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HEIGHT STRUCTURE OF COPPICE OAK (HUNGARIAN, SESSILE AND TURKEY) STANDS

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Abstract

The study has intended to reveal the height structure of relatively even-aged coppice stands of Hungarian oak (*Quercus conferta* L.), Sessile oak (*Quercus petraea* Liebl.) and Turkey oak (*Quercus cerris* L.) according to thickness levels in terms of curve forms, and to look for the general regularities occurring with these. Based on a total of 59 sample plots, the height curves have been investigated for the three groups of stands according to tree species. The height curves have been transformed into relative height curves and multiplied by the respective numbers of trees in order to obtain the complex relative height curves. Due to the numbers of trees, the complex relative height curves obtain paraboloid shape, and these have been investigated for finding out their asymmetry in terms of breast-height diameter, i.e. the natural thickness level of 1.0. The complex height curves have been investigated while using a special coefficient of asymmetry (C_{as}). As a result of the investigations, the distribution of sample plot numbers according to height structure asymmetry for the three investigated aggregates is almost the same. The average curves' values of the normal numbers have been calculated for the three aggregates through the natural indicators' method of Douhovnikov (1966), and the average curves have been compared with the uniform average curve of normal numbers by Tyurin. Extreme similarities of the curves' aspects have been found, which confirms that the tree species does not have substantial influence upon the height structure of stands.

Key words: asymmetry type, average curves of normal numbers, height structure, oak stands.

Introduction

It is important to permanently improve the normative and reference data about forests, including the models and tables for evaluating the growing stock volume. For this reason, it is always necessary for scientists to improve their knowledge of the regularities in the growth and structure of forest stands.

In 1965, the total area of coppice stands of Hungarian, Sessile and Turkey oak in Bulgaria amounted to 489 314 ha, and in 2000 it increased to 623 629 ha (Petrov 2008). Because of this, it is currently important to study the thickness structure of these stands.

A number of authors have carried out studies of forest stand's structure (i.e. Tyurin 1938; Tretyakov 1927, 1952; Sirakov 1947; Nedyalkov 1964, 1967; Mihov et al. 1996; Dimitrov 2003; Tonchev 2007). The more important inferences the above and other authors have made from their studies of stand structure according to height are as follows:

Tyurin (1938) used in his studies not the absolute height for the particular thickness levels but the relative one, which is obtained by dividing each particular tree height by stand average one. He also introduced the natural level of thickness instead of the absolute one. Tyurin found out that the height curves for homogenous, pure, even-aged stands resembled one another in their shape regardless tree species and site quality. Only tree age and forest management can alter the curve shape. This gave him the reason for calculating an average general curve of relative heights for all major tree species.

Tretyakov (1927, 1952) carried out a detailed study of the regularities in the structure and variation of some dendrobiometric characteristics in pure even-aged stands and in mixed uneven-aged ones of complex forms. He established that forest structure always has a constant nature, regardless of stocking, age, tree species and growth conditions, even though these might pertain as to normal stands so to complex mixed ones. Thus he formulated a Law about the Unity of Stand Structure.

Dimitrov (1978) demonstrated the ability for analytical expression curve heights as a link height-diameter spruce based on 3-4 altitudes of any degree of thickness. Dimitrov (2003) pointed out that the relative heights, alias reduction number, in Tyurin's general curve of relative heights needs to be specified.

Mihov et al. (1996) identified three types of structure in thickness and height – positive (left maximum of the average diameter curve) asymmetry, negative (with right maximum) asymmetry and normal or symmetric type.

Mihov (2005) showed the necessity of approximating the height curves by means of a parabola equation while using a polynomial raised to a certain power, or a logarithmic function. This approximation has successfully been applied into the present study.

For the structure of uneven-aged spruce stands in thickness Nedialkov (1964, 1967) established various distribution curves for different generations. For different age generations distribution curves have bell- or parabolic shape and aggregate curve – exponential form.

Tonchev (2007), comparing the average curve of relative heights for the coppice common beech growing stocks investigated with Tyurin's average general curve, and found differences indicative of a specificity proceeding from the tree species and the origin of stands.

An investigation has been carried out of the height structure of natural beech stands (Petrin et al. 2014). Using the natural indicators' method, the steepness of height curves was investigated and found that stand height structure does not depend on tree age and that it is possible to create common, order curves of the heights for more than one tree species.

The investigations of the above-mentioned and other authors have provided the methodological background for our study.

Purpose of the study

The purpose of the present study is to investigate the height structure of coppice stands by Hungarian, Sessile and Turkey oak with a view to solving the following tasks:

1. Find out the different types of height structure of Hungarian, Sessile and Turkey oak stands by investigating the asymmetry, of the complex height structure curves.

