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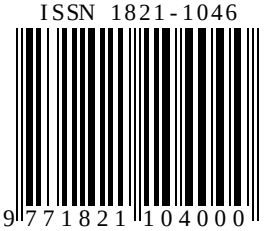

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BEECH FORESTS OF KOSMAJ AS A NATURAL RESOURCE OF MEDICINAL PLANTS

Snežana STAJIĆ[1], Vlado ČOKEŠA[1], Violeta BABIĆ[2], Suzana MITROVIĆ[1], Marija MILOSAVLJEVIĆ[3], Saša EREMIJA[1], Jelena BOŽOVIĆ[1]*

Abstract: *This paper presents the results of research on wild-growing medicinal plants in the beech forests of the protected area of Kosmaj. Beech forests in this region are widely distributed and occur either as pure stands (Helleboro odori–Fagetum moesiacae Soo & Borhidi 1960) or as mixed stands with sessile oak (Querco petraeae–Fagetum moesiacae Glišić 1971). The floristic composition of these forests was analyzed using 22 phytosociological relevés. Out of a total of 100 recorded plant taxa, 60 medicinal species belonging to 50 genera and 36 families were identified. The taxonomic analysis showed that the most represented medicinal plants belong to the families Rosaceae (15%) and Lamiaceae (13%), followed by Fagaceae (7%) and Liliaceae (5%). Species of the Central European distribution type were the most common (36%), while the analysis of life forms indicated a predominance of phanerophytes (48.4%) and hemicryptophytes (23.3%), with a notable share of geophytes (18%).*

Keywords: beech forests, medicinal plants, taxonomic analysis, phytogeographical analysis, biological spectrum.

BUKOVE ŠUME KOSMAJA KAO PRIRODNI RESURS LEKOVITIH BILJAKA

Sažetak: *U radu su prikazani rezultati istraživanja samoniklih lekovitih biljaka u bukovim šumama zaštićenog područja Kosmaja. Bukove šume na ovom području su široko rasprostranjene i javljaju se kao čiste (Helleboro odori-Fagetum moesiacae Soo &Borhidi 1960.) ili mešovite sa kitnjakom (Querco petraeae-Fagetum moesiacae Glišić 1971.). Za analizu florističkog sastava bukovih šuma korišćeno je 22 fitocenološka snimka. Od ukupnog broja registrovanih biljaka (100) zabeleženo je 60 lekovitih vrsta iz 50 rodova i 36 familije. Taksonomska analiza pokazala je da su najzastupljenije lekovite biljke iz familije Rosaceae (15%) i Lamiacae (13%), dok su nešto manje prisutne lekovite biljke iz familija Fagaceae sa 7% i Liliaceae sa 5%. Najzastupljenije su lekovite biljke srednjeevropskog areal tipa sa 36%, dok je analiza životnih formi pokazala da su najviše zastupljene fanerofita sa 48,4% i hemikriptofite (23,3%), uz visoko učešće geofita (18%).*

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Ključne reči: Bukove šume, lekovite biljke, taksonomska analiza, fitogeografska anliza, biološki spektar.

1. INTRODUCTION

Medicinal plants and fungi have been used for centuries in folk and traditional medicine. However, global demand for these resources has threatened certain species, contributing to biodiversity loss and the depletion of natural resources essential for human health (Howes et al., 2020). Serbia is characterized by exceptional floristic diversity, which includes a substantial number of medicinal plant species. The highest alpha diversity is found in deciduous forests of the class *Querco–Fagetea* which accounts for 52.49% of the total diversity of all analyzed ecosystem types (Lakušić, 2005). However, the natural potential of medicinal plants within forest ecosystems remains largely unexplored, often resulting in unsustainable use of this resource. Populations of medicinal plants are declining primarily due to overharvesting, habitat degradation, and the spread of invasive species (Chen et al., 2016). For this reason, it is essential to protect natural habitats containing valuable medicinal species. Identifying suitable areas and climatic parameters associated with the current distribution of medicinal plants can facilitate predictions of their future distribution and help estimate their level of endangerment.

