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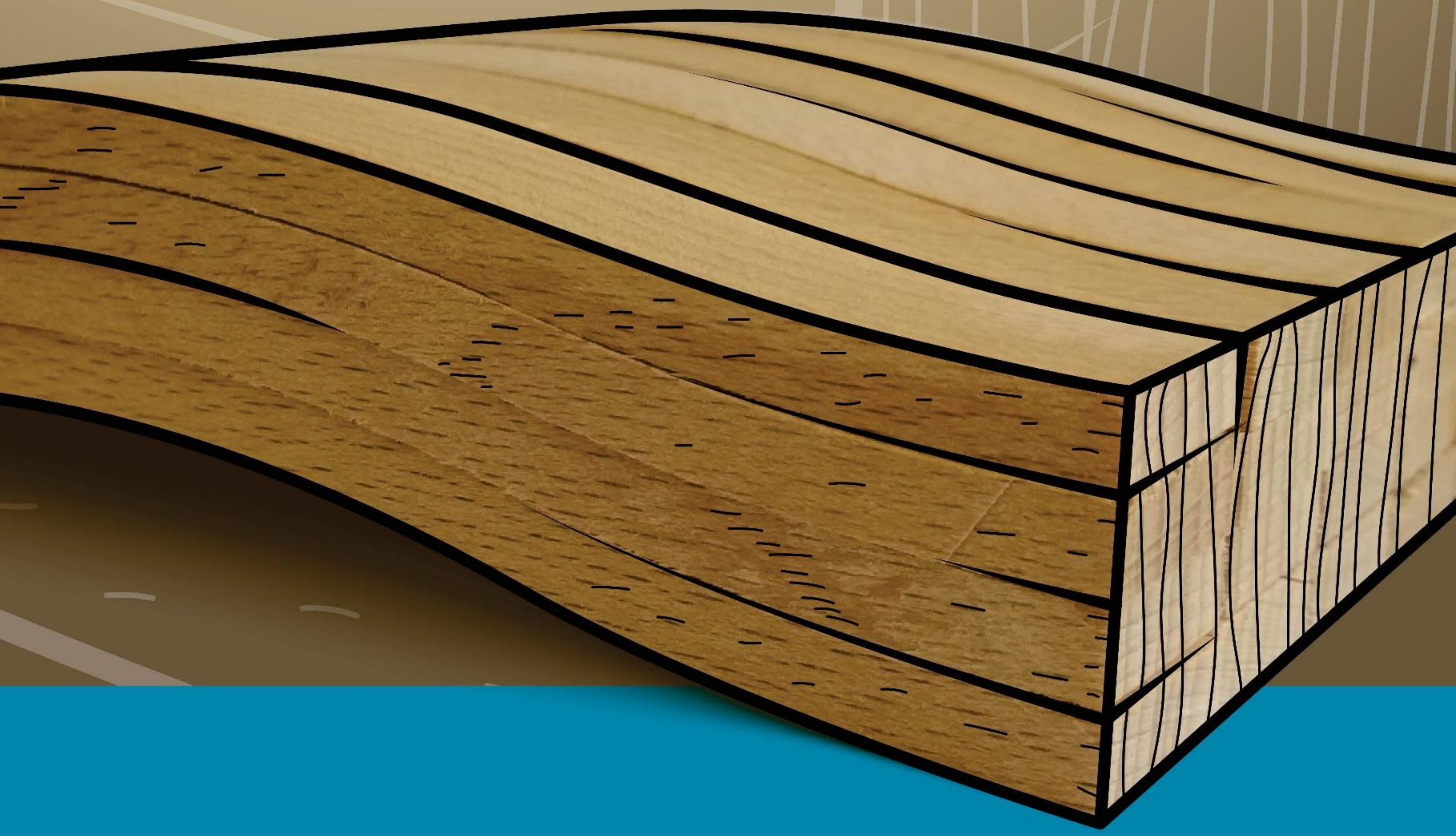

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Analysis of some anatomical features of field elm (*Ulmus minor* Mill.)

