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FLORISTIC DIVERSITY IN RELATION TO GEOMORPHOLOGICAL AND CLIMATIC FACTORS IN THE SUBALPINE-ALPINE BELT OF THE RODNA MOUNTAINS (THE ROMANIAN CARPATHIANS)

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*ABSTRACT.– As a part of the GLORIA-EUROPE project, the floristic diversity, frequency and species coverage in relation to the main ecological gradients (altitude,aspect) were studied in the alpine pasture (*Primulo-Caricetum curvulae, Oreochloo-Juncetum trifidi*) and subalpine dwarf shrub communities (*Rhododendro myrtifolii – Vaccinetum*) of the four summits from the Pietrosul Rodnei massif (Romanian Carpathians). Floristic diversity is higher in the plant communities from lower altitude summits (Golgota, Gropile), while it decreases in communities, to higher summits (Buhaiescu, Rebra). For each 100 m increase in the altitude of subalpine-alpine summits, a decrease of approximately 10% was found in the number of vascular plant species. Arctic-Alpine species (Carex curvula, Juncus trifidus, Hieracium alpinum, Oreochloa disticha, etc.) and a Carpatho-Balkanic regional species (Rhododendron myrtifolium) have the highest frequency and coverage in these plant communities. In northern and eastern slope areas, where the vegetation cover is 15-30% lower than on western and southern slopes and the soil temperature is generally 1-3°C lower during the vegetative season (June-August), the mean number of species per square meter is 25% higher than in southern and western slope areas.*

*RÉSUMÉ.– Dans le cadre du projet GLORIA EUROPE on a étudié la diversité floristique, la fréquence et le recouvrement des espèces, par rapport aux principaux gradients écologiques (altitude, exposition), au sein des associations de prés alpins (*Primulo-Caricetum curvulae, Oreochloo-Juncetum trifidi*) et des buissons subalpins de petite taille (*Rhododendro myrtifolii – Vaccinietum*), sur quatre sommets dans le massif Pietrosul Mare (Les Carpates Roumaines). La diversité floristique est plus grande chez les associations de plantes des sommets avec des altitudes plus basses (Golgota, Gropile) et elle s'abaisse chez les associations des sommets plus hauts (Buhaiescu, Rebra). Dans le cas où l'altitude des sommets subalpins-alpins est 100 m plus élevée, on a constaté une réduction du nombre des* *espèces de plantes vasculaires avec 10%. La fréquence et le recouvrement les plus élevées dans ces associations appartiennent aux espèces arctico-alpines (Carex curvula, Juncus trifidus, Hieracium alpinum, Oreochloa disticha etc.) et à une espèce régionale carpato-balkanique (Rhododendron myrtifolium). Dans les aires de versants nord et est, où le recouvrement de la végétation est 15-30% plus bas que sur les versants ensoleillés, et où la température dans le sol est, généralement, 1-3° C plus réduite dans la saison de végétation (juin-août), le nombre des espèces sur un mètre carré est, en moyenne, de 25% plus grand que dans les aires de versants sud et ouest.*

RESUMEN.– En el marco del proyecto GLORIA EUROPE hemos estudiado la diversidad florística, la frecuencia y la cobertura de las especies en relación con los principales gradientes ecológicos (altitud, exposición), con las asociaciones de pastos alpinos (Primulo-Caricetum curvulae, Oreochloo-Juncetum trifidi) *y con los matorrales bajos subalpinos* (Rhododendro myrtifolii – Vaccinietum), *todo ello en cuatro cimas del macizo Pietrosul Mare (Cárpatos Rumanos). La diversidad florística es mayor en las asociaciones de las cimas más bajas (Golgota, Gropile) y menor en las asociaciones de las cimas elevadas (Buh?iescu, Rebra). Cuando el intervalo altitudinal de las cimas subalpinas-alpinas es de 100 m la disminución en el número de plantas vasculares es aproximadamente del 10%. La mayor frecuencia y el más importante recubrimiento corresponden a las especies ártico-alpinas (Carex curvula, Juncus trifidus, Hieracium alpinum, Oreochloa disticha etc.) así como a una especie regional carpato-balcánica (Rhododendron myrtifolium). En las subparcelas de laderas norte y este, donde el recubrimiento vegetal es 15-30% menor que en las laderas soledas, y donde la temperatura del suelo es generalmente 1-3° C más fría en el período vegetativo (junio-agosto), el número de especies en un metro cuadrado es, por término medio, un 25% mayor que en las subparcelas de las laderas meridionales y occidentales.*

Key-words: Species diversity, plant gradients, climatic gradients, Rodna Mountains, Romania.

