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Heaths with dwarf ericaceous shrubs and Alpine juniper (*Juniperus alpina*) in the Dinaric Alps: A nomenclatorial and synsystematic re-appraisal

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Abstract – The ecology and phytosociology of north-western Dinaric heaths of the association *Rhododendro hirsuti-Juniperetum alpinae* Horvat ex Horvat et al. 1974 *nom. corr. prop.* as well as the syndynamics and synsystematics of heaths in the Dinaric Alps are discussed. While the structure (physiognomy) of these stands is very homogenous and dominated by few species, the flora is heterogeneous, since ecotonal areas, where heaths are most frequently developed, represent a contact zone of elements of different syntaxa. Due to an abrupt reduction in pasture activities strong encroachments of shrubs and trees have become common, which additionally contribute to the floristic heterogeneity of the heaths. Although the identification and circumscription together with synecology and synchorology of heaths in general are more or less easily understood and straightforward, their floristic affinities, in relation to structure homogeneity and syndynamics, are complicated, which led to the proposal of several synsystematic schemes depending on interpretation of the relationship between flora and structure of stands. Dinaric heaths are classified into three classes, *Erico-Pinetea*, *Vaccinio-Piceetea* and *Festuco-Brometea* and a classification scheme is proposed together with nomenclatorial revision of the analyzed heaths with dwarf ericaceous shrubs and Alpine juniper (*Juniperus alpina*) in the Dinaric Alps.

Key words: Dinaric Alps, Ericaceae, *Juniperus alpina*, phytosociology, *Rhododendron hirsutum*, synsystematics

Introduction

An accurate and updated vegetation map is an essential tool for successful conservation planning, monitoring and managing biological diversity and other natural resources both within and outside the existing protected areas. In order to delimit areas with various vegetation types accurately, while assigning them to objective categories that can be easily

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recognized in the field and that reliably reflect fundamental biological differences (primarily the floristic composition and physiognomy), we started with detailed vegetation mapping in the Obruč area (Liburnian karst, Dinaric Alps) in north-western Adriatic (Fig. 1), one of the most important plant areas in Croatia (see RANDIĆ 2009). Vegetation studies in the Obruč mountain range were initiated by Croatian botanist Ivo Horvat and resulted in a worked-out vegetation typology (e.g. HORVAT 1930, 1931, 1938) and a vegetation map (in collaboration mostly with Z. Pelcer, Z. Matan and S. Bertović) of the broader area (HORVAT 1962).

Based on a vegetation map of Horvat and co-workers (HORVAT 1962), the study area represents a mosaic of forest and non-forest vegetation types where (subalpine) beech forests of the association *Polysticho lonchitis-Fagetum* (=*Fagetum croaticum australe subalpinum*) generally prevail. Southern slopes are covered by thermophilic stands of the association *Seslerio autumnalis-Fagetum* (=*Fagetum croaticum australe seslerietosum*) and fir-beech stands of the association *Omphalodo-Fagetum* var. geogr. *Calamintha grandiflora* (=*Fagetum croaticum australe abietetosum*) *seslerietosum autumnalis*. Stony and steep slopes, intercepted with boulders, gravels and cracks, are covered with more or less pure fir stands of the association *Calamagrostido variae-Abietetum* (*piceetosum*). Recently, though not included in the vegetation map, beech stands from the summit were segregated into a new beech association *Calamagrostido arundinaceae-Fagetum* (CEROVEČKI 2009). Among non-forest vegetation types, botanists mapped three syntaxa: (a) mountain pine scrubs with *Pinus mugo* of the association *Hyperico grisebachii-Pinetum mugo* var. geogr. *Arabis scopoliana* (=*Pinetum mughi croaticum* [p.p.]), (b) dry and stony grasslands of the subassociation *Carici humilis-Centaureetum rupestris seslerietosum tenuifoliae* (=*Cariceto-Centaureetum rupestris* [p.p.]), and (c) heaths with *Rhododendron hirsutum* and *Juniperus alpina* (=*Juniperus communis* L. subsp. *sibirica* (Suter) Čelak., *J. nana* Willd.; *Rhodereto-Juniperetum*).

Syntaxonomy of »heaths«

Besides the many typological and nomenclatorial issues among most of the above-mentioned syntaxa (compare WEBER et al. 2000), we find the synsystematics and syndynamics of stands dominated by hairy Alpenrose (*Rhododendron hirsutum*), Alpine juniper (*Juniperus alpina*) and large-leaved willow (*Salix appendiculata*), although of homogenous structure, the most difficult problem to solve. These heaths are usually established in a phytoclimatic belt which is characterized by the timberline and/or isolated tree lines, within more or less large ecotone areas, once used for pastures but, due to overall changes in the socioeconomic situation, now almost completely abandoned (POLDINI et al. 2004). As a result, these areas are nowadays exposed to rapid dynamic phenomena and abrupt changes in vegetation cover. The climatogenic timberline in the Liburnian karst exceeds the highest peaks due to the overall relatively low altitude (the highest peak, Mt Snežnik, reaches 1796 m a.s.l.). However, under anthropogenic influence, and rarely due to extreme environmental site conditions (e.g. steep slopes, sites exposed to strong Bora etc.), the man-made limit of the timberline and/or isolated tree, due to pasture and logging economy, might lie considerably lower than the climatogenic one (e.g. WRABER 1997).

HORVAT (1962) found structurally homogenous and ecologically well defined heaths with *Rhododendron hirsutum* and *Juniperus alpina* developed on exposed ridges of lower altitude (between 1200–1400 m a.s.l.). He placed them into the association *Rhododendro-*

-*Juniperetum nanae* and afterwards supported this with an incomplete synoptic table (HORVAT et al. 1974, Tab. 135, col. 1, 16 relevés). These stands, according to vegetation map, are more or less frequent in the Obruč (the main ridge, Pakleno, Mts Suhi vrh, Fratar and Gornik), Snježnik (Bjela Škalja and Ceclje area, Medvejci, Planina and Guslice) and Risnjak area above 1200 m a.s.l. Similar stands were observed on sites with similar ecological conditions in the Slovenian part of the Liburnian karst as well, on the Snežnik plateau, between 1200–1600 m a.s.l., in the area of Gornji Dužovec, Zatrep, Grdobe, Planinc, Ilovca, Stanišče, Ždrocle etc. and mapped as *Rhododendro hirsuti-Salicetum appendiculatae*.

Structurally similar, but strikingly different in floristic composition are thermophilic stands with *Juniperus alpina* and *Sesleria robusta* from the Biokovo mountain range (Croatia, central Dalmatia) described by Domac as *Seslerio robustae-Juniperetum sibiricae* (DOMAC 1962, VRDOLJAK 1983). Besides hosting a considerable number of Dinaric tussock (*Seslerion tenuifoliae*) and sub-Mediterranean grassland taxa (*Satureion subspicatae*), these stands are characterized by the absence of *Rhododendron hirsutum* and other de-alpine taxa. Within these stands, a subassociation –*pinetosum dalmaticae* – was recognized on the basis of the presence and/or dominance of *Pinus nigra* ssp. *dalmatica*, the only real differential taxon for the floristically and structurally based subassociation. On Jahorina mountain range (central part of Bosnia and Herzegovina) BJELČIĆ (1966) placed stands dominated by *Juniperus alpina* into the association *Junipero sibiricae-Semperviretum schlechanii*, while similar stands on Mt Bjelasica in Montenegro, developed on somewhat more acidic soils, were studied by LAKUŠIĆ (1966) who at that time recognized two new associations: *Roso pendulinae-Juniperetum nanae* and *Hyperici-Vaccinietum montenegrini*. On Vranica mountain range (central Bosnia and Herzegovina), a geologically diverse area characterized by a mixture of calcareous and siliceous bedrocks, LAKUŠIĆ et al. (1979) studied more acidophytic (*Hyperici-Vaccinetum bosniacum, Vaccinio-Callunetum subalpinum*) and relatively basiphytic stands (*Aquilegio-Rhododendretum hirsuti*, *Arctostaphylletum uvae-ursi*) dominated by dwarf ericaceous species.

