed forest. In the vicinity of the described locality there were neither sunny glades nor humid meadows and waterlogged habitats. The presence of lithic and xeric habitats occurring in the gorge Wawóz Gorczynski, about 700 m far from the described locality, in the upper part of the valley, has not been marked in the molluscan assemblage.

The malacofauna of the sediments creating the terrace of the stream Potok Limbargowy (L_t) comprised 44 species (Tab. 1). Half of them were species prefering shaded habitats, belonging to ecological groups 1, 2, and 3. Mesophilous taxons of ecologic group 7 were also numerous, whereas only several taxons represented each of the other groups. Shells of freshwater molluscs comprised about 25%. Specimens of *Bythinella austriaca* were particularly numerous, being accompanied by *Lymnaea truncatula* and *Pisidium personatum*. As to the land fauna, the MSI malacological spectrum is similar to the MSS spectrum. Shells of the forest snails occurred in a considerable number (ca. 40%), the most numerous species being *Aegopinella pura*, *Vitrea transsylvanica*, and *V. subrimata*. Shells of the mesophilous snails of ecologic groups 7 and 8 comprised 17% and 15%, respectively, those of *Carychium tridentatum* occurring in a large number. The presence of typical snails of open environment, mainly represented by *Vallonia pulchella*, on one hand and hygrophilous snails like *Succinea putris*, on the other hand, is worth of attention. Each of the ecologic groups (5 and 9) comprised 12% of the total number of specimens (Fig. 3: L_t).

The fauna found in the sediments of the terrace of the stream Potok Limbargowy is similar to the one described above. It is a thanatocenosis (mixocenosis) corresponding to the assemblage with *Bythinella austriaca*, containing a diversified assemblage of land snails. This indicates a very high degree of the afforestation of the slopes bordering the valley of the stream, and also the presence of sun–exposed habitats and waterlogged ones in the stream basin.

5. Malacofauna of younger sediments

In the alluvial fan of the stream Potok Głęboki at Sromowce Wyżne (Gl) a rich molluscan assemblage was found to occur, comprising 45 taxons (Tab. 1). The MSS malacological spectrum indicates that forest species comprised 40% of the assemblage while the shares of the remaining groups were approximately equal. The MSI malacological spectrum illustrates a very big share of

shells of *Vallonia pulchella* and *V. costata* which are land snails being typical of open environment (ecologic group 5). This element comprised more than half of the total number of specimens (Fig. 3: Gl). In the structure of the described molluscan assemblage, *Vallonia pulchella*, with its greatest values of constancy and dominance (C5–D5), was the dominant. The characteristic taxons of the assemblage were *Vallonia costata*, *Carychium tridentatum*, and *Bythinella austriaca* (C5–D3, C4–D3). There were also some other species of a high constancy. They were forest snails: *Vitrea transsylvanica*, *Monachoides incarnata*, *Isognomostoma isognomostoma* (C5–D2), snails prefering shaded habitats: *Vitrea crystallina*, *Arianta arbustorum* (C4–D2), a species of open environment: *Pupilla muscorum* (C4–D2), and a hygrophilous species: *Succinea putris* (C4–D2) Most of the taxons can be considered accessory elements with C2–D1 and C1–D1 (Fig. 4: Gl). The structure of the assemblage covering only land snails did not differ from the one described above, the dominants and characteristic species (except *Bythinella austriaca)* showing the same C and D indices.

The malacofauna of the alluvial fan of the stream Potok Głęboki was medium-diversified. The ADI index calculated for the eight samples altogether is ADI = 0.606. It reflects the character of the assemblage being rather uniform and recognizable as a mixed thanatocenosis with a very large share of land snails (a paraautochthonous element). Freshwater molluscs were mainly represented by *Bythinella austriaca* whereas the main representative of land snails were *Vallonia pulchella* which is a species connected with open environment, a.o. with meadows with a dry substrate or of a medium humidity. The occurrence of the hygrophilous species *Succinea putris* indicates very humid habitats locally existing on the bottom of the valley. The numerous species of forest snails, being a component of the assemblage, are typical of the deciduous and mixed forests which now are widely distributed on the slopes of the valley in the basin of the stream Potok Głęboki.