2. Compare the average curves of the normal numbers of the height structure of the investigated stands with the uniform

average curve Tyurin developed for all tree species for finding-out similarities in the curves' aspects, which would be the basis of important inferences.

Objects and Methods

The present investigation pertains to coppice Hungarian, Sessile oak and Turkey oak stands in the Balkan Range (near Elena, Kotel and Sliven towns), in the Rhodopes (near Topolovgrad and Elhovo towns), and near the cities of Varna, Staro Oryahovo and Bourgas.

A total of 59 sample plots (SPs) have been established, 25 of these being in Hungarian oak stands, 26 – in Sessile and 8 – in Turkey oak.

Average stand age vary from 40 to 80 years, i.e. premature and mature stands, taking into account various rotation time from 60 to 100 years.

The natural levels of thickness have been calculated for each sample plot after Tyurin (1938), and these have been obtained by dividing the absolute levels of thickness by breast-height diameter, the results being relative, not round, levels of thickness, or relative diameters as, for example, 0.56, 0.67, 0.76, etc. up to 1.43. Further on, the height curves have graphically been approximated and the heights corresponding to the relative levels of thickness, which have been called 'natural levels of thickness', have been reported. The natural thickness-level values' interval for reliably investigating the curves is from 0.6 to 1.4. The absolute values of the heights are in their turn converted into relative heights by dividing them by height corresponding to natural thickness level of 1.0, i.e. by the average height of the even-aged stand. After this, the values for the relative heights' curves, in these aspects of theirs, are multiplied by the percentage number of trees, thus resulting in the complex, or generalised, curves of the heights for each thickness level. As the complex curves of the heights contain in their values the number of trees in percentages, they obtain paraboloid aspects and are investigated like thickness structure – the asymmetry of the curves is investigated in terms of the natural thickness level of 1.0, which corresponds to the average breast-height diameter of the stand. The right-hand asymmetry of the curves means that the parabola's maximum is on the right, and it reveals the availability of a larger volume of wood in the respective stand as it suggests the prevalence of taller and thicker trees. It is just the opposite with the left-hand asymmetry – the stand contains less wood because its trees are thinner and lower.

As it is seen from the above, the notion 'asymmetry of the structure curves according to height, and thickness,' does not mean the same as 'statistical asymmetry', which is calculated in terms of the maximum value of paraboloid curve. For measuring the asymmetry of the complex curves of heights, a special coefficient of asymmetry has been introduced, which can be expressed by means of the equation:

$$C_{as} = \frac{N_{0,x1} + N_{0,x2} + \ldots + N_{0.8} + \sum(N_{0.9} + N_{1.0} + N_{1.1})}{2},$$

where:

$N_{0,x1,}$ $N_{0,x2,}$ etc., $N_{0,8}$ are the complex relative heights corresponding to the thickness levels ranging up to 0.8, in percentages, and

Σ ($N_{0.9}$ + $N_{1.0}$+ $N_{1.1}$) is the sum of the complex relative heights for each of the three central levels of thickness, in percentages.

When C_{as} is less than 49 %, the curves have a right-hand asymmetry, more than

51 % – a left-hand asymmetry, and within the range from 49 % to 51 % we have assumed to consider them symmetric.

Further on, the values of the normal numbers's curves are calculated, as the values of the heights for the respective thickness levels are divided by the value of height corresponding to that of rightmost point on the abscise, i.e. the thickness level of 1.4. This is how all the normal numbers's curves are obtained through the natural indicators' method of Douhovnikov (1966) and, after this, the average curve of the normal numbers (q_{xav}) is calculated for the particular aggregates of curves, depending on the tree species.

While comparing our average curves of the normal numbers with the uniform average curve of Tyurin, the correlation coefficients have been calculated as well as other indicators of the conformity or proximity of the curves, such as the standard deviation, the coefficient of variation, and the error with the mean value.

Results and Discussion

Types of asymmetry of the complex relative heights curves

We have completed the distribution of the sample plots into three groups, on the basis of asymmetry coefficient values (C_{as}) for the height structure, thus forming three types of stand height structure according to the asymmetry of respective curves in terms of vertical imaginary line raised from the uniform average breast-height diameter 1.0. All the three types of asymmetry are available, namely left-hand, right-hand, and symmetric one. On figures 1, 2 and 3, these three types have respectively been illustrated for Hungarian, Sessile and Turkey oak coppice stands.

