Ekológia (Bratislava) Vol. 25, No. 2, p. 151–165, 2006

ROCKY EDGE AND MALACOCOENOSES OF THE ŻURAWNICA RIDGE (POLISH WESTERN CARPATHIANS)

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Abstract

Alexandrowicz S.W., Alexandrowicz Z.: Rocky edge and malacocoenoses of the Żurawnica ridge (Polish Western Carpathians). Ekológia (Bratislava), Vol. 25, No. 2, p. 151–165, 2006.

Żurawnica Mt. in the Polish Western Carpathians is specific due to the rocky edge formed of sandstones rich in calcium carbonate. The row of sandstone tors at their NE margin is the best outcrop of the Ciężkowice Sandstone Formation of the Magura Nappe. The considerable content of carbonates generates life conditions favourable for land snails and makes possible the preservation of shells in subfossil state. Recent and Late Holocene malacocoenoses are relatively rich in relation to the fauna of the other ranges of the Beskidy Mts and enclose numerous species characterising the fauna of karstlands, i.e. the Cracow Jura Chain. Calciphile lichens and vascular plants have been also found here. Sandstone tors of different size and shape as well as components of biocoenoses mentioned above distinguish the Żurawnica Mt. from the surrounding mountain ranges. It is a site, were relations between these components and a specific type of the bedrock may be studied. The presented natural values motivate the creation of the nature reserve and the didactic trail should be traced.

Key words: sandstone tors, malacocoenoses, environmental changes, Carpathians, Poland

Introduction

The mountain ridge Żurawnica (729 m a.s.l.) – Prorokowa (584 m a.s.l.) is situated in the western part of the Beskid Średni Range, close to the town Sucha Beskidzka, 15 km southward of Wadowice (45 km SW of Cracow). It stretches over 6 km between two left-side tributaries of the Skawa river along the Tarnawka stream (Fig. 1A). The ridge-crest elevated 280–300 m above the bottom of the Skawa valley corresponds with the intermontane denudation level. The main culmination formed of most resistant rocks and crowned with

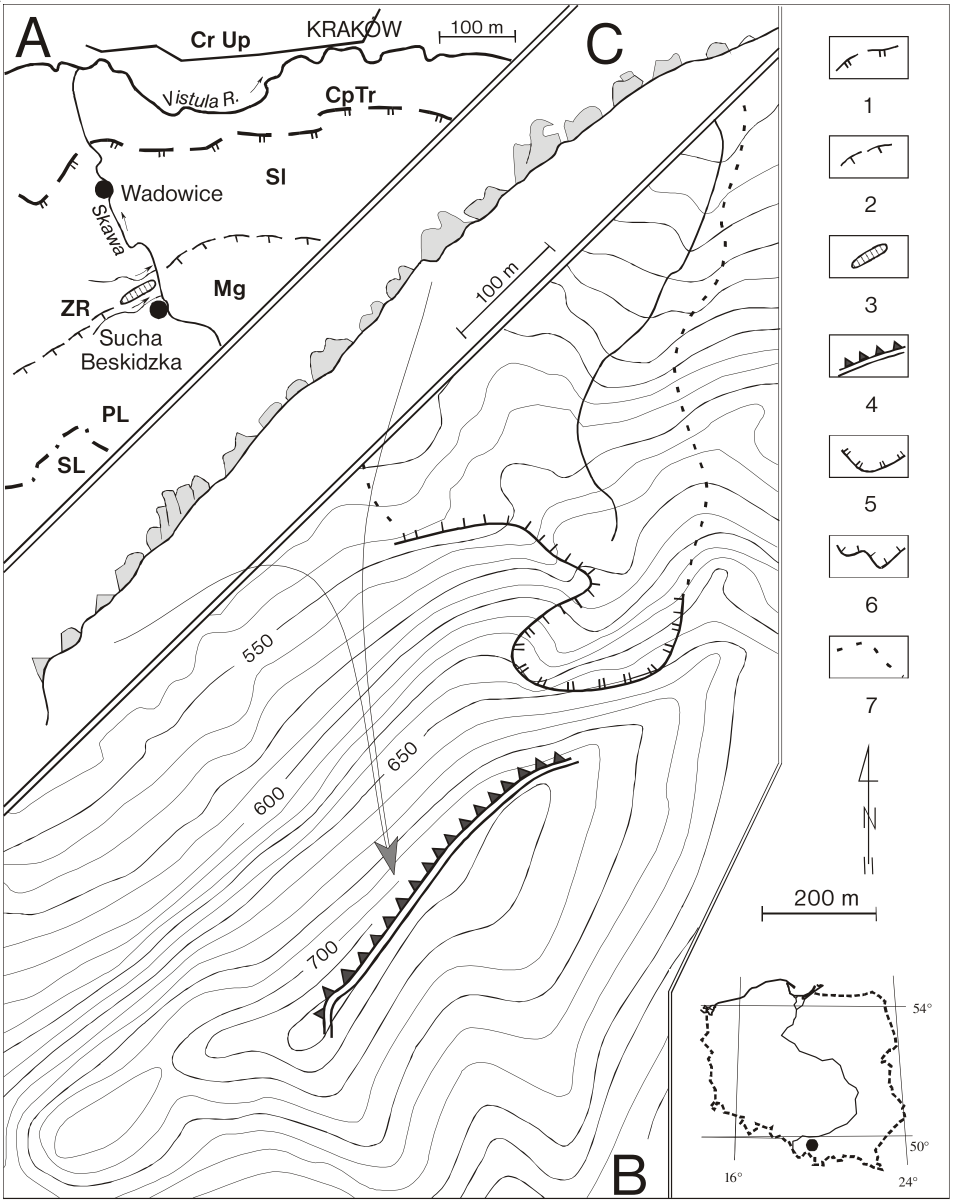

Fig. 1. The study area. A – geological position of the Żurawnica Range: CrUp – Cracow Upland, CpTr – Carpathian Trough, Sl – Silesian Nappe, Mg – Magura Nappe, ZR – Żurawnica Range, PL – Poland, SL – Slovakia, 1 – northern border of Carpathians, 2 – norther border of the Magura Nappe, 3 – Żurawnica Range; B – situation of the rocky edge and the landslide on NW slope of the Żurawnica Mt.: 4 – rocky edge, 5 – high head scarp of the landslide, 6 – low head scarp of the landslide, 7 – range of colluvia; C – row of tors forming the rocky edge.

the rocky edge raises about 150–200 m over them (Baumgart-Kotarba, 1974). Their northern slope is relative steep reaching 20–25°, locally in the upper part even up to 35–40° while the opposite one inclines only 10–12°. The whole ridge runs parallel to the northern border of the Magura Nappe build of the Upper Cretaceous – Paleogene flysch formations: Ropianka Beds, Gołynia Beds and Ciężkowice Sandstones intercalated with variegated shales, passing upward into Podmagura Beds and Magura Sandstones. They are thrust to the north over the Krosno Beds of the Silesian Nappe, which crop out in the valley of Tarnawka stream (Książkiewicz, 1935, 1951).