According to data from the Second National Forest Inventory of the Republic of Serbia (2023), beech forests are the most widespread forest type in the country, covering an area of 733,042 ha, or 25.68% of the total forested land. In Serbia, beech forests thrive under a wide range of ecological conditions, occurring from the submontane to the subalpine belt. In addition to their broad climatic, beech forests also exhibit a wide edaphic amplitude. They occur on acidic silicate, basic, ultrabasic, and carbonate bedrocks. In Serbia, beech grows on ten different soil types (Knežević, 2003). The vascular plant species composition and richness of beech forests are highly variable among European regions and habitats; however, European beech forests are generally regarded as species-poor. Compared to Central European shady forests, beech forests in Serbia are more complex and more diverse (Karadžić, 2018).

Submontane beech forests in Serbia are largely shaped by orographic conditions. They typically occur at lower elevations within the climatic oak forest belt, on cold exposures or in sheltered, shaded valleys with specific microclimatic conditions (Tomić & Rakonjac, 2013). Floristically, submontane beech forests differ considerably from montane beech forests: they contain a larger share of mesophilous species characteristic of lower elevations, as well as admixed elements typical of adjacent oak forests. The present-day stands of submontane beech forests, which fall within the belt of oak-dominated vegetation, may be regarded as remnants of a once much broader range of this forest type, which existed before the onset of the current, more arid climate (Jovanović, 1980).

A large part of the study area on Mount Kosmaj is covered by forest vegetation belonging syntaxonomically to the deciduous oak and beech forests of the class *Querco–Fagetea*. In this region, submontane beech forests are widely distributed, occurring either as pure stands (*Helleboro odori–Fagetum moesiacae* Soo & Borhidi 1960) or as mixed stands with sessile oak (*Querco petraeae–Fagetum*

moesiacae Glišić 1971). The aim of this study was to determine the representation of medicinal plants within the flora of these beech forests, accompanied by a detailed taxonomic and phytogeographical assessment, as well as an analysis of their biological spectrum.

2. MATERIAL AND METHODS

Kosmaj is a low mountain massif (626 m) belonging to the Šumadija mountain system. Its terrain has a distinctive geological structure, which has resulted in considerable pedological diversity across the area. From a phytogeographical perspective, this region belongs to the Balkan floristic province within the Central European region.

To analyze the floristic composition, 22 phytosociological relevés were collected in beech forests within the study area. The floristic composition of the investigated stands was assessed using the Braun-Blanquet floristic–ecological method (Braun-Blanquet, 1964). Plant species were identified based on the following botanical literature: *Flora of Serbia* I–X (Josifović et al., 1972–1977; Sarić et al., 1986, 1992; Stevanović et al., 2012), and nomenclature was harmonized with the Euro+Med PlantBase database (Euro+Med, 2006 -). The identification of medicinal plants followed Sarić (1989). The spectra of floristic elements were prepared according to Gajić's (1980) classification of phytogeographical elements, while life-form spectra were derived following the method of Kojić et al. (1997).

3. RESULTS AND DISCUSSION

In the Kosmaj area, submontane beech forests are widely distributed, occurring either as pure stands (*Helleboro odori–Fagetum moesiacae* Soo & Borhidi 1960) or as mixed stands with sessile oak (*Querco petraeae–Fagetum moesiacae* Glišić 1971). They are mainly found at elevations between 370 and 580 m.a.s.l., on colder exposures (northern, northwestern, northeastern) and on slopes of 15–28° (Stajić et al., 2021).

The floristic structure of these beech forests comprises 46 families, 73 genera, and 100 plant species. Of the total 100 recorded taxa, as many as 60 medicinal plant species belonging to 36 families and 50 genera were identified (Table 1).