1. Introduction

The Eastern Carpathian summits selected and investigated under the GLORIA-EUROPE project are situated in the western and north-western part of the Rodna Mountains and form together the Pietrosul Rodnei massif. These summits namely Golgota (2010 m), Gropile (2060 m), Buhaiescu (2221 m) and Rebra (2268 m), are situated within the perimeter of the Pietrosul Rodnei reserve (Figure 1). The anthropic impact on the vegetation of this area is very low due to the protection system applied in the reserve over the last 50 years.

The geological substrate of these summits predominantly consists of crystalline rocks represented by para- and orthoamphibolites, diorites, grani-

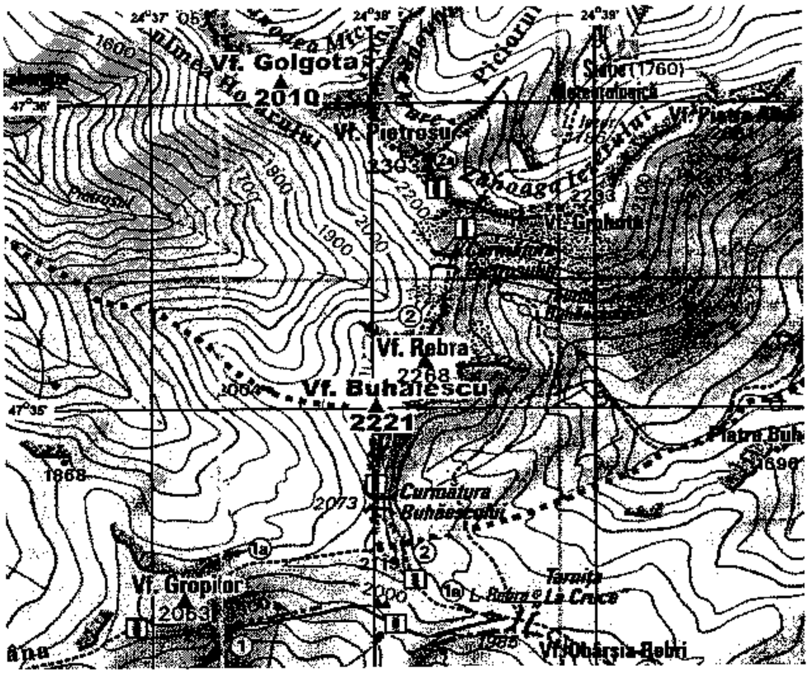

Figure 1. Position of the summits in the Pietrosu Massif (The Rodna Mts).

tes, micaschists, with the occasional chloritic schists. The soils formed in the area are humic-silicatic, superficial (15-25 cm), highly acid (pH=4.2-4.5), rich in organic matter and are low base saturated (V=8-23%).

Climate is moderate continental, with a mean annual air temperature of +1°C and annual precipitation of 1300 mm. The geological substrate, the soil and climate have favored the development of subalpine-alpine vegetation with Eastern Carpathian floristic character. On lower summits (Golgota, Gropile), dwarf shrub and grass plant communities belonging to the associations *Rhododendron myrtifolii-Vaccinetum* Borza 1959 and *Oreochloo-Juncetum trifidi* Szafer et al 1927 are predominant, whilst on higher summits (Buhaiescu, Rebra), acid alpine pastures grouped into the association *Primulo-Caricetum curvulae* Oberd. 1959 (COLDEA, 1990).

The aim of this paper is (a) to compare the diversity of species from the 4 summits investigated, (b) to show the interrelations between plant gradients and climatic gradients, and (c) to investigate the phytogeographical peculiarities and the evolution tendency of plant communities.

2. Material and method

Field investigations were performed according to the methods of the Field Manual, third version, elaborated by PAULI *et al.* (2004) for the GLORIA-EUROPE project. The following activities were carried out: selection of summits, setting of the 3 m x 3 m plot clusters and summit area sections, marking of plot clusters in the field, recording of frequency and species coverage in the 1 m x 1 m quadrat samples by using the 1 m x 1 m grid frame with 100 cells (0.1 x 0.1 m), recording of vegetation coverage in the summit area sections, installation of a temperature data logger in the soil and the mode of photographing the investigated areas in order to detect the changes in vegetation (Figures 1, 2).