The sediments of the alluvial fan of the stream Potok Limbargowy (L_S) were found to contain a poor molluscan assemblage consisted of 19 taxons (Tab. 1). The MSS malacological spectrum has shown approximately equal shares of species of ecologic groups 1, 5, 7, and 10, mesophilous snails of medium-humidity habitats slightly prevailing. The shells of lands snails covered more than 90% of the total number of specimens. The MSI malacological spectrum characterizing the land fauna has indicated a very conspicuous dominance of specimens of *Vallonia pulchella* and *Pupilla muscorum* belonging to ecologic group 5. The shells of slugs were also found to occur rather numerously, which is worth of attention (Fig. 3: L_S).

In the alluvial fan of the stream Potok Macelowy (M_S) there was found a molluscan assemblage consisted of only nine species of ecologic groups 1, 2, 5, 7, and 10. The shares of particular taxons representing the groups were equal and the MSI spectrum indicated a conspicuous quantitative dominance of the shells of typical snails of open environment (ecologic group 5). These were *Vallonia pulchella* and *Pupilla muscorum* (Tab. 1, Fig. 3: M_S).

The sediments accumulated at the mouth of the gorge Wąwóz Sobczański (Sb) were found to contain a malacofauna consisted of 15 taxons belonging to 6 ecologic groups (Tab. 1). The share of the shells of freshwater snails, which were only *Bythinella austriaca*, was 8%. More than 60% of the specimens, and mainly the species *Vallonia pulchella*, were a fauna of open environment.

A typical character of the assemblage in question is a considerable number of shells of *Cochlicopa lubricella* which is a snail connected with dry or even xeric habitats as well as with rocks and rubble (Fig. 3: Sb). In the calcareous gravels and sands that have been sedimenting close to the said profile by the stream Potok Sobczański one can find the shells of other two snail species that live on rock walls and blocks, limestone, in particular. The species are *Pyramidula rupestris* and *Chondrina clienta*.

The malacofauna of the alluvial fans of the streams Potok Limbargowy, Potok Macelowy, and Potok Sobczański is quite similar to the molluscan assemblage of the alluvial fan of the stream Potok Głęboki. On all the four localities, mixed thanatocenoses (mixocenoses) covering two separate elements occur. One of them is an assemblage with *Bythinella austriaca*, characteristic of an environment of the accumulation of shell material. The other element which is an assemblage with *Vallonia pulchella*, is the type of fauna which many times was described from the area of Middle Europe (HASSLEIN 1960, 1966, KÖRNIG 1966, FRANK 1979–1985). This is an assemblage indicating an open environment of a various humidity being typical of deforested areas taken by meadows and grazing lands utilized by man.

6. Thanatocenoses and Recent fauna

The assemblages of subfossil molluscs, found in sediments of the Late Holocene in the vicinity of Sromowce, cover the species living at present in the area of the Pieniny Mountains National Park and its closest vicinity. They contain more than 70% of the taxons recorded in the Pieniny Mountains by URBAŃSKI (1939), DZIĘCZKOWSKI (1971), and RIEDEL (1976, 1988). These are thanatocenoses, components of which are elements of several assemblages of recent fauna distinguished by URBAŃSKI (1939) as well as ones that has not been described so far (e.g. a fauna of cultivated areas).

To reconstruct a palaeogeographic environment and the conditions of sediment formation, the most important is the analysis of proportions between forest and non-forest snails, whereas the number of water-mollusc shells mainly reflects the local conditions and type of a sedimentary basin. The effect of the afforestation degree of a stream basin on the character of the thanatocenosis occurring in the sediments has not been the subject of a detailed study so far, however, the share of shade-prefering snails is regarded as an important index determining the distribution of forests.

Part of the southward slopes of the maine range of the Pieniny Mountains, in the Sromowce region, are contained within the borders of the National Park so that they are not subject to human impact, and another part of them are situated outside the borders and covered by fields and grazing lands. The areas of the basins of the streams in question, the lengths of their valleys, and the percentages of the afforested areas, are similar, respectively.

The basin of the stream Potok Głęboki covers an area of 2.5 sq. km, the length of the valley is 3.5 km, the height difference being 200 m, and the degree of afforestation is 60%. The upper part of the valley is narrow, the slopes being covered by a mixed forest, while in the lower part there is

a rather wide, low terrace covered by meadows and pasturies, passing into an alluvial fan. The stream Potok Limbargowy has a considerably smaller basin (1.3 sq. km), its valley length being 1.8 km and the difference of height of 230 km. I In the upper part of the basin there are glades and montane meadows, while in the lower one there are fields. The degree of afforestation is up to 38% here. The valley of the stream Potok Macelowy is 3.1 km long. The basin, covering an area of 2.7 sq. km, out of which 40% are afforested, has a height difference of 280 m. In its upper part, the valley has steep slopes, afforested or rocky, while in the lower part the slopes are little slanting and quite deforested. The basin of the stream Potok Sobczański shows the largest differences in height (310 m) and a considerable afforestation (65%). It covers an area of 1.5 sq. km and is 1.9 km long.