An essential prerequirement for the sustainable use of wild-growing medicinal plants is the preservation of forest or meadow ecosystems, as well as the key parameters such as abundance–cover and constancy (Obratov & Đukić, 2002). Species with the highest constancy (III–IV) in the investigated beech forests included *Lamium galeobdolon* (L.) Crantz, *Stachys silvatica* L., *Circaea lutetiana* L., *Helleborus odorus* Willd., *Hedera helix* L., *Dioscorea communis* (L.) Caddick & Wilkin, *Geranium robertianum* L. Considering that the abundance and cover of medicinal plants (as well as plant species in general) depend on habitat type—and despite the overall species-poor character of beech forests—this study recorded a somewhat higher number of medicinal plants compared to certain oak forests in the area (Stajić et al., 2025).

Table 1. *List of wild medicinal plants in the beech forests of Kosmaj*

Species	Family	Florisic element	Life form
Acer platanoides L.	*Aceraceae*	Subse.	p
Arum maculatum L.	*Araceae*	Se.	g
Hedera helix L.	*Araliaceae*	Subatl-subm.	pl
Asarum europaeum L.	*Aristolochiaceae*	Evr.	g
Ruscus aculeatus L.	*Asparagaceae*	Subatl-subm.	np
Ruscus hypoglossum L.	*Asparagaceae*	Subm.	np
*Alliaria petiolata (*M.Bieb.) Cavara&Grande	*Brassicaceae*	Subse.	h
Cardamine impatiens L.	*Brassicaceae*	Evr.	th
Campanula trachelium L.	*Campanulacae*	Subevr.	h
Lonicera caprifolium L.	*Caprifoliaceae*	Is.subm.	np
Stellaria media (L.) Vill.	*Caryophyllaceae*	Kosm.	th
Euonymus europaeus L.	*Celastraceae*	Subse.	np
Cornus mas L.	*Cornaceae*	Pont.subm.	np
Corylus avellana L.	*Corylaceae*	Subse.	p
Dioscorea communis (L.) Caddick & Wilkin	*Dioscoreaceae*	Subatl-subm.	g
Euphorbia amygdaloides L.	*Euphorbiaceae*	Subatl-subm.	zc
Fagus sylvatica L.	*Fagaceae*	Mez.	p
Quercus cerris L.	*Fagaceae*	Is.subm.	p
Quercus frainetto Ten.	*Fagaceae*	Is.subm.	p
Quercus petraea (Matt.) Liebl.	*Fagaceae*	Se.	p
Geranium robertianum L.	*Geraniaceae*	Subcirk.	th
Juglans regia L.	*Juglandaceae*	Subiran.-is.subm.	p
Ajuga reptans L.	*Lamiaceae*	Subse.	h
Clinopodium vulgare L.	*Lamiaceae*	Subm.	h
Glechoma hirsuta Waldst. & Kit.	*Lamiaceae*	Pont.-is.subm.	h
Lamium galeobdolon (L.) Crantz.	*Lamiaceae*	Subse.	zc
Melittis melissophyllum L.	*Lamiaceae*	Se.	g
Scrophularia nodosa L.	*Lamiaceae*	Evr.	h
Stachys alpina L.	*Lamiaceae*	Se.	g
Stachys silvatica L.	*Lamiaceae*	Subse.	g
Allium ursinum L.	*Liliaceae*	Se	g
Lilium martagon L.	*Liliaceae*	Evr.	g
Polygonatum odoratum (Mill.) Druce	*Liliaceae*	Subj.sib.	g
Circaea lutetiana L.	*Oenotheraceae*	Cirk.	g
Fraxinus excelsior L.	*Oleaceae*	Subse.	p
Fraxinus ornus L.	*Oleaceae*	Subm.	p
Chelidonium majus L.	*Papaveraceae*	Evr.	h
Dryopteris filix-mas (L.) Schott	*Polypodiaceae*	Kosm.	h
Lysimachia nummularia L.	*Primulaceae*	Subse.	zc
Lysimachia vulgaris L.	*Primulaceae*	Evr.	h
Clematis vitalba L.	*Ranunculaceae*	Subatl-subm.	p
Helleborus odorus Willd.	*Ranunculaceae*	Srbalk.	h
Crataegus monogyna Jack.	*Rosaceae*	Subse.	p
Crataegus nigra Waldst. & Kit.	*Rosaceae*	Subpan.	p
Fragaria vesca L.	*Rosaceae*	Evr.	h
Malus sylvestris (L.) Mill.	*Rosaceae*	Evr.	p
Prunus avium L.	*Rosaceae*	Subse.	p
Prunus spinosa L.	*Rosaceae*	Subpont.	np
Pyrus pyraster (L.) Burgsd.	*Rosaceae*	Subse.	p
Rosa canina L.	*Rosaceae*	Subse.	np
Rubus hirtus Waldst. & Kit.	*Rosaceae*	Se.	np
Galium odoratum (L.) Scop.	*Rubiaceae*	Subevr.	g
Populus tremula L.	*Salicaceae*	Subevr.	p
Sambucus nigra L.	*Sambucaceae*	Subse.	np
Atropa bella-donna L.	*Solanaceae*	Subse.	h
Tilia cordata Mill.	*Tiliaceae*	Se.	p
Tilia tomentosa Moench	*Tiliaceae*	Subbalk.	p
Ulmus minor Mill.	*Ulmaceae*	Subm.	p
Urtica dioica L.	*Urticaceae*	Evr.	h

