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PHYTOCOENOLOGICAL CHARACTERISTICS OF BEECH FORESTS ON THE SOUTHERN SLOPES OF MEDVEDNICA

FITOCENOLOŠKE ZNAČAJKE BUKOVIH ŠUMA NA JUŽNIM OBRONCIMA MEDVEDNICE

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Abstract

Phytocoenological research of beech forests comprised the southern slopes of Medvednica in the broader area of Adolfovac. Two forest communities were identified by means of phytocoenological relevés based on the standard method of the Central European Phytocoenological School and on statistical testing of the results. These are beech forest with woodrush (*Luzulo-Fagetum*) and beech forest with deadnettle (*Lamio orvalae-Fagetum*). Although these communities have already been described in Croatia, this is the first time that they have been identified in the study area. Phytocoenological analysis was accompanied by an ecological characterization of particular ecological factors on the basis of Ellenberg's values of the floristic composition. The compared sites and communities showed significant differences in terms of light, humidity, acidophility and nutrient content.

Key words: forest communities of common beech, floristic composition, Medvednica, Ellenberg, ecoindicator values

Sažetak

Na južnim padinama Medvednice, u širem području Adolfovca, provedena su fitocenološka istraživanja bukovih šuma. Fitocenološkim snimanjem standardnom metodom srednjoeuropske fitocenološke škole i statističkom provjerom rezultata utvrđene su dvije šumske zajednice: šuma bukve s bekicom (*Luzulo-Fagetum*) i šuma bukve s mrtvom koprivom (*Lamio orvalae-Fagetum*). Obje zajednice su već opisivane u Hrvatskoj, no prvi puta na istraživanom području. Uz fitocenološku analizu provedena je ekološka karakterizacija pojedinih ekoloških čimbenika na temelju Ellenbergovih vrijednost floorističkog sastava. Rezultati su pokazali znatne razlike između istraživanih sastojina u pogledu svjetla, vlage, acidofilnosti i sadržaja hraniva na uspoređivanim staništima, odnosno zajednicama.

Ključne riječi: šumske zajednice obične bukve, floristički sastav, Medvednica, Ellenberg, ekoindikatorske vrijednosti

INTRODUCTION
UVOD

The first phytocoenological surveys of forest vegetation on Medvednica were undertaken by Ivo Horvat in 1938. Within the description of the association *Fagetum sylvaticae croaticum boreale montanum*, he provides 9 heterogeneous phytocoenological relevés from Medvednica, which are currently classified within three different associations (Horvat 1938). After Horvat, there has been little research into forest vegetation of Medvednica, with the exception of recent detailed research into the forests of sessile oak (Vukelić 1991), sweet chestnut (Medak 2004) and beech and fir (Medvedović 1991, Dobrović et al. 2006, Vukelić & Baričević 2007).

Forest stands featuring common beech as the edifying species cover almost half of the forest area of Croatia; consequently, they deserve much more attention, study and evaluation. Guided by their significance, we investigated beech stands in the area of Adolfovac, where we expected to find several plant communities in a small area. Research into beech forests of neighbouring areas, in the first place of Samoborsko Gorje, Macelj, Strahinščica, Ivanščica, Bilogora and Zrinska Gora (Šegulja 1974, Regula-Bevilaqua 1978, Vukelić & Baričević 2002, Vukelić et al. 2003, Đodan 2005, Baričević et al. 2009) has shown all the complexity of phytocoenological analysis and interpretation of the community. A number of plant communities, which are diagnostically very important for Illyrian beech forests north of the Dinaric range, are either absent from these forests or are present to a much lesser degree.