The molluscan assemblages occurring in the alluvial fans of the four streams in question reflect, to a certain degree, the afforestation of the basins. The malacological spectra characterizing the land fauna of the younger series of the sediments point out that the share of typical snails of an open environment is 50...60% whereas the forest snails and the ones that mostly live in forests cover only 15...25% (Fig. 3: Gl, Ls, Ms, Sb).

No species connected with rocky walls and xeric habitats were found to be a component of the assemblages. It was only at the outlet of the Wąwóz Sobczański gorge where single shells and shell fragments representing ecologic group 4 were found, occurring in recently accumulated calcareous sands and gravels. Such shells, however, had been found in tufa in the Wąwóz Sobczański gorge, where many of them had occurred about 400 m above the outcrop of the sediments of the alluvial fan (ALEXANDROWICZ 1989).

The thanatocenoses of the younger series of the sediments were connected with areas part of which were afforested and the rest were covered with meadows and grazing lands and fields, the proportions between them having been similar to those observed at present. As a result of the transport and deposition of shell material in the montane streams, a considerable part of the snail shells were damaged or eliminated. Hence, the alluvial fans that were growing at the mouths of the valleys were relatively enriched in only those shells which had had a small distance to cover. As a result, the assemblages of subfossil molluscs occurring in the sediments in question are poor and at the same time they are characterized by the dominance of snails that inhabited the lower section of the valley (typical species of deforested lands).

In the older series of the sediments there occurs a fauna that consists of the same taxons but the shares of its components are completely different, respectively. The numerous occurrence of the shells of forest snails and of snails prefering shaded habitats belonging to ecologic groups 1, 2 and 3 (40...50%) along with the almost complete lack of typical species of an open environment, indicate that the thanatocenoses were being accumulated when forests were widely distributed. The subfossil molluscan assemblages of the sediments much resemble the forest fauna of the Pieniny Mountains National Park, described by URBAŃSKI (1939), DZIĘCZKOWSKI (1971), and RIEDEL (1976, 1982), although they contain a considerable admixture of the shells of mesophilous snails *(Carychium tridentatum)* and freshwater snails *(Bythinella austriaca)*. Hence, one can suppose that when the older series of the sediments were being formed the total area of the basins of the four streams was covered with a forest. In the period between the formation of

the terraces (older sediments) and the formation of the alluvial fans (younger sediments) a considerable part of the area got deforested, which resulted in an increase in erosional processes and in a change in molluscan assemblages.

7. Changes during the historical period

The southward slopes of the Pieniny Mountains were, for a very long time, not under human impact leading to the degradation of natural environment. In the vicinity of Sromowce, localities of natural settlement have been known, however, they were connected with the Late Glacial Period (KOŁODZIEJSKI et al. 1982). The afforestation of the area during the Holocene, as well as the configuration of the land, did not favour the development of the Neolithic colonization, though traces of the presence of the Neolithic/Bronze Age man were recorded from this part of the valley of the Dunajec River. From the beginning of the Christian era to the Early Middle Ages, the area in question stayed outside a zone of colonization. The natural conditions that occurred then were expressed in, a.o., a moderate intensity of erosional processes. That period corresponds to the fauna of the terrace of the stream Potok Macelowy. The fauna occurs is sediments, the age of which is determined by two dates (in the floor and in the roof): 1,430 ± 60 years B.P. and 900 ± 50 years B.P., respectively. This means that the sediments in question were being formed from the middle of the Vth century to the beginning of the XIIth century. The sediments and malacofauna of the terrace of the stream Potok Limbargowy can be acknowledged as being of the same age.