While the structure (physiognomy) of these stands is very homogenous and dominated by few species such as *Rhododendron hirsutum, Juniperus alpina, Salix appendiculata, Erica carnea, Calamagrostis varia* and *Rosa pendulina*, the flora is heterogeneous since this ecotonal area represents a contact zone of elements of different syntaxa. Additionally, due to a conspicuous reduction in pasture activities, strong encroachments of phanerophytes have become common contributing to a mixture of floristic composition of stands. Although the identification and circumscription together with synecology and synchorology of the heaths in general are more or less simple and straightforward, their floristic affinities, in relation to structure homogeneity and syndynamics, are complicated, which led to the proposal of several syntaxonomic schemes depending on the interpretation of the relationship of the two aspects, focusing either on the flora (e.g. WALLNÖFER 1993a, 1993b), the structure (e.g. HORVAT 1962, HORVAT et al. 1974, THEURILLAT et al. 1995, STANISCI 1997), or both (POLDINI et al. 2004). THEURILLAT et al. (1995) placed all mountain pine scrubs, regardless of the substrate, into a new class *Roso pendulinae-Pinetea mugi*, while they classified all the orotemperate heaths into the class *Loiseleurio-Vaccinietea.* On the other hand, WALLNÖFER (1993a, 1993b) differentiated acidophilic (*Vaccinio-Piceetea*) and basiphilic mountain pine scrubs (*Erico-Pinetea*), while acidophilic heaths were included into the class *Loiseleurio-Vaccinietea* and basiphilic into the class *Seslerietea albicantis*. In the Apennines (STANISCI

1997), mountain pine scrubs and formations with *Juniperus alpina* lack many boreo-alpine elements and were therefore referred to the class *Pino-Juniperetea,* a class consisting of orophilous communities dominated by conifers in the circum-Mediterranean area. In the Dinaric Alps (e.g. BLEČIĆ 1957, 1958, LAKUŠIĆ 1966, BJELČIĆ 1966, LAKUŠIĆ et al. 1979, ZUPANČIČ et al. 2004, 2006, VUKELIĆ et al. 2008), mountain pine scrubs and dwarf ericaceous scrubs, strongly influenced by the researches of BRAUN-BLANQUET (1931) and HORVAT (e.g. 1938, 1962, 1974), were classified in different subordinate syntaxa into the class *Vaccinio-Piceetea* without an exception.

In our study we aim to: (1) elucidate the phytosociological characteristics and site conditions of structurally similar but floristically different stands of north-west Dinaric heaths with hairy Alpenrose *Rhododendron hirsutum* and Alpine juniper *Juniperus alpina*, (2) identify the potential vegetation cover and syndynamic relationships between the north-west Dinaric heaths and surrounding forest and non-forest vegetation types and (3) to propose a sensible syntaxonomic scheme for the heaths of the Dinaric Alps.

Methods

In years 2005 and 2011, we recorded 22 relevés dominated by *Rhododendron hirsutum* and *Juniperus alpina* in the Liburnian karst (Fig. 1) applying the standard Central-European method (BRAUN-BLANQUET 1928, WESTHOFF and VAN DER MAAREL 1973, DIERSCHKE 1994). The plot size used for sampling averaged 30 m^2 and further details on the phytosociological parameters of sites are given in Appendix I. A complete floristic inventory is given in table 2, while taxa occurring in a single relevé are listed in Appendix II. Coverage index ($D_{\%}$, e.g.

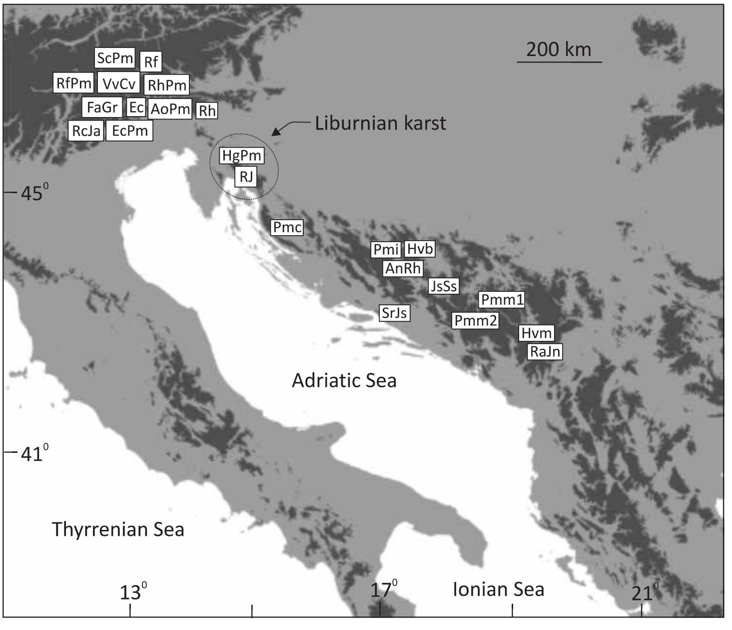

Fig. 1. Map showing the study area (hatched line) and approximate localities of the syntaxa from table 1 with corresponding acronyms.

Surina 2005) was calculated for each taxon in table 2. The nomenclature and taxonomic source for the names of vascular plants was Mala flora Slovenije (MARTINČIČ et al. 2007). Syntaxonomic groups in tables 2 and 3 were assigned according to Flora Alpina (AESCHIMANN et al. 2004), DAKSKOBLER (2006) and POLDINI et al. (2004) and the list of syntaxa with full names is given in Appendix III. Prior to numerical analysis, the original cover-abundance values for individual taxa were transformed into an ordinal scale as proposed by van der MAAREL (1979). Groups of vegetation types were ascertained using cluster and ordination analysis with the help of the programme package PAST (HAMMER et al. 2001). The arrangement of relevés in table 2 was done according to the results of cluster analysis (Fig. 2a) and diagnostic groups of species were subsequently tested by means of the SIMPER analysis, an algorithm implemented in programme package PAST. In order to explain the

