ACORN FORM VARIABILITY IN THE COMMON OAK (*QUERCUS ROBUR* L.) IN CROATIA

Formenvariabilität von Eicheln der Steineiche (*Quercus robur* L.) in Kroatien

by

Josip FRANJIĆ, Bojana DALBELO-BAŠIĆ & Željko ŠKVORC

Key words: *Quercus robur*, common oak, acorn, multivariate analysis, Croatia.

Schlagwörter: *Quercus robur*, Steineiche, Eicheln, multivariante Analysen, Kroatien.

Summary: In the work the results of the research concerning the acorn form variability in the common oak (*Quercus robur*) in Croatia are given. In total 24 populations were analysed, and in each population the analysis of 100 acorns was made. On each acorn, two properties (the length [L] and the diameter [D]) were measured and therefrom the third property - a L/D index was derivated. All measured and derivated data were subjected to the descriptive analysis, regression analysis, variance analysis and multivariate analysis. From the descriptive analysis it can be seen that the data are distributed normally with certain deviations which very likely are due to a strong ecological influence. By the variance analysis the differences in respect to each of the studied properties were determined showing that the populations differ, namely coicide among themselves depending upon the microhabitat, regardless of their regional belonging. Similar results were obtained by the multivariate cluster analysis, where the similarity level for the analysed populations was determined.

Zusammenfassung: In der Arbeit werden die Untersuchungsergebnisse der Formvariabilität der Eicheln der Steineiche *(Quercus robur)* in Kroatien dargestellt. Insgesamt wurden 24 Populationen und in jeder Population 100 Eicheln analysiert. Bei jeder Eichel wurden zwei Eigenschaften, Länge (L) und Durchmesser (D), gemessen. Aus ihnen wurde die dritte Eigenschaft, der L/D-Index, abgeleitet. Sämtliche gemessenen und abgeleiteten Daten wurde der deskriptiven Analyse, der Varianzanalyse, sowie der multivariateen Analyse unterzogen. Aus der deskriptiven Analyse geht heraus, dass es sich um ± normale Distribution mit gewissen Abweichungen handelt, die wahrscheinlich unter dem starken ökologischen Einfluss stehen. Durch die Varianzanalyse werden die Unterschiede in bezug auf jede untersuchte Eigenschaft festgestellt, woraus ersichtlich ist, dass sich die Populationen untereinander bzw. in Abhängigkeit vom Biotop unterscheiden. Zu ähnlichen Ergebnissen kam man durch die multivariate Cluster-Analyse, wobei das Niveau der Ähnlichkeit der analysierten Population festgestellt wurde.

Introduction

The variability and the polymorphism of the genus *Quercus*, as can be seen from the abundant literature (cf. SCHWARZ, 1936, 1936a; COUSENS, 1963; TUCOVIĆ & JOVANOVIĆ, 1970; TRINAJSTIĆ, 1974; VIDAKOVIĆ & KRSTINIĆ, 1974; BORCHERT, 1975; OLSSON, 1975, 1975a; JOVANOVIĆ & TUCOVIĆ, 1975; BROOKES & WIGSTON, 1979; RUSHTON, 1979; PARABUČSKI et al., 1980; GLOTOV et al., 1981; BAČIĆ, 1981, 1983; MARTINIS et al., 1987; TRINAJSTIĆ, 1988; VIDAKOVIĆ & TRINAJSTIĆ, 1988; FRANJIĆ, 1993, 1994, 1996a, 1996b; KRSTINIĆ et al., 1996), are conditioned also by the fact that practically all oaks cross among themselves, provided that they grow side by side and that a suitable stand for the survival of crosses exists (GRANT, 1981). To make distinction between individual species and inferior taxons of the genus *Quercus*, the leaf and fruit morphology is used in the first place.

The morphological variability in most plant species being often very large and inexplicable at first sight, it was a frequent challenge for many researchers who, using various statistical methods, tried to explain the regularity in the distribution of individual properties. Since the morphological variability of the common oak, because of its incomplete reproductive isolation in relation to the species of the genus *Quercus*, is very high, this work presents one of the attempts to improve the knowledge of the regularity in the distribution of the studied properties using modern statistical methods.

As no more detailed morphometric researches of the acorn forms in the Croatian populations of the common oak have been made, in the period from 1989 to 1998 the individual and population variability of certain morphological parameters of the acorn were researched (cf. FRANJIĆ, 1993, 1993a), and this work presents a continuation and an extension only of the said research.

