

**NUMERICAL AND PHYTOSOCIOLOGICAL ANALYSIS OF THE
Junipero sibiricae -*Pinetum dalmaticae* Domac (1956) 1965 ASSOCIATION
AND COMPARISON TO MEDITERRANEAN
FORESTS DOMINATED BY *Pinus nigra* Arn. s.l.**

NUMERIČKA I FITOSOCIOLOŠKA ANALIZA ZAJEDNICE
Junipero sibiricae -*pinetum dalmaticae* Domac (1956) 1965 TE USPOREDBA
S MEDITERANSKIM ŠUMAMA S DOMINANTNOM VRSTOM *Pinus nigra* Arn. s.l.

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SUMMARY: This study analyses the ecological and syntaxonomical characteristics of the Junipero sibiricae -Pinetum dalmaticae Domac (1956) 1965 association. This association is present only on higher altitudes of Biokovo Mountain situated on the eastern Adriatic coast. With its highest peak at an altitude of 1,762 m, Biokovo is one of the hotspots of plant endemism in Croatia. It is highly influenced by the Mediterranean climate which is expressed up to the higher parts of the mountain, although, due to its height, it has weakened montane and alpine conditions on the peaks. According to the present syntaxonomical solution, the researched association belongs to the sub-mediterranean alliance Ostryo-Carpinion orientalis in the Quercetalia pubescentis order in the Querco-Fagetea class. Numerical and syntaxonomical analyses suggest that Junipero sibiricae -Pinetum dalmaticae on Biokovo differs from all other Dalmatian pine vegetation types. Cluster analysis, Indicator species analysis together with Nonmetric multidimensional scaling used to compare it to forests dominated by Pinus nigra s.l. from other Mediterranean areas (Greece, Iberian peninsula, Corsica and Sicily) suggested it should be classified in the Pino-Juniperetea class, the Juniperetalia haemisphaericae order, and the eastern Mediterranean Berberido craeticae-Juniperion foetidissimae alliance. The resemblance of Junipero sibiricae -Pinetum dalmaticae with eastern Mediterranean associations and its inclusion into mentioned syntaxa is confirmed phytosociologically and ecologically.

Key words: Biokovo Mountain, multivariate analysis, Pinus nigra subsp. dalmatica, syntaxonomy

Abbreviations: ISA (Indicator Species Analysis), IV (Indicator Value), NMS (Nonmetric Multidimensional Scaling), p (Probability)

INTRODUCTION – Uvod

Black pine (*Pinus nigra* Arn.) is present in the Mediterranean in several subspecific taxa and mostly forms pure, but sometimes also, mixed forests with other broadleaved trees and conifers (Regato & al. 1995). The communities dominated by *Pinus nigra* s.l. are nowa-

days relegated to more vegetation zones, vertical belt and phytogeographical areas. However, they are mostly present in supra- and oromediterranean belt. Black pine, as a Mediterranean taxon, and habitats dominated by it are distributed in the Mediterranean on a wide area. They are in relatively small and, in between, isolated areas surrounded by other types of vegetation (Bergmeier 1990; Van Haverbeke 2009). Every wider area, inside the total geographical distribution, has its

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own special endemic taxon from *Pinus nigra* s.l. complex and can be rich in endemics (Brullo & al. 2001). The size of the Mediterranean basin and the geographical isolation of its islands and peninsulas drove to massive speciation process among the species forming in the high mountain vegetation. The biodiversity of Mediterranean orophilous communities is thus among the highest in Europe. This is why many local species enter into species assemblage of syntaxa of each *Pinus nigra* subspecies, as do species from neighbouring vegetation type. In the *Junipero sibiricae* -*Pinetum dalmaticae* Domac (1956) 1965 association species enter most frequently from *Quercetalia pubescentis* Br.Bl. (1931) 1932 order. Black pine forests often have in their structure a great number of species which grow on screes and rocks than zonal vegetation (Bergmeier 1990). This is why communities of different Mediterranean areas, formed by black pine, have low number of matching species and more expressed local floristic features than it is the case with zonal and other types of vegetation (Bergmeier 1990). The syntaxonomic classification is very difficult and an object of different discussions and different syntaxonomic solutions because of these reasons (Rivas-Martínez 1964; Domac 1965; Horvat & al. 1974; Trinajstić 1977, 1986, 1990, 1998; Bergmeier 1990; 2002; Rivas-Martínez & al. 1999; Brullo & al. 2001).

In classification of black pine forests there are several different concepts. The first concept is taking a pure numeric proportion of species from different syntaxa with which black pine forests adjoins as a classification basis for a higher level of syntaxa. According to this concept it is attempted to classify black pine forests into an existing higher level syntaxon or to present it as a subassociation or a facies of a neighbouring association which has the most matching species in species assemblage. The second concept introduces habitat differentiation, ecological and structural characteristics which make numeric part of different syntaxa relative. The third concept is to give greater meaning to the supraregional characteristics, of termophilous pine forests at merging to higher level syntaxa (Bergmeier 1990). Example for this concept is *Erico-Pinetea* Horvat 1959 class and lower syntaxa (Horvat 1959).

Pinus nigra subsp. *dalmatica* (Vis) Franco is an endemic taxon distributed on the coast, on some islands of southern Dalmatia and on the southern slopes of the Dinaric Alps at altitudes from 350 to 1,000 m and is one of the Mediterranean taxa of the *Pinus nigra* s.l. complex (Bogunić & al. 2003; Isajev & al. 2004; Pignatti 2005). It is a woody phanerophyte of the northeastern eurimediterranean, found in drier areas (Pignatti 2005). It is also an Illyrian floral element (Pignatti 1982a).

The distribution area of Dalmatian pine is spread over altitudes between 300 and 1,400 m and is divided into two parts: the Biokovo Mountain part and the coastal part (Trinajstić 1986). Dalmatian pine vegetation is mostly found in forms of different stages of degradation of *Quercus ilex* L. vegetation, mostly garrigues (Stefanović 1977). The largest complexes of Dalmatian pine vegetation are on the islands of Brač, Hvar, and Korčula and on the Pelješac peninsula (Figure 1), at altitudes between 300 and 750 metres. Here, they are situated in the Mediterranean region in both eumediterranean and submediterranean vegetation zones. Dalmatian pine vegetation is situated on Biokovo Mountain mostly in the northwestern part of the mountain and is divided into two altitudinal parts: an upper part at an altitude of 1,100-1,400 m, and a lower one at an altitude of 500-900 m (Domac 1961/62).

Until now, researchers have encountered problems connected to the typology of Dalmatian pine vegetation. It was often described as a unique type of vegetation (Beck-Mannagetta 1901; Horvatić 1928; Horvat 1950, 1954). Horvat 1950 and 1954 even marked it as a separate association with its temporary name “*Pinetum dalmaticae*”, but made no further attempt at syntaxonomical analysis.

Later, Horvatić 1958 defined Dalmatian pine vegetation only as the degradation stages of different associations and gave them a subassociation and facies level (*Genisto-Ericetum verticillatae pinetosum dalmaticae* Horvatić 1958, *Erico-Rosmarinetum pinetosum dalmaticae* Horvatić 1958, *Stipo-Salvietum officinalis pinetosum dalmaticae* Horvatić 1958, *Orno-Quercetum ilicis pinosum dalmaticae* Horvatić 1958).