The rocky edge composed of many sandstone tors and a large landslide on the northern slope of the Żurawnica Mt. are main features of their relief (Dudziak, 1962; Alexandrowicz, 1978; Jakubska, 1978; Margielewski, 2001; Pająk, Sobik, 2003). The ridge-crest is wooded. In its southern segment there is a fir forest, in the north-eastern part – the spruce-fir-beech forest and on the culmination – the beech forest (Błaszczyk, 1965). The hazel brushwood passing downslope into mixed forest spread along the edge as well as on blocks of sandstones and rock detritus accumulated behind them. About fifty years ago the range was considerably less wooded and sandstone tors were partly exposed and well marked in the landscape, what is documented on photos from those time. The nature monument called "Kozie Skały" (Goat's Rocks) has been established at 1968 to preserve several of them (Dudziak, 1962).

In Outer Carpathians a substantial part of flysch formations is poor in carbonates. Sandstones particularly resistant to weathering and erosion, forming main ridges and tors contain at most only a small admixture of this component. Soils developed on such substratum nearly devoid of lime are acid what bring life conditions hard for many species of molluscs. On this score the Żurawnica Range is exceptional because Ciężkowice Beds of the Magura Nappe cropped out along them and in quarries situated in the Tarnawka valley contain both calcareous grains and matrix giving a relatively high content of calcium carbonate. In consequence initial soils and residual deposits accumulated at the foot of the mentioned rocky edge are substantially enriched in lime. It generates habitats favourable both for calciphilous plants and land snails, which occur frequently. Assemblages of molluscs have been found also in sandy sediments filling rock-shelters and fissures within sandstone tors. Differences between living and ancient malacocoenoses correspond with changes of environment following the human impact.

Material and methods

Geological and geomorphological field-works were carried out in two phases. The first of them (1970–1977) was a part of the scientific programme concerning the distribution, geological features, relief, origin and protection of sandstone tors in the Polish Outer Carpathians (Alexandrowicz, 1977, 1978). During the second phase (last eight years) the rocky edge of the Żurawnica Mt. was investigated in detail with special regard to the lithology and sedimentological features of the Ciężkowice Beds, joints system, morphology of tors and effects of gravitational displacements. The content of calcium carbonate in sandstones and young sediments was determined using the Scheibler's apparatus.

At the same time malacological analysis according to standard methods described by Ložek (1964) and Alexandrowicz (1987, 1999) were undertaken additionally. About fifty samples (1–2 kg each one) of litter and soil as well as of mollusc-bearing sediments had been collected, washed, dried and sieved to pick up shells of molluscs. In each of them all the specimens were identified and counted. The whole material encloses 40 taxa represented by 1515 specimens. Most representative samples (26) have been used to the quantitative analysis and interpretation. Both living and subfossil malacocoenoses are described using few statistical indices such as constancy (C) and domination (D) of species, normalised values of C and D, the Q-index (geometric average of C and D), the diversity index according to Shannon-Weaver formula (SH) and the Spearman's rank correlation index r_S. Particular taxa are listed in the order of diminishing values of the Q-index and the number of specimens is presented as symbols in the logarithmic scale (I–V). Malacological spectra of species (MSS) and specimens (MSI) characterise both living and subfossil malacocoenoses as well as particular samples.

Results and discussion

Rocky edge

The row of sandstone tors 2–14 m high borders the ridge crest of the Żurawnica Mt. as an edge and about 750 m long (Fig. 1B). Tors are situated close to one another forming a rocky wall exposed to NW which stretches parallel to the strike of beds inclined 20–25^o to SE. They are builds of the Ciężkowice Sandstone Formation (Lower-Middle Eocene) of the Magura Nappe. These are coarse- and middle-grained sandstones, poorly sorted, locally intercalated with polymictic conglomerates. Sandstones have an admixture of feldspars and small fragments of red algae (Lithothamnium). The content of calcium carbonate is relative high and very differentiated, reaching 15–45% and locally even more. Resistant beds up to few meters thick follow one another and exceptionally are separated with less resistant thin grained sandstones or mudstones. Different sedimentary structures typical of fluxoturbidites occur. These are uncomplete discontinuous grading with spaced pebbles, parallel and cross lamination, washouts, loat-cast and shell balls well visible on weathered surfaces.

The shape and size of tors depend mainly on the density of bedding surfaces as well as on the density and direction of joints system. Longitudinal, transversal and diagonal joint have been distinguished according to Książkiewicz (1968). The majority of tors are angular and wedge-shaped with bounding walls developed on diagonal joint plains slightly remodelled by weathering. About 25 more or less isolated forms, steep rocky slope and segments of rocky walls constitute the whole edge (Fig. 1C). The highest tors (10–15 m) occur in their middle and eastern part. Nearly all of them are joined laterally with the top part of the slope inclined 30–60^o to NW (Fig. 2). According to the previously defined propositions they may be classified as pulpits or rocky steps (Alexandrowicz, 1978).

