Nature and occurrence of juvenile wood in chestnut (*Castanea sativa* Mill.) stems from Coppice Forest[1]

by Marco FIORAVANTI*

1 - Introduction

It is well established that during tree growth two different types of wood are produced (one after the other) by the cambium: the so called *juvenile* and *mature* wood.

Many definitions have been proposed for describing the characteristics of juvenile wood (j.w.); one of the more appropriate seems to be the one given by Rendle in 1960, in which j.w. is defined as follows:

- *secondary xylem produced during the early life of the part of the tree under consideration, and characterised anatomically by a progressive increase in the dimension and corresponding changes in the form, structure and disposition of the cells in successive growth layers.*

According to such definition, juvenile wood is always formed near the pith (for a number of years that may change with species), and is characterised, as compared to mature wood, by differences in both anatomical structure and physical-mechanical properties of wood.

In most species differences in the anatomical structure of juvenile wood concern two main features:

- cell sizes (cells are shorter and smaller in tangential direction);
- microfibril angle (larger in rings closer to pith);

These structural differences determine, as final consequence, an anomalous behaviour of juvenile wood especially for what concerns shrinkage and strength.

The effect of juvenile wood on wood quality has been object of many studies, mostly focused on softwood species, in which the presence of a large amount of this wood represent a limiting factor for many uses of timber, while only few researches have been performed on broadleaves species and particularly on ring porous ones (physical and anatomical properties that are normally attributed to j.w. are in fact relative to softwood species).

In this paper are reported the results of a preliminary, and mostly methodological, study performed with the aims of determining 1) the extension, 2) the density values and their pattern of variation and 3) the shrinkage behaviour of juvenile wood in Chestnut (*Castanea sativa* Mill.) trees coming from coppice forest.

2 - Material and methods

2.1 - Tree sampling

Experimental material was sampled in a coppice stand of around 40 ha located near Viterbo (Central Italy). The stand lies on a volcanic soil (high fertility) and the silvicultural practices applied in this region are focused towards the production of wood poles and sawn timber for both furniture and structural uses.

Within the stand 12 codominant stems of around 20 years in age (which is the most usual rotation period for chestnut coppice forest in Italy) were sampled from differents stools.

From each stem several small logs 50 cm in length were cut using the following criteria:

- first log as close as possible to stem base;
- one log at DBH (1,3 m above ground);

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- following logs every 1,5 m.

In total an average of 5 to 7 logs for each stem have been sampled.

2.2 - Anatomical studies

Anatomical studies have been performed on the following parameters:

- ring width;
- radial and tangential ring porous vessels diameter;
- microfibril angle.

Since anatomical measurements are very time consuming the observations were limited to two different heights in the stem (1,3 and about 5 m). Studies on ring porous vessels were carried out on microscopic sections, 25 μ thick, cut from small radial stripes. This anatomical feature was measured ring by ring from pith to bark, recording values of 25 vessel diameters for each ring.

Microfibril angle was measured with optical microscope using the technique proposed by Senft-Bendtsen[2] [1985] in which microfibril angle is derived by measuring the inclination angle of cell wall failures produced on S_2 layer as consequence of hygro-thermal treatments.

For each ring 25 angles were measured.

2.3 - Density

Density measurements were performed by means of a new methodical based on the use of x-ray Computed Tomography (CT) [Fioravanti-Ricci, 1991]. This methodical allows to determine density variation within growth rings; compared to conventional x-ray densitometry, it offers some advantages that may summarised as follows:

- the test is totally non-destructive;
- the dynamic linear interval of measurements (X-ray adsorption coefficient) allows to obtain a better resolution (+/- 0.5 % as compared to +/- 3% obtainable with radiographic films);
- ability to represent and process directly the data obtained from the scanning;
- definite decrease of time needed for densitometric measurements.

The machine used for this study is a third generation x-ray medical scanner model GE CT PEACE.

Measures were carried out on clear specimens prepared excluding eye detectable defects (such as small knots and tension wood) and having the following dimensions : base 10 mm, 15 mm height and length equal to the radial distance from pith to bark. Before measurements the specimens have been conditioned in a climatic chamber at 20°C temperature and 65% relative humidity.

For each ring minimum (Dmin), maximum (Dmax) and average density (Dmean) have been recorded.

2.4 - Shrinkage

For determining the pattern of variation from pith to bark of total shrinkage (i.e. from green to oven -dry) in two different anatomical directions (longitudinal (L) and tangential (T)), measurements were carried out on radial stripes sampled at the various height in the stem.