In contrast, Trinajstić 1977 named a new, higher level, syntaxa, found on the island of Hvar and described as *Erico manipuliiflorae-Pinetum dalmaticae* Trinajstić 1977 and in 1986 another association from the islands of Korčula and Brač, *Quercus ilicis-Pinetum dalmaticae* Trinajstić 1986.

The research and classifications of Horvatić 1958 and Trinajstić 1977, 1986 and 1990 do not include the area of Biokovo Mountain. The only attempt to describe and classify Dalmatian pine vegetation on Biokovo Mountain was made by Domac in 1965. He takes the syntaxa from Horvatić 1958 into consideration and describes a new association, found on the higher part of Biokovo Mountain, as *Junipero sibiricae -Pinetum dalmaticae* Domac 1965, classifying it into the deciduous submediterranean *Quercetalia pubescentis* order, the *Quercus-Fagetea* Br.-Bl. et Vlieger 1937 class.

This review shows that the syntaxonomy of the Dalmatian pine vegetation is not simple, although it takes up a relatively small area. It shows that there are no

unique syntaxonomic solutions, that the Dalmatian pine vegetation on Biokovo Mountain is different from all similar vegetation types in the region and that the relation to similar vegetation is questionable, as is its syntaxonomical position. This study was therefore

made to research the syntaxonomical and ecological position of the *Junipero sibiricae* -*Pinetum dalmaticae* association on Biokovo Mountain and its relation to other types of Dalmatian pine vegetation and black pine vegetation from other Mediterranean areas.

MATERIALS AND METHODS – Materijal i metode

Study area – Područje istraživanja

The study area is situated in Croatia, the central Dalmatia region, between N43°27'36", E16°08'34.2" and N42°43'47.9", E17°49'42.8". The geological base of the islands, the peninsula and Biokovo Mountain is carbonate, Mesozoic limestone and dolomite (Cvi-tanović 1974).

Biokovo Mountain rises from the sea coast and runs parallel with it up to a height of 1,700 m (highest peak at 1,762 m). The altitude of the coastal side slope is between 500 and 1,100 m and is very steep with many vertical cliffs. Above that height there is an undulating karst plateau. In this zone on karst ridges and exposed habitats *Junipero sibiricae* -*Pinetum dalmaticae* is found.

The islands of Hvar, Brač, and Korčula and the Pelješac peninsula also have hills, but of lower altitudes than Biokovo: the highest peak of the island of Hvar is at 628 m, that of the island of Brač is at 778 m, the island of Korčula's highest peak measures 569 m, and the highest peak of the Pelješac peninsula rises to 961 m.

The climate in this area is basically Mediterranean with an expressed summer drought. On higher parts, of course, lower temperatures and less expressed drought occur. The higher parts of Biokovo have an alpine climate, but the Mediterranean summer drought still occurs to some degree. The continental slope of Biokovo is also exposed to the effect of the continental climate

which is not present on the islands of Hvar, Brač and Korčula and on the Pelješac peninsula.

Biokovo is one of the hotspots of plant endemism in Croatia. Together with Velebit Mountain, the coastal area of Dubrovnik and Quarnero islands, this is an area with a high concentration of endemic and subendemic plant taxa. Out of more than 1,500 plant taxa present, on the mountain area alone there are more than 30 endemic (Borzan & al. 1992). For this high endemism rate there are several reasons. Biokovo is quite isolated from other mountains of the Dinaric Alps, separated on the coastal side by the sea and on the continental side by a wide plane. Another reason for the high number of endemic plant species is the mountain relief which allows for the existence of different types of habitats and specific edaphic and microclimatic characteristics. This relief even causes the isolation of different habitats on the mountain (Kušan 1969). Biokovo is also on the boundary of two phytogeographical regions: the Mediterranean region and partly the Eurosiberian-Northamerican region (Trinajstić 1986). This also explains the presence of a large number of species from both regions which enlarge the plant diversity on Biokovo. Such specific phytogeographical features give good reason to expect specific types of vegetation on Biokovo.

Data collection – Prikupljanje podataka

The data used in this study were taken from the publications of Domac 1965, Trinajstić 1986 and 1990 and Horvatić 1958. Domac 1965 made the most comprehensive research of the distribution area of Dalmatian pine by taking a total of 41 phytosociological relevés in Dalmatian pine vegetation on the Dalmatian islands of Hvar (7 relevés) and Brač (14 relevés), on the Pelješac peninsula (4 relevés) and Biokovo Mountain (16 relevés). Trinajstić 1986 and 1990 took relevés of Dalmatian pine vegetation on the islands of Brač (13 relevés), Hvar (3 relevés), Korčula (5 relevés) and on the Pelješac peninsula (4 relevés). Horvatić 1958 took 6 relevés on the island of Hvar.

Our study is mostly based on the studies done by Domac 1965 and Trinajstić 1986 and 1990. Figure 1 shows the area where *Pinus nigra* subsp. *dalmatica* vegetation was researched. Relevés taken by Domac 1965 contain altitude data, but others do not. However,

the mentioned islands have relatively low peaks so the altitudes are not different from those measured by Domac. On the island of Hvar, the altitudes of the relevés vary from 300 to 480 m, on the island of Brač the relevé altitudes vary from 400 to 740 m, and for the peninsula of Pelješac they vary from 500 to 800 m. For the island of Korčula, there were no measured altitudes, but its highest peak is in the range of the altitudes of the relevés taken on the other islands. Domac 1965 made his relevés on Biokovo Mountain at altitudes between 560 and 900 m and between 1,180 and 1400 m.

The relevés taken by Domac 1965, Trinajstić 1986 and 1990 and Horvatić 1958 were made based on the Braun-Blanquet method using the classic abundance/cover scale proposed by Braun-Blanquet (Braun-Blanquet 1964).

To compare the species composition with vegetation dominated by the black pine in other parts of Mediter-

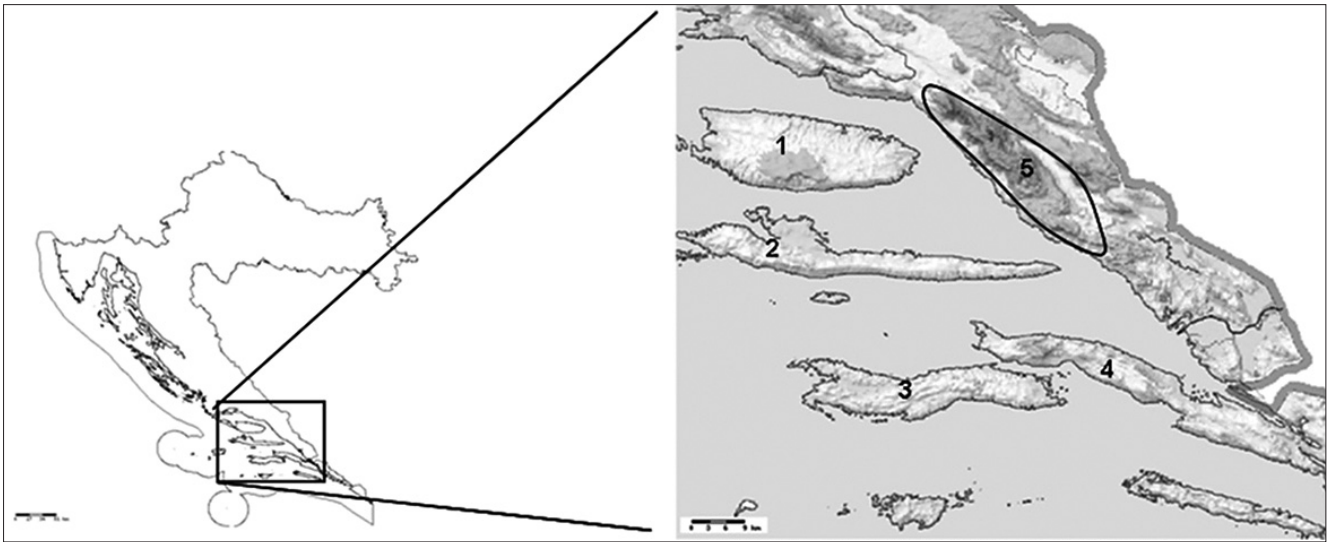


Figure 1. Geographical position of the study area. Islands of Brač (1), Hvar (2), Korčula (3), the Pelješac Peninsula (4) and Biokovo Mountain (5).