The density of joints system has an effect on fragmentation of the rocky edge and on stability of tors. Particular monoliths divided along joint by fissures and widened crags subside, draw aside and incline little by little or even fall down. It generates the step-like profile of some tors. Gravitational displacements of three types: toppling, transitional and rotational ones, distinguished in landslides of the Polish Carpathians by Margielewski (2004)

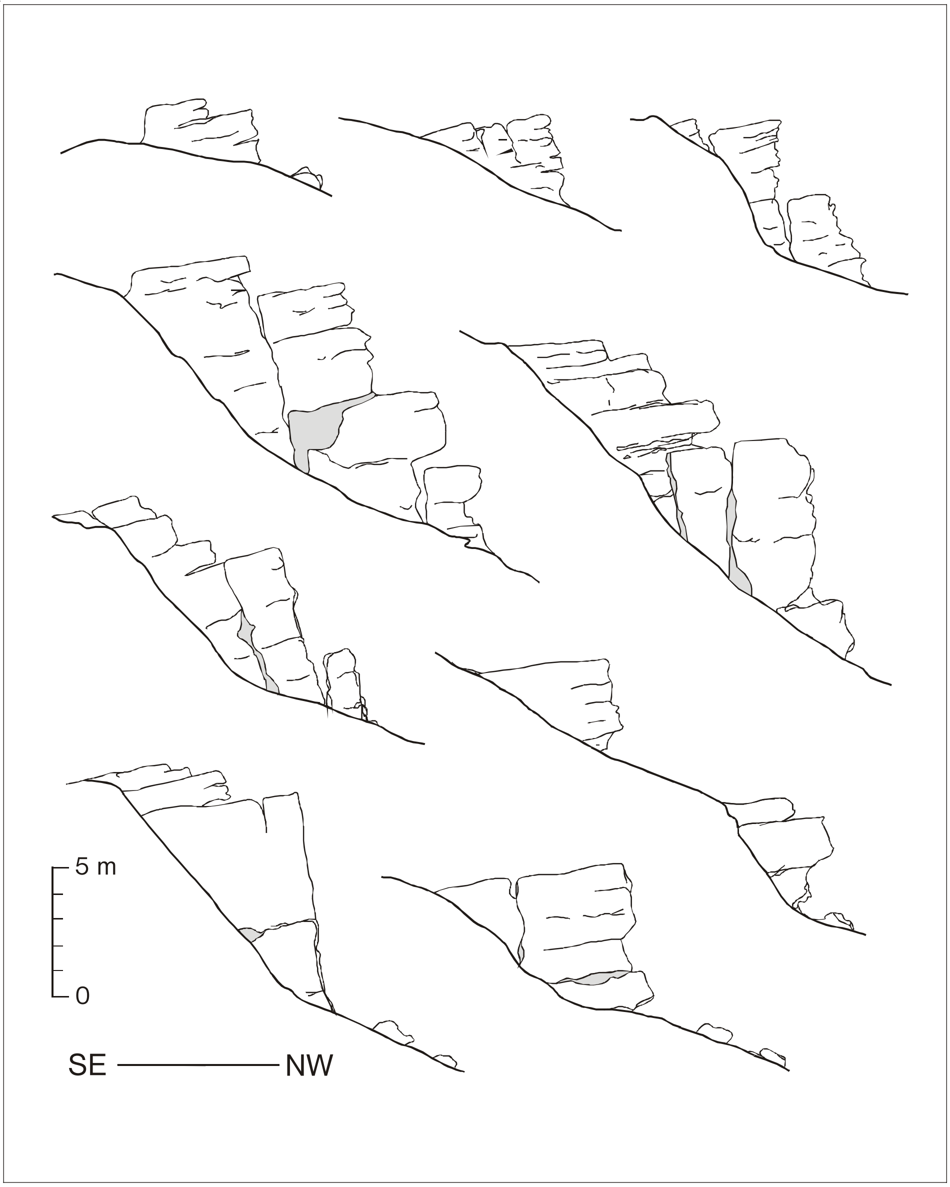

Fig. 2. Types of sandstone tors forming the rocky edge of the Żurawnica Mt.

are observed here. Fissures open or closed at the top and small rock-shelters are supplementary effects of these processes. Such forms have been attributed to pseudokarst phenomena (Vitek, 1979). Together with crevice-type caves they are indicated as initial forms of rock landslides (Margielewski, Urban, 2003). A crevice-type cave about 2 m long and wide occurs in the middle part of the Żurawnica rocky edge (Pulina, 1997).

Numerous huge blocks detached from free faces of tors rest on the slope at the foot of the rock wall within rock detritus and scree. Big fragments of sandstones occur also just behind the edge as traces of weathered layers sliding on the surface of the ridge-crest, which incline gently and consequently to the dipping of beds.

Fine-grained sand of the medium diameter 0.15–0.25 mm with an admixture of calcium carbonate (4–12%) occurs at the bottom of many rock shelters and open fissures. It contains more or less numerous shells of molluscs and their fragments (subfossil malacocoenoses). These sediments up to 20 cm thick are not stratified and probably represent a short geological episode. Similar mollusc-bearing deposits have been found in many small rock-shelters developed within Upper Jurassic limestones of the Cracow Upland. Most of them are of Late Holocene age (Alexandrowicz, 2000).

Sandstone tors of the Żurawnica Mt. are exceptional in relation to many others known in the Polish Outer Carpathians. They had developed on the face of the Ciężkowice Sandstones formation, a particularly resistant complex of beds, which stretches along the border of the Magura Nappe. This complex spreads several kilometres to SW and NE but tors occur only on the distance of 700 m on the described ridge. Edge-building sandstones of the Żurawnica Mt. rich in calcareous matrix are less differentiated and in consequence particular rocky forms are similar in shape and not distinctly separated each other.

More than 150 sandstone tors have been described in the western part of the Polish Outer Carpathians. They occur among lithostratigraphical formations of Silesian and Magura Nappes: Upper Godula Beds, Isdebna Beds, Ciężkowice Sandstones, Krosno Beds and Magura-type sandstones. They all are developed within thick-bedded, coarse-grained deposits defined as fluxoturbidites and contain poor and uneven distributed argillaeous-ferrous matrix, which is locally enriched. Strongly cemented parts of these complexes have features of concretions much more resistant than surrounding rocks and finally they become stripped as isolated forms or groups of tors (Alexandrowicz, 1977, 1978).

Sandstone tors of different size and shape isolated, forming groups, walls and rocky edges originated on slopes and among ridge crests under conditions of the periglacial climate. Many of them have been reported as forms connected with Pleistocene cryoplanation terraces or even as frost-riven cliffs world-wide distributed (Demek, 1969). Long rocky walls have been described from Moravian Carpathians (i.e. Czudek et al., 1965; Demek, 1966; Buzek, 1973). In the Bieszczady Mts (Eastern Carpathians) rows of tors associated with block fields formed below have been described by Pękala (1969). They crown ridge crests as a characteristic feature of the landscape. Quite similar landforms recently shaped and transformed occur in the arctic zone i.e. in Siberia and Alaska (Demek, 1968, 1969; Czudek, 1989).