Figures 1, 2 and 3 reveal that the high

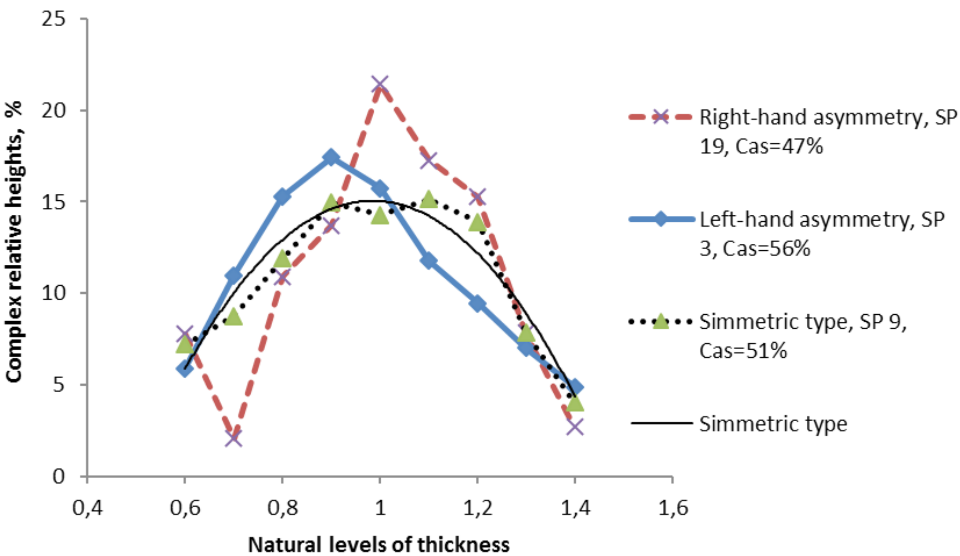

Fig. 1. Three types of curves according to the asymmetry of the generalised curve of heights for coppice Hungarian oak stands.

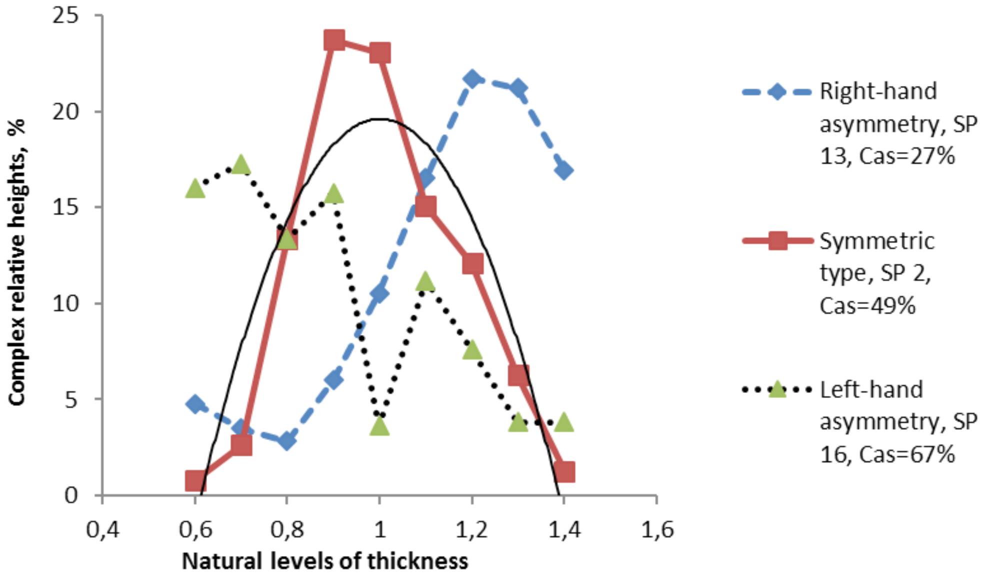

Fig. 2. Three types of curves according to the asymmetry of the generalised curve of heights for coppice Sessile oak stands.

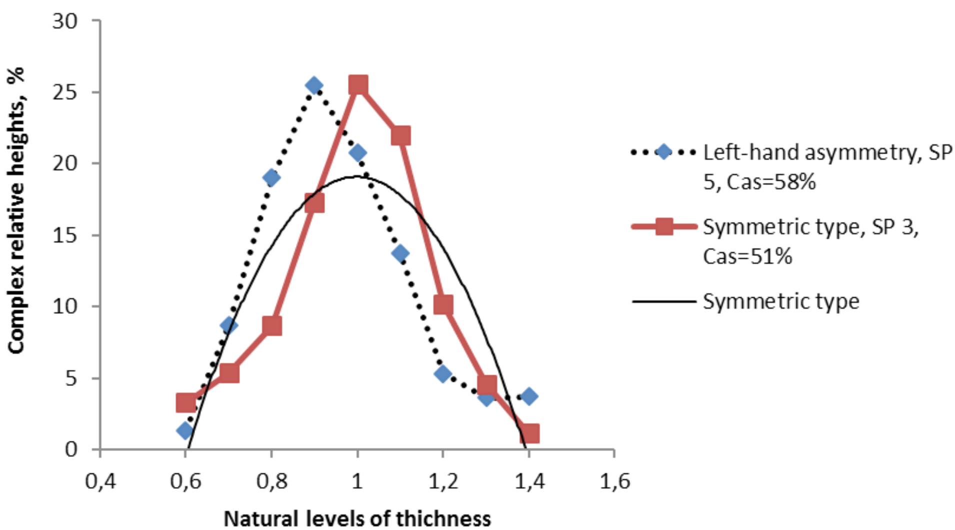

Fig. 3. Two types of curves according to the asymmetry of the generalised curve of heights for coppice Turkey-oak stands.