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ABSTRACT

The aim of the research is to investigate the annual ring structure of the field elm or English elm (*Ulmus minor* Mill.). The special feature of the elm is that it is a ring-porous wood species with wavy vessel bands (ulmiform arrangement) in the latewood. 24 specimens in their green state were examined. We measured annual ring widths, earlywood and latewood widths, vessel diameters in the earlywood, and wave amplitudes of the wavy vessel bands in latewood. Our goal is to find correlations between the measured data, how vessel diameters and vessel wave amplitudes vary for the earlywood and latewood width. The widths of earlywoods were nearly identical, and at the same time the vessel diameters were almost the same. In contrary, significantly different results were observed for the widths of the latewoods. The amplitudes of the wavy vessel bands in the latewood are mostly between 0.138 and 0.230 mm. Almost straight vessel bands occur, but also more wavy vessel bands, clearly visible to the naked eye, are found on the cross-sectional surface, with an average amplitude of 0.184 mm. Initial research has shown that there is no correlation between the width of the latewood and the amplitude of the vessel bands. However, a relationship was observed between the proximity of the vessel bands and the size of the amplitudes.

INTRODUCTION

Field elm is a deciduous ring-porous species. Its vessels are 35 μm in diameter in the latewood and 150 μm in diameter in the earlywood, so the vessel lumina are clearly visible and typically large. In the latewood, wavy vessel bands appear, called ulmiform arrangement, which is interrupted in some places (Fig. 1) (Molnár and Börcsök 2016). The size and quantity of the vessels affect the technical properties. Due to the smaller amount of wood in the ring-porous wood species, the earlywood is significantly weaker than the much denser latewood, which often leads to fissures during machining and makes it more difficult to produce thin veneers (Molnár 1999). In this research, we investigated anatomical properties such as the width of growing zones and the height of the vessel bands, which were compared to the width of the annual rings. These data and results can be later compared with the physical and mechanical properties of the wood. Thus, the aim of this study is to analyse the mentioned anatomical properties of field elm and to compare them.

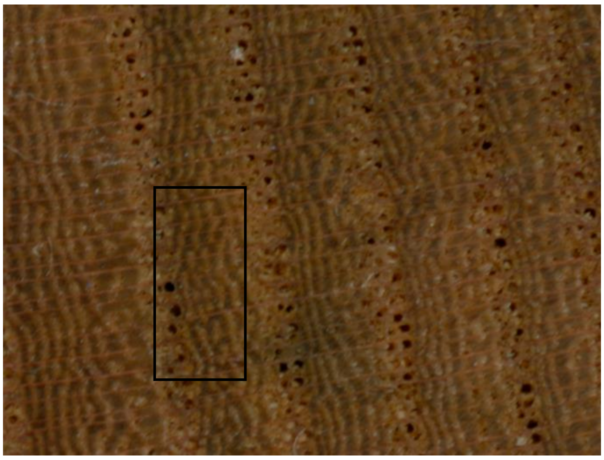

Figure 1: Wavy vessel bands in the latewood, interrupted in some places as indicated in the rectangle

EXPERIMENTAL METHODS

The 24 specimens came from 19.5x29x200 mm field elm (*Ulmus minor* Mill.) wood pieces using a circular saw developed for small and fine applications. 50 millimetres long parts were cut from each end of the wood pieces, and the freshly cut end-grains of the resulting 50 millimetres long specimens were scanned with an HP Scanjet G4050 scanner (Hewlett-Packard Development Company, Palo Alto, CA, USA), alongside a ruler. The images were then inserted into software AutoCAD (Autodesk, San Rafael, CA, USA) and scaled using the aforementioned ruler to produce accurate data for later use. For the annual ring width analysis (Fig. 2a), a straight line was fitted perpendicular to the annual rings on the test specimens, following the long wood rays. Along this line the earlywood and latewood widths were measured. The second step was the examination of the diameter of the vessel lumina in the earlywood (Fig. 2b). Here, the diameters within a 4 mm wide area perpendicular to the annual rings for each specimen were measured. Due to the use of a circular saw to prepare the specimens, some of the vessels got clogged with sawdust or small slivers and were distorted, thus, in these cases the diameters could not be determined. The focus of the third study was on the latewood vessels, where the amplitudes of the wavy vessel bands were measured (Fig. 2c). A perpendicular line was drawn on the axis of the 4 mm wide area used for the previous test, and the perpendicular line was placed at the highest point of the vessel bands. The amplitudes of the waves could be determined relative to this line.