As the CT methodical is totally non-destructive, measurements of shrinkage were performed on the same specimens used for density measurements. Those specimens were measured twice, i.e. at green and at oven-dry conditions.

In order to measure in continuously the variation of the specimen's thickness, a special apparatus has been designed, made by the following main parts (ref. Photo 1):

- a high precision translation table that allows to move the specimen respect to the measurement system;
- a system for supporting and positioning the specimen respect to the measurement system; the specimen is supported by three steel needles which determine an univocal reference plane, allowing therefore to repeat the measurement along the same line at the two different moisture contents.
- an inductive electronic transducer which measures the movements of the table (and of the specimen);
- a couple of inductive electronic transducers which measure the specimen's thickness, and that are mounted perpendicular to the advancing direction of the specimen ;
- a data acquisition system, consis-

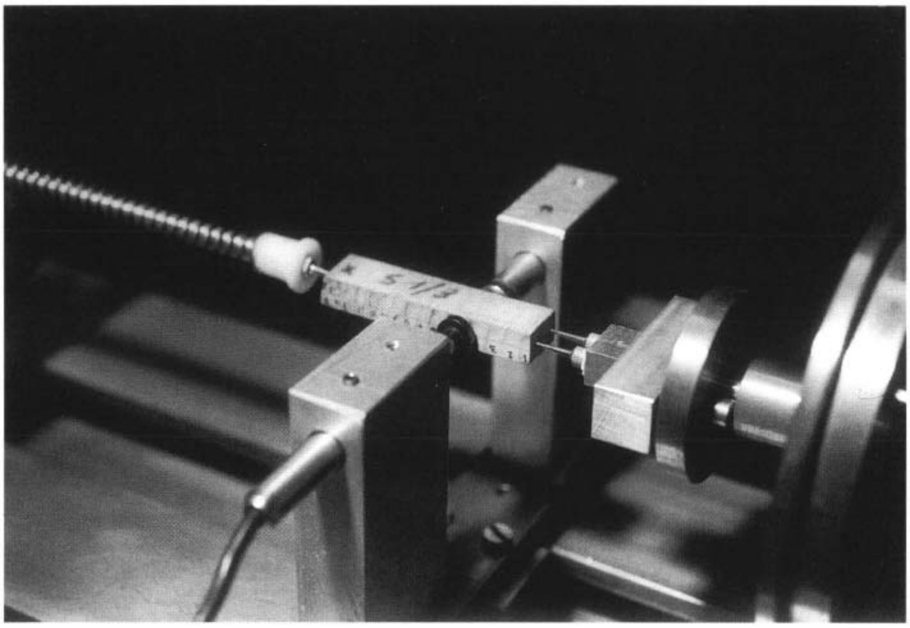


Photo 1 : Device used for shrinkage measurements. Particulars of the displacement transducers and of the specimen supporting system; the 3 needles determine an univocal reference plane.

2 On small radial stripes each single growth ring is splitted and subjected to a treatment consisting in several cicles of wetting and drying at 103 °C. After this treatment radial longitudinal sections 12 μ thick are cut and successively dried in ethanol, dipped in a 2% solution of I-KI for 5 seconds and finally washed in HNO_3 (solution 60%).

ting of a 16-bit acquisition board (mod. National Instruments NB MIO 16) linked to a PC, that allows to measure in continuous the dimensional variation of the specimen profile from pith to bark.

3 - Results and discussion

3.1 - Anatomical measurements

3.1.1 - Diameters of ring porous vessels

The performed anatomical observations have shown the presence of different characters in the first years, from which is possible to deduce that the formation process of mature structure in ring porous vessels is characterised by two different phases: the first one typical of the first 2 years of secondary xylem formation, in which a clear ring porous structure is not present yet and vessels show small and almost constant size within the growth ring. Starting from ring number 3 from pith the ring porous zone becomes more clearly evident, and at the same time a fast process of increment in both radial and tangential vessels diameter begins (see Graph 1).