Species	Family	Florisic element	Life form
Viola odorata L.	*Violaceae*	Subatl-subm.	h

Legend:p-phanerophytes;np-nanophanerophytes;pl-phanerophytic lianas;zc-herbaceous chamaephytes;h-hemicryptophytes; g- geophytes; th-therophytes/chamaephytes.

The taxonomic analysis showed that the most represented medicinal plants belong to the families *Rosaceae* (15%) and *Lamiaceae* (13%), while medicinal species from *Fagaceae* (7%) and *Liliaceae* (5%) were less common. The two most species-rich families were also the richest in terms of genera: *Rosaceae* (*Crataegus, Rubus, Prunus, Rosa, Fragaria, Malus*) and *Lamiaceae* (*Calamintha, Scrophularia, Glechoma, Lamium, Ajuga, Melittis, Stachys*). The results of the taxonomic analysis of medicinal plants in the Nature Monument "Košutnjak Forests" likewise indicate a dominance of the families *Lamiaceae* and *Rosaceae* (Jokanović et al., 2021).

Figure 1. *Circaea lutetiana* L.

Figure 2. *Stachys silvatica* L.

Figure 3. *Atropa bella-donna* L.

Figure 4. *Helleborus odorus* Willd.

A total of seven wild fruit tree species were also recorded in the floristic composition of these beech forests: *Prunus avium* L., *Prunus spinosa* L., *Pyrus pyraster* (L.) Burgsd., *Malus sylvestris* (L.) Mill., *Juglans regia* L., *Cornus mas* L., and *Rosa canina* L. In recent years, both in Europe and in Serbia, increasing attention has been devoted to forest fruit trees, as the collection of their seeds, the production of planting material, and their introduction into existing forests or into afforestation of bare areas contribute to the preservation of biological diversity.

In the spectrum of floristic elements, plants of the Central European range type were the most prevalent, accounting for 36.7% of the total (Table 2). Plant species of Eurasian range type had a somewhat smaller representation (21,7%), followed by plants of Sub-Mediterranean (11,7%), Sub-Atlantic (10%), Pontic (6,7%), and Balkan (5%) elements. Cosmopolitan and Circumpolar elements each represented 3.3% of the medicinal flora, while the desert floristic element was the least represented, with a share of 1.7%.