MATERIAL AND METHODS
MATERIJALI I METODE

Research area
Područje istraživanja

Mount Medvednica (Zagrebačka Gora) is a mountain massif situated north of Zagreb. Extending in the north-east – south-west direction, it comprises the total length of 42 km. The Adolfovac area is situated in the management unit "Sljeme-Medvedgradske Šume", Zagreb Forest Administration, Zagreb Forest Office (Figure 1). The name of this unit is a combination of the names of two localities: the first is the highest peak of Sljeme and the second is the medieval castle of Medvedgrad. The management unit "Sljeme-Medvedgradske Šume" lies on the southern and south-western slopes of Mount Medvednica. The highest point of this MU is the peak Sljeme (1,032 m), while the lowest point is found in compartment 40 e (Vrapčak stream, 170 metres above sea level). MU "Sljeme-Medvedgradske Šume" is divided into 57 compartments consisting of a total of 411 sub-compartments, of which 17 are situated in selection forests (Management Plan of the Management Unit "Sljeme-Medvedgradske Šume" 2008 – 2017). This project was conducted in compartments 1-4 as part of the research graduate thesis of Sonja Kuzmanić.

As stated in the Management Plan of the Management Unit "Sljeme-Medvedgradske Šume", the dominant soil type in the study area is dystric cambisol.

According to the data from the Meteorological Station Puntijarka, the mean annual air temperature is 6.2 °C, while the annual pattern of precipitation is continental. The least rainfall occurs during winter, with the minimum in February (73 mm) and the maximum in June (138 mm). The average annual precipitation is 1,249 mm with oscillations ± 157 mm.

Figure 1 Adolfovac area.
Slika 1 Područje Adolfovca.

Phytocoenological survey was conducted in fifteen localities using the classical Central European phytocoenological method (Braun-Blanquet 1964). Phytocoenological relevés were entered into the Turboveg database (Hennekens 1995) and processed using Syn-Tax 2000 (Podani 2001). Two methods of numerical analyses were employed: Cluster Analysis and Multidimensional Scaling.

Average Ellenberg's values were calculated for each relevé using JUICE 6.3 software (Tichý 2002). The obtained data were processed in STATISTICA 8.0 (StatSoft Inc. 1984-2008). The data were grouped into two clusters, which were then compared with the t-test in order to determine the extent to which the diversity of the floral composition coincides with the ecological factors in different plant communities.

The Latin names of the plant species were adjusted to the Internet source – Flora Croatica Database (2004) (http://hirc.botanic.hr/fcd/).

RESULTS AND DISCUSSION
REZULTATI ISTRAŽIVANJA I RASPRAVA

The analysis of the floristic composition of 15 phytocoenological relevés (Table 1) and statistical data processing with cluster analysis (Figure 2) showed the presence of two beech forest associations in the study area: forest of beech and woodrush (*Luzulo-Fagetum* Meusel 1973, relevés 1, 5, 7, 11 and 12), and beech forest with deadnettle (*Lamio orvalae-Fagetum* (Horvat 1938) Borhidi 1963, relevés 3, 4, 6, 8-10 and 13.15). This is also confirmed by the results of multidimensional scaling with the PCoA method. However, due to the restricted space, these results are not presented here.

The results of these investigations show fundamental differences between the two associations in terms of the floristic composition, syntaxonomic affiliation and ecological conditions. They will be described in brief.

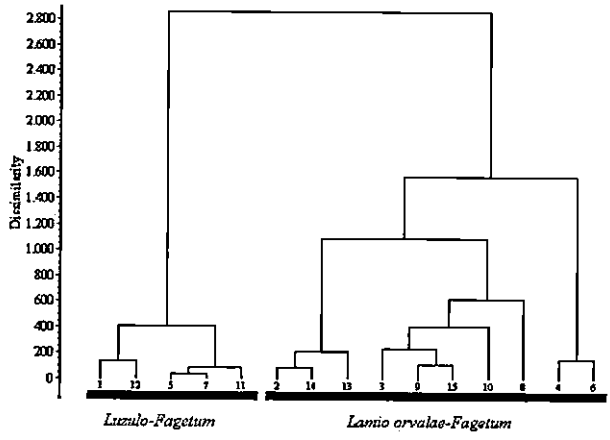

Figure 2 Dendrogram constructed by cluster analysis - Incremental sum of squares.
Slika 2 Dendrogram izrađen klasterskom analizom - Incremental sum of squares.