T a b l e 1. List of species

		Recent					Subfossil					
E	S p e c i e s	C	D	Q	Qr	N	C	D	Q	Qr	N	RL
7	*Punctum pygmaeum* (D r a p a r n a u d)	5	5	42.6	1	V	5	5	40.8	1	V	
7	*Vitrina pellucida* (M ü l l e r)	5	4	41.8	2	V	5	3	18.2	4	III	
1	*Aegopinella pura* (A l d e r)	5	3	30.9	3	III	4	2	14.8	9	III	
2	*Alinda biplicata* (M o n t a g u)	5	3	27.0	4	IV	5	4	29.8	2	V	
7	*Laciniaria plicata* (D r a p a r n a u d)	5	3	21.4	5	IV	5	3	25.6	3	IV	
1	*Acicula polita* (H a r t m a n n)	4	3	17.2	6	IV	4	3	18.2	5	III	
1	*Trichia unidentata* (D r a p a r n a u d)	4	2	15.7	7	III	3	1	6.2	22	II	NT
7	*Nesovitrea hammonis* (S t r ö m)	4	2	14.0	8	III	4	2	15.1	8	III	
1	*Perforatella incarnata* (M ü l l e r)	4	2	13.8	9	III	4	2	10.2	16	III	
7	*Vertigo alpestris* A l d e r	3	2	12.0	10	III	4	2	14.0	11	III	
1	*Ruthenica filograna* (R o s s m ä s s l e r)	3	2	11.8	11	III	2	1	3.4	27	I	
7	*Clausilia dubia* D r a p a r n a u d	3	2	10.9	12	III	3	2	13.1	12	III	
1	*Acanthinula aculeata* (M ü l l e r)	3	2	10.6	13	III	3	2	9.5	17	III	
7	*Euconulus fulvus* (M ü l l e r)	3	2	9.3	14	III	4	2	14.8	10	III	
1	*Vertigo pusilla* (M ü l l e r)	3	2	8.7	15	III	3	1	5.7	23	II	
1	*Cochlodina orthostoma* (M e n k e)	3	2	8.3	16	III	3	2	7.4	20	II	
1	*Chilostoma faustinum* (R o s s m ä s s l e r)	3	2	8.1	17	III	1	1	1.6	39	I	
8	*Carychium tridentatum* (R i s s o)	3	2	7.3	18	II	3	2	16.8	7	III	
1	*Daudebardia rufa* (D r a p a r n a u d)	2	2	6.4	19	III	2	1	3.4	28	I	
7	*Cochlicopa lubrica* (M ü l l e r)	2	1	4.8	20	II	1	1	2.8	33	I	
1	*Vitrea diaphana* (S t u d e r)	2	1	4.5	21	II	2	1	5.6	24	II	
5	*Vallonia costata* (M ü l l e r)	2	1	4.2	22	II	2	2	9.4	18	III	
1	*Oxychilus depressus* (S t e r k i)	2	1	3.6	23	II	3	2	8.8	19	III	
1	*Vitrea transsylvanica* (C l e s s i n)	1	1	3.1	24	I	4	2	11.8	14	III	
2	*Discus rotundatus* (M ü l l e r)	2	1	3.1	25	II	3	2	10.4	15	III	
1	*Eucobresia nivalis* (D u m o n t & M o r t i l l e t)	2	1	3.3	26	II	2	1	3.4	29	I	NT
1	*Semilimax semilimax* (F e r u s s a c)	2	1	3.1	27	I	1	1	2.8	34	I	NT
1	*Cochlodina laminata* (M o n t a g u)	2	1	3.1	28	II	0	0	0.0	40	0	
1	*Isognomostoma isognomostoma* (S c h r ö t e r)	2	1	2.7	29	I	3	2	6.7	21	III	
5	*Vallonia pulchella* (M ü l l e r)	1	1	2.2	30	I	3	3	17.3	6	IV	
2	*Vitrea crystallina* (M ü l l e r)	1	1	1.8	31	II	2	1	5.6	25	II	
1	*Orcula doliolum* (B r u g u i e r e)	1	1	1.8	32	I	2	1	5.1	26	II	VU
8	*Columella edentula* (D r a p a r n a u d)	1	1	1.3	33	II	2	1	3.4	30	I	
3	*Macrogastra tumida* (R o s s m ä s s l e r)	1	1	0.9	34	I	1	1	2.3	36	I	NT
8	*Trichia villosula* (R o s s m ä s s l e r)	1	1	0.9	35	0	1	1	2.3	37	I	NT
7	*Limacidae*	0	0	0.0	38	0	4	2	12.1	13	III	
1	*Ena montana* (D r a p a r n a u d)	0	0	0.0	38	0	2	1	3.4	31	I	
1	*Macrogastra plicatula* (D r a p a r n a u d)	0	0	0.0	38	0	2	1	3.4	32	I	
5	*Truncatellina cylindrica* (F e r u s s a c)	0	0	0.0	38	0	1	1	2.8	35	I	
2	*Bradybaena fruticum* (M ü l l e r)	0	0	0.0	38	0	1	1	2.3	38	I	

Explanations: E – ecological groups of species (according to Ložek, 1964): 1 – shadow–loving species, 2 – snails of partly shady habitats, 3 – species of moist forest, 5 – open–country snails, 7 – mesophile species of moderately humid sites, 8 – mesophile species of humid sites; C – constancy (1–5), D – dominance (1–5), Q – geometrical geometrical mean of C and D, Qr – rank of the Q–index; N – number of species in the logarithmic scale (according to Alexandrowicz 1987): I – 1–3, II – 4–9, III – 10–31, IV – 32–99, V – 100–316; RL – species included on the red list of threatened animals in Poland (Głowaciński, 2002): VU – vulnerable, NT – near threatened.

The edge of the Żurawnica ridge formed of a line of sandstone tors culminating above the intermanotane denudation level is similar to them and may by attributed to processes connected with the Pleistocene periglacial climate. Up today it have transformed only in a very limited degree. The widening of crags, drawing aside and falling of sandstone blocks as well as the subsidence of particular tors or parts of them were the main agents of these changes. Block of different size, rock detritus and scree accumulated on the slope just at the foot of the edge originated in this way.