Slika 1. Zemljopisni položaj proučavanih područja. Otoki Brač (1), Hvar (2), Korčula (3), poluotok Pelješac (4) Biokovo (5).

reanean we used data from Dalmatia, Eastern, Central and West Mediterranean taken from Bergmeier 1990 and 2002, Brullo & al. 2001 Sánchez-Gómez &

Alcaraz 1992. As in all mentioned areas, from which data was taken, there is a different taxon of *Pinus nigra* complex. All were treated as one taxon *Pinus nigra* s.l.

Data processing – Obrada podataka

The relevé table based on the Braun-Blanquet scale was transformed into a data matrix using the Van der Maarel 1979 ordinal transformation for further statistical analysis. The table was purified before transformation by removing species with only one and two appearances, thus reducing the total number of species from 239 to 193 species. A cluster analysis was performed on this data matrix using the Bray-Curtis distance (Bray & Curtis 1957) as a resemblance measure, and the UPGMA (group average) linkage as clustering method. Indicator species analysis (Dufrene & Legendre 1997) was then performed on the groups defined by the clustering results to obtain the optimal number of clusters. Relevés were clustered into a different number of clusters (3, 5, 6, 7, 9, 12 and 15) using a cluster dendrogram. The optimal number of

clusters in the cluster analysis was obtained using the lowest average probability value, computed in separate indicator species analyses for each number of clusters (McCune & Grace 2002). The probability value was computed using the Monte Carlo permutation test with 4999 random permutations. Species with indicator values over 50.0 ($IV > 50$) and a probability level under 0.05 ($p < 0.05$) were then marked as indicator species (McCune & Grace 2002). Synoptic table with combined data from Dalmatia and other parts of Mediterranean was used to make data matrix on which Nonmetric multidimensional scaling (NMS) using the Bray-Curtis distance (Bray & Curtis 1957) as a resemblance measure was performed. Numerical analyses were done using PCOrd 5.0 software (McCune & Mefford 1999).

Results – Rezultati

According to the ISA analysis and its method of dendrogram pruning, the obtained optimal number of clusters was 7. Figure 2 represents the group average clustering dendrogram divided according to this result.

In our research, on these newly formed clusters we can distinguish different syntaxa, determined by the relevé authors and grouped in clusters based on the cluster analysis and ISA.

Inspection of this dendrogram shows a clear separation of the cluster marked as number 7, which includes relevés of the higher (1150–1400 m) parts of Biokovo,

taken by Domac 1965 and phytosociologically defined as the *Junipero sibiricae* - *Pinetum dalmaticae* association. This cluster is separated at the beginning of clustering and is completely distinguished from all other relevé groups. The syntaxonomical classification of relevés from cluster 7 is the object of this research.

Clusters 1–6 are separated on the other side and are composed of relevés from the coastal part of the Dalmatian pine distribution area and of three relevés from the lower part of Biokovo Mountain. Cluster 1 comprises relevés taken by Domac 1965 on the islands of

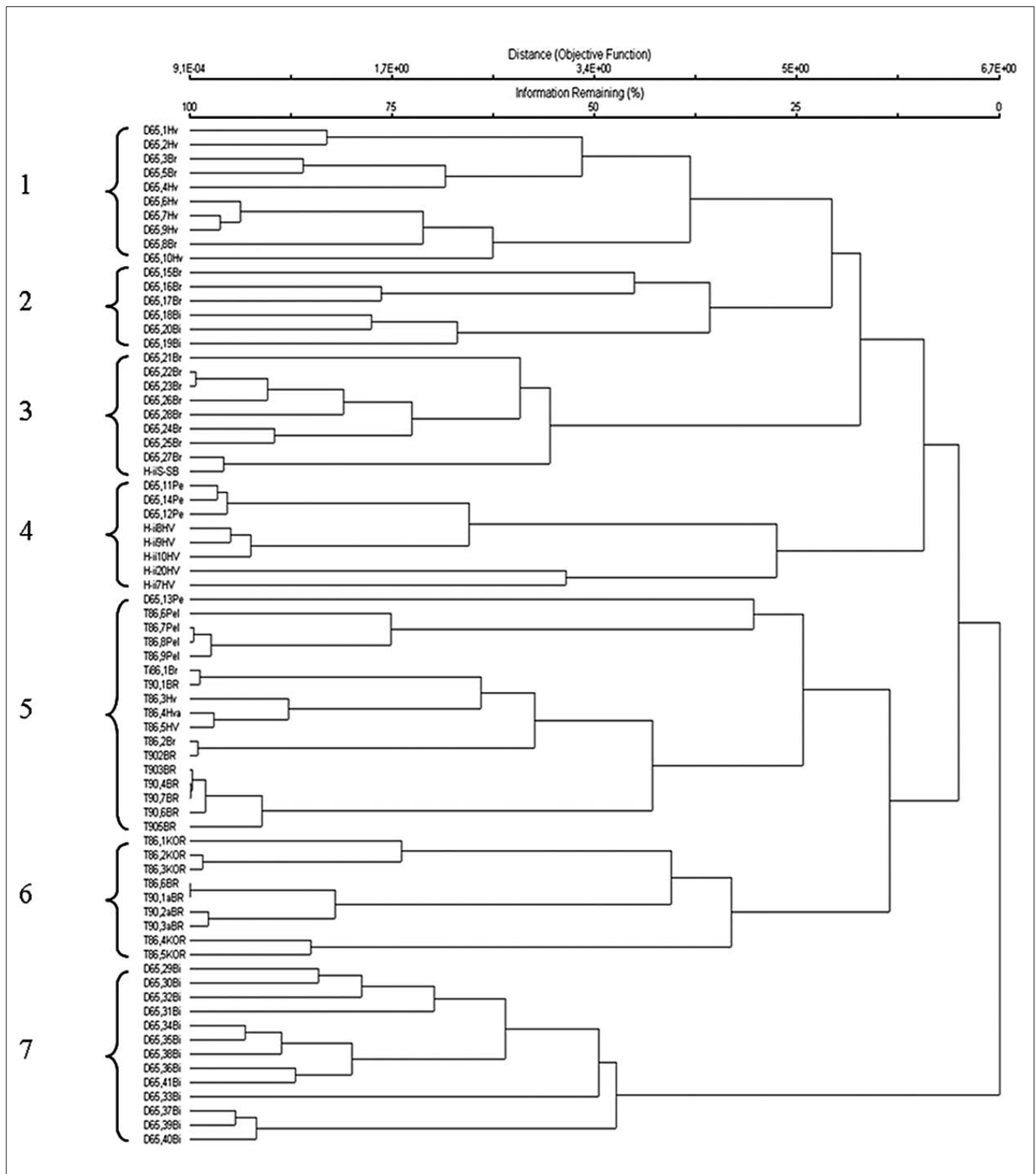


Figure 2. Cluster analysis dendrogram divided into 7 groups according to ISA analysis results.

