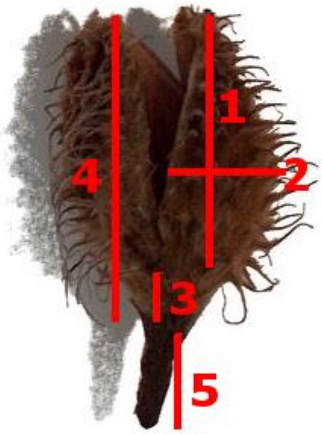

Variability of beech cupules in Serbia

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Abstract

Beech is the most important tree species in forests of Serbia. However, despite its significance, the taxonomic status of beech in Serbia is unclear. Morphology of the cupules can be successfully used to distinguish species and within species taxa. In this paper we report results on cupules morphology, measuring the same attributes reported by Mišić (1955): 1) Length of the longest valve of cupule, 2) Width of that valve (at widest point), 3) Distance between base of the longest valve and peduncle, 4) Length of cupule without peduncle, and 5) Length of peduncle. The length of cupule and peduncle length from 12 populations in Serbia are in the range reported for *Fagus sylvatica* in Serbia and western Eurasia. Results of cluster analysis shows a grouping of populations in two groups: 1) the southeast group, and 2) group consist of populations from northwest, east and southeast of Serbia. Populations from this southeast group also consist the group of populations on altitude over 850 m, indicating presence of ecotypes. The exception is population from Stara Planina (1,520 m a.s.l.) which is grouped with populations from altitudes under 850 m.

Keywords

European Beech; Cupules; Variability

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1 Introduction

Beech (*Fagus moesiaca* /Domin, Maly/ Czeczott. or *Fagus sylvatica* L.) is the most important tree species in forests of Serbia. Beech forests in Serbia covers 660,400 ha (29.3% of forest cover area) with 40.5% of total wood volume (Banković et al. 2009). Beech forests can be found on altitudes from 40 m a.s.l. at northeast to 2,100 m a.s.l. at the southwest (Jovanović and Cvjetićanin 2005). However, despite its significance, the taxonomic status of beech in Serbia is unclear. A number of authors, describe beech in Serbia as a separate species - Fagus moesiaca (Czeczott 1933, Jovanović M 1971, Jovanović B 1985, 2000, Hazler *et al*. 1997, Jovanović and Cvjetićanin 2005). Others consider it as a subspecies of *Fagus sylvatica* (Janković 1970, Denk 1999, Denk et al. 2002, Gömöry *et al*. 1999, Gömöry *et al.* 2007).

Although *Fagus moesiaca* is described as a separate species based on biometrical studies (Czeczott 1933) its morphological description is unclear and authors disagree on morphological attributes which separate this species from *Fagus sylvatica*. Some of used characters are leaf and cupule size and shape (see Jovanović 2000). However, morphotypes which were described as *Fagus sylvatica*, are well within the range of *Fagus sylvatica subsp. sylvatica* (Denk 1999). Even in Serbian forestry practice some populations are described as *Fagus moesiaca* and others as *Fagus sylvatica*, without any spatial pattern.

Morphology of the cupule/nut complex can be successfully used to distinguish living species of Fagus (Denk and Meller 2001). However, there are just a few researches on cupules size and shape (Mišić 1955, 1957; Istratii 1980; Denk 1999; Denk et al. 2005). This research is a part of a larger project aiming to determine the taxonomic status of beech in Serbia, using anatomical, morphological, and molecular markets. In this paper we report results on cupules morphology, measuring the same attributes reported by Mišić (1955, 1957).

2 Material and method

This research is a part of a larger project where beech samples (leaves, buds, and cupules) were sampled from 20 seed trees distanced no less 50 m from each other, in 12 populations in Serbia (Figure 4). During that occasion, cupules were collected according to their abundance, resulting with unequal sample size. In addition, due to lack of masting in populations Golija, Javor, and Tara, only a minimal bulk samples were collected. For analysis of cupules within and between population variability, following attributes were measured (Mišić 1955, Figure 1): 1) Length of the longest valve of cupule, 2) Width of that valve (at widest point), 3) Distance between base of the longest valve and peduncle, 4) Length of cupule without peduncle, and 5) Length of peduncle.

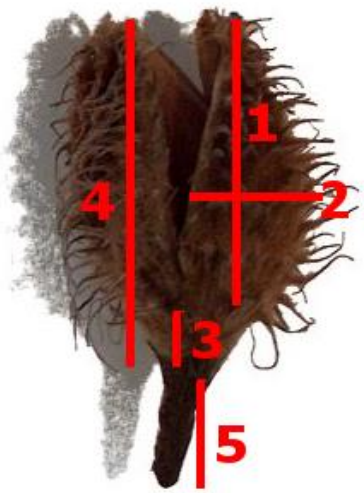

Figure 1. Measured attributes of cupules: 1) Length of the longest valve of cupule, 2) Width of the longest valve (at widest point), 3) Distance between base of the longest valve and peduncle, 4) Length of cupule without peduncle, and 5) Length of peduncle.