Beech forest with woodrush
Luzulo-Fagetum Meusel 1937

Beech forest with woodrush represents a basic community of acidophilic beech forests in the major part of Europe. It is of a relatively homogeneous and poor floral composition throughout its vast distribution range. It is distributed in the mountains of north-west Croatia (Macelj, Ivanščica, Medvedica, Samoborsko Gorje), as well as on Papuk and Psunj, reaching the altitude of 800 m. On Mount Medvednica it inhabits smaller areas on steep, erosion-exposed terrains, generally forming enclaves within the beech forest with deadnettle.

The community grows over silicate lithological bedrock overlaid by shallow dystric cambisols and podzolized soils. It can also occur secondarily over carbonate parent material as the result of profile acidification. The soils are of acidic reaction, and are shallower and poorer in humus than the soils inhabited by stands of beech forest with deadnettle.

As seen in Table 1, the phytocoenosis is relatively poor in species. Common beech plays the dominant role in the tree layer, but sweet chestnut and sessile oak have also been recorded.

The shrub layer is composed of beech, sweet chestnut and bilberry (*Vaccinium myrtillus*).

The ground layer is dominated by species that indicate acidity: *Luzula luzuloides, Hieracium murorum, Hieracium racemosum, Melampyrum pratense and Prenanthes purpurea.* These are also differentiating species in relation to other beech communities. Some drier and more exposed fragments are dominated by roadside fescue (*Festuca drymeia*), but this fact does not suffice to join these stands to the subassociation *Luzulo-Fagetum festucetosum drymeiae*, which was described by Hruška del Uomo (1974) on Garjevica, and later by Baričević (2002) in the mountains of Požega (Požeško Gorje). After completing research of a broader area, this subassociation will most probably also be confirmed on Medvednica.

Table 1 Floristic composition of the investigated beech communities on Mt. Medvednica.
Tablica 1. Floristicki sastav istraživanih bukovih zajednica na Medvednici.

Association *Asocijacija*		*Luzulo-Fagetum*					Participation degree *Stupanj udjela*	*Lamio orvalae-Fagetum*										Participation degree *Stupanj udjela*	Lectotypus *Lamio orvalae-Fagetum*
Number of relevé Broj snimke		1	12	5	7	11		2	14	13	3	9	15	10	8	4	6		18
Date (2008. year) *Datum (2008. godina)*		12.6.	12.6.	25.4.	25.4.	12.6.		12.6.	12.6.	12.6.	12.6.	25.4.	12.6.	25.4.	25.4.	25.4.	25.4.		
Površina snimke Record area (m^2)		400	400	400	400	400		400	400	400	400	400	400	400	400	400	400		400
Altitude *Nadmorska visina* (m)		410	490	360	430	390		450	600	550	750	500	750	600	450	270	420		680
Exposition *Ekspozicija*		I	I	SI	I	SI		SI	SI	I	J	I	J	I	I	SI	SI		SSZ
Inclination *Nagib* (°)		25	20	20	20	25		5	25	10	5	20	10	20	15	30	10		16
Cover of tree layer *Pokrovnost sloja drveca* (%)		85	70	100	100	75		95	100	90	80	100	70	100	100	100	80		
Cover of shrub layer *Pokrovnost sloja grmlja* (%)		40	40	60	15	60		20	5	10	5	5	5	5	60	90	40		
Cover of layer ground vegetation *Pokrovnost sloja prizemnog bilja* (%)		50	90	50	80	70		80	40	100	80	60	100	70	40	50	90		
Number of species *Broj vrsta*		12	21	17	12	18		37	31	41	36	25	33	43	26	29	31		
Floral composition - Florni sastav																			
Characteristic and differentiating species of the alliances *Luzulo-Fagion*, *Quercion robori-petraeae* and other acidofil species *Svojstvene i razlikovne vrste sveze Luzulo-Fagion, Quercion robori-petraeae i ostale acidofilne vrste*																			
Castanea sativa	A	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Castanea sativa	B	.	+	+	.	.	2	.	.	+	.	.	.	.	.	.	.	1	.
Vaccinium myrtillus	B+C	3	+	.	1	.	3	.	.	.	.	.	.	.	.	.	.	.	.
Luzula luzuloides	C	2	3	3	5	3	5	1	1	+	.	+	.	+	.	+	.	3	.
Melampyrum pratense		+	2	3	2	3	5	+	+	.	.	.	.	+	.	.	.	2	.
Hieracium murorum		+	+	3	3	2	5	+	+	.	.	.	.	.	.	+	.	2	.
Prenanthes purpurea		+	.	+	+	2	4	+	1	+	.	.	.	.	.	+	+	3	.
Hieracium racemosum		.	1	+	.	1	3	.	.	.	.	.	.	.	.	.	.	.	.
Festuca heterophylla		2	.	.	1	.	2	+	+	+	+	.	.	+	.	.	.	3	.
Polypodium vulgare		+	.	.	.	+	2	.	.	.	.	.	.	.	.	.	.	.	.
Luzula pilosa		.	.	+	+	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Pteridium aquilinum		+	.	.	.	.	1	.	.	1	.	.	.	.	.	.	2	1	.
Chamaecytisus supinus		.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Solidago virgaurea		.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Lathyrus venetus		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.
Hieracium sphaerocephalum		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.