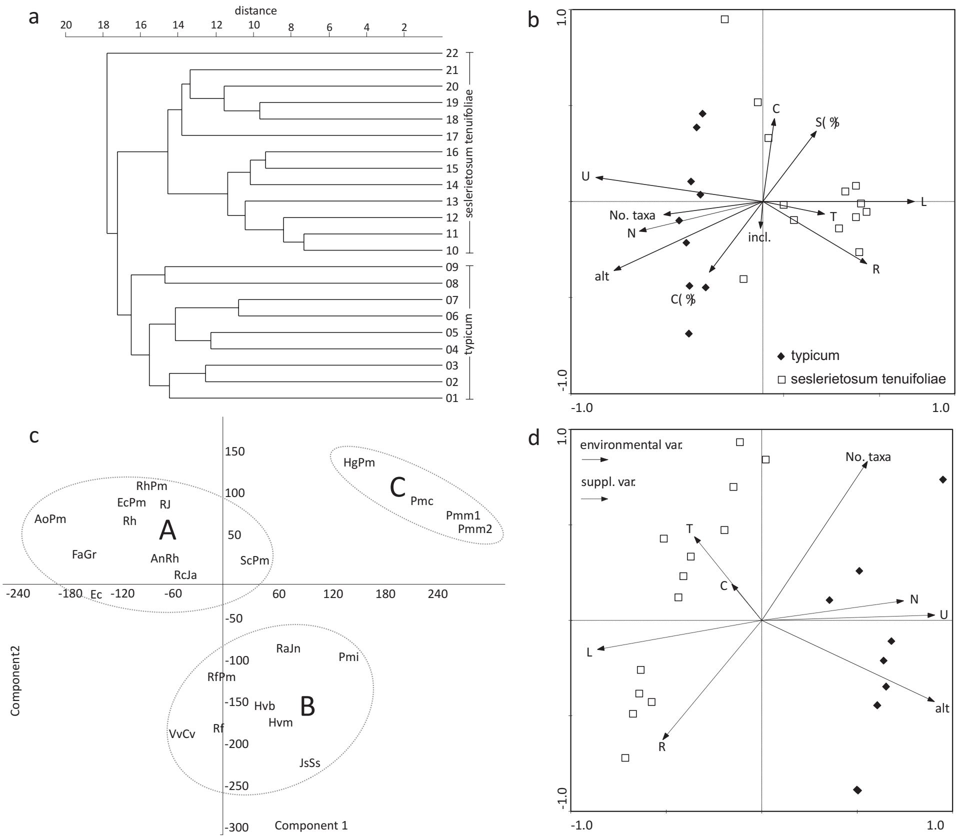

Fig. 2. The results of (**a**) cluster (UPGMA), (**b**) PCA (eigenv.: 1 – 0.883, 2 – 0.687, 3 – 0.679 4 – 0.695; cumulative percentage variance of species-environment relation [in %]: 1 – 45.1, 2 – 58.5, 3 – 68.7, 4 – 77.6; (**c**) ordination (Euclid distances, eigenv.: 1 – 19,7%, 2 – 12%, 3 – 10,5%; acronyms correspond to those in Fig. 1 and Tab. 1) and (**d**) DCA (eigenv.: 1 – 0.885, 2 – 0.703, 3 – 0.759, 4 – 0.585; cumulative percentage variance of species-environment relation [in %]: 1 – 42.8, 2 – 50.0, 3 – 76.9, 4 – 82.2) analysis of stands with dominating *Rhododendron hirsutum* and *Juniperus sibirica* in the Liburnian karst (north-west Dinaric Alps) and structurally similar stands from the South-eastern Calcareous and Dinaric Alps.

Tab. 1. List of floristically and/or structurally similar syntaxa with *Ericaceae*, Alpine juniper and mountain pine in the South-eastern Calcareous and Dinaric Alps.

syntaxa	acronym	country	region	Mount. range	reference	Tab.	no. rel.
Rhododendro hirsuti-Juniperetum sibiricae	RJ	SLO, HRV	NW Dinaric Alps	Snežnik-Risnjak	this work	2	22
Roso-Juniperetum nanae	RaJn	MNE	SE Dinaric Alps	Bjelasica	LAKUŠIĆ 1966	23	10
Hyperici-Vaccinietum montenegrini	HVm	MNE	SE Dinaric Alps	Bjelasica	LAKUŠIĆ 1966	22	12
Junipero-Sempervivetum schlechanii	JsSs	BH	C Dinaric Alps	Jahorina	BJELČIĆ 1966	2	10
Rhododendretum hirsuti	Rh	SLO	SE Calcareous Alps	Julian Alps	SURINA 2005	25	7
Hyperico grisebachii-Pinetum mugo	HgPm	SLO	NW Dinaric Alps	Snežnik	ZUPANČIČet al. 2004	1	20
Seslerio robustae-Juniperetum sibiricae	SrJs	HRV	C Dinaric Alps	Biokovo	DOMAC 1962 VRDOLJAK 1983	1, 2	25+1
Aquilegio-Rhododendretum hirsuti	AnRh	BiH	C Dinaric Alps	Vranica	LAKUŠIĆ et al. 1979	24	6
Hyperici-Vaccinietum bosniacum	HVb	BH	C Dinaric Alps	Vranica	LAKUŠIĆ et al. 1979	23	9
Pinetum mugi montenegrinum	Pmm1	MNE	SE Dinaric Alps	Ljubišnja	BLEČIĆ1957	2	7
Pinetum mugi montenegrinum	Pmm2	MNE	SE Dinaric Alps	Maglić. Golija. Durmitor	BLEČIĆ1958	9	8
Pinetum mugo illyricum	Pmi	BH	C Dinaric Alps	Vranica	LAKUŠIĆ et al. 1979	29	11
Pinetum mugi croaticum	Pmc	HRV	NW Dinaric Alps	Gola Plješivica. Velebit	HORVAT1938	9	8
Rhododendro hirsuti- Pinetum prostratae	RhPm	I	SE Calcareous Alps	.	POLDINI et al. 2004	1	13
Erico carneae-Pinetum prostratae	EcPm	I	SE Calcareous Alps	.	POLDINI et al. 2004	2	14
Sorbo chamaemespili-Pinetum mugo	ScPm	I	SE Calcareous Alps	.	POLDINI et al. 2004	3	7
Rhodothamno-Juniperetum alpini	RcJa	I	SE Calcareous Alps	.	POLDINI et al. 2004	4	14
Amelanchiero-Pinetum mugo	Ao-Pm	I	SE Calcareous Alps	.	POLDINI et al. 2004	5	6
Ericetum carneae	Ec	I	SE Calcareous Alps	.	POLDINI et al. 2004	6	12
Festuco alpestris-Genistetum radiatae	FaGr	I	SE Calcareous Alps	.	POLDINI et al. 2004	7	21
Rhododendretum ferruginei	Rf	I	SE Calcareous Alps	.	POLDINI et al. 2004	8	20
Rhododendro ferruginei-Pinetum prostratae	RfPm	I	SE Calcareous Alps	.	POLDINI et al. 2004	9	13
Vaccinio vitis-ideae-Callunetum vulgaris	VvCv	I	SE Calcareous Alps	.	POLDINI et al. 2004	10	8

variation by specific environmental and structural (phytosociological) variables, unconstrained (PCA, DCA) and constrained (RDA) ordination analyses were performed, using the CANOCO computer programme (BRAAK TER and ŠMILAUER 2002). In order to determine the lengths of gradients, DCA analyses, detrended by segments, were initially performed and the models (linear, unimodal) used accordingly. The statistical significance of the site parameters ($p<0.05$) was tested using the Monte Carlo test, with 499 permutations. Only the significant parameters were then analyzed together, in order to produce a general view of the environmental impact on floristic composition and structure of stands. For estimating the environmental affinities of the relevés, we used Pignatti's indicator values for vascular plants (PIGNATTI 2005). The environmental value in a relevé (EV_w) was estimated as the weighted average of the indicator values of all present species, their abundances being used as weights (LEPŠ and ŠMILAUER 2003).

Heaths from the Liburnian karst were compared with mountain pine scrubs and structurally similar stands with dwarf ericaceous scrubs and/or Alpine juniper from other parts of the Dinaric Alps and South-eastern Calcareous Alps between Italy and Montenegro (Tab. 1, Fig. 1).

Results

Floristic composition and structure of the Liburnian (the north-western Dinaric) heaths