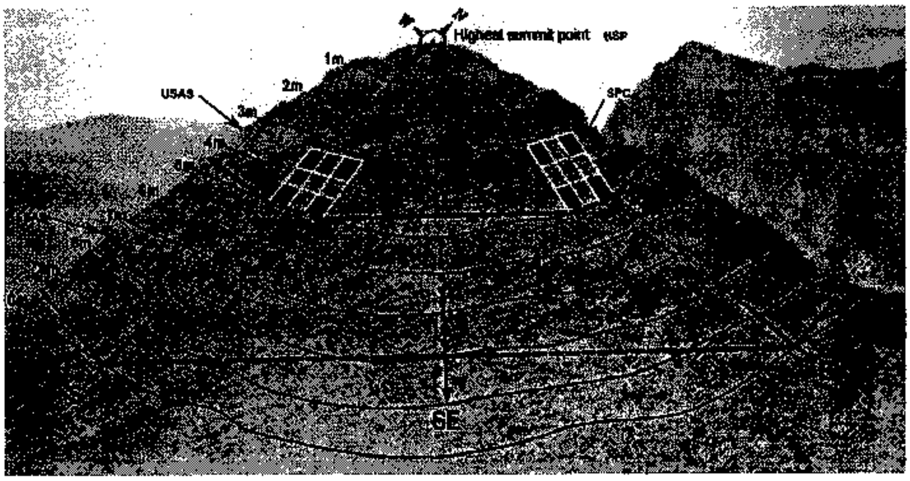

Figure 2. Method and sampling design.
USAS – upper summit area section (5 m).
LSAS – lower summit area sectioin (10 m).
SPC – 3 m x 3 m summit plot cluster.

The 16 plot clusters of 3 m x 3 m were established on the four summits selected at 5 m contour line, in the main geographical directions (N, E, S, W), with the 16-quadrat areas of 1 m x 1 m on each summit, and the exact frequency and species coverage were recorded. In the central quadrat of each 3 m x 3 m plot cluster, a T data logger was installed in the soil at about 10 cm in order to record soil temperature.

Similarly, 8 summit area sections were established on each summit, giving a total of 32 area sections, where the plant species found, the coverage and abundance of each species were recorded separately for each area, and for rare taxa, the exact place where they were found in the field was also noted. All data obtained were included in the database of the GLORIA-EUROPE project set up at the Institute of Ecology of Vienna.

3. Results and discussion

3.1 Species diversity

In all the areas investigated on the 4 summits of the Pietrosul Rodnei massif, the target area CRO (RO), 46 vascular plant species (*Pteridophyta* and *Spermatophyta*) were identified. Table 1 shows in separate columns the "area section species"(SAS) and the "plot cluster species"(SPC) of the four summits. The number of the species in the area sections varies between 22 and 34, and that of plot cluster species between 11 and 20. Of all species inventoried on each summit, 50% to 62% species were found in the 3 m x 3 m plot cluster areas. On the lower summits (Golgota, Gropile), which are situated within the treeline ecotone zone, between the subalpine and lower alpine belt, several grass and wood species are present, such as: *Pinus mugo, Picea abies, Vaccinium vitis-idaea, V. uliginosum, Carex atrata, Veratrum album, Hypericum richeri, Deschampsia flexuosa, D. caespitosa,* which are not found on higher summits (Buhaiescu, Rebra). On the contrary, on higher summits, cryophilous species are found, which are characteristic of late snowbed communities such as *Sedum alpestre, Omalotheca supina, Poa granitica* subsp. *disparilis, Soldanella hungarica* subsp. *hungarica* and *Lychnis nivalis*. The last 3 species are endemic in the Romanian Carpathians.

Analyzed from the point of view of life forms, the 46 species are grouped as follows: 72% hemicryptophytes, 15% chamaephytes, 4% geophytes, 4% nanophanerophytes and 4% phanerophytes. We should mention that phanerophytes (*Picea abies, Pinus mugo*) were only identified on the lowest summit (Golgota) of the treeline ecotone zone (Table 1).

3.2 Interrelations between plant gradients and climatic gradients

The high number of species of the investigated areas, the frequency and abundance of these species per m^2, and the functional vegetation types of the region are correlated with the climatic gradients.

Table 1. Plant species list from Target region 12 CRO (RO).