Material and methods

The studied material belongs to the common oak *(Quercus robur)*, and it originates from the continental lowland region of Croatia, namely from the region between the Kupa, Sava and Drava Rivers. The research includes in total 24 populations with various microhabitat properties (Fig. 1). Each population is represented by 100 absolutely healthy and fully developed acorns. On each acorn two properties were measured (its length [L] and its diameter [D]) and from these two properties the third one - a L/D index was derived. The measurements were made with the accuracy of 0,1 mm. All measured and derived data were statistically processed, that included the descriptive analysis, the regression analysis, the variance analysis and the multivariate cluster analysis (JOHNSON, 1988; MCCLARE, 1988; SHARMA, 1996).

The descriptive analysis was used to obtain the distribution model of the measured and derived data, as one of the prerequisites for proceeding with further analysis by means of more sophisticated methods. The regression analysis was made to determine an equality model, and then on the basis of this model the similarities and the differences between the populations were determined. The variance analysis was used to determine the population differences in respect to each of the studied properties. The multivariate cluster analysis was made to determine the degree of grouping between individual populations and to identify the similarity level for the analysed populations.

Analysis of the results researches and discussion

The descriptive analysis of the acorn length in all 24 studied populations of the common oak *(Quercus robur)* showed that the data range from x_{min} = 15,1 mm to x_{max} = 41,6 mm, with the arithmetic mean ranging from 26,2 mm to 31,9 mm, the standard deviation from 2,0 to 4,1 mm, the variability coefficient (VC) from 6,43 to 14,19%, the skewness coefficient from –1,38 to 1,01 and the kurtosis coefficient from –0,83 to 2,63.

The descriptive analysis of the acorn diameter in all 24 studied populations of the common oake showed that the data range from x_{min} = 9,8 mm to x_{max} = 21,5 mm, with the arithmetic mean ranging from 13,0 mm to 17,8 mm, the standard deviation from 1,0 mm to 2,0 mm, the variability coefficient (VC) from 7,57 to 13,0%, the skewness coefficient from –1,21 to 0,90 and the kurtosis coefficient from –0,72 to 2,31.

The descriptive analysis of the acorn L/D index in all 24 studied populations of the common oak showed that the data range from x_{min} = 1,09 to x_{max} = 2,85, with the arithmetic mean ranging from 1,68 to 2,35, the standard deviation from 0,12 to 0,32, the variability coefficient (VC) from 5,41 to 15,55%, the skewness coefficient from –1,43 to 1,76 and the kurtosis coefficient from –1,02 to 5,23.

From the descriptive analysis it can be seen that the populations are grouping among themselves, and that the form and the regularity of their grouping depend upon the microhabitat conditions. Very similar forms of population grouping in respect to the analysed properties are shown also by the regression analysis, the variance analysis and the multivariate cluster analysis. However, due to space restrictions, this time the results of the multivariate cluster analysis only will be given. The cluster analysis was made using several methods, but as the highest cophenetic correlation coefficient has been noted for the unweighted pair-group average method, the said method was taken for the analysis. The results of the cluster method can be seen in Figure 2, in which the dendogram such as obtained with two measured properties (the length and the diameter), (cf. Fig. 2) is given.

In Figure 2 it can be seen that three clusters which differ at a very high level are clearly noticeable. The number of clusters is determined on the basis of the average distance which is 2,1 (cf. Fig. 2). To the first cluster belong the populations (Zdenci, Velika Ves, Županja, Križevci, Gradište, Jastrebarsko, Vinkovci) from the Sava River basin, with the exception of the Repaš and Ludbreg populations which belong to the Drava River basin, as well as the Našice population which presents a transitional area between the said two basins and belongs to the Vuka River basin. To the second cluster belong the populations of the Drava River basin (Velika Pisanica, Orahovica, Varaždin, Valpovo, Koprivnica, Ivanec, Bjelovar), with the exception of the Popovača, Kaniška Iva, Vrbovec, Maksimir and Lipovljani populations which all belong to the western part of the Sava River basin, as well as the Eminovci population which belongs to the Požega complex. The similar results were obtained also during the earlier researches, where the populations from the western Sava River basin and from the Požega complex showed similarity with the Drava River populations (cf. FRANJIĆ, 1993, 1994, 1996, 1996a, 1996b). The third cluster comprises the Slatina population only which belongs to the Drava River basin although it differs from other populations in this basin as well as from those belonging to the Sava River basin, and this at a very high level. Such big differences as regards all research methods lead to the hypothesis that there must be something that disturbs every assumed model of grouping. Since the oak acorn in general, and especially the common oak acorn, was transported to large distances, and since the artificial regeneration of the common oak forests has a centenary tradition, it can be assumed that this population was produced by the "genetic pollution" of an extra-Croatian provenance. This population has a very narrow and long acorn such as cannot be found in any other Croatian population.