Descriptive statistics (mean value, standard variation, minimal and maximal values, and variance), as well as results of ANOVA and Tukey Unequal N HSD multiple comparison test on population and individual level, are given in Appendix 1. Because of a bulk samples of minimal size, populations Golija, Javor, and Tara were excluded from analysis on individual level. We used a Variance Components and Mixed Model ANOVA with "population" and "tree" as a random effects, in a hierarchically nested random effects design to estimate the components of variance. The populations were clustered based on combined mean value of measured attributes using a Joining (Tree Clustering) following the rule of Single Linkage on a non-standardized Euclidean distances. All statistics was done in Statistica 7 (StatSoft 2004) software.

3 Results

The mean value of length of the longest valve of cupule for all populations is 19.17 mm (SD=3.5), and range from 7.1 mm to 29.8 mm (Appendix 1). The mean value of width of that valve (at widest point) for all populations is 10.44 mm (SD=1.56), and range from 5.3 mm to 21.1 mm. The mean value of distance between base of the longest valve and peduncle for all populations is 5.69 mm (SD=1.53), and range from 1.9 mm to 12.6 mm. The mean value of length of cupule without peduncle for all populations is 24.66 mm (SD=2.99), and range from 10.1 mm to 36.5 mm. The mean value of peduncle length for all populations is 12.90 mm (SD=5.58), and range from 1.4 mm to 35.9 mm.

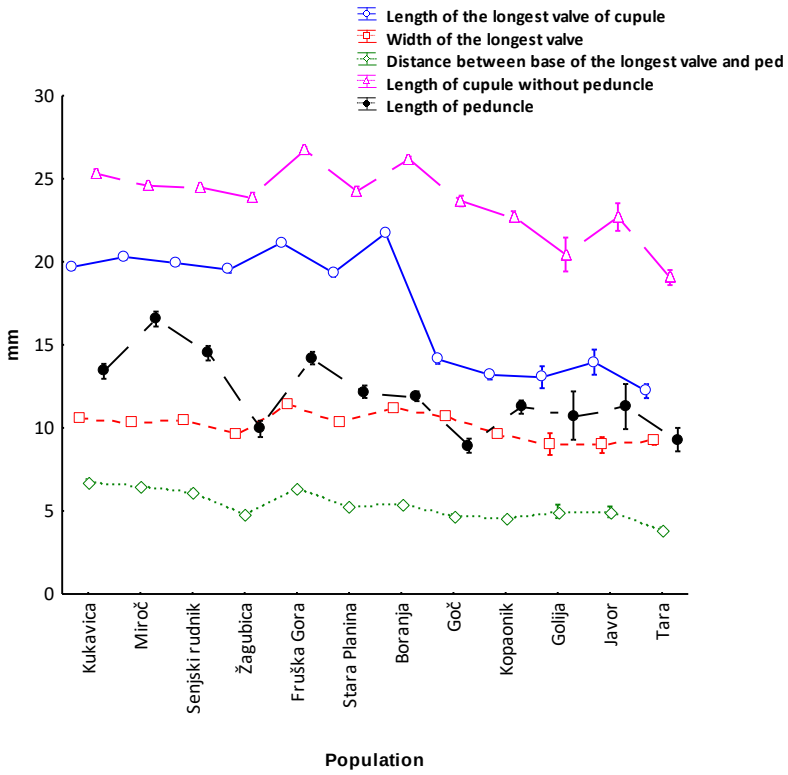

Figure 2. Mean values of five measured attributes of beech cupules from 12 populations in Serbia. Vertical bars shows confidence interval (CI=95%).

Populations with largest cupules are Fruška Gora and Boranja, and populations with smallest are Golija and Tara (Figure 2). The length of peduncle shows the largest variability, followed by length of cupule.