We recorded 98 taxa of phanerogams in 22 relevés with a median number of 27 per relevé (min=17, max=37; Tab. 2). Coefficient of variation of the number of taxa per relevé is 19.63%. *Rhododendron hirsutum*$^{+-4}$ ($D_{\%}$=7.7), *Juniperus alpina*$^{+-4}$ (6.7), *Salix appendiculata*$^{1-3}$ (6.4) and *Calamagrostis varia*$^{1-2}$ (5.4) occurred in all relevés with high or the highest coverage of all recorded taxa. Almost one quarter of the all registered taxa occurred in more than 50% of relevés, with the highest presence and coverage shown by *Cyclamen purpurascens*$^{+-2}$ (3.5), *Rosa pendulina*$^{+-2}$ (3.9), *Allium ericetorum*$^{+-2}$ (3.7), *Erica carnea*$^{1-4}$ (4.5), *Campanula cochleariifolia*$^{+-2}$ (2.6), *Thesium linophyllum*$^{+-2}$ (2.2), *Picea abies*$^{+-1}$ (1.7), *Clematis alpina*$^{+-2}$ (2.2) and *Aster bellidiastrum*$^{+-2}$ (2.5). The structure of stands is defined by their edificators, *Rhododendron hirsutum*, *Juniperus alpina* and *Salix appendiculata*, forming more or less dense scrubby vegetation type not exceeding 1 m in height. As a rule, these stands are developed on very shallow organogenic soil – lithosol or even over a bare, compact to fragmented limestone bedrock on gravelly slopes of mountain ridges above 1200 m a.s.l., with long-lasting snow cover where northerly exposed sites prevail. Here, the studied stands are in close contact with subalpine beech (*Polysticho-Fagetum*), fir-spruce (*Calamagrostido-Abietetum*) and Dinaric fir-beech forest stands (*Omphalodo-Fagetum*) as well as with scrubby stands of mountain pine (*Hyperico-Pinetum mugo*), forming transitions toward forest vegetation types. In frost hollows, an ecologically extreme habitat with specific microsite conditions (e.g. MARTINČIČ 1977, SURINA and VREŠ 2004, 2009, MODRIĆ SURINA and SURINA 2010), the studied stands prefer southerly exposed gravelly slopes and close contact with azonal spruce (*Lonicero caeruleae-Piceetum, Hacquetio-Piceetum*) and extrazonal subalpine beech forest stands with hairy Alpenrose – *Polysticho-Fagetum rhododendretosum* (SURINA and RAKAJ 2007), but more frequently with non-forest stands with *Carex ferruginea, Salix appendiculata* stands, *Doronico austriaci-Adenostyletum alliariae,* and *Drepanoclado uncinati-Heliospermetum pusilli*, the last representing the most cryophilic stands developed specifically in frost hollows of north-western Dinaric Alps.

Tab. 2. Analytical table of the association *Rhododendro hirsuti-Juniperetum alpinae* Horvat ex Horvat et al. 1974 *nom. corr. prop.* in the Liburnian karst (north-west Dinaric Alps).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22			
	Characteristic group of species for the association																							$D_{\%}$typ	$D_{\%}$ses	$Dtot_{\%}$
EP	*Rhododendron hirsutum*	2	3	3	4	4	3	3	3	4	+	3	3	3	3	3	3	2	3	3	3	3	3	7.4	7.6	7.7
EP	*Juniperus alpina*	4	3	4	3	4	2	4	3	3	3	3	3	3	3	3	2	2	1	1	1	1	+	7.6	5.8	6.7
MA	*Salix appendiculata*	2	2	3	2	2	2	2	1	2	3	3	3	3	3	3	2	1	3	2	2	3	2	5.3	7.1	6.4
EP	*Calamagrostis varia*	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	1	2	2	2	5.0	5.5	5.4
VP	*Rosa pendulina*	2	1	2	1	.	2	2	2	2	1	2	2	2	1	1	.	.	+	2	2	1	1	4.3	3.8	3.9
EP	*Erica carnea*	4	1	3	3	3	.	.	.	.	1	1	3	3	1	2	1	1	2	2	2	1	2	3.8	5.2	4.5
	Differential species for the subassociation seslerietosum tenuifoliae																									
ES	*Sesleria juncifolia/tenuifolia*	.	.	.	.	.	.	.	.	.	+	.	3	1	+	2	4	3	3	3	4	4	3		6.7	4.0
TR	*Athamanta cretensis s.l.*	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	2	2	2	2	1	1	1		3.3	2.1
AT	*Daphne alpina*	.	.	.	.	.	.	.	.	.	2	2	2	.	+	+	.	+	+	.	.	.	.		2.0	1.2
EP	***Erico-Pinetea***																									
	Allium ericetorum	.	.	2	2	+	2	2	+	1	+	.	2	1	+	1	+	2	1	2	2	2	2	3.1	4.2	3.7
	Rubus saxatilis	.	2	1	1	1	1	+	2	3	.	1	.	1	1	+	.	.	.	.	1	.	.	3.6	1.1	2.2
	Cirstium erisithales	1	1	2	+	2	1	1	1	.	.	.	1	2	+	2	.	.	.	.	.	1	.	3.2	1.5	2.1
	Buphtalmum salicifolium	1	.	2	1	2	+	+	1	.	+	.	+	+	.	.	.	.	.	.	.	.	.	2.7	0.6	1.4
	Cotoneaster integerrimus	.	1	1	1	+	.	.	+	.	.	+	+	.	.	.	.	.	.	.	+	+	.	1.5	0.8	1.0
	Amelanchier ovalis	.	+	.	.	.	.	.	.	.	+	.	1	.	.	+	.	.	.	+	.	.	.	0.3	0.8	0.6
	Aquilegia nigricans	+	.	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1.0	0.3	0.5
	Cotoneaster tomentosus	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	.	.	.		0.7	0.4
	Pinus mugo	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	0.2	0.3	0.3
	Carex alba	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.		0.3	0.2
VP	***Vaccinio-Piceetea***																									
	Clematis alpina	+	.	.	1	.	+	.	2	1	+	2	.	.	+	.	+	+	1	.	2	1	1	1.7	2.5	2.2
	Picea abies	+	1	+	+	1	+	+	.	+	.	+	.	+	.	.	+	+	.	+	+	+	.	2.1	1.3	1.7
	Homogyne sylvestris	+	.	.	1	1	+	1	.	+	.	.	.	1	+	+	.	.	.	+	+	1	1	1.6	1.5	1.6
	Solidago virgaurea s.l.	1	1	.	1	1	.	.	1	+	+	+	.	+	.	+	.	.	.	.	.	.	.	1.9	0.7	1.2

Tab. 2. – continued

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22			
	Lonicera caerulea		+	+	.	.	.	.	1	+	.	1	1	+	+	.	.	.	.	.	+	+	+	1.1	1.4	1.2
	Abies alba		.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	+	+	+	+	+	.		2.0	1.1
	Hieracium murorum agg.		.	.	.	+	+	1	.	1	.	.	+	.	.	.	+	.	.	+	+	+	+	1.1	1.2	1.1
	Valeriana tripteris	1	.	+	1	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	1.4	0.2	0.7
	Polystichum lonchitis		.	+	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	0.9		0.3
	Vaccinium vitis-idaea		.	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	0.6		0.2
FS	***Fagetalia sylvaticae (incl. Aremonio-Fagion)***																									
AF	*Cyclamen purpurascens*	2	1	2	1	2	2	2	1	+	+	.	1	2	+	1	.	1	1	1	1	2	+	4.2	3.2	3.5
	Lonicera alpigena	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.	.	0.2	0.3	0.3
	Mercurialis perennis	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.4		0.2
	Ranunculus platanifolius	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.5		0.2
	Fagus sylvatica	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	0.2	0.2	0.2
QP	***Quercetalia pubescentis***																									
	Convallaria majalis	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.5		0.2
QF	***Querco-Fagetea***																									
	Carex digitata	.	1	+	.	1	.	1	.	+	.	.	+	.	.	.	+	.	+	.	+	.	.	1.5	0.9	1.1
	Anemone nemorosa	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	0.3	0.2	0.2
TG	***Trifolio-Geranietea***																									
	Laserpitium siler	.	.	.	.	.	+	.	.	.	+	.	1	1	+	1	.	+	.	.	.	.	.	0.2	1.2	0.8
	Laserpitium latifolium	.	.	+	.	.	.	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	0.5	0.3	0.4
TR	***Thlaspietea rotundifolii***																									
	Campanula cochleariifolia	1	.	1	.	1	2	.	+	1	+	.	1	+	.	1	1	2	1	1	1	+	+	2.2	2.9	2.6
	Gymnocarpium robertianum	.	.	.	.	.	+	1	+	.	+	1	+	.	2	1	+	.	.	.	+	1	+	0.8	2.0	1.6
	Adenostyles glabra	+	.	.	.	.	1	+	+	+	+	.	.	+	.	.	.	+	.	.	.	.	.	1.3	0.5	0.9
	Biscutella laevigata	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	+	+	+	.	.	.		1.1	0.6
	Campanula caespitosa	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.8		0.3
	Peltaria alliacea	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.		0.6	0.3
	Valeriana montana	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.		0.5	0.3