Overall, mesophilous plants were the most prevalent, accounting for as much as 46.7% of the flora. These included mainly Central European and Sub-Atlantic floristic elements, which are indicative of the mesophilous character of beech forests. They were followed by species with a broad ecological amplitude (25%), represented by Eurasian and Cosmopolitan range types, and xerothermophilous plants (23.3%), which included Pontic, Sub-Mediterranean, and Balkan elements. The somewhat higher proportion of Mediterranean and Pontic elements can be explained by the fact that beech in this area occurs at relatively low elevations, allowing a considerable number of thermophilous species from the oak forest zone to enter the community.

Table 2. *Spectrum of floristic elements*

Cumulative range types	Number	Share (%)	
Pontic	4	6.7	23.3
Sub-Mediterranean	7	11.7	
Balkan	3	5.0	
Central European	22	36.7	46.7
Subatlantic	6	10.0	
Desert	1	1.7	1.7
Eurasian	13	21.7	
Cosmopolitan	2	3.3	25.0
Circumpolar	2	3.3	3.3

The analysis of life-form spectra among medicinal plants revealed a dominance of phanerophytes, which accounted for 48.4%, followed by hemicryptophytes with 23.3% (Table 3). Geophytes were also well represented (18.3%), indicating favorable edaphic conditions (soil moisture, structure, and depth). This was to be expected, given that geophytes are typically associated with more mesophilous communities of a denser canopy structure.

Table 3. *Spectrum of life forms*

Life forms	Broj	Učešće (%)	
Phanerophytes	19	31.7	48.4
Nanophanerophytes	9	15.0	
Phanerophytic lianas	1	1.7	
Herbaceous chamaephytes	3	5.0	5.0
Hemicryptophytes	14	23.3	23.3
Geophytes	11	18.3	18.3
Therophytes /Chamaephytes	3	5.0	5.0

5. CONCLUSIONS

Of the total 100 plant species recorded in the beech forests of the Kosmaj area, as many as 60 medicinal plants were identified, belonging to 36 families and 50 genera. The most represented medicinal species belonged to the families *Rosaceae* (15%) and *Lamiaceae* (13%), while species from *Fagaceae* (7%) and *Liliaceae* (5%) were less common. Regarding the distribution of floristic elements, the Central European element was dominant, accounting for 36% of the occurring flora, followed by Eurasian (22%), Sub-Mediterranean (11%), and Sub-Atlantic (10%) elements. The analysis of life forms revealed a predominance of phanerophytes (48.4%), followed by hemicryptophytes (23.3%), with geophytes also well represented (18%).

The fact that approximately 60% of the entire flora of these beech forests consists of medicinal plants highlights the potential for harvesting this increasingly important natural resource. For this reason, future research should prioritize the assessment of the abundance and biotic potential of individual medicinal species. Identifying the areas and climatic parameters that currently determine the distribution of specific medicinal plants, as well as forest fruit trees, can contribute to predicting their future ranges and evaluating their level of threat, which is all fully aligned with the broader goal of preserving biodiversity in Serbia.

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BEECH FORESTS OF KOSMAJ AS A NATURAL RESOURCE OF MEDICINAL PLANTS

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Summary

The aim of this study was to determine the representation of medicinal plants within the flora of beech forests in the study area, accompanied by a detailed taxonomic, phytogeographical, and biological-spectrum analysis.

In the Kosmaj region, submontane beech forests are widely distributed, occurring either as pure stands (*Helleboro odori–Fagetum moesiacae* Soó & Borhidi 1960) or as mixed stands with sessile oak (*Querco petraeae–Fagetum moesiacae* Glišić 1971). These forests are generally found at elevations between 370 and 580 m, on colder exposures (northern, northwestern, northeastern) and slopes ranging from 15° to 28°. A total of 22 phytosociological relevés were used in the analysis of floristic composition.