A large landslide is developed on the northern slope of the Żurawnica Mt. (Fig. 1 B). Their head scarp is situated about 60 m below the eastern part of the rocky wall and colluvial masses cover the surface of about 4 hectares. It has no relation to this wall although Jakubska (1978) suggested the connection between both forms. The first stage of sliding falls to the Preboreal Phase of the Holocene and was dated by Margielewski (2001) to 9235 ± 60 years BP. Scarps and other forms evidencing the rejuvenation of the landslide were described by Jakubska (1978) and Pająk, Sobik (2003).

Malacocoenoses

Relatively rich fauna of molluscs occurs on the Żurawnica Mt. along the described rocky edge. The list of living snails comprises 35 species represented by 873 specimens (Table 1). Fife of them are most important components of the assemblage, characterised by highest indices of constancy and domination: C–D = 5–5, 5–4, 5–3, and values of Q > 20. These are: *Punctum pygmaeum*, *Vitrina pellucida*, *Aegopinella pura*, *Alinda biplicata* and *Laciniaria plicata.* Two first mentioned count more than hundred specimens each. Few other species: *Acicula polita*, *Trichia unidentata*, *Nesovitrea hammonis* and *Perforatella incarnata* reache relatively high values of the C index (4–3, 4–2). Sixteen species are accessory elements with C–D indices = 2–1, 1–1 and Q index < 5 (Table 2). The structure of constancy and domination is characterised by low normalised indices: C_i = 15.0 and D_i = 7.0. Woodland snails and mesophile species are main components of the recent malacocoenose particularly in relation to number of specimens evidenced on the spectrum MSI (Fig. 3). In assemblages from particular samples the proportion between the number of woodland snails and mesophile species (ecological groups: E–1 and E–7) change up to 20%, while the content of snails connected with partly shady habitats (E–2) reaches 15-25% (Fig. 4). Species of other ecological groups occur only as an admixture.

T a b l e 2. Structures of constancy and dominance of living (Liv) and subfossil (Sbf) malacocoenoses

Liv.	D-1	D-2	D-3	D-4	D-5		Sbf.	D-1	D-2	D-3	D-4	D-5
C-5			3	1	1		C-5			2	1	1
C-4		3	1				C-4		7	1		
C-3		9					C-3	2	7	1		
C-2	9	1					C-2	9	1			
C-1	7						C-1	7				

C-1 – C-5 – classes of constancy, D-1 – D-5 – classes of dominance (according to Alexandrowicz, 1978)

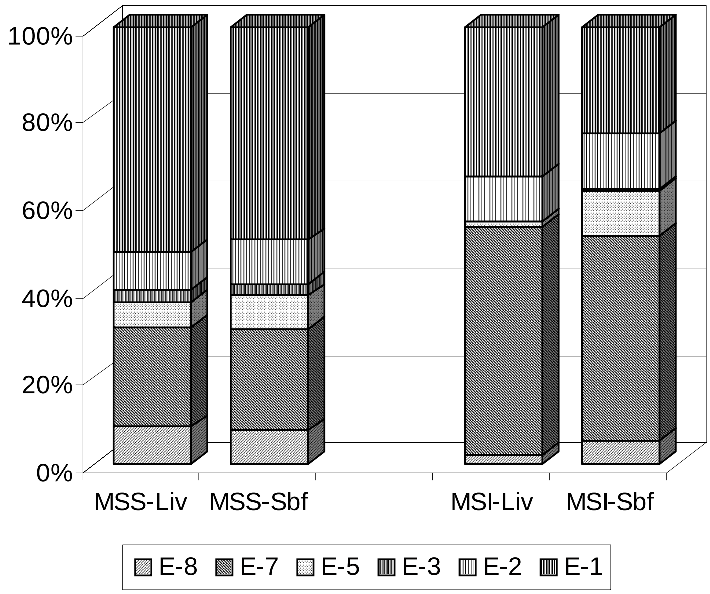

Fig. 3. Malacological spectra of species (MSS) and specimens (MSI) characterising living (Liv) and subfossil (Sbf) malacocoenoses of the Żurawnica Mt. Ecological groups of molluscs (according to Ložek 1964): E-1 – woodland snails, E-2 – snails of partly shady habitats, E-3 – snails of moist forests, E-5 – open-country species, E-7 – mesophile species of moderately humid habitats, E-8 – mesophile species of humid habitats.

Subfossil malacocoenose derives from sediments found in rock-shelters and open fissures. It contains 38 species of snails and shells of slugs, determined conventionally as *Limacidae* (Table 1). Four dominating species have indices C–D = 5–5, 5–4, 5–3 and values of the Q index exceeding 18: *Punctum pygmaeum*, *Alinda biplicata*, *Laciniaria plicata*, and *Vitrina pellucida*. Seven other species belong to C–D = 4–3, 4–2 (i.e. *Acicula polita*, *Nesovitrea hammonis*, *Aegopinella pura*, *Euconulus fulvus*) while 16 taxa with C–D = 2–1, 1–1 are accessory components (Table 2). Normalised indices of constancy and domination are respectively: C_i = 17.5 and D_i = 7.5. Malacospectra of species (MSS) and of specimens (MSI) of the whole malacocoenose differ one another mainly in the relation between ecological groups E–1 and E–7 (Fig. 3). Particular assemblages are characterised by the high content of open-country snails (E–5) exceeding 30%, while some others are composed nearly exclusively of woodland and mesophile species (Fig. 4).

The described malacocoenoses are quite similar to one another. 85% of species are common and dominating components mentioned above are nearly the same. The rank correlation was used to compare both lists of species, ordered according to the Q-index (Table 1 – Qr). Their value: r_S = 0.67 is valuable on the confidence level 001 and confirms the similarity.