Tab. 2. – continued

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22			
AT	***Asplenetea trichomanis***																									
	Aster bellidiastrum	2	1	.	2	2	2	2	+	1	+	1	2	2	+	.	.	.	.	.	.	+	.	3.7	1.7	2.5
	Asplenium ruta-muraria	.	.	1	.	.	+	1	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	1.0	0.5	0.7
	Carex brachystachys	.	1	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1.1	0.2	0.6
	Asplenium viride	.	.	1	+	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2		0.4
	Hieracium bupleuroides	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.	.	.	.		0.4	0.3
	Campanula justiniana	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	0.4	0.2	0.3
	Aquilegia kitaibeliana	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.5		0.2
MA	***Mulgedio-Aconitetea***																									
	Pleurosperum austriacum	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.6		0.3
ES	***Elyno-Seslerietea***																									
	Phyteuma orbiculare	.	.	1	+	1	.	.	.	.	.	.	.	2	1	1	1	2	2	2	2	2	2	0.9	4.0	2.8
	Galium anisophyllum	.	.	.	.	.	.	.	.	.	+	2	.	.	1	+	.	.	.	.	.	.	.		0.9	0.6
	Erigeron glabratus	.	.	.	.	.	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	0.5	0.2	0.3
	Ranunculus carinthiacus	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.		0.3	0.2
PT	***Poo alpinae-Trisetalia***																									
	Campanula scheuchzeri	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	+		0.7	0.5
	Carex ferruginea	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.0	0.0	0.4
FB	***Festuco-Brometea***																									
	Thesium linophyllum	1	+	1	1	1	2	2	.	.	.	.	+	1	+	1	.	.	.	1	+	1	1	2.7	1.9	2.2
	Gentiana lutea/symphyandra	2	1	.	.	.	2	2	.	.	1	1	+	1	+	+	.	.	.	.	+	+	.	2.1	1.6	1.9
	Carlina acaulis s.l.	+	+	+	.	1	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1.3	0.2	0.6
	Galium lucidum	.	.	.	.	.	.	.	.	.	1	2	1	+	+	+	.	.	.	.	2	1	+		2.3	1.3
	Other taxa																									
	Galium mollugo	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1		0.4
	Fragaria vesca	.	.	+	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	0.9		0.3
	Hieracium sp.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	0.2	0.1	0.2

Generally, species of the class *Erico-Pinetea* completely dominate in stands, being the most frequent and achieving the highest coverage indices ($D_{\%}$=44.4, Tabs. 2, 3), followed by spruce forest species (*Vaccinio-Piceetea*, 15.5) and petrophytic species of screes and rock crevices (*Thlaspietea rotundifolii*, 9.6 and *Asplenietea trichomanis*, 6.7, respectively). Dry grassland species of the class *Festuco-Brometea* (6.2) are represented by six species, the most frequent, occurring in more than 50% of relevés, being *Thesium linophyllum* and *Gentiana lutea* subsp. *symphyandra*$^{+-2}$ (1.9). There are 11 beech forest species (*Fagetalia sylvaticae*, 5.2) recorded in the studied stands, but although *Cyclamen purpurascens*$^{+-2}$ (3.5), occurs in more than 90% of relevés, the others, a negligible coverage, are much less frequent.

Although structurally very similar, the studied stands form floristically and ecologically two well circumscribed vegetation types (Tabs. 2, 3, Fig. 2 a, b, d). Stands from the first group (»typical« ones) are developed at more elevated, cooler, moister, shadier, sheltered and more nutrient-rich sites. These stands are characterized by higher number and coverage of spruce forest species which is in line with overall lower values for the substrate pH reaction and cooler sites. On the other hand, stands from the second group (-*seslerietosum tenuifoliae*) are developed on warmer and lighter sites at lower altitudes but, also thrive on northerly exposed slopes of the ridge, more exposed to strong winds. These stands host a considerably higher number and greater coverage of species preferring open habitats (screes – *Thlaspietea rotundifolii*, subalpine Dinaric tussock grasslands – *Elyno-Seslerietea*). Among the phytosociological parameters, the altitude (P=0.002) and the number of species per relevé (P=0.006) turned out to be statistically significant factors in floristic differentiation of stands. The first group of stands is clearly separated from the second one along the altitudinal gradient. Results of the SIMPER analysis showed the overall average dissimilarity between the two groups to be 51.84 with the taxa that contributed most to the dissimilar-

Tab. 3. Coverage indices ($D_{\%}$) according to syntaxonomic groups within the association *Rhododendro hirsuti-Juniperetum alpinae* Horvat ex Horvat et al. 1974 *nom. nov. prop.* in the Liburnian karst (north-west Dinaric Alps).

syntaxa	typical stands	seslerietosum	association
Erico-Pinetea	38.2	47.8	44.4
Vaccinio-Piceetea	17.2	14.4	15.5
Thlaspietea rotundifolii	6.0	11.7	9.6
Elyno-Seslerietea	1.5	12.2	1.6
Mulgedio-Aconitetea	7.1	7.2	7.1
Asplenietea trichomanis	7.2	6.6	6.7
Festuco-Brometea	6.1	6.1	6.2
Fagetalia sylvaticae	6.7	4.2	5.2
Trifolio-Geranietea	0.7	1.9	1.4
Querco-Fagetea	2.1	1.1	1.4
Poo alpinae-Trisetalia	1.0	0.7	0.9
Other taxa	2.1	0.2	0.8
Quercetalia pubescentis	0.7	.	0.3
Molinio-Arrhenatheretea	0.3	.	0.1

ity being *Sesleria juncifolia* subsp. *tenuifolia* (3.1), *Erica carnea* (1.8), *Phyteuma orbiculare* (1.7), *Aster bellidiastrum* (1.5), *Athamanta cretensis* (1.5), *Rubus saxatilis* (1.4) etc. Even the coefficient of variation of the number of taxa per relevé showed differences, being in the first group (»typical« stands) significantly lower (16.5%) than in the second one (21.5%) which might indicate more homogenous floristic composition of stands within the first group. Based on the results of the SIMPER analysis and ecological preferences of taxa in general, as a differential group of species for the second group of stands we chose *Sesleria juncifolia* subsp. *tenuifolia*$^{+-4}$ (6.7), *Athamanta cretensis*$^{+-2}$ (3.3) and *Daphne alpina*$^{+-2}$ (2), exclusively differentiating the two groups. A taxonomic note: the taxonomic status of specimens of *Athamanta cretensis* (var. *mutellinoides*?) from the Liburnian karst is uncertain; specimens at lower altitudes (1000–1300 m) differ morphologically and physiognomically from typical ones found on higher altitude summits (e.g. Mt. Snežnik, 1796 m, or Mt. Snježnik, 1524 m), and are similar to specimens of *A. haynaldii* Borb. et Uechtr.

Syntaxonomic position and notes on nomenclature of Dinaric heaths

Comparison of the floristic inventory in table 2 and that in the reduced synoptic table 135 in HORVAT et al. (1974) clearly showed that the studied stands belong to the association *Rhododendro hirsuti-Juniperetum* Horvat 1962. However, in his original diagnosis (HORVAT 1962), the author failed to designate the type relevé (Art. 2b, 7 and 17 of the Phytosociological code), nor did he provide an analytical and/or synoptic table, although subsequently (HORVAT et al. 1974) he did publish a synoptic table (Tab. 135, col. 1), which, according to Art. 7 (WEBER et al. 2000), is the first valid publication of a name (Definition III) – *Rhododendro hirsuti-Juniperetum alpinae* Horvat ex Horvat et al. 1974 *nom. corr. prop.* (=*Rhododendro hirsuti-Juniperetum* Horvat 1962 *nom. nud.*). As a neotype (Definition VIII) we chose a relevé no. 4 in table 2, *neotypus* hoc loco. Within the studied stands, we recognized a new subassociation *Rhododendro hirsuti-Juniperetum alpinae seslerietosum tenuifoliae subass. nova* hoc loco, and as a differential group of species for the subassociation we chose *Sesleria juncifolia* subsp. *tenuifolia, Athamanta cretensis* and *Daphne alpina*. Nomenclature type for the new subassociation is relevé no. 17 in table 2, *holotypus* hoc loco.