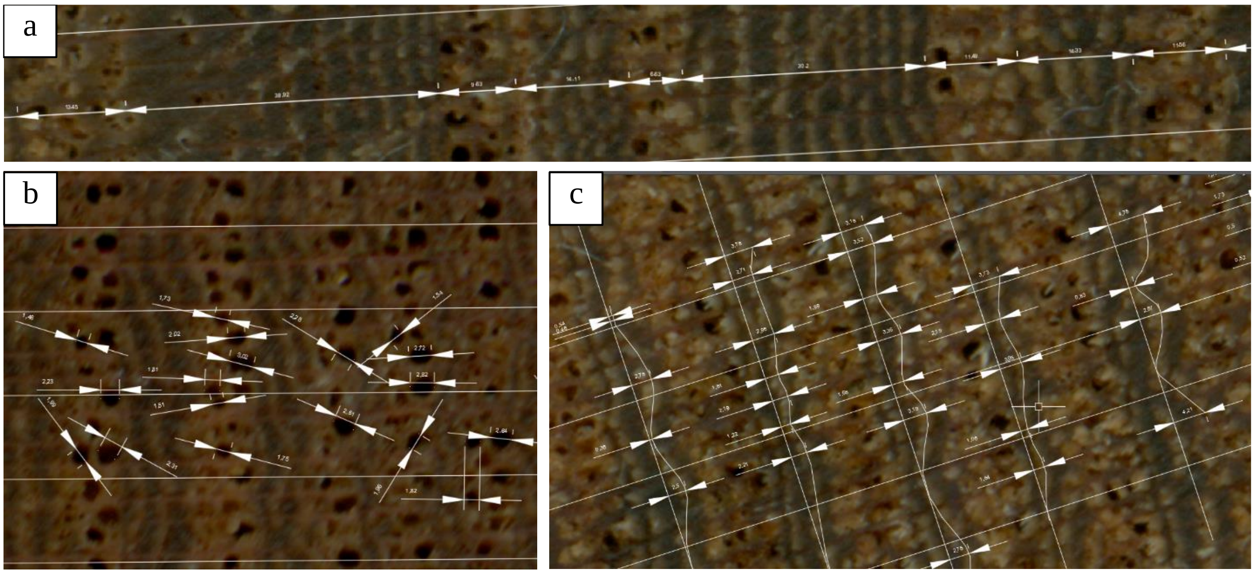

Figure 2: Measurement of the growing zone width (a), measurement of the vessel lumina diameters in the earlywood (b), measurement of wave amplitudes of wavy vessel bands (c)

RESULTS AND DISCUSSION

For the annual ring width analysis, we compared the results of the earlywood and latewood (Fig. 3a). The earlywood widths varied between 0.747 mm and 1.153 mm. The latewood had a larger variation in the widths (between 0.775 mm and 2.776 mm) and thus had a larger standard deviation than the earlywood, where we measured almost identical values. Therefore, in the following, only the latewood widths will be considered to investigate the outcomes of the larger variation, while at the same time we focus on the mechanically stronger growing zone. The latewood widths were divided into three groups: below 1 mm, between 1 and 2 mm and above 2 mm (Fig. 3b). These groups were defined based on the average of the measured values.

When examining the vessel lumen diameters of the earlywood, the measured diameters were also divided into three groups, while the width of the earlywood was taken into account (Fig. 3c). The groups were created by calculating the average of the measured diameters and taking 75% (0.721 mm) and 125% (1.232 mm) of it. The results were then ranked into the corresponding groups. The averages and standard deviations show clearly in Fig. 3c, how the vessel lumen diameters vary as a function of the earlywood width, which mostly determines the width of the annual ring. The average diameter of the vessel lumina in the earlywood is 0.202 mm, which is slightly higher value compared to the statement of Molnár and Börcsök (2016). Most of the vessels (77%) are located in earlywoods narrower than 0.721 mm (Fig. 3c), despite the average earlywood width of 1.018 mm in the whole sample set (Fig. 3a). That is, the width of the earlywood rarely exceeds 0.721 mm and, as shown in Fig. 3c, there is no relationship between earlywood and the diameter of the vessels.