Species name	Summit: / Altitude m / Area:	Golgota 2010 SAS	Golgota 2010 SPC	Gropile 2060 SAS	Gropile 2060 SPC	Buhaiescu 2221 SAS	Buhaiescu 2221 SPC	Rebra 2268 SAS	Rebra 2268 SPC
Agrostis rupestris All.		-	-	+	+	-	-	-	-
Anthoxanthum odoratum L. subsp. alpinum (Löve)		+	-	+	-	-	-	-	-
Avenula versicolor (Vill.) M. Laínz		+	+	+	-	+	+	+	+
Campanula alpina Jacq. subsp. alpina		+	+	+	+	+	+	+	+
Carex atrata L. subsp. atrata		+	-	-	-	-	-	-	-
Carex curvula All. subsp. curvula		+	+	+	-	+	+	+	+
Crocus vernus (L.) Hill subsp. vernus		-	-	+	-	-	-	-	-
Deschampsia cespitosa (L.) P. Beauv.		+	-	+	-	-	-	-	-
Deschampsia flexuosa (L.) Trin.		+	+	+	-	-	-	-	-
Doronicum clusii (All.) Tausch		-	-	+	-	-	-	-	-
Festuca airoides Lam.		+	+	+	+	+	+	+	+
Festuca nigrescens Lam.		-	-	-	-	-	-	+	-
Gentiana punctata L.		+	-	-	-	-	-	+	-
Geum montanum L.		+	-	+	+	-	-	+	-
Hieracium alpinum L.		+	+	+	+	+	+	+	+
Homogyne alpina (L.) Cass.		+	+	+	+	+	-	+	-
Huperzia selago (L.) Bernh. ex Schrank & Mart.		+	+	+	-	+	-	+	-
Hypericum richeri subsp. grisebachii (Boiss.) Nyman		+	-	+	-	-	-	-	-
Juncus trifidus L. subsp. trifidus		+	+	+	+	+	+	+	+
Juniperus communis subsp. alpina (Suter) Celak.		-	-	+	-	-	-	-	-
Ligusticum mutellina (L.) Crantz		+	+	+	+	+	+	+	+
Loiseleuria procumbens (L.) Desv.		-	-	+	-	-	-	-	-
Luzula alpinopilosa subsp. obscura S. E. Fröhner		+	-	+	+	+	+	+	+
Lychnis nivalis Kit.		-	-	-	-	-	-	+	-
Omalotheca supina (L.) DC.		-	-	-	-	+	-	+	-
Oreochloa disticha (Wulfen) Link		+	+	+	+	+	+	+	+
Phyteuma orbiculare L.		-	-	+	-	-	-	-	-
Picea abies (L.) H. Karst. subsp. abies		+	-	-	-	-	-	-	-
Pinus mugo Turra		+	-	-	-	-	-	-	-
Poa alpina L.		-	-	-	-	+	-	-	-
Poa granitica subsp. disparilis (Nyár.) Nyár.		-	-	-	-	-	-	+	+
Poa media Schur		-	-	+	-	+	-	+	-
Polygonum bistorta L.		-	-	+	-	-	-	-	-
Potentilla aurea subsp. chrysocraspeda (Lehm.) Nyman		+	-	+	+	-	-	-	-
Primula minima L.		+	+	+	+	+	-	+	+
Pulsatilla alba Rchb.		+	-	+	+	+	+	-	-
Ranunculus crenatus Waldst. & Kit.		-	-	+	+	+	-	+	+
Rhododendron myrtifolium Schott & Kotschy		+	+	+	+	+	-	+	+
Sedum alpestre Vill.		-	-	-	-	-	-	+	-
Soldanella hungarica Simonk. subsp. hungarica		-	-	-	-	+	+	+	+
Soldanella hungarica subsp. major (Neilr.) Pawlowska		+	+	+	+	+	-	+	+
Solidago virgaurea L.		+	-	+	+	+	-	-	-
Vaccinium myrtillus L.		+	+	+	+	+	-	-	-
Vaccinium uliginosum subsp. microphyllum Lange		+	-	+	+	-	-	-	-
Vaccinium vitis-idaea L. subsp. vitis-idaea		+	-	+	+	-	-	-	-
Veratrum album L.		+	-	-	-	-	-	-	-
Nr. of species		30	15	34	20	22	11	24	15

SAS - summit area section; SPC - summit plot clusters

Altitude is a main factor that determines the floristic diversity of mountainous areas. It is known that at high altitudes occurs a decrease in mean annual temperatures and an increase in precipitation (OZENDA & BOREL, 1995), this directly influences the diversity of the flora. The number of species recorded on the four investigated summits varies in relation to their altitude. Thus, on lower summits (Golgota, Gropile) more species are found (30-34 species), compared to higher summits (Buhaiescu, Rebra), where the number of species is much lower (22-24 species). The per cent value of this difference is 25% for a 250 m increase in altitude. So, based on the results obtained, we can say that in the alpine belt of the Eastern Carpathians, a 100 m increase in the summit altitude, decreases the number of vascular plant species by approximately 10%.