Association *Asocijacija*		*Luzulo-Fagetum*					Participation degree *Stupanj udjela*	*Lamio orvalae-Fagetum*										Participation degree *Stupanj udjela*	Lectotypus *Lamio orvalae-Fagetum*
Characteristic and differentiating species of the alliance *Aremonio-Fagion* *Svojstvene i razlikovne vrste sveze Aremonio-Fagion*																			
Cyclamen purpurascens	C	.	.	.	.	.	.	+	2	1	+	1	1	+	+	3	2	5	+
Lamium orvala		.	.	.	.	.	.	+	.	+	1	+	+	1	+	+	+	5	1
Dentaria trifolia		.	.	.	.	.	.	2	3	3	+	+	1	.	.	1	.	4	+
Vicia oroboides		.	.	.	.	.	.	+	.	1	.	.	2	+	+	.	.	3	.
Aposeris foetida		.	.	+	.	.	1	+	.	+	+	.	.	+	.	.	.	2	.
Dentaria enneaphyllos		.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	1	1
Erythronium dens-canis		.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	1	.
Hacquetia epipactis		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.
Characteristic and differentiating species of the alliance *Carpinion betuli* *Svojstvene i razlikovne vrste sveze Carpinion betuli*																			
Carpinus betulus	A	.	.	.	.	.	.	.	.	.	.	+	+	.	1	.	.	2	.
Carpinus betulus	B	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	+
Prunus avium		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.
Acer campestre		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Stellaria holostea	C	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	1	.
Prunus avium		.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	1	+
Acer campestre		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Characteristic and differentiating species of the order *Fagetalia* *Svojstvene i razlikovne vrste reda Fagetalia*																			
Fagus sylvatica	A	5	4	5	5	4	5	5	5	5	5	4	5	5	5	4	5	5	4
Fagus sylvatica	B	1	3	4	2	3	5	1	+	.	+	+	+	1	+	5	3	5	2
Acer pseudoplatanus		.	.	.	.	.	.	1	.	.	+	.	.	.	1	+	+	3	1
Acer platanoides		.	.	.	.	.	.	1	.	+	+	.	.	.	.	.	.	2	+
Fraxinus excelsior		.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	2	2	.
Daphne mezereum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+
Fagus sylvatica	C	.	1	3	3	2	4	+	+	2	.	1	.	3	.	1	3	4	.
Galium odoratum		.	+	+	.	+	3	1	2	2	2	2	3	2	1	3	2	5	2
Pulmonaria officinalis		.	+	+	.	.	2	.	1	+	+	+	2	1	+	+	1	5	+
Carex pilosa		.	.	1	.	.	1	3	+	5	+	3	5	.	+	3	5	5	+
Lathyrus vernus		.	.	.	.	.	.	+	2	1	+	1	1	1	.	2	1	5	.
Dryopteris filix-mas		.	.	.	.	.	.	+	+	+	+	+	.	+	1	1	+	5	.
Dentaria bulbifera		.	.	.	.	.	.	1	1	1	1	1	+	2	3	2	+	5	2
Sanicula europaea		.	.	.	.	+	1	1	1	2	.	+	.	+	.	1	1	4	+
Mycelis muralis		.	.	.	.	.	.	+	+	+	+	+	+	+	1	.	.	4	1
Acer pseudoplatanus		.	.	.	.	.	.	+	+	+	+	+	+	+	.	.	.	4	+
Viola reichenbachiana		.	.	.	.	.	.	+	+	+	+	.	.	+	+	1	+	4	+
Galium sylvaticum		.	+	1	+	2	4	1	+	+	+	+	.	1	.	.	.	3	.