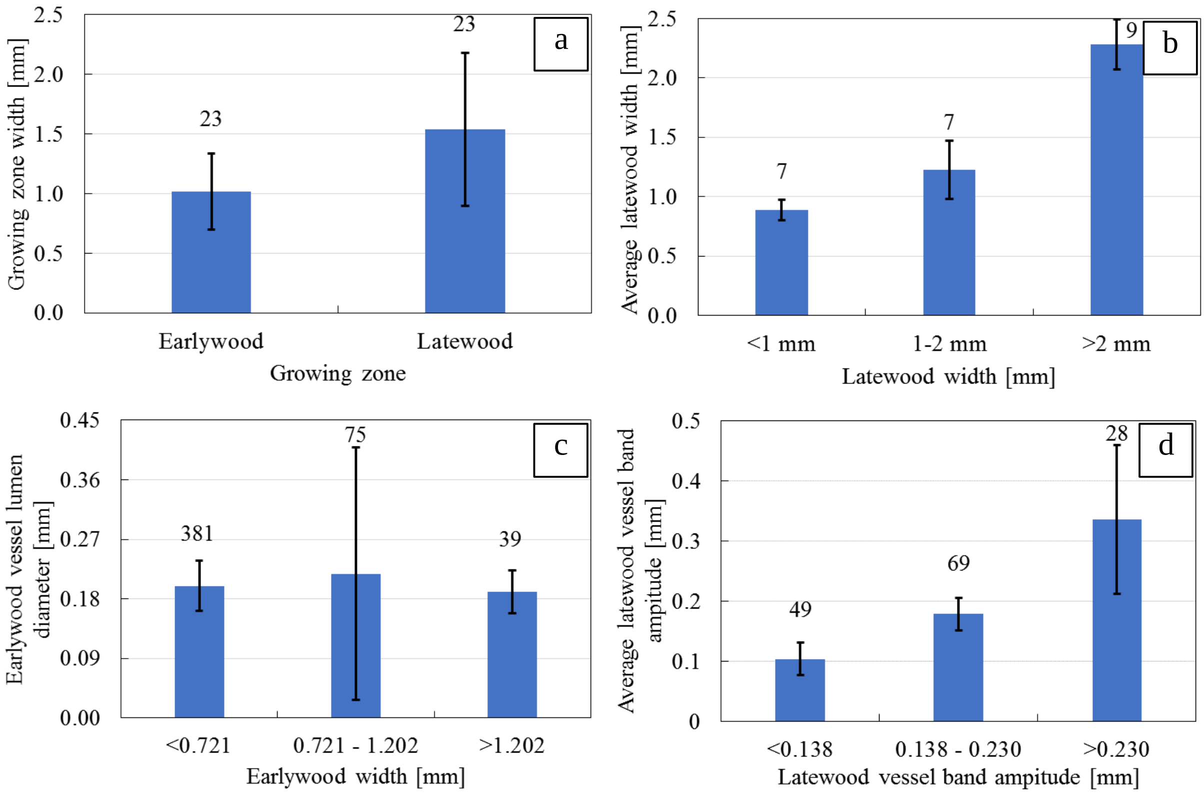

Figure 3: Comparison of average earlywood and latewood widths (a), latewood width distribution (b), earlywood vessel diameters as a function of earlywood width (c), latewood vessel band amplitudes (d). The values above the columns represent the number of elements.

By examining the wavy vessel bands of the latewood, the average of the measured maximum amplitudes was also divided into three groups at 75% (0.138 mm) and 125% (0.230 mm; Fig. 3d) of the average. It should be noted when evaluating the results that the wavy bands are sometimes interrupted. Taking into account the standard deviation, it is clear that there vessel bands can have from very small to very large amplitudes. Almost half of the results are between 0.138 and 0.230 mm, close to the average of 0.184 mm. This indicates a natural, normal distribution. The standard deviation is large for the column of vessel band with the largest amplitude because outliers occurred up to 0.746 mm. No correlation was found between the width of the latewood and the amplitude of the vessel bands. However, the more densely the vessel bands appear in the latewood, the smaller their amplitude typically is.

CONCLUSIONS

The aim of this study was to investigate how the large vessels and wavy vessel bands typical of the field elm (*Ulmus minor* Mill.) vary in the annual ring structure according to the growing zone widths. These data can subsequently be related to certain physical and mechanical properties. The earlywood widths were almost identical. In contrast, there was a significant variation in the width of the latewoods. While the earlywood widths varied from 0.747 mm to a maximum of 1.153 mm, the latewood widths varied between 0.775 mm and 2.776 mm. For the vessel diameters in earlywood, most results (77%) represent values below 0.721 mm. Rarely, significantly higher values of over 1.202 mm were found (8%). For the amplitude of the wavy vessel bands in the latewood, values between 0.138 and 0.230 mm were obtained for the most part. Large amplitudes, which can be considered as very large compared to the 0.184 mm average value, were rare (e.g. 0.746 mm).

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