The different aspects of the slopes, with their microclimatic peculiarities, also represent a determinant factor of diversity. In northern and eastern slope areas of the higher summits which are predominantly under the influence of cold air the number of species recorded was 3-9 species higher (6-40%) than in western and southern slope areas. Between shaded slopes (N, E) and those exposed to the sun (S, W), there are also obvious differences in the soil temperature of plant communities (Figure 3). Over the full vegetation period (June-August), the soil temperature in northern and eastern slope areas is 1-3 °C lower than in southern and western slope areas. Moreover, on the Rebra summit, there are days in summer when the soil temperature is below zero degrees (-2, -3 °C). These low temperatures favor the development and maintenance within the structure of alpine plant communities of some cryophile species such as *Soldanella hungarica* subsp. *hungarica*, *Ranunculus crenatus*, *Poa granitica* subsp. *disparilis* and *Omalotheca supina*.

Also, in northern slope areas, the extent of vegetation coverage is smaller (35-76%), compared to that of southern slopes (67-91%). The alpine species *Carex curvula*, *Festuca airoides*, *Juncus trifidus*, *Oreochloa disticha* and *Hieracium alpinum*, which have a higher frequency per m^2 in higher summit areas (Rebra, Buhaiescu), also have the highest coverage in these areas (Table 2-3). The type of vegetation specific for this area is that of primary alpine pastures grouped into the association *Primulo-Caricetum curvulae* Oberd. 1959.

On lower summits (Golgota, Gropile) the alpine species *Juncus trifidus*, *Oreochloa disticha*, *Festuca airoides*, *Hieracium alpinum*, *Rhododendron myrtifolium*, *Vaccinium myrtillus* and *V. uliginosum* subsp. *microphyllum* (Table 4-5) have a higher frequency and coverage, and they form two associations, i.e. *Oreochloo-Juncetum trifidi* Szafer *et al.* 1927 frequently found on slopes exposed to the sun (S, W) and wind, and *Rhododendro myrtifolii - Vaccinietum* Borza 1959, found more frequently on shaded and more wind protected slopes (N, E).