Association *Asocijacija*		*Luzulo-Fagetum*					Participation degree *Stupanj udjela*	*Lamio orvalae-Fagetum*										Participation degree *Stupanj udjela*	Lectotypus *Lamio orvalae-Fagetum*
Platanthera bifolia		.	+	+	.	1	3	.	+	+	.	.	.	+	+	.	1	3	.
Phyteuma spicatum		.	.	+	+	+	3	+	1	1	+	.	.	+	.	+	.	3	.
Epipactis helleborine		.	+	.	.	.	1	+	+	1	+	.	+	.	.	.	.	3	.
Melica uniflora		.	.	.	.	.	.	+	.	1	4	.	2	2	.	.	.	3	.
Mercurialis perennis		.	.	.	.	.	.	+	.	2	2	3	2	2	.	.	.	3	.
Athyrium filix-femina		.	.	.	.	.	.	.	.	.	+	.	.	+	1	.	.	2	.
Acer platanoides		.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	2	.
Euphorbia dulcis		.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	2	+
Polygonatum multiflorum		.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	2	+
Symphytum tuberosum agg.		.	.	.	.	.	.	+	.	.	+	.	+	.	.	.	.	2	+
Scrophularia nodosa		.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.	2	.
Festuca drymeia		.	5	.	+	+	3	1	.	.	.	.	+	.	.	.	.	1	.
Euphorbia amygdaloides		.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	1	+
Circaea lutetiana		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1	.
Geranium robertianum		.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	1	+
Stachys sylvatica		.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	1	.
Galeobdolon luteum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.
Polystichum aculeatum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.
Carex sylvatica		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	+
Veronica montana		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.
Brachypodium sylvaticum		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.
Actaea spicata		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.
Epilobium montanum		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.
Ranunculus lanuginosus		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	+
Asarum europaeum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Heracleum sphondylium		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	+
Campanula trachelium		.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	+
Characteristic and differentiating species of the order *Quercetalia pubescentis* / *Svojstvene i razlikovne vrste reda Quercetalia pubescentis*																			
Fraxinus ornus	B	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.
Sorbus torminalis		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.
Cephalanthera damasonium	C	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.	+	2	.
Tamus communis		.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	2	+
Cephalanthera longifolia		.	1	.	.	.	1	.	.	+	.	.	.	.	.	.	.	1	.
Campanula persicifolia		.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.
Melittis melissophyllum		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	1	.