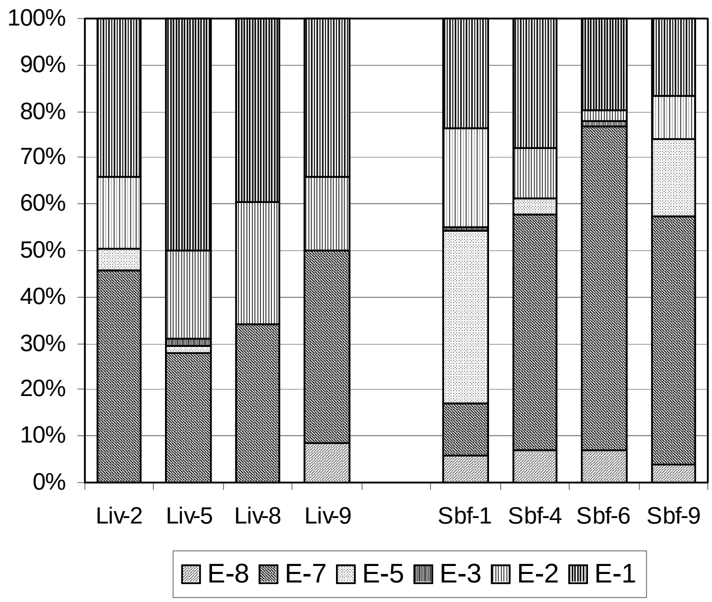

Fig. 4. Malacological spectra of specimens (MSI) of living (Liv) and subfossil (Sbf) molluscan assemblages from selected samples. Ecological groups as in Fig. 3.

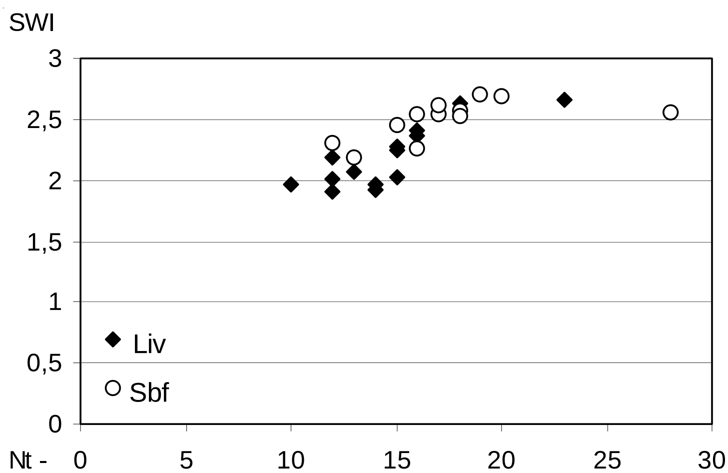

Fig. 5. Relation between number of species (Nt) and differentiation index (SWI) of living (Liv) and subfossil (Sbf) assemblages of molluscs.

The number of species (Nt) and values of the Shannon-Weaver differentiation index (SWI) are some higher in assemblages of subfossil molluscs than of recent ones. Points corresponding with particular samples of both malacocoenoses are separated in a major degree (Fig. 5). It means that the fauna living now is somewhat poorer and less differentiated as the ancient one. The difference between them reflect changes of environment indicated also by malacological spectra MSS and MSI (Figs 3, 4).

The age of mentioned mollusc-bearing sediments is hard to be defined. The similarity between living and subfossil malacocoenoses as well as the analogy with comparable deposits described by Alexandrowicz (2000) from the Cracow Upland gives the suggestion that they may by attributed to the late phase of the Holocene and even the last millennium. In this mean relations between the content of shadow-loving snails and open-country species in both malacocoenoses indicate, that not long ago was a time when the Żurawnica Range had been significantly less wooded as now.

During the historical period, particularly since 14th century, subsequently to growing colonisation and increasing of population density, cultivated areas and pasturelands within the Carpathian Foothills and the Beskidy Mts widened gradually. It caused the forest clearing advancing especially along river valleys and within low parts of mountains. Such effects of the human activity are documented in several publications (i.e., Hensel, Łowmiański, 1964; Grodziski, Dwornicka, 1987). After the Second World War the nationalisation of forests partly checked the deforestation. During the last fifty years the succession of trees and bushes gradually eliminated open habitats, which changed biotopes and biocoenoses including assemblages of molluscs. Shadow-loving and mesophile snails replaced open-country species.

In the Polish Outer Carpathians the mollusc fauna is not rich and depends in a high degree on the type of background. Argillo-marly flysch formations with thin-bedded sandstones are much more favourable for snails as complexes composed mainly or even exclusively of thick-bedded sandstones. Young Quaternary slope deposits developed as loam with rock detritus give also life conditions acceptable for molluscs, especially when they have an admixture of carbonates. In particular mountain ranges malacocoenoses have been not studied till now (Riedel, 1988). In the Western Beskidy Mts only the fauna inhabiting the Babia Góra National Park has been described in detail (Dzięczkowski, 1972; Alexandrowicz, W.P., 2003). Different and uneven distributed malacocoenoses occur within wooded and not cultivated habitats on the background formed of various flysch deposits.

The rocky edge of the Żurawnica Mt. with several tors formed of thick-bedded sandstones with a high content of calcium carbonate (Ciężkowice Sandstones of the Magura Nappe) offers conditions friendly for many species of snails. On the other hand rocky forms shaped within the Godula Beds, Istebna Beds, Magura Sandstones and others are less favourable for them. It is noteworthy, that on more than hundred sandstone tors build of such lime-free rocks as well as close around them living snails occur rarely and subfossil molluscs never have been found.

On the other hand relative rich and differentiated malacocoenoses were reported from ruins of castles, towers and castellated manors build in Polish Carpathians during the Middle Ages or somewhat later (Alexandrowicz, 1995). Soil enriched in lime coming from disintegrated walls with a considerable content of calcareous mortar was in the past and is up till now a favourable environment for land snails. Similar conditions occur also in the Andrychów region around outcrops of olistolithes formed of limestones enbedded within flysch (Alexandrowicz, 1994).

Assemblages of molluscs of the Żurawnica Mt. are surprisingly similar to recent and subfossil malacocoenoses of the Polish Jura Chain, described in detail from the Cracow Upland (Alexandrowicz, 2000, 2002; Alexandrowicz, Alexandrowicz, 1995, Alexandrowicz, Alexandrowicz, 2003). Lists of taxa in both areas have a high percent of common species although in the Jura Chain few petrophile and xerophile snails living on limestone rocks connected with warm grasslands occur additionally.