Slika 2. Dendrogram klusterske analize podijeljen u 7 grupa prema rezultatima ISA analize.

Hvar and Brač, at altitudes of 300-500 m. Those relevés are classified by the author as *Orno-Quercetum ilicis pinosum dalmaticae* for the first five relevés, and as *Erico-Rosmarinetum pinosum dalmaticae*.

In cluster 2, there are six relevés, three from the island of Brač and three from the lower part of Biokovo Mountain. All the relevés were taken by Domac 1965 at alti-

tudes of 460-900 m a.s.l and the author classified them as *Seslerio-Ostryetum carpinifoliae pinetosum dalmaticae*.

Cluster 3 comprises relevés taken only on the island of Brač at altitudes of 600-740 m. One relevé was made by Horvatić 1958 and the rest by Domac 1965. Altitudes vary between 600 and 740 m. Both authors determined the relevés as the *Stipo-Salvietum officinalis pinetosum dal-*

maticae subassociation. This is the only cluster syntaxonically classified into the grassland order and class.

In cluster 4 there are 8 relevés, three made by Domac 1965 on the Pelješac peninsula and five taken by Horvatić 1958 on the island of Hvar. Seven relevés are classified as *Genisto-Ericetum verticillatae pinetosum dalmaticae*, taken at 500-800 m, and only one relevé as *Erico-Rosmarinetum pinetosum dalmaticae*, taken at 300 m.

Cluster 5 comprises sixteen relevés made by Trinajstić 1986 and 1990 on the Pelješac peninsula and on the islands of Hvar and Brač, and one relevé made by Domac 1965 on the Pelješac peninsula. The sixteen

relevés in this cluster were taken and classified by Trinajstić as *Erico manipuliiflorae-Pinetum dalmaticae*. The relevé taken by Domac was classified as *Genisto-Ericetum verticillatae pinetosum dalmaticae*.

Cluster 6 includes relevés taken and classified by Trinajstić 1986 and 1990 on the islands of Brač and Korčula. He classified them as *Quercu ilicis-Pinetum dalmaticae*.

The results of the indicator species analysis are shown in Table 1. Two species have the maximal possible indicator value ($IV=100$) for cluster 7 from the cluster analysis, *Juniperus communis* L. ssp. *nana* Syme and *Sesleria robusta* Schott, Nyman & Kotschy.

Table 1. Indicator species for cluster 7 with an indicator value (IV) higher than 50 and p lower than 0.05 for *Junipero sibiricae -Pinetum dalmaticae* determined using ISA

Tablica 1. Indikatorske vrste za klaster 7 s indikatorskom vrijednosti (IV) većom od 50 i p nižim od 0,05 za *Junipero sibiricae -Pinetum dalmaticae* određen korištenjem ISA metode

Species	Observed indicator value (IV)	IV from randomised groups		
		Mean	S.Dev	p *
<i>Arenaria serpyllifolia</i> L.	53,8	9,6	4,99	0,0002
<i>Asplenium ruta-muraria</i> L.	53,8	9,6	5,23	0,0002
<i>Asplenium trichomanes</i> L.	53,8	9,5	5,14	0,0004
<i>Cerastium grandiflorum</i> Waldst. & Kit	69,2	10,1	4,88	0,0002
<i>Vincetoxicum hirundinaria</i> Medik. ssp. <i>adriaticum</i> (Beck) Margr.	69,2	10,1	5,03	0,0002
<i>Juniperus communis</i> L. ssp. <i>nana</i> Syme.	100	11,3	4,81	0,0002
<i>Muscari botryoides</i> (L.) Mill.	84,6	10,6	4,9	0,0002
<i>Polygala vulgaris</i> L.	92,3	10,8	4,74	0,0002
<i>Sesleria robusta</i> Schott, Nyman & Kotschy	100	11,2	4,84	0,0002

Figure 3 represents the result of Nonmetric Multidimensional Scaling (NMS) ordination scatterplot using Bray Curtis as distance measure. The data that entered this analysis came from relevés of different local associations from all round Mediterranean (Dalmatian coast, Greece, Iberian Peninsula and Corsica and Sicily, all belonging to *Pino-Juniperetea* class). Associations are clearly divided into three groups. They are divided biogeographically, as the western, central and eastern group of their Mediterranean distribution of *Pinus nigra* s.l. (Van Haverbeke 2009). On NMS scatterplot the associations are grouped the same way. Group 1 consists of associations from Dalmatia and Greece and as such makes the eastern biogeographical group. In this group there are also, and very close ordinated together, *Junipero sibiricae-Pinetum dalmaticae* and *Sesleria robustae-Pinetum pallasianae*. Association *Sesleria robustae-Pinetum pallasianae* Barbéro & Quézel 1976 corr. Bergmeier 1990 was included by Bergmeier 1990, and following Horvat's 1959 concept, into

alliance *Orno-Ericion* Horvatić 1959 and *Erico-Pinetea* class. In contrast, Brullo & al. 2001 considers that *Sesleria robustae-Pinetum pallasianae* association should be classified into west Mediterranean class *Pino-Juniperetea* Rivas-Martínez 1964.

Group 2 consists of associations from Iberian peninsula and as such makes the western Mediterranean group. Group 3 makes the central Mediterranean group with associations from Sicily and Corsica.