values of C_{as} (SPs 3, 16 and 5) stand for a clearly expressed left-hand asymmetry of generalised curves of the three tree species height structure, respectively. This means that thinner and lower trees prevail, hence, the availability of lower volume of wood. The lower values of C_{as} (SPs 19 and 13) stand for curves of a right-hand asymmetry, which means that thicker and taller trees prevail and the wood volume are higher and, when C_{as} is about 50 % (SPs 9, 2 and 3), the curves are symmetric, i.e. they occupy an intermediate position.

The distribution of the sample plots according to types of asymmetry has been presented for the three groups of stands in Table 1.

Table 1. Distribution of coppice stands according to types of asymmetry of the generalised curves.

Types of asymmetry according to height	Number of sample plots according to tree species						Total number of sample plots	Share, %
	Hungarian oak	Share, %	Sessile oak	Share, %	Turkey oak	Share, %		
Left-hand	13	52	13	50	3	43*	29	50
Right-hand	5	20	6	23	-	-	11	19
Symmetric	7	28	7	27	4	58*	18	31
Total	25	100	26	100	7	100	58	100

Note: * – SP distribution do not ensure reliability of results for Turkey oak.

Table 1 reveals similarity and conformity in terms of the sample plots distribution of Hungarian and Sessile oak according to asymmetry types. This pertains also to their total distribution, as the percentage is almost the same. The left-hand asymmetry is seen to prevail, about 50 %, next followed by the symmetric type, about 30 %, and the right-hand asymmetry – about 20 %. The prevalence of the left-hand asymmetry suggests prevalence of thinner and lower, or medium-high trees with the formation of total wood volume in the stands, and the close proximity of sample-plot distribution for Hungarian and Sessile oaks suggests conformity in their height structure, as this same could quite probably be said about the Turkey oak, if the sample plots were more. Therefore, it can be assumed that the first two, or even the three, of the tree species have the same height structure or similar one.

In Table 2 is presented the comparison between our average relative curves of heights (or the average curves of the normal numbers) and Tyurin's uniform curve of relative heights, which pertains to all the tree species.

Table 2 shows similarity of all three tree species and Tyurin's average data. The height structure normal-number rows of coppice Hungarian, Sessile and Turkey oak stands are similar not only for these three species, but also for other, so it is possible to elaborate a common model of height structure.

Conclusions

Three types of height structure have been found with Hungarian, Sessile and Turkey oak stands: with a right-hand asymmetry, a left-hand asymmetry, and a symmetric type. Same trend has been observed for all three oak species stands in the distribution of their sample plots according to asymmetry types. For this reason, studying them either separately or as a whole in terms of their height structure does not affect their distribution according to asymmetry types.

The comparison between the average curves of the normal numbers (quality indicators) of the height structure of investigated coppice oak stands and Tyurin's average curve of normal numbers has shown close proximity of the curves'

Table 2. Comparison of average height curves with Tyurin's uniform average curve of normal numbers.

Belonging of the curve	Natural Levels of Thickness									Indicators of similarity			
	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	Correlation coefficient	Standard deviation	Variation coefficient, %	Error of average, %
	Average complex curves of the normal numbers ($q_{xav.H}$) for height structure												
Hungarian oak	0.69	0.76	0.81	0.86	0.90	0.94	0.96	0.99	1	0.997	0.04	3.9	1.3
Sessile oak	0.69	0.75	0.8	0.84	0.89	0.92	0.95	0.98	1	1.000	0.04	4.4	1.5
Turkey oak	0.68	0.74	0.8	0.84	0.89	0.92	0.95	0.98	1	1.000	0.04	4.8	1.6
Tyurin's uniform average curve of normal numbers ($q_{xav.H}$)	0.77	0.81	0.85	0.88	0.91	0.94	0.96	0.98	1	-	-	-	-

aspects, and this convincingly proves the possibility of developing common models of their wood volumes and assortment structure, as long as these depend on height structure.

The proximity of the studied medium curves normal numbers to total average curve of Tyurin, designed for all tree species, showed the possibility of developing common diluted curves heights oak and other tree species such as Scots pine, beech, etc.

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