Association *Asocijacija*		*Luzulo-Fagetum*					Participation degree *Stupanj udjela*	*Lamio orvalae-Fagetum*										Participation degree *Stupanj udjela*	Lectotypus *Lamio orvalae-Fagetum*
Characteristic and differentiating species of the class *Querco-Fagetea* *Svojstvene i razlikovne vrste razreda Querco-Fagetea*																			
Quercus petraea	A	+	+	.	.	.	2	.	+	.	.	+	.	.	+	.	2	2	.
Corylus avellana	B	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	+
Anemone nemorosa	C	.	.	.	.	.	.	1	1	2	+	1	1	1	+	.	.	4	.
Hedera helix		.	.	.	.	.	.	+	.	+	+	.	.	+	2	2	+	4	2
Quercus petraea		.	+	.	.	.	1	.	.	.	.	+	.	.	.	.	1	1	.
Convallaria majalis		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.
Other species - *Ostale vrste*																			
Abies alba	A	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.
Abies alba	B	.	+	.	.	.	1	+	+	+	.	.	.	.	.	.	.	2	.
Picea abies		.	.	1	+	+	3	.	+	.	.	.	.	.	.	.	.	1	.
Sambucus racemosa		.	.	.	.	.	.	.	.	+	.	.	+	+	3	.	.	2	+
Doronicum austriacum	C	.	.	1	.	1	2	2	1	2	.	.	1	+	1	.	+	4	.
Rubus hirtus		.	.	.	.	.	.	.	+	+	.	.	+	.	.	+	1	3	.
Fragaria vesca		.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	2	+
Silene dioica		.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	2	.
Alliaria petiolata		.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	2	.
Cephalanthera rubra		.	1	.	.	.	1	.	.	1	.	.	.	.	.	.	.	1	.
Veronica chamaedrys		.	+	.	.	+	2	.	.	.	.	+	.	+	.	.	.	1	.
Senecio ovatus		.	.	.	.	+	1	.	.	+	.	.	.	.	.	.	+	1	1
Festuca gigantea		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.
Lunaria rediviva		.	.	.	.	.	.	.	.	.	+	.	.	.	1	.	.	1	+
Primula vulgaris		.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	1	.
Sambucus racemosa		.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
Petasites albus		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
Bromus racemosus		.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	1	.
Vicia sp.		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	.
Galeopsis tetrahit		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.
Gentiana asclepiadea		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	1	.
Laburnum sp.		+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.

The nomenclatural type features the following species - U nomenklaturnom tipu pojavljuju se još vrste:

A *Ulmus glabra* (+), *Malus sylvestris* (+)

B *Daphne laureola* (+), *Euonymus latifolia* (+), *Rubus* sp. (+), *Crataegus* sp. (+), *Cornus mas* (+), *Clematis vitalba* (+), *Viburnum lantana* (+)

C *Arum maculatum* (2), *Corydalis cava* (2), *Paris quadrifolia* (1), *Galanthus nivalis* (1), *Scilla bifolia* (1), *Anemone ranunculoides* (1), *Eranthis hiemalis* (1), *Glechoma hederacea* (1), *Scrophularia vernalis* (1), *Isophyrum thalictroides* (1), *Carex digitata* (+), *Urtica dioica* (+), *Scolopendrium vulgare* (+), *Chelidonium majus* (+), *Aremonia agrimonoides* (+), *Oxalis acetosella* (+), *Aegopodium podagraria* (+), *Aconitum lycoctonum* ssp. *vulparia* (+)

Beech trees are of relatively good quality. The soil, however, is often degraded due to being intensively trampled on by visitors to Medvednica.

In some earlier works, the association *Luzulo-Fagetum* was subordinated to the alliance *Luzulo-Fagion* Lohm. et R. Tüxen in R. Tüxen 1954, but more recently it has been reduced to the level of sub-alliance *Luzulo-Fagenion* Lohm. et R. Tüxen in R. Tüxen 1954 within the alliance *Fagion sylvaticae* Luquet 1926. The most commonly cited reason for this is the absence of characteristic species needed for the rank of alliance, since only *Luzula luzuloides* (Oberdorfer 1994, Willner & Grabherr 2007 et al.) is mentioned as a weak characteristic species.