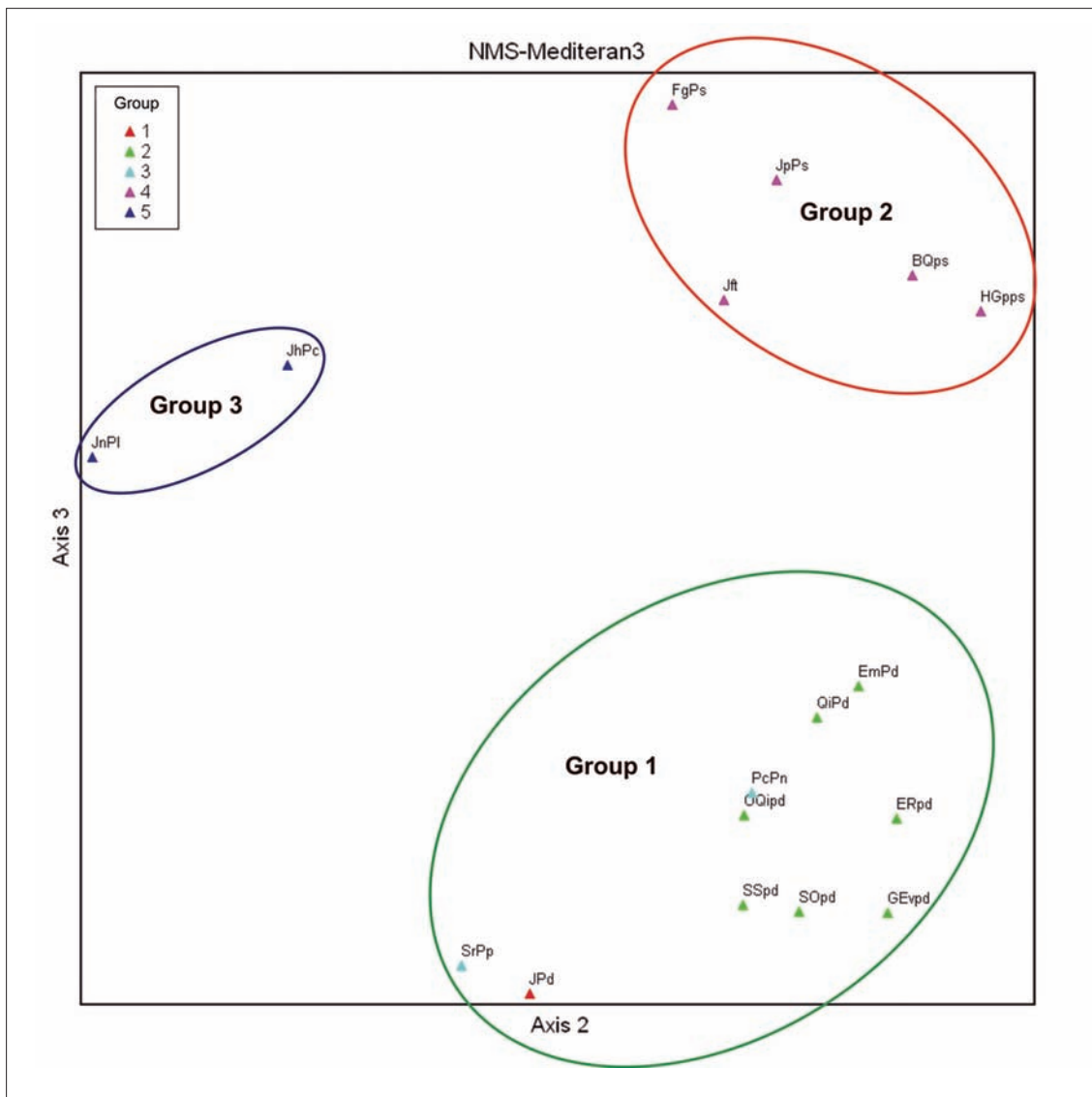


Figure 3. Nonmetric Multidimensional Scaling (NMS) ordination scatterplot of forest vegetation dominated by *Pinus nigra* s.l.

Slika 3. Ordinacijski dijagram raspšenja metode Nemetričko višedimenzionalno skaliranje (NMS) šumske vegetacije dominirane vrstom *Pinus nigra* s.l.

Legend/Legenda: JPd – *Junipero sibiricae-Pinetum dalmaticae* Domac (1956) 1965, SOpd – *Seslerio-Ostryetum carpinifoliae pinetosum dalmaticae* Horvatić 1958, SSpd – *Stipo-Salvietum officinalis pinetosum dalmaticae* Horvatić 1958, ERpd – *Erico-Rosmarinetum pinetosum dalmaticae* Horvatić 1958, OQipd – *Orno-Quercetum ilicis pinosum dalmaticae* Horvatić 1958, GEvpd – *Genisto-Ericetum verticillatae pinetosum dalmaticae* Horvatić 1958, EmPd – *Erico manipuliflorae-Pinetum dalmaticae* Trinajstić 1977, QiPd – *Quercu ilicis-Pinetum dalmaticae* Trinajstić 1986, PcPn – *Pyrolo chloranthae-Pinetum nigrae* Bergmeier 2002, SrPp – *Seslerio robustae-Pinetum pallasianae* Barbéro et Quézel 1976 corr. Bergmeier 1990, FgPs – *Festuco gautieri-Pinetum salzmannii* Regato 1992, JpPs – *Junipero phoeniceae-Pinetum salzmannii* Valle et al. 1988, Jptpc – *Juniperetum phoeniceo-thuriferae pinetosum clusianae* Sánchez-Gómez et Alcaraz 1992, HGpps – *Hedero-Genistetum patentis pinetosum salzmannii* Regato 1992, BQps – *Bupleuro-Quercetum rotundifoliae pinetosum salzmannii* Regato et al. 1995, JnPl – *Junipero nanae-Pinetum laricionis* Brullo et al. 2001, JhPc – *Junipero hemisphaericae-Pinetum calabricae* Brullo et Siracusa 2001).

DISCUSSION – Rasprava

According to Domac 1965, Trinajstić 1986 and 1990 and Horvatić 1958, all vegetation types found containing Dalmatian pine were syntaxonically classified into the higher level syntaxa present in Croatia. For all types of forests dominated by Dalmatian pine, except *Junipero sibiricae-Pinetum dalmaticae*, good arguments can be found for such classification, although

there is also space for a detailed discussion. Our research has established that *Junipero sibiricae-Pinetum dalmaticae* is completely different by its species assemblage from all other communities dominated by Dalmatian pine. Domac 1965 classified *Junipero sibiricae-Pinetum dalmaticae* into deciduous thermophilous forests of the *Quercetalia pubescentis* order,

and the *Carpinion orientalis* Horvat 1958 alliance from *Querc-Fagetea* class, based on presence of more species from these syntaxa. However species from this order are present here with a low constancy. Further more, *Junipero sibiricae -Pinetum dalmaticae* is not a deciduous forest, it does not have deciduous tree species, and bushes are present with a low constancy. This association is rather dwarf shrub-like vegetation dominated by Dalmatian pine.

Domac 1965 specifies *Pinus nigra* subsp. *dalmatica* and *Sesleria robusta* as characteristic species and *Juniperus communis* L. ssp. *nana*, *Cerastium grandiflorum* Waldst. & Kit. and *Cynanchum adriaticum* Beck (Fritsch) as differential species to differentiate this vegetation from others containing *Pinus nigra* subsp. *dalmatica*. All these species, except Dalmatian pine, have a high indicator value (*IV*) for the specific cluster in our analysis. In contrast, *Pinus nigra* subsp. *dalmatica* did not have any statistically significant indicator value because of its presence on both the coastal part and on Biokovo Mountain. Therefore, Dalmatian pine cannot be taken into account as a characteristic species for the *Junipero sibiricae -Pinetum dalmaticae* association.

Trinajstić 1986 had a different approach. He classified *Junipero sibiricae -Pinetum dalmaticae* into *Erico-Pinetea* class. Horvat 1958, while defining this class, made species composition more relative, by using mutual supraregional characteristics. Therefore he indicated as class' characteristic species ones also characteristic for other termophilous syntaxa. This way there are as much arguments for classifying *Junipero sibiricae -Pinetum dalmaticae* into *Erico-Pinetea* and *Erico-Pinetalia* as there are for *Quercetalia pubescentis*. *Erico-Pinetea* according to its concept comprises termophilous coniferous forests, but in a more continental areas without expressed summer drought, which is present near the coast where Biokovo mountain is situated. Similar concept represents Bergmeier 1990 who classified *Sesleria robusta -Pinetum pallasianae* also into *Erico-Pinetea*.