Results of the ordination analysis (Fig. 2c) and cluster analyses using various similarity measures (not shown) suggest great floristic similarity between stands of the association *Rhododendro hirsuti-Juniperetum* from the Liburnian karst (RJ) and stands from the South-eastern Calcareous Alps, belonging to the associations *Rhododendro hirsuti-Pinetum prostratae* (RhPm), *Erico carneae-Pinetum prostratae* (EcPm) and *Rhododendretum hirsuti* (Rh; group A). In all three associations, species from the class *Erico-Pinetea* prevail both in number and coverage over the species of the other syntaxa and we classified stands from the Liburnian karst into class *Erico-Pinetea*, order *Erico-Pinetalia* and alliance *Ericion carneae* (see below). Stands of the association *Aquilegio-Rhododendretum hirsuti* (AnRh) were nested in the same group of relevés (Fig. 2c, group A) indicating close floristic and ecological similarity. Hence, we classified them into the alliance *Ericion carneae*. Although the syntaxon *Aquilegio-Rhododendretum hirsuti* is supported with the analytical table (Tab. 24 in LAKUŠIĆ et al. 1979), the type relevé has not been designated and is, according to *Definition IV* of the Code (compare also Articles 5, 15–18), treated as an unpublished name. As a lectotype of the association *Aquilegio nigricantis-Rhododendretum hirsuti* Lakušić et al. ex

Surina *ass. nova* (=*Aquilegio -Rhododendretum hirsuti* Lakušić et al. 1979 *nom. inv.*), we chose relevé no. 2 in tab. 24 in LAKUŠIĆ et al. 1979, *lectotypus* hoc loco.

Dinaric scrubs of Mountain pine (HgPm, Pmc, Pmm 1, 2) formed a group C (Fig. 2c), while more acidophilic syntaxa, either heaths (VvCv, Rf, HVb, HVm, RaJn, JsSs) or mountain pine scrubs (RfPm, Pmi), formed another homogenous group (group B, Fig. 2c). We classified the later, being distinctly acidophilic, into the class *Vaccinio-Piceetea*, order *Vaccinio-Piceetalia* and alliance *Rhododendro-Vaccinion.* The associations *Hyperico-Vaccinietum bosniacum, Hyperici-Vaccinietum montenegrinum* and *Vaccinio-Callunetum subalpinum* are invalidly published, violating the principles of phytosociological nomenclature in several articles (e.g. Art. 5, 10, 15–18, 46). Hence, validly published names with selected lectotypes are proposed: *Hyperico maculati-Vaccinietum myrtilli* Lakušić et al. ex Surina *ass. nova* (=*Hyperico-Vaccinietum bosniacum* Lakušić et al. 1979 *nom. inv.*), *lectotypus* hoc loco: relevé no. 2 in table 23 in LAKUŠIĆ et al. (1979); *Hyperico grisebachii-Vaccinietum myrtilli* Lakušić ex Surina *ass. nova* (=*Hyperici-Vaccinietum montenegrinum* Lakušić 1966 *nom. inv.*), *lectotypus* hoc loco: relevé no. 6 in table 22 in LAKUŠIĆ (1966); *Vaccinio myrtilli-Callunetum vulgaris* Lakušić et al ex Surina *ass. nova* (=*Vaccinio-Callunetum subalpinum* Lakušić et al. 1979 *nom. inv.*), *lectotypus* hoc loco: relevé no. 10 in table 23 in LAKUŠIĆ et al. (1979). According to the results of the analyses, stands of the associations *Roso pendulinae-Juniperetum alpinae* Lakušić 1966 *nom. corr. prop.* (Art. 41; =*Roso pendulinae-Juniperetum nanae* Lakušić 1966) and *Sempervivo schlechanii-Juniperetum alpinae* Bjelčić 1966 *nom. invers. et corr. prop.* (Art. 42; =*Junipero-Semperviretum schlechanii* Bjelčić 1966), gathered in group C together with stands of the associations *Hyperico maculati-Vaccinietum myrtilli*, *Hyperico grisebachii-Vaccinietum myrtilli* and *Vaccinio myrtilli-Callunetum vulgaris*, showed considerable floristic similarities and are thus classified accordingly. For the two mentioned syntaxa, lectotypes were here designated: *Roso pendulinae-Juniperetum alpinae* Lakušić 1966 *nom. corr. prop.*, *lectotypus* hoc loco: relevé no. 4 in table 22 in LAKUŠIĆ (1966); *Sempervivo schlechanii-Juniperetum alpine* Bjelčić 1966 *nom. invers. et corr. prop.*, *lectotypus* hoc loco: relevé no. 6 in table 2 in BJELČIĆ (1966).

In all the numerical analyses we performed, relevés of the association *Seslerio robustae-Juniperetum alpinae* Domac 1962 *nom. corr. prop.* formed a completely separated and floristically clearly distinct group of stands, being the most thermophilic and composed of a significant number of species of the class *Festuco-Brometea.* Therefore, we omitted this syntaxon from the subsequent analyses and classified it within the class *Festuco-Brometea,* order *Scorzonero-Chrysopogonetalia* and alliance *Satureion subspicatae.*

Erico-Pinetea Horvat 1959
Erico-Pinetalia Horvat 1959
Ericion carneae Rübel ex Grabherr et al. 1993
Aquilegio nigricantis-Rhododendretum hirsuti Lakušić et al. ex Surina *ass. nova hoc loco* (=*Aquilegio-Rhododendretum hirsuti* Lakušić et al. 1979 *nom. inv.*)
Rhododendro hirsuti-Juniperetum alpinae Horvat ex Horvat et al. 1974 *nom. corr. prop.* (=*Rhododendro-Juniperetum* Horvat 1962 *nom. nud.*)
-seslerietosum tenuifoliae Surina *subass. nova hoc loco*
Vaccinio-Piceetea Br.-Bl. in Br.-Bl. et al. 1939 emend. Zupančič (1976) 2000
Piceetalia excelsae Pawlowski in Pawlowski et al. 1928
Rhododendro-Vaccinion (Br.-Bl. in Br.-Bl. et Jenny 1926) Br.-Bl. 1948
Roso pendulinae-Juniperetum alpinae Lakušić 1966 *nom. corr. prop.*

(=*Roso pendulinae-Juniperetum nanae* Lakušić 1966)
Sempervivo schlechanii-Juniperetum alpinae Bjelčić 1966 *nom. invers. et corr. prop.*
(=*Junipero-Sempervivetum schlechanii* Bjelčić 1966)
Hyperico maculati-Vaccinietum myrtilli Lakušić et al. ex Surina *ass. nova hoc loco*
(=*Hyperici-Vaccinietum bosniacum* Lakušić et al. 1979 *nom. inv.*)
Hyperici grisebachii-Vaccinietum myrtilli Lakušić ex Surina *ass. nova hoc loco*
(=*Hyperici-Vaccinietum montenegrinum* Lakušić 1966 *nom. inv.*)
Vaccinio myrtilli-Callunetum vulgaris Lakušić et al. ex Surina *ass. nova hoc loco*
(*Vaccinio-Callunetum subalpinum* Lakušić et al. 1979 *nom. inv.*)
Festuco-Brometea Br.-Bl. et Tx. 1943
Scorzonero-Chrysopogonetalia Horvatić et Horvat (1956) 1958
Satureion subspicatae Horvat 1961
Seslerio robustae-Juniperetum alpinae Domac 1962 *nom. corr. prop.*

Discussion

According to our observations, heaths of the association *Rhododendro hirsuti-Juniperetum alpinae* persist in sites with extremely low winter temperatures, but with long duration of snow cover, where stands covered with snow are sheltered from low temperature extremes, winter desiccation, ice blast and solar radiation. The same pattern with structurally similar stands on Mt. Jahorina was thoroughly discussed by BJELČIĆ (1966). It seems that in our case extreme winter temperatures on sites with ericaceous heaths are buffered with deep and persistent snowpacks originating either from blasts of snow along the mountain ridges or specific microclimate of frost dolines (temperature inversion!). The specific origin of snowpacks, as well as specifics in relief, are well reflected in floristic composition of stands and distinction of the two subassociations: (a) –*typicum*, with cryophilic stands developed in moister and cooler sites at the margins or on slopes of frost dolines, and (b) –*seslerietosum tenuifoliae*, with relatively thermophilic stands developed on warmer, lighter and wind exposed sites on mountain ridges.