The trend of porous vessels development may be well fitted by a model based on a function such as y= ax/(b+x) (knows as linearizable model of Michaelis-Menten). From the examined data the following general set of parameters has been obtained (all trees all levels in the stem process together):

	R^2	sign.lev.	
y_r= (382*x)/ 2,51+x	0,84	+++	[1]
y_t= (296*x)/3,07+x	0,85	+++	[2]

where:

y_r= radial diameter of ring porous vessels

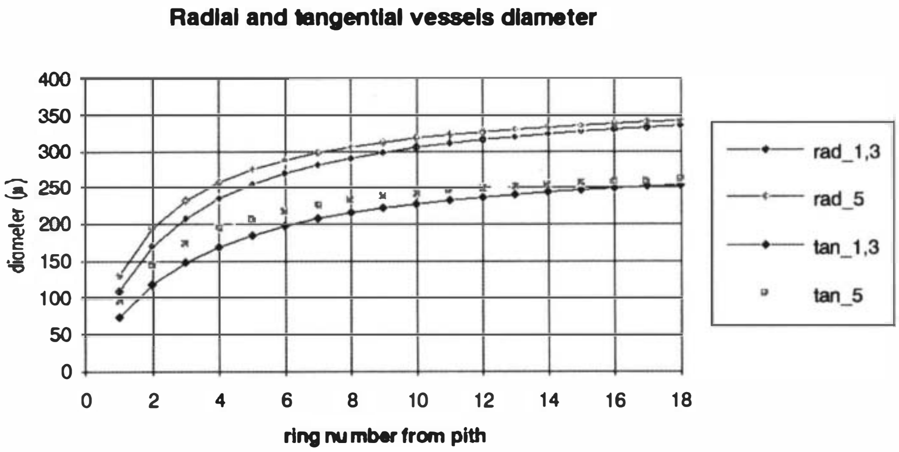
y_t= tangential diameter of ring porous vessels

x = ring number from pith

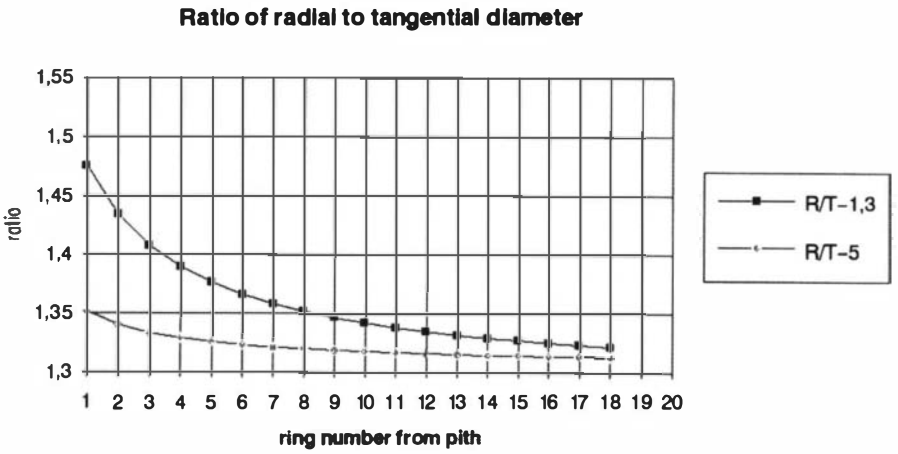
As clearly shown in Graph 1 radial diameter results always larger than the tangential one, both at 1,3 and at 5 m. At the higher level the two vessel diameters result, on the average, a little larger than those at the lower level, phenomenon that might be explain considering the two stages of the process of maturation which affect the vascular cambium : those transmitted by the apical meristem (longitudinal maturation), at the time of cambium formation at different level in the stem, and those which the cambium undergoes after its formation (radial maturation) [Olesen - 1982].

The pattern of variation of the ratio between radial and tangential diameter has been also observed. As shows in Graph 2, for the examined trees, the ratio is higher for the rings closer to the pith and it tends to an asymptotic value (1,3 in examined trees) after ring 8-10 from pith (higher values in the ratio means that the vessels shape is elliptical, on the contrary values as close as to 1 indicate a more circular shape).

According to previous observations on vessels expansion in sycamore [Dodd-1984], it seems possible to adopt this ratio as an index of the intensity in cambial activity. During their expansion the porous vessels, the first formed at the beginning of the growing period, are placed between an unyielding tissue represent by the latewood of the previous year inside, and the cambial zone (consider here as the total amount of already divided cells) and lignified bark outside. If cambial zone is large (which means high intensity in cambial activity) the expanding



Graph 1 : Radial variation of porous vessels diameters at two different heights in the stem



Graph 2 : Trend of radial to tangential diameters ratio vessels find a yielder tissue in radial direction than in tangential (where even age cell are present [3]), whereas when cambial zone is less thick the proximity of the lignified bark make easier the expansion in the opposite direction which become the unique possible.