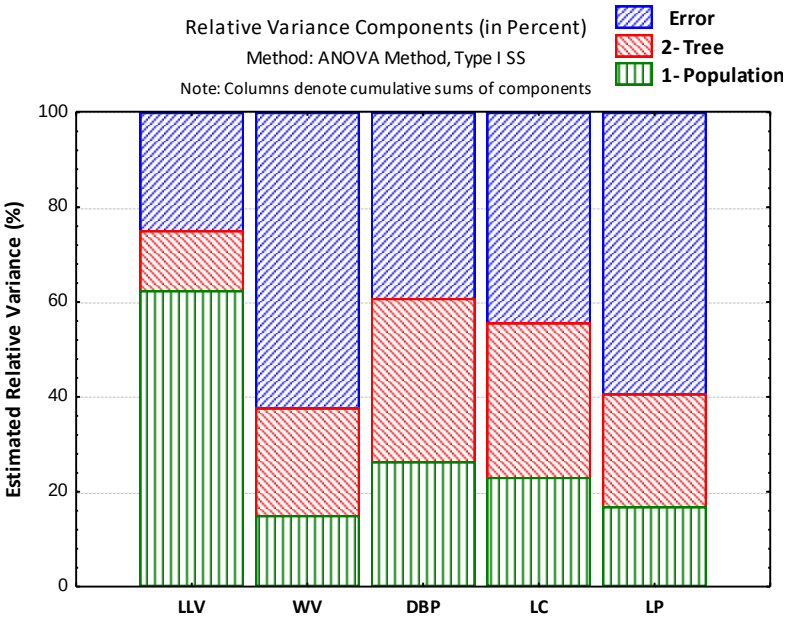

Figure 3. Relative Variance Components (in Percent) for: LLV - Length of the longest valve of cupule, WV - Width of the longest valve (at widest point), DBP - Distance between base of the longest valve and peduncle, LC - Length of cupule without peduncle, and LP - Length of peduncle.

Except for length of the longest valve of cupule, individual component of variance overcomes the population component (Figure 3). In addition, except for length of the longest valve of cupule, error is the largest component of variance for the measured attributes of cupules.

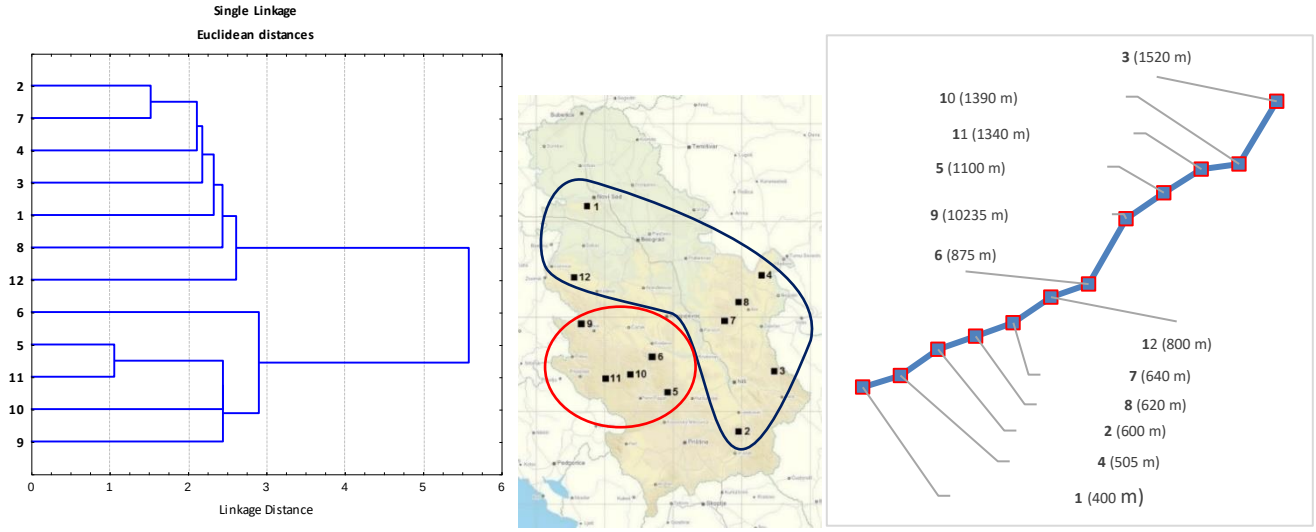

Figure 4. Tree diagram of cluster analysis for 12 beech populations in Serbia (1 – Fruška Gora, 2 – Kukavica, 3 – Stara Planina, 4 – Miroč, 5 – Kopaonik, 6 – Goč, 7 – Senjski rudnik, 8 – Žagubica, 9 – Tara, 10 – Golija, 11 – Javor, 12 – Boranja) – left, and their location – middle, and altitude – right (meters above sea level).

Results of cluster analysis shows a grouping of populations in two groups (Figure 4 – left). The southeast group of populations consists of Golija, Javor, Kopaonik, Tara, and Goč, while the second group consist of populations from northwest, east and southeast of Serbia (Figure 4 – middle). Populations from this southeast group also consist the group of populations on altitude over 850 m (Figure 4 – right). The exception is population from Stara Planina (1,520 m a.s.l.) which is grouped with populations from altitudes under 850 m (Boranja, Senjski rudnik, Žagubica, Miroč and Fruška Gora).

4 Discussion

Mišić (1957) reports a wide polymorphism of beech cupules, especially on shape, length and width of valve, length of peduncle, and shape of the cupule base. Although our research did not involve the shape of cupules, our findings support Mišić's (1957) report that length of peduncle is the most variable attribute.