Beech forest with deadnettle

Lamio orvalae-Fagetum (Horvat 1938) Borhidi 1963

This is a climatozonal community of the montane belt of Croatia. In the continental part of the Dinaric area it occurs between 400 and 800 m and continues over the northern slopes of Mala Kapela to the mountains of north-western Croatia. According to the published phytocoenological relevés, the floristically impoverished community is found in Samoborsko Gorje, on Macelj and on Medvednica. Its eastern distribution is yet to be investigated, although its range largely coincides with the range of the species *Lamium orvala*. Since this community does not have a uniform composition across its distribution range in Croatia, two variants can easily be distinguished: the southern one in the Dinaric part and the northern one in the uplands of north-western Croatia.

The lithological parent material that supports the community is composed of limestone and dolomite. The community can also grow on silicate rocks, but only in fragmentary form. The soil is predominantly calcocambisol of very good properties (pH above 7, deep, humous in the upper horizon, of good consistency and rich in nutrients). The results of statistical comparison of these two communities show that the soil properties are more favourable in relation to the soil properties of the association *Luzulo-Fagetum* (Table 2).

Beech forest with deadnettle was identified in ten relevés in the study area. As seen in Table 1, the main edifying species in the tree layer is common beech, while several of the relevés also feature sessile oak and common hornbeam.

The shrub layer has the least cover and is mostly composed of beech, maples (*Acer pseudoplatanus* and *Acer platanoides*), common ash (*Fraxinus excelsior*), mezereon (*Daphne mezereum*), and silver fir (*Abies alba*) in higher positions.

The layer of ground vegetation is marked by a medium cover. The stronger or weaker characteristic and differentiating species of Illyrian beech forests (alliance *Aremonio-Fagion*) include *Lamium orvala*, *Cyclamen purpurascens*, *Dentaria trifolia*, *Vicia oroboides* and others, and the species characteristic of European beech forests consist of *Galium sylvaticum*, *Carex sylvatica*, *Mercurialis perennis*, *Galium odoratum*, *Sanicula europaea*, *Pulmonaria officinalis*, *Hedera helix*, *Dryopteris filix-mas* and other, even more widespread species.

The association *Lamio orvalae-Fagetum* is rarely cited in literature under this name as an independent association; it is more often analyzed within Horvat's complex Fagetum sylvaticae montanum croaticum. Consequently, emphasis should be made of some of its specific features, which this research has also done. In relation to the distribution range of the community in the Dinaric part of Croatia (Horvat, Glavač & Ellenberg 1974, Vukelić & Baričević 2002), the northern part of the association's range does not contain any important Illyrian species, such as *Rhamnus fallax*, *Calamintha grandiflora* and *Omphalodes verna*. Moreover, no important species of the northern part of the range of beech forest with deadnettle have been found in Adolfovac, although they were identified in this association in Samoborsko Gorje (Vukelić, Baričević & Drevenkar 2003) and in beech-fir forests on Medvednica (Vukelić & Baričević 2007): *Aremonia agrimonoides*, *Ruscus hypoglossum*, *Cardamine trifolia*, *Cardamine waldsteinii*, *Daphne laureola*, *Epimedium alpinum*, *Polystichum setiferum* and others. This is attributed to the relatively small size of the

research area, as well as to the predominantly silicate lithological base which sporadically supports more acidophilic soils. However, the presence of the diagnostically most important species *Lamium orvala* and *Cardamine enneaphyllos*, which are considered the characteristic species of the association (Marinček et al. 1993) and other species of the alliance *Aremonio-Fagion*, indicates that this is an impoverished variant of beech forest with deadnettle. To prove this point, we present relevé No. 18 in Table III from Horvat's paper from 1938, also labeled as the nomenclatural type (lectotype) in the cited work of Marinček et al. from 1993.

The Central European elements of the alliance Fagion and the order Fagetalia have a significant share in the forest of beech with deadnettle.

The phytocoenological table reveals not only the floristic differences between the described forest communities, but also the differences in particular ecological parameters that characterize their sites (Table 2). After the average ecoindicator values (Ellenberg 1979) were calculated with STATISTICA 8.0, the t-test was used to obtain the following results:

Table 2 T-test results.
Tablica 2. Rezultati T-testa.