According to these results the following aspects emerge:

- radial diameter of ring porous vessels is always bigger than tangential one;
- both radial and tangential diameter culminate between rings number 8 to 10 from pith;
- the ratio between the two diameters become almost constant after ring 8 to 10 from pith.

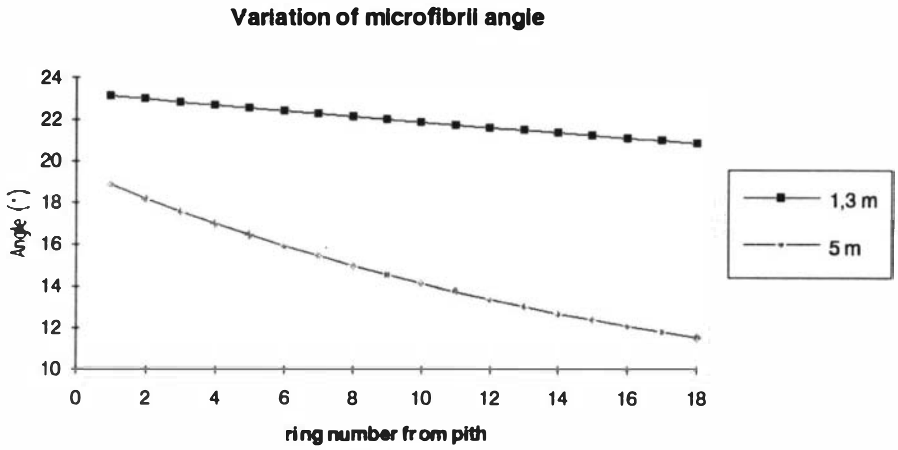
3.1.2 - Microfibril angle

For which concern microfibril angle, results show a characteristic trend both within the growth ring and between rings from pith to bark.

Within the rings the mean values measured in the earlywood resulted always larger than those measured in latewood. The differences resulted quantitatively small but is of some relevance the systematic occurrence of this feature. Because of the method used for angle measuration those results need of confirmation from observation carried out with more sophisticate techniques, in order to be sure that in earlywood the measured angles are not which belonging to the S_1 layer which are normally arranged with higher angles then S_2.

Microfibril angle resulted decreasing from pith to bark with differences between the two level of sampling (see Graph 3): at DBH level values results, on the average, higher (18°-25°) than those at 5 m (12°-19°) with a larger variability to the bottom level.

These results suggest that, at least partly, also in chestnut microfibril angle is linked to the maturation of



Graph 3 : Radialvariation of the microfibrill angle at the two heights of sampling.

cambial initials, following a process of radio-longitudinal maturation similar to that just describe for porous vessels.

The best fit of experimental data has been obtained using a reciprocal model having the following global set of parameters (obtained processing all the tree together):

	R^2	Sign Lev.
$1/y_{(1,3)} = 0043 + 0,000276 * x$	9%	++
$1/y_{(5)} = 0,051 + 0,001983 * x$	51%	+++

Where :
$y_{(i)}$ = microfibril angle to *i* level
x = ring number from pith

3.1.3 - Ring width

Ring width itself does not represent a feature that could be linked neither to the presence nor to the limit of juvenile wood within the stem. Despite this it is normally consider as an useful predictor of some wood properties (e.g. density, mechanical strength).

Measures performed have shown a negative linear correlation between ring width and ring position from the pith.

The main results for the different height of sampling are reported in table I (model y= a+bx, where y = ring width and x = ring number from pith) :

The low values of the determination coefficient indicate also for this feature the occurrence of a large variability in the experimental data, mostly explainable considering the influences of the dominance relationships both between and within the stools.

The average R coefficient obtained for the stand was equal to -0,54, value very close to that determined by Chanson [1988] in some French chestnut provenance (-0,57).

3.2 - Density

Density variations have been studied at different levels of observation: at ring level, in radial direction (by ring from pith to bark) at each height of sampling, and among the different heights in the stem.