Out of 100 recorded plant species, 60 medicinal species were identified, belonging to 36 families and 50 genera. The most represented families were *Rosaceae* (15%) and *Lamiaceae* (13%), followed by *Fagaceae* (7%) and *Liliaceae* (5%).

Within the spectrum of floristic elements, medicinal plants of the Central European range type were predominant (36.7%). They were followed by species of the Eurasian type (21.7%), sub-Mediterranean (11.7%), sub-Atlantic (10%), Pontic (6.7%), Balkan (5%), Circumpolar (3.3%), and Cosmopolitan types (3.3%), while species of the Desert range type were the least represented (1.7%).

The analysis of life forms revealed that phanerophytes were dominant (48.4%), followed by hemicryptophytes (23.3%).

The floristic composition of these beech forests also includes seven species of wild fruit trees: *Prunus avium* L., *Prunus spinosa* L., *Pyrus pyraster* (L.) Burgsd., *Malus sylvestris* (L.) Mill., *Juglans regia* L., *Cornus mas* L., and *Rosa canina* L.

Identifying the current distribution areas of medicinal plant species provides a basis for predicting their future range of distribution and assessing their level of endangerment.

Therefore, future research in these forests should prioritize evaluating the abundance and biotic potential of some medicinal species.

BUKOVE ŠUME KOSMAJA KAO PRIRODNI RESURS LEKOVITIH BILJAKA

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Rezime

Cilj ovog rada bio je da se utvrdi zastupljenost lekovitih biljaka u flori bukovih šuma ovog područja, sa detaljnom taskonomskom i fitogeografskom, kao i analizom biološkog spektra.

Na području Kosmaja brdske bukove šume imaju široko rasprostranjenje, bilo da se javljaju kao čiste (*Helleboro odori-Fagetum moesiacae* Soo &Borhidi 1960.) ili mešovite sa kitnjakom (*Querco petraeae-Fagetum moesiacae* Glišić 1971.). Prisutne su uglavnom na terenima 370 to 580 m nadmorske visine, hladnijim eskpozicijama (sever, severozapad, severoistok) i nagibima 15-28° U analizi floističkog sastava korišćeno je 22 fitocenološka snimka.

Od ukupnog broja biljnih vrsta (100), registrovano je 60 lekovitih vrsta biljaka iz 36 familije i 50 rodova. Najzastupljenije su lekovite biljke iz familije *Rosaceae* (15%) i *Lamiaceae* (13%), a nešto manje su prisutne lekovite biljke iz familija *Fagaceae* (7%) i *Liliaceae* (5%).

U spektru flornih elemenata, najzastupljenije su lekovite biljke srednjeevropskog areal tipa sa 36,7%. Nešto manju zastupljenost imaju biljne vrste evroazijskog areal tipa (21,7%), dok za njima slede biljke submediteranskog (11,7%), subatalanskog (10%), pontskog (6,7%), balkanskog (5%), cirkumpolarnog (3,3%), kosmopolitskog tipa (3,3%) i najmanje florni element pustinjskih predela (1,7%).

Analiza životnih formi lekovitih biljaka pokazuje da dominiraju fanerofite sa 48,4%, a zatim slede hemikriptofite sa 23,3%.

U floističkom sasatvu bukovih šuma ovog područja registrovano je i 7 vrsta divljih voćkarica: *Prunus avium* L., *Prunus spinosa* L., *Pyrus pyraster* (L.) Burgsd., *Malus sylvestris* (L.) Mill., *Juglans regia* L., *Cornus mas* L,, *Rosa canina* L.

Identifikacija područja gde se danas nalaze pojedine lekovite biljke može pomoći u definisanju njihove buduće rasprostranjenosti i proceni nivoa ugroženosti, zbog čega bi u daljem istraživanju ovih šuma prioritet bio na utvrđivanju brojnosti i biotičkog potencijala pojedinih lekovitih vrsta.