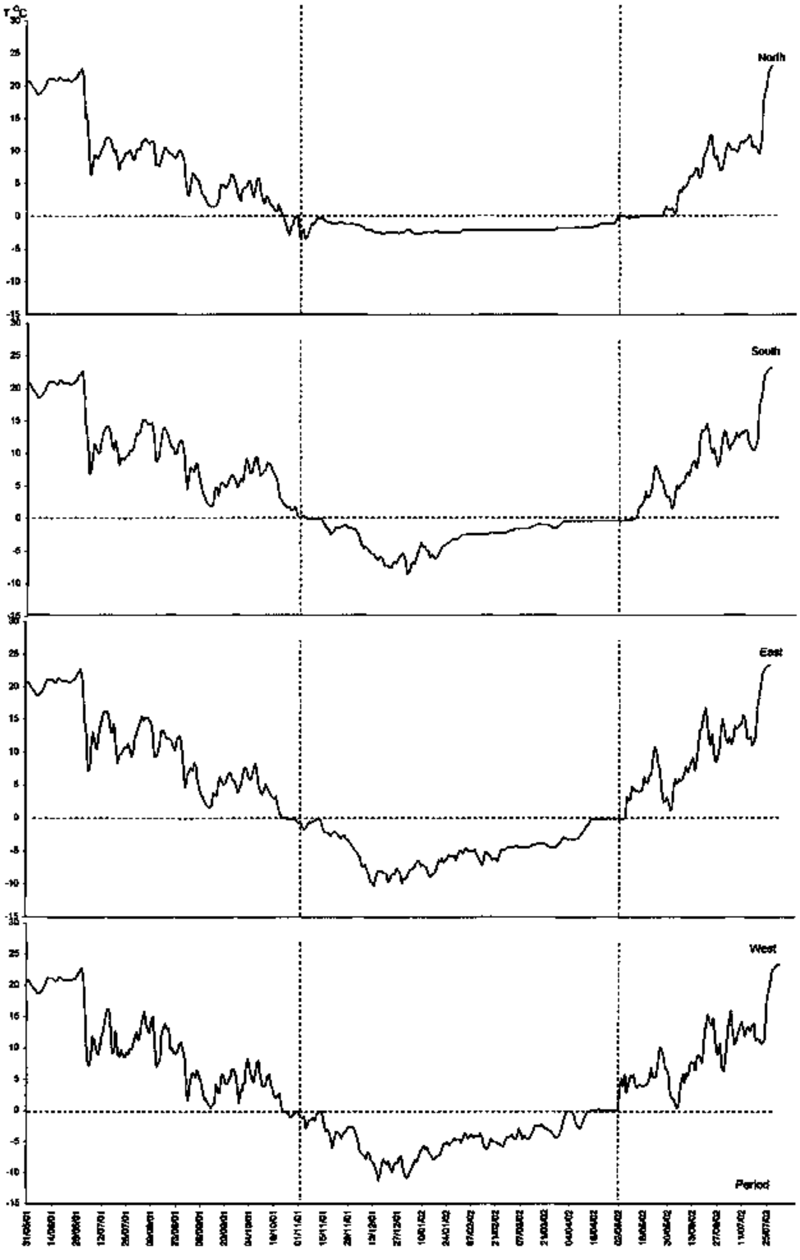

Figure 3. The soil temperature on the four aspects of the Rebra summit (vertical lines mark temperatures below 0 °C).

Table 2. Mean frequency (F%) and cover of species (C%) in 3x3 m areas in Rebra summit (2268 m).

Species cod	Species name / Aspect	N		S		E		W	
		F %	C %	F %	C %	F %	C %	F %	C %
136	Avenula versicolor (Vill.) M. Laínz	–	–	0,50	0,01	0,75	0,56	–	–
162	Campanula alpina Jacq. subsp. alpina	–	–	5,75	1,00	–	–	–	–
192	Carex curvula All. subsp. curvula	30,75	20,50	69,50	45,50	46,00	33,63	63,75	32,25
358	Festuca airoides Lam.	5,00	0,88	28,25	5,13	35,50	16,63	65,50	22,63
463	Hieracium alpinum L.	4,25	0,39	14,75	1,81	0,50	0,06	9,00	1,88
500	Juncus trifidus L. subsp. trifidus	1,75	1,75	11,25	3,28	4,00	3,13	–	–
539	Ligusticum mutellina (L.) Crantz	12,00	1,00	–	–	–	–	–	–
558	Luzula alpinopilosa subsp. obscura S. E. Fröhner	5,00	1,03	–	–	–	–	–	–
619	Oreochloa disticha (Wulfen) Link	5,25	19,88	–	–	3,75	1,38	–	–
698	Poa granitica subsp. disparilis (Ny r.) Ny r.	5,00	0,81	–	–	–	–	–	–
738	Primula minima L.	11,25	1,68	–	–	1,25	0,19	–	–
757	Ranunculus crenatus Waldst. & Kit.	1,25	0,03	–	–	–	–	–	–
782	Rhododendron myrtifolium Schott & Kotschy	10,75	7,25	16,50	10,50	34,75	15,38	–	–
921	Soldanella hungarica Simonk. subsp. hungarica	3,00	0,14	–	–	–	–	–	–
922	Soldanella hungarica subsp. major (Neilr.) Pawlowska	0,50	0,01	–	–	–	–	–	–
15	Number of species	13	–	7	–	8	–	3	–
	Mean covering %	–	55,35	–	67,23	–	70,40	–	56,76

Table 3. Mean frequency and cover of species (%) in 3x3 m areas in Buhaiescu summit (2210 m).

Species cod	Species name / Aspect	N		S		E		W	
		F %	C %	F %	C %	F %	C %	F %	C %
136	Avenula versicolor (Vill.) M. Laínz	–	–	1,80	0,25	8,30	0,55	–	–
162	Campanula alpina Jacq. subsp. alpina	–	–	–	–	0,30	0,01	–	–
192	Carex curvula All. subsp. curvula	62,50	39,80	88,80	71,30	71,80	51,90	48,80	29,50
358	Festuca airoides Lam.	32,80	14,80	63,80	17,50	15,00	4,80	65,50	37,80
463	Hieracium alpinum L.	58,80	11,50	7,80	1,88	0,30	0,01	0,30	0,03
500	Juncus trifidus L. subsp. trifidus	–	–	3,00	0,90	25,00	18,00	–	–
539	Ligusticum mutellina (L.) Crantz	–	–	–	–	1,80	0,08	–	–
558	Luzula alpinopilosa subsp. obscura S. E. Fröhner	1,50	0,02	–	–	–	–	–	–
619	Oreochloa disticha (Wulfen) Link	18,50	5,90	–	–	–	–	6,50	3,90
746	Pulsatilla alba Rchb.	–	–	–	–	1,00	0,08	–	–
921	Soldanella hungarica Simonk. subsp. hungarica	0,50	0,02	–	–	0,30	0,01	–	–
11	Number of species	6	–	5	–	9	–	4	–
	Mean cover %	–	72,04	–	91,90	–	76,42	–	71,23