Although within a rather restricted area of the Liburnian karst, structurally identical but, in terms of their origin, floristic composition and specifics in site ecology, nevertheless different groups of stands were identified. Due to site ecology and pronounced human impact (deforestation due to intensive logging and subsequent soil erosion and pasture activities), these stands, which are in contact with various forest and non-forest stands, but in general developed within the stands of zonal association *Polysticho lonchitis-Fagetum*, host a plethora of species of different vegetation types (classes, see POLDINI et al. 2004), rendering synsystematic and syndynamic analyses particularly troublesome. Although there were earlier attempts to explain the origin and syndynamics of studied heaths (e.g. HORVAT 1962, BJELČIĆ 1966), none of the proposed schemes actually suffice and the question of heath syndynamics, at least in the Dinaric Alps, remains an open question. This is followed with uncertainties in heath synsystematics where several authors proposed various synsystematic schemes based either on floristic principle, structure of stands of both. In our proposal we followed the compromise made by POLDINI et al. (2004), placing heaths on the basis of floristic principle into two classes: *Erico-Pinetea* and *Vaccinio-Piceetea*, and only latter, while classifying the associations into the syntaxa ranked bellow the class, took into the consideration their structure. Hence, the Dinaric associations *Rhododendro hirsuti-Juniperetum alpinae* and *Aquilegio nigricantis-Rhododendretum hirsuti* (their stands being developed on calcareous soils) were placed within the class *Erico-Pinetea*, while associations *Roso pendulinae-Juniperetum alpinae*, *Sempervivo schlechanii-Juniperetum alpinae* (their stands being developed on non-calcareous soils or on sites with close contact to spruce forests, respectively), *Hyperico maculati-Vaccinietum myrtilli* and *Vaccinio myrtilli-Callunetum vulgaris* (their stands being developed on non-calcareous soils) within the class *Vaccinio-Piceetea*. This scheme is well supported by the results of the numerical analyses (Fig. 2c). The association *Arctostaphylletum uvae-ursi silicicolum* Lakušić et al. 1979 *nom. inv.*, since documented with only a single relevé, was not analyzed, but most probably belongs to the same group of syntaxa. The stands of the association *Seslerio robustae-Juniperetum alpinae* from the Biokovo mountain range in central Dalmatia, structurally similar, but floristically quite distinct, synsystematically better fit within the class *Festuco-Brometea* than *Erico-Pinetea* or even *Vaccinio-Piceetea* (for further discussion see TRINAJSTIĆ 1987) and to ascertain their syntaxonomic position more accurately would require much more comprehensive analyses comparing syntaxa not only of two, but three or four classes. Being aware that their syntaxonomic position is not entirely clear we followed the proposal of TRINAJSTIĆ (1987, 2008), although Sedlar and co-workers placed similar stands with *Pinus nigra* subsp. *dalmatica* dominating in a tree layer within the class *Pino-Juniperetea* (SEDLAR et al. 2011).

Although resolving the syntaxonomy of mountain pine scrubs communities was far beyond the scope of the present paper, the results of our preliminary analyses showed a certain (phyto)geographical structure (Fig. 3c), where Dinaric stands represented a distinct group of syntaxa in all of the performed analyses. However, only a thorough synoptic approach taking into account all the south-eastern-European stands of the Mountain pine would properly challenge their current syntaxonomy.

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Appendix I – phytosociological and site parameters of relevés in table 1 (rel. no. and field no., altitude, exposition, inclination, coverage: S – stoniness, C – herb layer

1–8 – Mt. Snežnik, 9–22 – Mt. Obruč

1 (20111004/07), 1413 m, NNE, 36 m^2, 20^0, S 40%, C 60%, leg. A. Radalj et B. Surina; 2 (20111004/08), 1412 m, SE, 36 m^2, 10^0, S 60%, C 40%, leg. A. Radalj et B. Surina; 3 (20111004/04), 1390 m, S, 36 m^2, 25^0, S 60%, C 40%, leg. A. Radalj et B. Surina; 4 (20111004/03), 1375 m, NNE, 30 m^2, 35^0, S 20%, C 80%, leg. A. Radalj et B. Surina; 5 (20111004/05), 1400 m, E, 25 m^2, 40^0, S 30%, C 70%, leg. A. Radalj et B. Surina; 6 (20111004/01), 1391 m, E, 20 m^2, 40^0, S 50%, C 50%, leg. A. Radalj et B. Surina; 7 (20111004/02), 1400 m, NNE, 25 m^2, 60^0, S 40%, C 60%, leg. A. Radalj et B. Surina; 8 (20050724/05), 1340 m, S, 25 m^2, 20^0, S 30%, C 70%, leg. A. Žnidaršič et B. Surina; 9 (20111004/06), 1350 m, NNE, 50 m^2, 30^0, S 40%, C 60%, leg. A. Radalj et B. Surina; 10 (20110907/08), 1242 m, ESE, 36 m^2, 30^0, S 40%, C 60%, leg. B. Surina; 11 (20110907/12), 1220 m, E, 30 m^2, 35^0, S 60%, C 40%, leg. B. Surina; 12 (20110907/11), 1260 m, NNE, 30 m^2, 30^0, S 40%, C 60%, leg. B. Surina; 13 (20110907/07), 1239 m, N, 25 m^2, 30^0, S 30%, C 70%, leg. B. Surina; 14 (20110907/06), 1243 m, NNE, 20 m^2, 30^0, S 40%, C 60%, leg. B.

Surina; 15 (20110907/10), 1248 m, N, 25 m^2, 40^0, S 50%, C 50%, leg. B. Surina; 16 (20110830/10), 1260 m, NNE, 30 m^2, 25^0, S 60%, C 40%, leg. Ž. Modrić Surina et B. Surina; 17 (20110907/05), 1252 m, ENE, 30 m^2, 30^0, S 60%, C 40%, leg. B. Surina; 18 (20110907/09), 1244 m, NNE, 25 m^2, 35^0, S 60%, C 40%, leg. B. Surina; 19 (20110907/04), 1260 m, NE, 50 m^2, 25^0, S 50%, C 50%, leg. B. Surina; 20 (20110907/01), 1255 m, ENE, 20 m^2, 30^0, S 40%, C 60%, leg. B. Surina; 21 (20110907/02), 1246 m, ENE, 30 m^2, 35^0, S 30%, C 70%, leg. B. Surina; 22 (20110907/03), 1250 m, NE, 36 m^2, 40^0, S 40%, C 60%, leg. B. Surina.