A similar form of population grouping into clusters has been obtained in the earlier researches, too, so it can be stated with a considerable measure of certainty that the ecological conditions (the microhabitat) are decisive for the formation of a genotype structure within every population. In this case it can also be said that the assumptions of the earlier researches (cf. FRANJIĆ, 1996, 1996a, 1996b), namely that every common oak population has the same number of genotypes but that the frequency (proportion) of each genotype differs from one population to the other, are very probable. The different genotype structure of each population very likely is the consequence of the differences in the stand, an element to which the common oak is very sensitive.

The Sava River and the Drava River regions have a completely different water regime. The Sava River reaches its maximum in spring, when the precipitation (rain) is abundant, while the Drava River reaches its maximum in summer when the snow in the Alps melts. The soil structure and type are different, too, that is closely connected with the underground water regime to which the common oak is very sensitive. Characteristic for the researched area is also a big difference in the amount of precipitation between the western and eastern parts of the Sava and Drava River regions (cf. ILIJANIĆ, 1963). For all these reasons, the grouping of the populations from the Drava River region with those from the western Sava River region requires additional researches which should absolutely include the pedological and phytosociological researches, too, that very likely would give the reply to many questions connected with the type of population grouping into clusters.

Having in view the above said, a special attention should be paid to the artificial regeneration of the common oak forests, which nowadays is very popular and more and more spread. In that, special care must be taken of ecological properties of the stands to be regenerated and afforested with the material (acorns or seedlings) which must belong to the provenance with similar properties, since the consequences of mistakes will not be evident immediately but after 10, 50, 100 or more years. It can often be heard or read about tons and tons of imported or exported acrons, but the origin of these acorns is rarely known. It was written about, and still today is talked about, the oak forests which wither away on more or less large surfaces. This is attributed to various causes (such as waterstream regulations, acid rains, etc.), that is absolutely correct, but a mistake made in the regeneration of the common oak forests should also be added to the list of causes, because the artificial regeneration of the common oak forests is a centenary tradition whose consequences are visible just now.

Conclusion

In the work, the results of the research concerning the acorn form variability in the common oak *(Quercus robur)* in Croatia are given. The analysis of 24 populations was made, with 100 analysed acorns each. On each acorn, two properties (the length [L] and the diameter [D]) were measured and from them the third property - a L/D index was derived. All measured and derived data underwent the descriptive analysis, the regression analysis, the variance analysis and the multivariate analysis. From the descriptive analysis it can be seen that in general the data are distributed normally with certain deviations most probably due to strong ecological influences. By the variance analysis the differences in each researched property have been determined showing that the populations differ, or coincide, among themselves depending upon their microhabitats. Similar results were obtained by the multivariate cluster analysis by means of which the similarity level between the analysed populations was determined.

In Figure 2 it can be seen that three clusters which differ at a very high level are clearly noticeable. The first cluster includes the populations (Zdenci, Velika Ves, Županja, Križevci, Gradište, Jastrebarsko, Vinkovci) from the Sava River basin, with the exception of the Repaš and Ludbreg populations which belong to the Drava River basin, as well as the Našice population which presents a transitional area between the said two basins and belongs to the Vuka River basin. The second cluster includes the populations from the Drava River basin (Velika Pisanica, Orahovica, Varaždin, Valpovo, Koprivnica, Ivanec, Bjelovar), with the exception of the Popovača, Kaniška Iva, Vrbovec, Maksimir and Lipovljani populations which all belong to the western part of the Sava River basin, as well as the Eminovci population which belongs to the Požega complex. The third cluster includes the Slatina population only, which belongs to the Drava River basin and which differs from other populations in this basin as well as from those belonging to the Sava River basin at a very high level and is, therefore, assumed to be the product of the "genetic pollution" of an extra-Croatian provenance. This population has a very narrow and long acorn such as cannot be found in any other Croatian population.

For these reasons, the grouping of the populations from the Drava River region and from the western part of the Sava River region as well as the grouping of two populations from the Drava River basin with those from the Sava River basin indicates the need for further researches. These researches should absolutely include the pedological and phytocenological researches, which very likely would give the reply to many questions connected with the type of population grouping into clusters.