The ISA showed species of different distribution areas as indicator species. *Juniperus communis* L. ssp. *nana* reveals a eurasiatic distribution, and, in this study, is determined as one of the two most important indicator species. Several indicator species show rather montane and alpine conditions present in *Junipero sibiricae -Pinetum dalmaticae* habitats. Together with these species, there are three species of endemic chorotype (Pignatti 2005): *Sesleria robusta*, defined by Domac 1965 as characteristic, and *Cynanchum adriaticum* and *Cerastium grandiflorum* as differential species for this association. All three species are distributed on the coastal part of Croatia and Dinaric Alps. *Sesleria robusta* is, with the same in-

dicator value (*IV*) and probability (*p*) value as *Juniperus communis* L. ssp. *nana*, the second most indicative species. Out of these two species, *Sesleria robusta* shows Mediterranean, and *Juniperus communis* L. ssp. *nana* alpine characteristics. *S. robusta* is a species of an endemic chorotype (Pignatti 2005). It is distributed in the central Mediterranean (Pignatti 1982b), and in central and southern Dalmatia (FCD 2007), which gives a Mediterranean ecological character to this association. On the other hand, *Juniperus communis* L. ssp. *nana* is an alpine species (Vidaković 1982). This suggests that the habitats of *Junipero sibiricae -Pinetum dalmaticae* have both Mediterranean and alpine ecological characteristics on Biokovo Mountain. Based on these species and their characteristics, we decided to carry out a new approach for the taxonomical classification of *Junipero sibiricae -Pinetum dalmaticae*.

In spite the fact there are not many floristic arguments, but accepting the concept of mutual ecological, bio geographical and structural characteristics, we believe that *Junipero sibiricae -Pinetum dalmaticae* should not be put in *Quercetalia pubescentis*, nor into *Erico-Pinetea*, but into *Pino-Juniperetea* class. This class was first described by Rivas-Martínez 1964 in west Mediterranean and it comprises a group of orophilous woody communities dominated by gymnosperms occurring in Spain. The structure of this vegetation is generally consisted by tree layer with more or less open canopies, thick shrub layer, and rather poor species assemblage. It also has relic character (Pignatti 1985, 1998; Brullo & al. 2001). Nowadays more associations are described from *Pino-Juniperetea* class, scattered throughout the Mediterranean area. Vegetation belonging to this class is on arid soil and is a final stage of climatogenous vegetation for southern Eurosiberian and Mediterranean areas (Rivas-Martínez & al. 1991). *Pino-Juniperetea* class consists of orophilous communities dominated by conifers and its range extends to the whole Mediterranean basin. Brullo & al. 2001 have expanded the distribution area of the *Pino-Juniperetea* into eastern Mediterranean describing the eastern Mediterranean alliance *Berberido creticae -Juniperion foetidissima* Brullo & al. 2001 which is distributed in Greece, Cyprus and western and southern Anatolia. This alliance belongs to *Juniperetalia haemisphaericae* Rivas-Martínez & Molina 1999 order distributed in central and eastern Mediterranean.

Within the *Pino-Juniperetea* class the pioneer orophilous vegetation counts, in general, quite a low number of specialized species. In spite of this, the lack of character species is compensated by their high biogeographic significance and allegiance to a precise ecological context. *Pino-Juniperetea* communities ac-

cept a large number of endemics and these species contribute to territorial autonomy of these orophilous communities (Brullo & al. 2001).

The NMS in our study showed that according to species assemblage *Seslerio robustae-Pinetum pallasianae* association is the most resembling with *Junipero sibiricae-Pinetum dalmaticae*. The *Seslerio robustae-Pinetum pallasianae* association is a pioneer forest with a tree layer formed by a local subspecies of *Pinus nigra* s.l., *P. nigra* Arnold subsp. *pallasiana* (Lamb.) Holmboe. The constant dwarf shrub *Juniperus communis* L. subsp. *nana* is dominant in the shrub layer, while the grass species *Sesleria robusta* is dominant in the ground layer, just as in the Dalmatian pine forests on Biokovo. This vegetation occurs on slopes at altitudes from 1,000 and 1,300 m. It is an open pine-wood, primarily occurring on rocky soils (Brullo & al. 2001). It was previously classified to the *Quercetalia pubescentis*, as was *Junipero sibiricae-Pinetum dalmaticae* which shows similar conditions on habitats where these associations are found. According to Habitat Classification 2003, forests of Dalmatian pine and Pallas's pine forests are both classified in the same classification group of Mediterranean pine forests with endemic black pines. These forests are of the montane-Mediterranean level, on dolomitic substrate dominated by pines of the *Pinus nigra* group. Both *Pinus nigra* subsp. *pallasiana* and *Pinus nigra* subsp. *dalmatica* are said to be distributed on the Balkan area (Habitat Classification 2003) and appear morphologically and genetically quite similar (Isajev & al. 2004). *Seslerio robustae-Pinetum pallasianae* is an association very similar to *Junipero sibiricae-Pinetum dalmaticae* with regard to ecological and phytogeographical attributes, but also concerning its characteristic species structure. This similarity can be explained by the fact that Biokovo is somewhat similar, in some aspects, to

mountains outside the coastal Dinaric Alps. The vegetation similarity and the analogy of the phytocenoses of Biokovo are especially distinct in comparison to mountains in Macedonia and Greece (Lovrić 1987) where the mentioned alliance is found.

Because *Junipero sibiricae-Pinetum dalmaticae* is not climazonal vegetation, but rather a local association found in specific conditions, it is rather hard to classify it only by characteristic species. Characteristic species for such specific and locally distributed associations also have a local character, and are often endemic. Therefore, this association has been difficult to classify into the syntaxonomical system only according to the number of characteristic species. Other features, exceeding regional ones, should be included. These specific features are recognised in the Habitat Classification 2004 where Mediterranean endemic pines forest have a separate classification group.

Our analysis suggests that the association Domac 1965 described is well defined and differs from other vegetation types with Dalmatian pine that occur in the Dalmatian area. However, based on floristic and ecological elements we consider that the association *Junipero sibiricae-Pinetum dalmaticae* should be classified in the *Pino-Juniperetea* class, the *Juniperetalia haemisphaericae* order, the *Berberido craeticae-Juniperion foetidissimae* alliance. It can be expected that such a local vegetation type includes local endemic taxa, such as *Pinus nigra* subsp. *dalmatica* regarding the phytogeographical particularity of Biokovo Mountain, and *Pinus nigra* subsp. *pallasiana*, of which both give their vegetation type special characteristics. Further more, classifying it into *Pino-Juniperetea* emphasises the relic character of the Mediterranean forests dominated by *Pinus nigra* s.l. which they without a doubt have (Brullo & al. 2001), whereas a classification into any other class would repress this aspect into the background.

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Appendix 1. Synoptic table of *Junipero sibiricae -Pinetum dalmaticae* Domac (1956) 1965 and *Seslerio robustae-Pinetum pallasianae* Barbéro et Quézel 1976 corr. Bergmeier 1990.

Dodatak 1. Sintetska tablica *Junipero sibiricae -Pinetum dalmaticae* Domac (1956) 1965 i *Seslerio robustae-Pinetum pallasianae* Barbéro et Quézel 1976 corr. Bergmeier 1990.