3.3 Phytogeographical peculiarities and evolution tendency of plant communities

The structure of alpine pastures of the Pietrosul Rodnei massif, have the following dominant phytogeographical elements, i. e. Circumpolar (28%), European (24%), Alpine Carpathian (11%), Alpine-Carpatho-Balkanic (8%), Eurasiatic (7%), Ubiquist (4%), though some regional endemic Eastern Carpathian (7%) and Carpatho-Balkanic (11%) elements are also present. These regional elements give the pasture associations (*Primulo-Caricetum curvulae* and *Oreochloo-Juncetum trifidi*) their south-eastern European character. Of the group of endemic species, two taxa are local endemic (*Lychnis nivalis* and *Soldanella hungarica* subsp. *hungarica*), and one is endemic for the Eastern

Table 4. Mean frequency and cover of species (%) in 3x3 m areas in Gropile summit (2060 m).

Species cod	Species name / Aspect	N		S		E		W	
		F %	C %	F %	C %	F %	C %	F %	C %
24	Agrostis rupestris All.	–	–	11,00	3,77	3,25	1,50	18,50	6,50
162	Campanula alpina Jacq. subsp. alpina	–	–	–	–	1,50	0,43	–	–
288	Deschampsia flexuosa (L.) Trin.	–	–	0,50	0,01	26,50	2,73	17,00	8,25
358	Festuca airoides Lam.	36,50	16,50	28,75	4,38	2,00	0,39	13,50	2,88
439	Geum montanum L.	–	–	–	–	0,50	0,00	–	–
463	Hieracium alpinum L.	16,00	1,19	–	–	–	–	48,00	15,75
480	Homogyne alpina (L.) Cass.	5,75	0,51	3,75	0,50	4,50	0,22	1,50	0,63
500	Juncus trifidus L. subsp. trifidus	41,50	16,00	91,25	71,75	25,25	11,88	63,00	32,50
539	Ligusticum mutellina (L.) Crantz	1,00	0,13	1,50	0,01	2,25	0,30	–	–
558	Luzula alpinopilosa subsp. obscura S. E. Fröhner	0,50	0,00	–	–	–	–	–	–
619	Oreochloa disticha (Wulfen) Link	3,50	1,13	–	–	–	–	–	–
718	Potentilla aurea subsp. chrysocraspeda	–	–	–	–	0,25	0,08	–	–
738	Primula minima L.	2,50	0,31	–	–	–	–	–	–
746	Pulsatilla alba Rchb.	–	–	–	–	1,75	0,13	–	–
757	Ranunculus crenatus Waldst. & Kit.	0,25	0,01	–	–	–	–	–	–
782	Rhododendron myrtifolium Schott & Kotschy	58,75	39,50	–	–	62,75	53,50	–	–
922	Soldanella hungarica subsp. major (Neilr.) Pawlowska	16,75	0,99	–	–	0,25	0,00	–	–
924	Solidago virgaurea L.	–	–	–	–	0,25	0,00	–	–
984	Vaccinium myrtillus L.	–	–	–	–	36,75	8,38	2,75	0,50
985	Vaccinium uliginosum subsp. microphyllum Lange	–	–	–	–	37,25	12,00	–	–
987	Vaccinium vitis-idaea L. subsp. vitis-idaea	–	–	1,50	0,02	–	–	–	–
21	Number of species	11	–	7	–	15	–	7	–
	Mean cover %	–	76,28	–	80,43	–	91,54	–	67,01

Tabel 5. Mean frequency and cover of species (%) in 3x3 m areas in Golgota summit (2010 m).