The intensive development of colonization in the Sromowce region proceeded in the XIIIth and XIVth centuries. It was then when the castle situated on the Zamkowa Góra Mountain, in the Trzy Korony Mountain range, the village of Sromowce (the left-hand bank of the Dunajec), and a monastery (the so called Czerwony Klasztor) were built (KOŁODZIEJSKI et al. 1982). As a result of this colonization, a vast area of little diversified relief and small height differences of 100...140 m got deforested. It is a zone of outcrops of Upper Cretaceous marls, sandstones, and shales, which border the main range of the Pieniny Mountains from south; the range is characterized by large height differences (300...500 m) and deeply-cut valleys. The forests of the Pieniny Mountains were for a long time being exploited and if it were not for the creation of the National Park, they would not exist today.

On the deforested areas which had been converted to arable lands or pasturies, the processes of erosion and denudation were intensified. Initially, their intensity was limited, which was due to the fact that the fields were cultivated every three or two years, but in the recent centuries, since the yearly ploughing and the raising of root crops had started, the erosion of soil and rainwash became much more intensive. This brought about the deepening of the bottom of the valleys, slits in the older and mediaeval terraces and their bases, and the formation of alluvial fans. The said processes were followed by the development of a fauna that could survive in such a deforested habitat, under human impact.

The molluscan assemblages found in the older and younger series of the sediments in the valleys of the left-hand tributaries of the Dunajec River very well reflect the environmental changes caused by man in the historical period. Such environmental changes were observed by various authors, as EVANS (1972), LOŽEK (1982), ALEXANDROWICZ (1988).

The dominant element of the freshwater fauna of the Late Holocene sediments of the Sromowce area is the stenothermic species *Bythinella austriaca*. The species was recorded from sediments of various ages, among them from all the climatic phases of the Holocene (LOŽEK 1964, 1982) while in the Polish part of the Central Carpathians it is largely connected with the Upper Holocene. The mass occurrence of the shells of *Bythinella austriaca* is a typical character of the malacofauna of the Late Holocene tufas found in the region situated at the foot of the Carpathians, in the Pieniny Mountains, and Outer Carpathians (ALEXANDROWICZ 1985). This is also characteristic of the two molluscan assemblages described.

REFERENCES

ALEXANDROWICZ S. W. 1984. Środkowoholoceńska malakofauna z Harcygrundu koło Czorsztyna (Pieniński Pas Skałkowy). – *Studia Geol. Pol.*, **88**: 95–114.

ALAEXANDROWICZ S. W. 1985. Malacofauna of the Holocene Calcareous Tufa from Podhale and Pieniny Mts. Proc. Rep. XIII Congr.Karp. – *Balk.Geol.Ass.*, **1**: 7–10.

ALEXANDROWICZ S. W. 1986. Datowane osuwiska w dolinie Potoku Ścigockiego. Przew. **57** Zjazdu PTG: 229–232, Kraków.

ALEXANDROWICZ S. W. 1987. Subfosylne zespoły mięczaków w osuwiskach karpackich. – *Sprawozdania z Posiedzeń Komisji Naukowych PAN, Kraków*, **29**, 1 – 2: 372–374.

ALEXANDROWICZ S. W. 1988a. Analiza malakologiczna w badaniach osadów czwartorzedowych. – *Kwartalnik AGH – Geologia*, **13**, 1 – 2: 1–240.

ALEXANDROWICZ S. W. 1988b. The subfossil malacofauna identified from a dammed up lake the Potok Ścigocki valley. Guide book Symp. Late Glacial and Holocene Envir. Changes: 93–95, Wydawnictwo AGH, Kraków.

ALEXANDROWICZ S. W. 1989. Stożki martwicowe w parkach narodowych Tatrzańskim i Pienińskim. – *Ochrona Przyrody*, **49**.

ALEXANDROWICZ S. W., NADACHOWSKI A., VALDE-NOWAK P. & WOŁOSZYN B. W. 1985. Subfossil Fauna from a Cave in the Sobczański Gully (Pieniny Mts., Poland). – *Folia Quaternaria*, **56**: 57–78.

DZIĘCZKOWSKI A. 1971. Badania ilościowe ślimaków buczyn południowo-zachodniej Polski. – *Prace Komisji Biologicznej Poznańskiego Towarzystwa Przyjaciół Nauk*, **35**, 5: 1–90.

EVANS J. G. 1972. Land snails in archaeology. Seminar Press, London.

FRANK C. 1979 – 1985. Aquatische und terrestrische Molluskenassociationen der niederösterreichischen Donau-Auengebiete und der angrenzenden Biotope. I – V. –

Malakologische Abhandlungen, Staatliches Museum für Tierkunde Dresden, **7**: 59-93; **8**: 95-124; **8**: 209-220; **10**: 29-38; **11**: 25-37.