	<i>Junipero sibiricae - Pinetum dalmaticae</i>	<i>Seslerio robustae-Pinetum pallasianae</i>			
			Ranunculus sartorianus	.	II
			Char. ass. Seslerio-Ostryetum, Ostryo Carpinion, Quercetalia pubescentis, Quercu-Fagetia		
			Acer monspessulanumB	II	.
			Carex humilis	II	.
			Cnidium silaifolium	II	.
			Satureja montana	II	.
			Trifolium alpestre	II	.
			Colutea arborescensC	I	.
			Crataegus monogynaC	I	.
			Dorycnium germanicum	I	.
			Fraxinus ornusB	I	.
			Prunus mahalebB	I	.
			Rhamnus rupestrisB	I	I
			Sesleria autumnalis	I	.
			Char. ass. Stipo-Salvietum		
			Salvia officinalis	II	.
			Char. class Brachypodio-Chrysopogonetea		
			Aethyonema saxatile	IV	I
			Bromus erectus	IV	.
			Sanguisorba muricata	IV	.
			Euphorbia myrsinites	III	.
			Brachypodium pinnatum	II	.
			Dorycnium herbaceum	II	.
			Sesleria juncifolia	II	.
			Globularia cordifolia	II	.
			Euphorbia spinosa	I	.
			Stachys subcrenata	I	.
			Teucrium montanum	I	.
			Species of screes and rocky habitats		
			Cynanchum adriaticum	IV	.
			Asplenium ceterach	III	.
			Asplenium ruta muraria	III	.
			Asplenium trichomanes	III	.
			Campanula portenschlagiana	III	.
			Arabis muralis	II	.
			Inula verbascifolia	II	.
			Linaria cymbalaria	II	.
			Moltkia petraea	II	.
			Cephalaria leucantha	I	.
			Rumex scutatus	I	.
			shrubs		
			Abies borissii regisA	.	V
			Quercus daleschampii	.	V
Number of releves	14	13			
Dominant canopy species					
Pinus nigra s.l.A	V	V			
Char. ass. Seslerio robustae-Pinetum pallasianae, Junipero-Pinetum dalmaticae					
Sesleria robusta C	V	V			
Juniperus communis subsp. nanaC	V	V			
Species of Pino-Juniperetea					
Juniperus sabinaC	II	.			
Char. alliance Berberido craeticae-Juniperion foetidissimae, Juniperetalia haemisphaericae, Pino-Juniperetea					
Chamaecytisus polytrichus	.	V			
Daphne oleoides	.	V			
Ferulago sylvatica	.	V			
Centaurea pindicola	.	IV			
Daphne blagayana	.	IV			
Trifolium alpestre	II	III			
Cardamine glauca	.	II			
Cytisus procumbens	.	II			
Aremonia agrimonoides	.	V			
Polygala nicaeensis	.	V			
Brachypodium sylvaticum	.	III			
Eryngium amethystinum	.	III			
Sanguisorba minor	.	III			
Lonicera etruscaB	.	II			
Teucrium chamaedrys	I	II			
Juniperus oxycedrusB	.	V			
Pinus nigra var caramanicaA	.	V			
Pinus nigra var caramanicaB	.	V			
Pinus nigra var caramanicaC	.	V			
Crocus veluchensis	.	III			
Cyclamen hederifolium	.	III			
Doronicum orientale	.	III			
Galium rotundifolium	.	III			
Luzula forsteri	.	III			
Pteridium aquilinum	.	III			
Veronica chamaedrys	.	III			
Fragaria vesca	I	II			
Leontodon cichoriaceus	.	II			

Rosa arvensis	.	IV	Hieracium biokovoense	II	.
Fagus sylvatica	.	III	Hieracium psamogenes	II	.
Abies borissii regisB	.	II	Lathyrus pratensis	II	.
Berberis cretica	.	II	Lilium martagon subsp. cattaniae	II	.
Crataegus orientalis	.	II	Luzula multiflora	II	.
Ilex aquifolium	.	II	Poa bulbosa ssp. vivipara	II	.
Erica arborea	.	I	Poa pumila	II	.
Rhamnus rupestris	.	I	Ranunculus montanus subsp.		
Sorbus torminalis	.	I	carinthiacus	II	.
Serpentin species			Thalictrum aquilegifolium	II	.
Festuca callieri	.	III	Thymus balcanus	II	.
Anthemis cretica	.	II	Tragopogon balcanicus	II	.
Asperula thessala	.	II	Valeriana tuberosa	II	.
Asyneuma linifolium	.	II	Cerastium campanulatum	I	.
Centaurea grisebachii	.	II	Leontodon crispus	I	.
Cuscuta epithymum	.	I	Medicago orbicularis	I	.
Danthonia alpina	.	I	Ononis spinosa	I	.
Thymus candilicus	.	I	Plantago lanceolata	I	.
Forest species			Rhamnus fallaxC	I	.
Lathyrus alpestris	.	IV	Rhamnus saxatilisC	I	.
Luzula sylvatica	.	IV	Veronica dentata subsp. austriaca	I	.
Potentilla micrantha	.	IV	Genista carinalis	.	V
Silene multicaulis	.	IV	Carlina acanthifolia	.	IV
Bromus benekenii	.	II	Galium exaltata	.	IV
Limodorum abortivum	.	II	Hieracium bauhinii	.	IV
Physospermum cornubiense	.	II	Platanthera chlorantha	.	IV
Primula vulgaris	.	II	Thymus sibthorpii	.	IV
Comp.			Viola riviniana	.	IV
Bunium montanum	V	.	Anthoxanthum odoratum	.	II
Muscari botryoides	V	.	Brachypodium rupestre	.	II
Polygala vulgaris	V	.	Briza media	.	II
Cerastium grandiflorum	IV	.	Campanula spathulata subsp.		
Arenaria serpyllifolia	III	.	sprunerana	.	II
Carduus candicans subsp. cyllindricus	III	.	Carlina vulgaris	.	II
Cerastium viscosum	III	.	Centaurea deusta	.	II
Festuca rubra subsp. fallax	III	.	Dactylis glomerata	.	II
Lotus hirsutus	III	.	Dactylorhiza romana	.	II
Satureja acinos	III	.	Hieracium pilosella	.	II
Trifolium pratense var. nivale	III	.	Lilium chalcedonicum	.	II
Armeria canescens	II	.	Lychnis viscaria	.	II
Asperula longifolia	II	.	Thesium linophyllum	.	II
			Veronica officinalis	.	II

Appendix 2. Syntaxonomy of mentioned syntaxa.

Dodatak 2. Sintaksonomija spomenutih sintaksona.