Species cod	Species name / Aspect	N		S		E		W	
		F %	C %	F %	C %	F %	C %	F %	C %
136	Avenula versicolor (Vill.) M. Laínz	–	–	9,25	1,63	–	–	–	–
162	Campanula alpina Jacq. subsp. alpina	0,50	0,09	1,75	0,38	1,25	0,13	3,75	0,85
192	Carex curvula All. subsp. curvula	0,50	0,25	11,25	4,10	–	–	–	–
288	Deschampsia flexuosa (L.) Trin.	–	–	46,00	28,50	–	–	–	–
358	Festuca airoides Lam.	31,25	21,63	–	–	44,75	21,38	59,00	28,00
463	Hieracium alpinum L.	1,75	0,38	19,50	2,63	3,25	0,40	12,75	3,05
480	Homogyne alpina (L.) Cass.	–	–	3,00	0,08	–	–	–	–
485	Huperzia selago (L.) Bernh.	3,00	0,61	–	–	–	–	0,25	0,01
500	Juncus trifidus L. subsp. trifidus	6,25	2,65	18,00	8,63	22,25	6,80	15,25	8,25
539	Ligusticum mutellina (L.) Crantz	–	–	1,50	0,30	–	–	–	–
619	Oreochloa disticha (Wulfen) Link	6,50	4,63	0,50	0,03	–	–	2,50	4,63
738	Primula minima L.	5,00	2,10	0,50	0,03	–	–	0,25	0,01
782	Rhododendron myrtifolium Schott & Kotschy	4,25	2,88	47,00	34,25	77,25	56,38	21,25	9,00
922	Soldanella hungarica subsp. major (Neilr.) Pawlowska	–	–	2,75	0,35	–	–	–	–
984	Vaccinium myrtillus L.	–	–	6,75	1,03	2,25	0,17	–	–
15	Number of species	9	–	13	–	6	–	8	–
	Mean cover %	–	35,22	–	81,94	–	85,30	–	54,25

Carpathian (*Poa granitica* ssp. *disparilis*). Also, in the structure of nanophanerophyte communities (*Rhododendro myrtifolii-Vaccinietum*), some Carpatho-Balkanic regional species (*Rhododendron myrtifolium, Poa media, Hypericum richeri* subsp. *grisebachii, Potentilla aurea* subsp. *chrysocraspeda*) are found, which differentiate them from analogous communities of Central Europe

(OBERDORFER, 1992). In the Rodna Mountains the floristic structure of these acidophilic associations has a lower number of species (mean number 52, range 41-55) as compared with the basophilic associations (mean number 67, range 45-92) and seems to be predominantly induced by the geological substrate (COLDEA & CRISTEA, 1998).

The current structure of plant communities is supposed to undergo qualitative and quantitative changes due to climate warming in this area. Climatic data from the Iezerul meteorologic station (the Rodnei Mts) shows that in the last decade of the 20th century, the air mean temperature in alpine and subalpine zones has been raised with 1-1.5°C, while the mean rainfall has been diminished by aproximately 200-250 mm (COLDEA, 2003). Thus, some cryophile species which are still found in coenoses with *Carex curvula* on the shaded slopes of high summits (Rebra, Buhaiescu), such as *Lychnis nivalis, Poa granitica* subsp. *disparilis, Ranunculus crenatus, Soldanella hungarica* subsp. *hungarica* and *Omalotheca supina,* will gradually disappear as a result of the melting of the snow layer 2-3 weeks earlier. The current spatial niches of cryophile species will be occupied by the populations of Arctic-Alpine species such as *Juncus trifidus, Festuca airoides* and *Hieracium alpinum* (GUISAN *et al.*, 1995). Also, in the treeline ecotone communities formed by *Rhododendron myrtifolium* (Golgota), the actual number of individuals of the species *Picea abies, Pinus mugo* and *Juniperus communis* subsp. *alpina* will increase, as climate warming favor the development of these phanerophytes.

4. Conclusions

The actual floristic composition and the structure of subalpine-alpine pastures and dwarf shrubs of the Pietrosul Rodnei massif are mainly determined by geological and pedological conditions, while the probable structural changes will be induced by the changing climatic factors.

Subalpine-alpine summits with acid substrates (crystalline schists) have a lower floristic diversity than those with basic substrates (limestone). In the subalpine-alpine belt, the number of vascular plant species decreases with the altitude of the summits (for each 100 m altitude, the number of species decreases by approximately 10%).

Subalpine-alpine plant communities of shaded (northern and eastern) slopes are richer in species (approx. 25%) than those of (southern and western) slopes exposed to the sun.

Soil temperature in plant communities of northern and eastern slopes is 1-3 °C lower during the vegetation period than in the areas of southern and western slopes.

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