Having in view the above said, special attention must be paid to the artificial regeneration of the common oak forests, which is now very popular and more and more spread. In that, care must be taken in particular of the ecological properties of the stands to be regenerated and afforested with the material (acorns or seedlings) which must belong to the provenance with similar properties.

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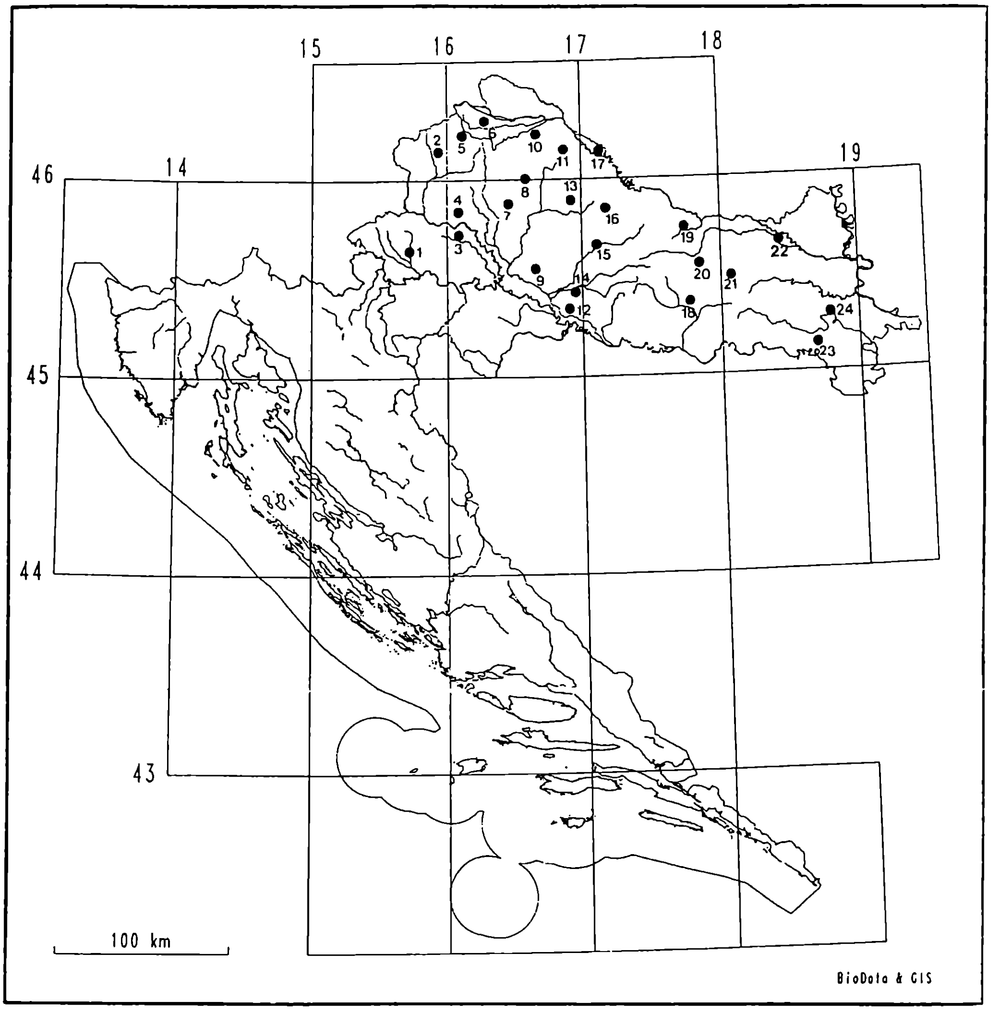
Addresses:

Doc. dr. sci. Josip FRANJIĆ
Dipl. ing. Željko ŠKVORC
Faculty of Forestry
Svetošimunska 25
HR-10000 Zagreb
Croatia
E-Mail: jozo.franjic@zg.tel.hr
Zeljko.skvorc@zg.tel.hr

Doc. dr. sci. Bojana DALBELO-BAŠIĆ
Faculty of Electrical Engineering and Computing
Unska 3,
HR-10000 Zagreb
Croatia
E-Mail: bojana.dalbelo@fer.hr

Figure 1: Research populations of common oak (*Quercus robur* L.) in Croatia.