Quercetea ilicis Br.-Bl. 1947*Quercetalia ilicis* Br.-Bl. (1931) 1936*Quercion ilicis* Br.-Bl. 1936*Orno-Quercetum ilicis pinosum dalmaticae* Horvatić 1958*Quercio ilicis-Pinetum dalmaticae* Trinajstić 1986*Bupleuro-Quercetum rotundifoliae*(Br.-Bl. &O. de Bolos 1957) Rivas-Matrinez 1982 *pinetosum salzmännii* Regato et al. 1995*Hedero-Genistetum patentis* Mateo 1983 *pinetosum salzmännii* Regato 1992*Erico-Cistetea* Trinajstić 1985*Cisto-Ericetalia* Horvatić 1958*Cisto-Ericion* Horvatić 1958*Erico-Rosmarinetum pinetosum dalmaticae* Horvatić 1958*Genisto-Ericetum verticillatae pinetosum dalmaticae* Horvatić 1958*Erico-Pinetea* Horvat 1959*Erico-Pinetalia* Horvat 1959*Orno-Ericion* Horvat 1956*Erico manipuliflorae-Pinetum dalmaticae* Trinajstić 1977

- Quercus-Fagetea* Br.-Bl. Et Vlieger 1937
Quercetalia pubescentis Br.-Bl. (1931) 1932.
Carpinion orientalis Horvat (1954) 1959
Seslerio-Ostryetum carpinifoliae pinetosum dalmaticae Horvatić 1958
Junipero sibiricae -Pinetum dalmaticae Domac (1956) 1965
- Brachypodio-Chrysopogonetea* H-ić (1956) 1958
Scorzonero-Chrysopogonetalia H-ić et Horv. (1956) 1958
Chrysopogoni-Satureion Horv. Et H-ić 1934
Stipo-Salvietum officinalis pinetosum dalmaticae Horvatić 1958
- Pino-Juniperetea* Rivas-Martinez 1964
Juniperetalia haemisphaericae Rivas –Martínez & Molina 1999
Berberido creticae-Juniperion foetidissimae Brullo & al. 2001
Seslerio robustae-Pinetum pallasianae Barbéro et Quézel 1976 corr. Bergmeier 1990
Berberidion aetnensis Brullo, Giusso et Guarino 2001
Pineion calabrica Brullo, Giusso et Guarino 2001
Junipero hemisphaericae-Pinetum calabrica Brullo et Siracusa 2001
Roso-serafinii-Juniperion nanae Brullo, Giusso & Guarino 2001
Junipero nanae-Pinetum laricionis Brullo et al. 2001
- Pino-Juniperetalia* Rivas-Matrinez 1964
Pino-Juniperion sabiniae Rivas-Goday (1956) 1960
Festuco gautieri-Pinetum salzmännii Regato 1992
Junipero phoeniceae-Pinetum salzmännii Valle et al. 1988
Juniperion turiferae Rivas-Martinez 1969
Juniperetum phoeniceo-thuriferae pinetosum clusianae Sánchez-Gómez et Alcaraz 1992,
- Quercetalia pubescentis-petreae* Klika 1933
Abietion cephalonicae Horvat et al. 1974
Pyrolo chloranthae-Pinetum nigrae Bergmeier 2002

SAŽETAK: *Junipero sibiricae-Pinetum dalmaticae Domac (1956) 1965* karakterizira *Pinus nigra subsp. dalmatica (Vis) Franco* – endemična svojta prisutna u obalnom području te nekim otocima južne Dalmacije, ali i na južnim padinama Dinarida (Biokovo), na nadmorskim visinama od 350 do 1000 m. Uz jak utjecaj mediteranske klime koja je izražena do viših dijelova planine, zbog svoje nadmorske visine prisutni su i oslabljeni planinski i alpski uvjeti na samim vrhovima. Budući da je Biokovo na granici mediteranske i eurosibirsko-sjevernoameričke regije, u istraživanoj zajednici prisutne su vrste iz obje regije, što povećava posebnost zajednice.

Mnogi znanstvenici su se do sada bavili sintaksonomskim položajem zajednice *Junipero sibiricae-Pinetum dalmaticae*, ali je uvijek opisivana kao jedinstven tip vegetacije.

Šume s crnim borom (*Pinus nigra s.l.*) često u svojoj strukturi imaju velik broj lokalnih, za razliku od zonalne vegetacije. Zato zajednice s crnim borom, prisutne na različitim područjima mediterana, imaju mali broj međusobno podudarajućih vrsta i više izražene lokalne florističke karakteristike, nego što to imaju drugi, zonalni, tipovi vegetacije.

Prema trenutnim sintaksonomskim rješenjima, istraživana zajednica pripada submediteranskoj svezi *Carpinion orientalis unutar reda Quercetalia pubescentis* u razredu *Quercus-Fagetea*. Cilj ovoga rada bio je analizirati ekološke i sintaksonomske karakteristike zajednice *Junipero sibiricae-Pinetum dalmaticae*.

Za analiziranje podataka upotrijebili smo klustersku analizu, analizu prema indikatorskim vrstama (ISA) te nemetričko višedimenzionalno skaliranje (NMS).

Pomoću klusterske analize te ISA, uspoređivali smo sve sintaksone u kojima dominira dalmatinski bor, dok smo pomoću nemetričkog višedimenzionalnog skaliranja (NMS) uspoređivali šume u kojima dominira vrsta *Pinus nigra* s.l. u ostalim dijelovima Mediterana (Grčka, Pirenejski poluotok, Korzika i Sicilija) sa istraživanom zajednicom u Hrvatskoj.

Numeričke i sintaksonomske analize pokazuju da se zajednica *Junipero sibiricae-Pinetum dalmaticae* sa Biokova razlikuje od ostalih vegetacijskih tipova s dalmatinskim borom. Klusterska analiza pokazala je da se *Junipero sibiricae-Pinetum dalmaticae* jasno odvaja od ostalih sintaksona (Slika 2) u kojima dominira *Pinus nigra* subsp. *dalmatica*, dok su pomoću ISA (Tablica 1) utvrđene indikatorske vrste koje ju odvajaju, ponajprije *Juniperus communis* L. subsp. *nana* Syme te *Sesleria robusta* Schott, Nyman & Kotschy. NMS metodom pokazana je bliskost zajednice *Junipero sibiricae-Pinetum dalmaticae* s grčkom zajednicom *Seslerio robustae-Pinetum pallasianae* Barbéro & Quézel 1976 corr. Bergmeier 1990 (Slika 3) te njihovo zajedničko grupiranje odvojeno od ostalih mediteranskih zajednica s crnim borom, grupiranih prema geografskom području na kojemu su prisutne (zapadni i centralni mediteran). Ova je zajednica također pionirska, a sloj drveća formira *Pinus nigra* subsp. *pallasiana*. Struktura ovih zajednica je također međusobno vrlo slična, sloj drveća u kojemu dominira vrsta *Pinus nigra* s.l. s manje više otvorenim sklopom krošanja, gusti sloj niskog grmlja koje uglavnom čini *Juniperus communis* subsp. *nana* i relativno mali broj prizemnih vrsta u kojemu dominira *Sesleria robusta*. Obje zajednice javljaju se na sličnim nadmorskim visinama te imaju slične ekološke i biljnogeografske karakteristike, a prema klasifikaciji staništa iz 2003 uvrštene su u istu skupinu, Mediteranske šume s endemskim vrstama crnoga bora. Time smo utvrdili da bi istraživana zajednica trebala biti klasificirana unutar razreda *Pino-Juniperetea*, reda *Juniperetalia haemisphaericae* i istočnomediteranske sveze *Berberido creticae-Juniperion foetidissimae*. Zajednice prisutne u ovome razredu raspršene su po cijelom području mediterana, a vegetacija koja mu pripada nalazi se na suhom tlu i završni je stadij klimazonalne vegetacije za južna eurosibirska i mediteranska područja. Zajednice razreda *Pino-Juniperetea* sadržavaju mnoge endemske vrste koje pridonose njihovoj teritorijalnoj autonomiji.

Sličnost zajednice *Junipero sibiricae-Pinetum dalmaticae* sa istočnomediteranskim zajednicama i njezino uvrštavanje u spomenute sintaksone fitocenološki i ekološki je potvrđena.

Ključne riječi: Biokovo, multivarijatna analiza, *Pinus nigra* subsp. *dalmatica*, sintaksonomija