Lichens are another component of biocoenoses joining two mentioned regions. In this aspect Żurawnica Ridge is quite exceptional in the Western Beskidy Mts. About 30 calciphile species have been found on sandstone tors and block along the described rocky edge. Within surrounding mountain ranges it is one and only site of their occurrence. This assemblage of lichens is nearly the same as in the Cracow Upland, than from six species typical of the Polish Jura Chain even fife have been found on the Żurawnica Mt. (Nowak, 1965, 1972). Beside them few species of calciphile plants grow here. The most interesting are: *Saxiphraga aizoon* J a c q. and *Asplenium viridae* H u t s. (Błaszczyk, 1965).

Conclusions

In the Outer Flysch Carpathians sandstone tors are important components of geodiversity (Alexandrowicz, Poprawa, 2000). These are particularly attractive landforms as well as permanent outcrops, which evidence several types of geological formations, sedimentary structures typical of fluxoturbidites and effects of weathering. The row of tors forming the rocky edge of the Żurawnica Mt. is specific due to lithological features of sandstones rich in calcium carbonate. No other tors build of such rocks (Ciężkowice Sandstones of the Magura Nappe) occur in Carpathians.

The mollusc fauna of the Żurawnica Mt. is relatively rich in comparison to surrounding mountain ranges and resembles these living in Polish karstlands. It was just noted as the interesting assemblage, which indicate a particular value of this site (Alexandrowicz, 1997). Sediments filling rock shelters and fissures contain shells of subfossil snails not known up till now from other rocky forms in Flysch Carpathians. Differences between ancient and living malacocoenoses evidence changes of the environment during the historic period.

A specific flora of calciphile lichens occurs on sandstone walls and blocks of the described rocky edge. Together with assemblages of molluscs it give evidence, that some components of the biocoenoses developed on the Żurawnica range are quite another as in surrounding mountains but similar to those from the Cracow Jura Chain.

According to results of presented investigations the Żurawnica Mt. is significantly valuable both from geomorphological and biocoenotical point of view. Actually a part of the

Fig. 6. An example of a sandstone tor from the rocky edge on the trail for tourists.

rocky edge is preserved as a nature monument. The described new data motivate the creation of nature reserve, which should enclose the whole row of rocky tors with the block-field at the foot and with adjacent part of the ridge crest (about 8 hectares). The occurrence of species placed in Red Lists of threatened plants and animals (6 species of snails and 4 species of lichens) supplementary motivate this conclusion (Zarzycki et al., 1992; Głowaciński, 2002).

Outcrops of Ciężkowice Sandstones of the Magura Nappe, the best in Polish Carpathians as well as specific rocky landforms promote the Żurawnica Mt. to the European List of Geosites prepared actually (Alexandrowicz, Z., 2003). The range is also particularly interesting for tourists and useful for education. Two tourist trails have been traced till now but another didactic trail should by organise additionally (Fig. 6).

Translated by the authors

Acknowledgement

The present study is a contribution to the scientific project supported by the Polish Committee for Scientific Research KBN – P04G 092 23. The authors are grateful to A. Kalemba for help with preparing the draws.

References

Alexandrowicz, S.W., 1987: Malacological analysis in Quaternary research (in Polish). Kwartalnik AGH, Geologia, *13*, 1–2, 240 pp.

Alexandrowicz, S.W., 1995: Ruins of Carpthian castles as refuges of land snails. Ochrona Przyrody, *52*, p. 3–18.

Alexandrowicz, S.W., 1997: Malacofauna as an element of geosites evaluation (in Polish). Chrońmy Przyrodę Ojczystą, *53*, 5, p. 46–56.

Alexandrowicz, S.W., 1999: Shell accumulations in fluviatile sedimentary environment – methods and interpretation (in Polish). Kwartalnik AGH, Geologia, *35*, 3, p. 211–295.

Alexandrowicz, S.W., 2000: Malacofauna of Holocene cave sediments of the Cracow Upland (Poland). Folia Quaternaria, *71*, p. 85–112.

Alexandrowicz, S.W., 2002: Recent and subfossil mollusc fauna in the Bielany-Tyniec Landscape Park (in Polish). Prądnik, Prace Muzeum Szafera, *13*, p. 189–215.

Alexandrowicz, S.W., Alexandrowicz, Z., 2003: Pattern of karst landscape of the Cracow Upland (South Poland). Acta Carcologica, *32*, 1, p. 40–56.

Alexandrowicz, W.P., 1994: Recent and subfossil molluscan fauna at Pańska Góra Hill in Andrychów, Southern Poland (in Polish). Ochrona Przyrody, *51*, p. 147–156.

Alexandrowicz, W.P., 2003: Snails (Mollusca: Gastropoda) and bivalves (Mollusca: Bivalvia) of the Babia Góra Massif. In Wołoszyn, B.W., Wołoszyn D., Celary, W. (eds): Fauna of the Mt. Babia Góra, Poland (in Polish). Komitet Ochrony Przyrody PAN, p. 69–97.

Alexandrowicz, Z., 1977: The origin of sandstone tors in the Polish Western Carpathians. Bulletin de l'Academie Polonaise des Sciences, Ser. Sci. Terre, *25*, p. 83–90.

Alexandrowicz, Z., 1978: Sandstone tors of the Western Flysch Carpathians (in Polish). Prace Geol. Kom. Nauk Geol. PAN Oddział Kraków, *113*, 87 pp.

Alexandrowicz, Z., 2003: Protection of the Polish geological heritage within the European framework of geosites (in Polish). Przegląd Geologiczny, *51*, 3, p. 224–230.

Alexandrowicz, Z., Alexandrowicz, S.W., 1995: Geological and malacological evaluation of the Skała Kmity Nature Reserve (Cracow Upland) (in Polish). Ochrona Przyrody, *52*, p. 95–110.

Alexandrowicz, Z., Poprawa, D. (eds), 2000: Geodiversity conservation of the Polish Carpathians (in Polish). Państwowy Instytut Geologiczny, 142 pp.

Baumgart-Kotarba, M., 1974: Development of mountain ridges in the Flysch Carpathians (in Polish). Prace Geograficzne PAN, *106*, 133 pp.

Błaszczyk, H., 1965: Some floristic notes from the hill Żurawnica in Beskid Mały (Polish Western Carpathians) (in Polish). Fragmanta Floristica et Geobotanica, *11*, 4, p. 537–540.

Buzek, L., 1973: The slopes of the Radhoštské Beskydy Mts and the Štramberská Vrchovina Upland (in Czech). Acta Facultatis Pedagogicae Ostraviensis, Ser. E – 3, *33*, p. 47–59.