FUHRMANN R. 1973. Die spätweichselglaziale und holozäne Molluskenfauna Mittel- und Westsachsens. - *Freiberger Forschungshefte*, **C, 278**: 1-121.

HÄSSLEIN L. 1960. Weichtierfauna der Landschaften an der Pegnitz. - *Abhandlungen Naturhistorischen Gesellschaft Nürnberg*, **29**, 2: 1-148.

HÄSSLEIN L. 1966. Die Molluskengesellschaften des Bayerischen Waldes und des anliegenden Donautales. - *Ber. Nat.-Forsch. Ges. Augsburg*, **20**: 1-176.

KOŁODZIEJSKI S., PARCZEWSKI M., RYDLEWSKI J. & VALDE-NOWAK P. 1982. Dzieje osadnictwa w Pieninach od czasów najdawniejszych do połowy XIV wieku. - *Studia Naturae*, **B, 30**: 403-421.

KÖRNIG G. 1966. Die Molluskengesellschaften des mitteldeutschen Hügellandes. - *Malakologische Abhandlungen Staatliches Museum für Tierkunde Dresden*, **2**: 1-112.

LOŽEK V. 1964. Quartärmollusken der Tschechoslowakei. - *Rozpravy Ustredniho ustavu geologickeho, Praha*, **31**: 1-374.

LOŽEK V. 1982. Faunengeschichtliche Grundlinien zur spät und nacheiszeitlichen Entwicklung der Molluskenbestände in Mitteleuropa. - *Rozpravy Ceskoslovenskej Akademie Ved*, **92**, 4: 1-106.

PUISSEGUR J. J. 1976. Mollusques continentaux quaternaires de Bourgogne. - *Mem. Geol. Univ. Dijon*, **3**: 1-241.

REYMENT R. A. 1971. Introduction to Quantitative Palaeoecology. Elsevier Publishing Company, Amsterdam.

RIEDEL A. 1976. Uzupełnienia i sprostowania do znajomości malakofauny Pienin. - *Fragmenta Faunistica*, **21**, 8: 189-199.

RIEDEL A. 1982. Fauna Pienin - ślimaki i pozostałe bezkregowce lądowe. - *Studia Naturae*, **B, 30**: 292-310.

RIEDEL A. 1988. Ślimaki lądowe *(Gastropoda terrestria)*. Katalog Fauny Polski, **36, 1**, PWN, Warszawa.

URBAŃSKI J. 1939. Mięczaki Pienin. - *Prace Komisji Matematyczno-Przyrodniczej, Poznańskie Towarzystwo Przyjaciół Nauk*, **B, 9**, 3: 263-505.

URBAŃSKI J. 1948. Reliktowe mięczaki ziem polskich i niektórych krajów przyległych. - *Ochrona Przyrody*, **18**: 66-95.

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STRESZCZENIE

Malakofauna osadów późnego holocenu w Sromowcach (Pieniny, Południowa Polska)

W osadach późnego holocenu okolic Sromowiec, reprezentujących dwie fazy sedymentacji, występują bogate zespoły subfosylnych mięczaków. Zespół z osadów starszych, datowanych na V – XII wiek AD, zawiera 49 gatunków, ze znaczną przewagą ślimaków leśnych. Udział ich w stosunku do pozostałej fauny lądowej wynosi 40 – 50%. Zespół z osadów młodszych, które były akumulowane przypuszczalnie w czasie dwóch ostatnich stuleci, obejmuje 48 taksonów. Składnikiem dominującym są tu ślimaki typowe dla środowiska otwartego, osiągające udział 50 – 65%. W obu omawianych zespołach występują bardzo liczne skorupki mięczaków wodnych, zwłaszcza *Bythinella austriaca*. Zmiany malakofauny zostały wywołane działalnością człowieka, a ich zakres odzwierciedla stopień przekształcenia środowiska naturalnego w czasach historycznych. W okresie wczesnego średniowiecza południowe stoki głównego pasma Pienin, aż po dolinę Dunajca, były całkowicie zalesione. Rozwój osadnictwa, zapoczątkowany w XIII wieku, spowodował wylesienie znacznych obszarów, a stan taki utrzymuje się do czasów współczesnych.