Variable *Varijabla*	Mean	Mean	t-value	df	p	Valid N	Valid N	Std.Dev.	Std.Dev.	F-ratio	p
	Luzulo-Fagetum	*Lamio-Fagetum*				*Luzulo-Fagetum*	*Lamio-Fagetum*	*Luzulo-Fagetum*	*Lamio-Fagetum*	Variances	Variances
Light *Svjetlost*	4,24	4,04	2,19	13	0,0478	5	10	0,21	0,15	2,08	0,3318
Temperature *Temperatura*	5,05	5,27	-1,65	13	0,1226	5	10	0,41	0,12	12,24	0,0022
Continentality *Kontinentalnost*	3,37	3,35	0,3	13	0,7721	5	10	0,14	0,09	2,4	0,2536
Moisture *Vlaga*	4,88	5,13	-3,34	13	0,0045	5	10	0,19	0,09	4,73	0,0495
Soil reaction *Reakcija tla*	4,98	6,53	-5,59	13	0,0001	5	10	0,85	0,21	15,98	0,0008
Nutrients *Hraniva*	4,17	5,62	-5,99	13	0,0005	5	10	0,5	0,41	1,5	0,5624

According to the results, these two groups of relevés do not show statistically significant differences in the ecological factors of temperature and continentality. However, there are statistically significant differences in terms of light, humidity, soil reaction and nutrients. In relation to the community *Luzulo-Fagetum*, the forest community *Lamio orvalae-Fagetum* occurs in the sites with more light and humidity.

The differences are even bigger in terms of soil reaction and nutrient supply. In the community *Luzulo-Fagetum* the value of soil reaction is 4.98, which represents a moderately acid site, while the community *Lamio orvalae-Fagetum* reaches the value of 6.53, which denotes weakly basic soil. In terms of nutrients there is similar relationship: the community *Luzulo-Fagetum* is poor with nutrients (nitrogen) – value 4.24, whereas the site of the community *Lamio orvalae-Fagetum* is richer in nutrients, i.e. nitrogen, and reaches the value of 5.62.

CONCLUSIONS
ZAKLJUČCI

Based on the analysis of phytocoenological relevés of beech forests shows in the study area, we can conclude that there are two associations with the related systematics.

Class: *Querco-Fagetea* Braun-Blanquet et Vlieger 1937
Order: *Fagetalia* Pawlovski in Pavlovski et al. 1928
Alliance: *Luzulo-Fagion* Lohmeyer et R. Tüxen in R. T Tüxen 1954
Association: *Luzulo-Fagetum sylvaticae* Meusel 1937
Alliance: *Aremonio-Fagion* (I. Horvat1938) Borhidi in Török et al. 1989
Sub-alliance: *Lamio orvalae-Fagenion* Borhidi ex Marinček et al. 1993
Association: *Lamio orvalae-Fagetum* (I. Horvat 1938) Borhidi 1963

Beech forest with woodrush covers some twenty percent of the study area and has typical floral composition of this community. There are sporadic occurrences of Festuca drymeia in drier and warmer sites, which confirms the similarity of this site with other mountains between the rivers Sava and Drava in Croatia.

Beech forest with deadnettle is the dominant community in the investigated area. It is poorer in the species of the Illyrian-Dinaric distribution from the southern part of its range, as well as in some species which were found in beech forests in the neighbouring mountains and in beech-fir forests on Mount Medvednica. Nevertheless, the existing diagnostic species allow us to describe them as the association Lamio orvalae-Fagetum. These species show more similarity to this association than to other beech communities known in Croatia to date.

The differences in the floral composition are the reflection of different site conditions in which these two communities occur. This is also confirmed by the result of the ecoindicator value analysis. According to these values, the sites of the investigated phytocoenoses differ significantly in terms of the amount of light and humidity, soil reaction and nutrient quantity.

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