Czudek, T., 1989: Kryoplanationterrasen im rezenten Dauerfrostboden. Acta Scientarum Naturalium Academiae Scientarum Bohemoslovacae, Nov. Ser., *8*, 41 pp.

Czudek, T., Demek, J., Stechlik, O., 1965: Study on the development of the Carpathians' relief in Moravia. Geographia Polonica, *9*, p. 35–51.

Demek, J., 1966: Contribution to the problem of slope development of the Moravian Carpathians in the Pleistocene period. Geographia Polonica, *10*, p. 149–172.

Demek, J., 1969: Crioplanation terraces, their geographical distribution and development. Rozpravy Československé Akademie Ved, Řada Mat.-Přir. Věd, *79*, 4, 80 pp.

Dudziak, J., 1962: Sandstone tors on Żurawnica in the Beskid Mały Mts. Wszechświat, *4*, p. 97–99.

Dzięczkowski, A., 1972: Quantitative recherches of Gastropods in the beech forests of South-Western Poland – an ecology-faunistical study (in Polish). Poznańskie Towarzystwo Przyjaciół Nauk, Prace Komisji Biologicznej, *35*, 5, 90 pp.

Głowaciński, Z. (ed.), 2002: Red List of threatened animals in Poland (in Polish). Instytut Ochrony Przyrody PAN, Kraków, 155 pp.

Grodziski, S., Dwornicka, U. (eds), 1987: Chronograph or historiography of the Żywiec region (in Polish). Towarzystwo Miłośników Ziemi Żywieckiej, 745 pp.

Hensel, W., Łowmiański, H. (eds), 1964: Outline of history of farms in Poland (in Polish). Państwowe Wydawnictwa Rolniczo-Leśne, *3*, 807 pp.
Jakubska, O., 1978: Landslides in the Tarnawka valley (north-east of Beskid Makowski) (in Polish). Geographia Studia et Dissertationes, *2*, p. 46–53.
Książkiewicz, M., 1935: Sur la structure des masses marginales de la nappe de Magura entre Sułkowice et Sucha (in Polish). Rocznik Polskiego Towarzystwa Geologicznego, *11*, p. 104–122.
Książkiewicz, M., 1951: Explanations of the Wadowice survey sheed (in Polish). Państwowy Instytut Geologiczny, 283 pp.
Książkiewicz, M., 1968: Observations on jointing in the Flysch Carpathians (in Polish). Rocznik Polskiego Towarzystwa Geologicznego, *38*, 2–3, p. 335–394.
Ložek, V., 1964: Quartärmollusken der Tschechoslowakei. Rozpravy Ústředného Ústavu Geologického, *31*, 374 pp.
Margielewski, W., 2001: Dated landslide forms and deposits of the Maków Beskid as the refletion of Late Glacial and Holocene climatic changes (in Polish). Sprawozdania z Czynności i Posiedzeń Polskiej Akademii Umiejetności, *65*, p. 177–183.
Margielewski, W., 2004: Patterns of gravitational movements of rock masses in landslide forms of the Polish Flysch Carpathians (in Polish). Przegląd Geologiczny, *52*, 7, p. 603–614.
Margielewski, W., Urban, J., 2003: Crevice-type caves as initial forms of rock landslide development in the Flysch Carpathians. Geomorphology, *54*, p. 325–338.
Nowak, J., 1965: The lichens of the Beskid Mały (Polish Western Carpathians) (in Polish). Fragmenta Floristica et Geobotanica, *11*, 3, p. 421–462.
Nowak, J., 1972: Problems of the Distribution of Lichens in the Polish Western Beskids (Silesia-Babia Góra subdistrict) (in Polish). Fragmenta Floristica et Geobotanica, *18*, 1, p. 45–143.
Pająk, R., Sobik, K., 2003: The landslide of Żurawnica in Beskid Średni Mts (in Polish). Wszechswiat, *104*, 10-12, p. 252–256.
Pękala, K., 1969: Block fields and recent morphogenetic processes in the Western Bieszczady Mts (in Polish). Annales Univ. M. Curie-Skłodowska, ser. B, *24*, 2, p. 47–98.
Pulina, M. (ed.), 1997: Caves of Polish Flysch Carpathians (in Polish). Polskie Towarzystwo Przyjaciół Nauk o Ziemi, *2*, 228 pp.
Riedel, A., 1988): Land snails – Gastropoda terrestria (in Polish). Katalog Fauny Polski, *36*, 1, 316 pp.
Vítek, J., 1979: Pseudokarst phenomena in block sandstones in North-east Bohemia (in Czech). Rozpravy Československé Akademie Ved, Řada Mat.-Přir. Věd, *89*, 4, 57 pp.
Zarzycki, K., Wojewoda, W., Heinrich, Z. (eds), 1992: List of threatened plants in Poland (in Polish). Instytut Botaniki PAN im. W. Szafera, Kraków, Ed. 2, 98 pp.

Received 12. 10. 2004

Alexandrowicz S.W., Alexandrowicz Z.: **Skalnaté okraje a malakocenózy v horskom hrebeni Zurawica (Poľské Západné Karpaty).**

Pohorie Zurawica v poľských Západných Karpatoch je špecifické pre pieskovcové skalnaté okraje bohaté na uhličitan vápenatý. Rad pieskovcových skál na ich severovýchodnom okraji je najlepším východom Ciezkowických pieskovcových formácií Magurského príkrovu. Veľký obsah uhličitanov vytvára vyhovujúce podmienky pre slimákov a umožňuje zachovať ich ulity v subfosílnom stave. V porovnaní s ostatnými časťami Beskýd sú bohaté na malakocenózy skorého a neskorého holocénu a vymedzujú veľa druhov charakterizujúcich faunu krasových oblastí, napr. Krakowský Jurský horský hrebeň. Nachádzajú sa tu aj vápnomilné lišajníky a cievnaté rastliny. Pieskovcovými skalami rôznej veľkosti a tvaru, ako aj zložkami uvedených biocenóz sa hory Zurawnice rozlišujú od okolitých horských hrebeňov. Je to stanovište, kde sa môžu skúmať vzťahy medzi týmito zložkami a špecifickými typmi podložia. Takéto prírodné hodnoty motivujú k tvorbe prírodných rezervácií a k vyznačeniu náučných chodníkov.