Appendix II – taxa occurring once in table 1

Erico-Pinetea: *Arctostaphyllos uva-ursi* 1 (12), *Gymnadenia conopsea* + (18), *Peucedanum austriacum* s.l. + (8); *Vaccinio-Piceetea*: *Huperzia selago* + (4), Luzula sylvatica + (4); *Fagetalia sylvaticae* (incl. *Aremonio-Fagion**): *Hacquetia epipactis** + (8), *Euphorbia carniolica* + (8), *Melica nutans* + (8), *Dryopteris filix-mas* + (9), *Scrophularia nodosa* + (9), *Acer pseudoplatanus* + (13); *Querco-Fagetea* (incl. *Quercetalia pubescentis**): *Melittis melissophyllum** + (9), *Hepatica nobilis* + (8); *Trifolio-Geranietea*: *Ligusticum seguerii* 2 (11); *Thlaspietea rotundifolii*: *Petasites paradoxus* 2 (18), *Dryopteris submontana* 1 (9), *Festuca nitida* 1 (9), *Scrophularia laciniata* + (10), *Trisetum argenteum* + (4); *Asplenietea trichomanis*: *Asplenium fissum* + (6), *Kernera saxatilis* + (6), *Cystopteris fragilis* + (9); *Mulgedio-Aconitetea*: *Viola biflora* + (6), *Aconitum ranunculifolium* + (9), *Hypericum maculatum* ssp. *maculatum* + (9), *Veratrum album* s.l. + (3), *Tephroseris ovirensis* + (4); *Elyno-Seslerietea*: *Polygala alpestris* ssp. *croatica* + (20); *Festuco-Brometea*: *Teucrium montanum* + (10), *Ruta divaricata* 1 (10); *Molinio-Arrhenatheretea*: *Leontodon hispidus* 1 (4).

Appendix III – list of syntaxa mentioned in text and table 1

Amelanchiero-Pinetum mugo Minghetti in Pedroti 1994; *Aquilegio nigricantis-Rhododendretum hirsuti* Lakušić et al. ex Surina *ass. nova hoc loco* (=*Aquilegio-Rhododendretum hirsuti* Lakušić et al. 1979 *nom. inv.*); *Arctostaphylletum uvae-ursi* Lakušić et al. 1979 *nom. inv.*; *Aremonio-Fagion* (Horvat 1938) Borhidi in Török, Podani et Borhidi 1989; *Asplenietea trichomanis* Br.-Bl. in Meier et Br.-Bl. 1934; *Berberido creticae-Juniperion foetidissimae* Brullo et al. 2001; *Calamagrostido arundinaceae-Fagetum* Cerovečki 2009; *Calamagrostido variae-Abietetum* Horvat 1950 *piceetosum*; *Carici humilis-Centaureetum rupestris* Horvat 1931 *seslerietosum tenuifoliae* Horvat 1962 *nom. nud.*; *Doronico austriaci-Adenostyletum alliariae* Horvat ex Horvat 1974;

Drepanoclado uncinati-Heliospermetum pusilli Surina et Vreš 2004; *Elyno-Seslerietea* Br.-Bl. 1948; *Ericetum carneae* Rübel 1911; *Ericion carneae* Rübel ex Grabherr et al. 1993; *Erico carneae-Pinetum prostratae* Zötl 1951 *nom. inv.*; *Erico-Pinetea* Horvat 1959; *Erico-Pinetalia* Horvat 1959; *Fagetalia sylvaticae* Pawlowski in Pawlowski et al. 1928; *Festuco-Brometea* Br.-Bl. et Tx. 1943; *Festuco alpestris-Genistetum radiatae* Peer ex Poldini et al. 2004; *Hacquetio-Piceetum* Zupančič (1980) 1999; *Hyperico maculati-Vaccinietum myrtilli* Lakušić et al. ex Surina *ass. nova hoc loco* (=*Hyperici-Vaccinietum bosniacum* Lakušić et al. 1979 *nom. inv.*); *Hyperico grisebachii-Vaccinietum myrtilli* Lakušić ex Surina *ass. nova hoc loco* (=*Hyperici-Vaccinietum montenegrinum* Lakušić 1966 *nom. inv.*);

Hyperico grisebachii-Pinetum mugo Wraber et al. in Zupančič et al. 2004 var. geogr. *Arabis scopoliana* (=*Pinetum mughi croaticum* Horvat 1938 *p.p.*; *Pinetum mughi montenegrinum* Blečić 1957 *nom. inv.*); *Juniperetalia haemisphaericae* Rivas-Martinez et Molina 1999; *Junipero sibiricae-Semperviretum schlechanii* Bjelčić 1966 (=*Sempervivo schlechanii-Juniperetum sibiricae* Bjelčić 1966 *nom. invers. prop.*); *Lonicero caeruleae-Piceetum* Zupančič (1980) 1999; Loiseleurio-*Vaccinietea* Eggler ex Schubert 1960*; Mulgedio-Aconitetea* Hadač et Klika in Klika et Hadač 1944; *Molinio-Arrhenatheretea* R. Tx. 1937 em. R. Tx. 1970; *Omphalodo-Fagetum* (Tregubov 1957 corr. Puncer 1980) Marinček et al. 1993 var. geogr. *Calamintha grandiflora* Surina 2001 *seslerietosum autumnalis* nom. nud. (=*Fagetum croaticum australe abietetosum* Horvat 1938, *Abieti-Fagetum dinaricum* Tregubov 1957); *Piceetalia excelsae* Pawlowski in Pawlowski et al. 1928; *Pinetum mughi Illyricum* Lakušić et al. 1979 *nom. inv.*; *Pino-Juniperetea* Rivas-Martinez 1964; *Polysticho lonchitis-Fagetum* (Horvat 1938) Marinček in Poldini et Nardini 1993 (=*Fagetum croaticum australe subalpinum* Horvat 1938) *rhododendretosum hirsuti* Surina et Rakaj 2007; *Poo alpinae-Trisetalia* Ellmauer et Mucina 1993; *Quercetalia pubscentis* Klika 1933; *Querco-Fagetea* Br.-Bl. et Vlieg. 1937; *Rhododendretum ferruginei* Rübel 1911; *Rhododendro ferruginei-Pinetum prostratae* Zötl 1951 *nom. inv.*; *Rhododendro hirsuti-Juniperetum sibiricae* Horvat ex Horvat et al. 1974 (=*Rhododendro hirsuti-Juniperetum sibiricae* Horvat 1962 *nom. nud.*); *Rhododendro hirsuti-Pinetum prostratae* Zötl 1951 *nom. inv.*; *Rhododendro hirsuti-Salicetum appendiculatae* Tomažič nom. nud. (=*Salicetum appendiculatae* Horvat ex Horvat et al. 1974); *Rhododendro-Vaccinion* (Br.-Bl. in Br.-Bl. et Jenny 1926) Br.-Bl. 1948; *Rhodothamno chamaecisti-Juniperetum alpini* Poldini et al. 2004; *Roso-Juniperetum nanae* Lakušić 1966 (=*Roso pendulinae-Juniperetum sibiricae* Lakušić 1966 *nom. corr.*); *Roso pendulinae-Pinetea mugi* Theurillat in Theurillat et al. 1995; *Satureion subspicatae* Horvat 1962; *Scorzonero-Chrysopogonetalia* Horvatić et Horvat (1956) 1958; *Seslerio autumnalis-Fagetum* (Horvat 1938) M. Wraber ex Borhidi 1963 (=*Fagetum croaticum australe seslerietosum autumnalis* Horvat 1938); *Seslerion tenuifoliae* Horvat 1962; Seslerietea albicantis Oberdorfer 1978 corr. Oberdorfer 1990; *Seslerio robustae-Juniperetum sibiricae* Domac 1962; *Sorbo chamaemespili-Pinetum mugo* Minghetti 1996; *Thlaspietea rotundifolii* Br.-Bl. in Br.-Bl. et Jenny 1926; *Trifolio-Geranietea* Th. Mueller 1961; *Vaccinio myrtilli-Callunetum vulgaris* Lakušić et al. ex Surina *ass. nova hoc loco* (*Vaccinio-Callunetum subalpinum* Lakušić et al. 1979 *nom. inv.*); *Vaccinio-Piceetea* Br.-Bl. 1939 emend. Zupančič (1976) 2000; *Vaccinio vitis-ideae-Callunetum vulgaris* Poldini et al. 2004.