1. Jastrebarsko	9. Popovača	17. Repaš
2. Velika Ves	10. Ludbreg	18. Eminovci
3. Maksimir	11. Koprivnica	19. Slatina
4. Gradići	12. Lipovljani	20. Orahovica
5. Ivanec	13. Bjelovar	21. Našice
6. Varaždin	14. Kaniška Iva	22. Valpovo
7 Vrbovec	15. Zdenci	23. Županja
8. Križevci	16. Velika Pisanica	24. Vinkovci



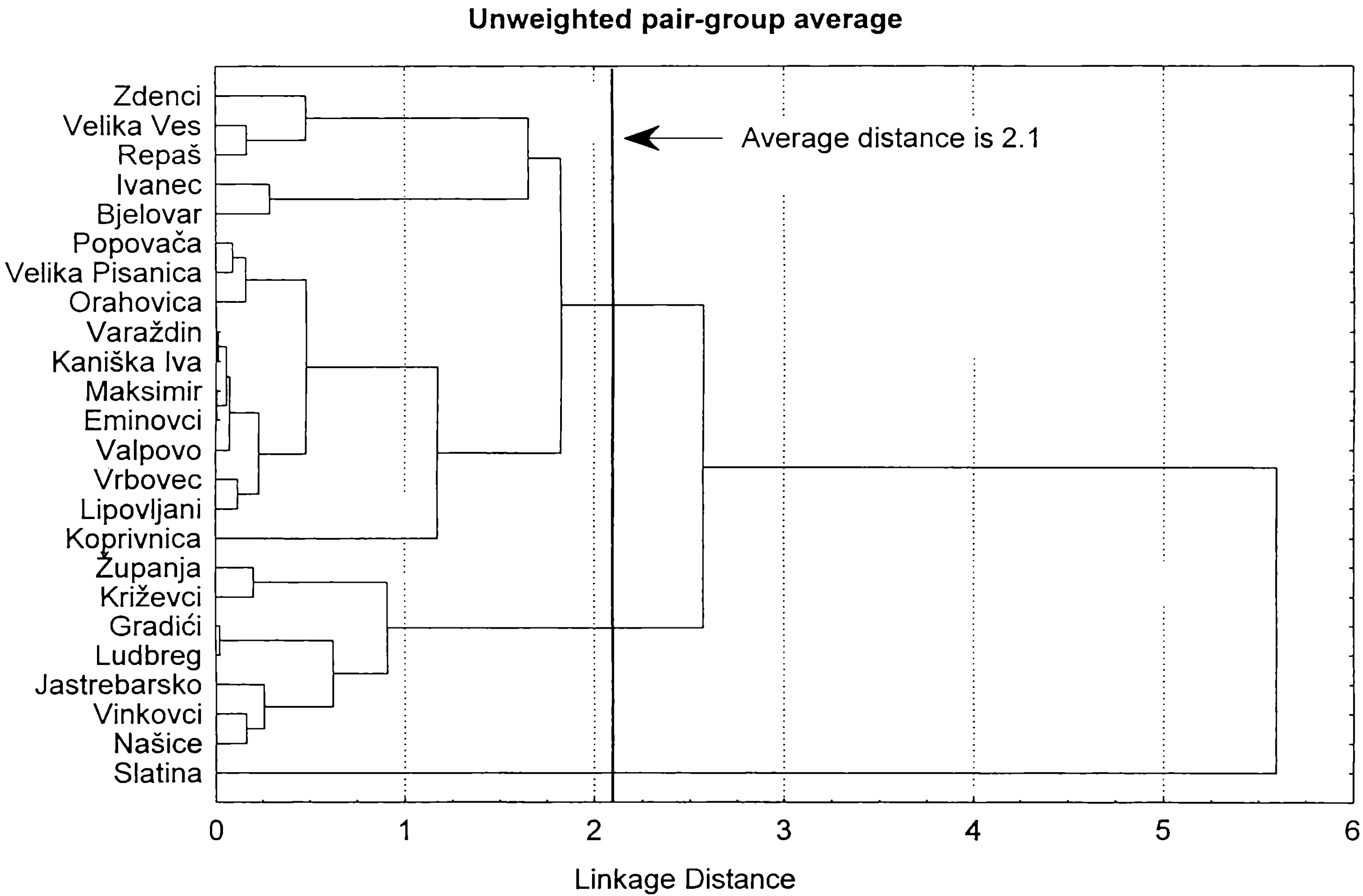


Figure 2: Dendrogram obtained by the UPGA method Linkage's distance.