The length of cupule and peduncle length from 12 populations in Serbia are in the range reported for *Fagus sylvatica* in Bulgaria (Denk 1999) and other morphotypes in western Eurasia, as described by Denk et al. (2005). The length of the longest valve in this research shows the wider range compared to results reported by Mišić (1957), probably because of the larger sample regarding number of populations and cupules measured in our research.

Grouping of populations in this research support the finding of Mišić (1957) on presence of altitudinal ecotypes of beech in Serbia. The exception is population Stara Planina which is grouped with populations from altitudes under 850 m, is consistent with claim that for proper testing of hypothesis about altitudinal ecotypes requires a detailed research of beech populations from different altitude zones inside the same mountain massif (Ivetić 2009).

Results of this research, combined with results of leaf morphology, anatomical markers, and DNA markers can be used in defining of taxonomic status of beech in Serbia. We did not find evidences on existence of a separate species *Fagus moesiaca* in Serbia and our results suggest that beech in Serbia, or at least in 12 studied provenances, belong to *Fagus sylvatica*.

5 References

Banković S, Medarević M, Pantić D, Petrović N (2009) Nacionalna inventura šuma Republike Srbije. Ministarstvo poljoprivrede, šumarstva i vodoprivrede Srbije, Uprava za šume, Beograd.

Czeczott H (1933) Studium nad zmiennoscia lisci bukow: *Fagus orienralis* Lipsky, *Fagus sylvatica* L. i form przejsciowych. Part 1. - Roczn Polsk Tow Dendrol 5: 44-121.

Denk T (1999) The taxonomy of Fagus in western Eurasia. 2: *Fagus sylvatica subsp. sylvatica*. Feddes Repert 110: 381-412. doi:10.1002/fedr.19991100510

Denk T, Grimm G, Hemleben V (2005) Patterns of molecular and morphological differentiation in Fagus: Phylogenetic implications. Am J Bot 92: 1006-1016.

Denk T, Grimm G, Stögerer K, Langer M, Hemleben V (2002) The evolutionary history of Fagus in Western Eurasia: Evidence from genes, morphology and the fosill record. Plant Syst Evol 232: 213-236

Denk T, Meller B (2001) Systematic significance of the cupule/nut complex in living and fossil Fagus. Int J Plant Sci 162(4): 869-897.

Gömöry D, Paule L, Brus R, Zhelev P, Tomović Z, Gračan J (1999): Genetic differentiation and phylogeny of beech on the Balkan peninsula. J Evol Biol 12: 746-754.

Gömöry D, Paule L, Vyšný (2007): Patterns of allozyme variation in Western Eurasian *Fagus*. Bot J Linn Soc 154: 165-174.

Hazler K, Comps B, Šugar I, Melovski L, Tashev A, Gračan J (1997) Genetic structure of *Fagus sylvatica* L. populations in Southeastern Europe. Silvae Genet 46 (4): 229-236.

Istratii AI (1980) Variability of the reproductive organs of a Moldavian beech population. Floristich i geobotan issled v Moldavii, pp 3-11.

Ivetić V (2009) Izdvajanje regiona provenijencija bukve u Srbiji primenom prostorne analize genetičkog diverziteta. Doktorska disertacija. Univerzitet u Beogradu – Šumarski fakultet. (UDK 630*232.311.3:630*165.3:582.632.2(497.11))

Janković M (1970) Fam Fagaceae Dum. Rod *Fagus* L., *Quercus* L. Flora SR Srbije (Josifović M ed). Srpska akademija nauka i umetnosti (SANU) – Odeljenje prirodno-matematičkih nauka. Knjiga 2, pp 69-98.

Jovanović B (2000) Dendrology. University Press – University of Belgrade. 536 p.

Jovanović B, Cvjetićanin R (2005) Taksonomija, morfologija i rasprostranjenost mezijske bukve (*Fagus moesiaca* /DM/Cz) u Srbiji. Monografija Bukva (*Fagus moesiaca* /DM/Cz) u Srbiji. Udruženje šumarskih inženjera i tehničara Srbije i Šumarski fakulteta Univerziteta u Srbiji, Beograd, pp 75-82

Mišić V (1955) Principi i metode u istraživanju sistematike bukve u Jugoslaviji [Principles and methods in the research work of systematics of beech in Yugoslavia]. – Zbornik radova Instituta za ekologiju i biogeografiju SAN 6(1): 3-14.

Mišić V (1957) Varijabilitet i ekologija bukve u Jugoslaviji [The variability and ecology of the beech in Yugoslavia]. – Posebno izdanje, Biološki institut NR Srbije, Beograd 1. 181 p.

StatSoft Inc. (2004) "Statistica" Data Analysis Software System, version 7.