3.2.1 - Density within growth ring

Within a growth ring the densitometric profile results determine by the

Sampling heights	function parameters	R	R square	Signif.
base	a= 0,678 b=-0,016	- 0,46	0,21	+++
1,3	a= 0.572 b=-0,013	- 0,42	0,18	+++
3,5	a= 0,626 b= 0,019	- 0,60	0,36	+++
5	a= 0,603 b= 0,019	- 0,60	0,37	+++
6,5	a= 0,580 b= 0,019	- 0,57	0,33	+++

Tab.I : Statistic of ring width model

3 In the cited paper Dodd reports that studies by different authors have established that tangential expansion of vessels is possible since tissue tangentially adjacent to differentiating vessels tends to mature later than vessels.

anatomical structure of the ring itself, that in chestnut, as well knows, is characterised by two distinct zones: the initial (earlywood), always present, where big porous vessels are concentrated, and the terminal one in which both vessels size and fibre cell lumens are smaller (latewood).

Because of this structure, the densitometric profile of chestnut rings, as well as in many other species, presents two extreme values, which correspond to the lowest (earlywood) and to the highest (latewood) values of ring density.

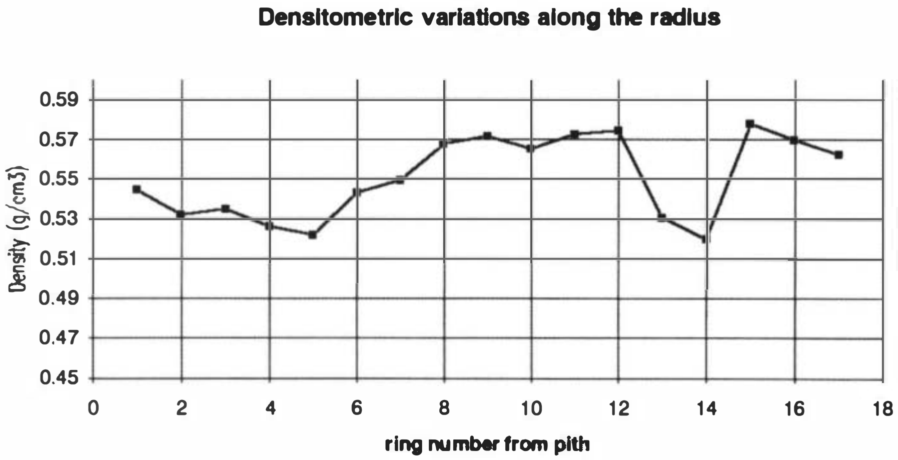
The variation shown by density values recorded in the examined trees was very large and it ranged between two extreme values of 0,38 g/cm^3 for the earlywood and 0,72 g/cm^3 for latewood.

Preliminary observation on densitometric profiles of single rings has shown a strong variability in density trend between the two extreme values, which is linked to the difference in the anatomical structure of the transition zone of the ring, that may varies according to ring age (ring number from pith) growing conditions (here consider as the complex of climatic and enviromental growth factors) and by presence of tension wood[4].

The first pilot observation that have been conduced seem to indicate that the 5 structural typologies already describe by Chanson [1988] for chestnut ring are sufficient for describing accurately the variability in ring morphologies, however a deeper examine of measured profiles needs.

3.2.2 - Density variation along the radius, and within the stem

The examination of densitometric profiles in their variation from pith to bark, has shown the presence of characteristic tracts which occurred in most part of the considered profiles.



Graph 4 - Exemple of the radial pattern of variation of density .The abrupt variation in density around ring 14 has to be attribute to the social competition of the shoot within the stool.

The typical radial trend (Graph 4) can be consider as constitute by the following main parts:

- a first decreasing tract which interests the rings located between the pith and ring number 4-6 from the centre;
- a successive increasing tract which asymptotically culminates around ring 8-10 from the pith;
- a final tract which presents values ranging around the asymptotic value, with deviations from it that are strongly dependent by growth conditions of the stem .

The initial tract can be explain considering the evolution of the porous structure of the ring: as already describe (§ 3.1.1) the porous structure is not present in the firsts (1-2) rings from pith, and it begins its differentiation only from the second or the third year, reaching values close to its mature structure by ring 5-6 from pith.

In concomitance with cell's maturation, it is also observable an increment in cell walls thickness [Fioravanti 1992], probably linked to the development of the crown structure and to the consequent increase in nutritional substances avability, and which contribute to the increasing of density values (ring 5 to 10 from pith).Because of the influences of both climatic factors and dominance position of the stem within the stoll , density values of the final tract (rings older than 10 in age) may varied within a wide range.

According to the above explanations, seem possible to conclude that the radial pattern of variation of density in chestnut is controlled by both an "age effect" and a "growth effect" [as defined by Fukazawa-1984]: in first years from pith (until 10 in age) ring density is mostly determined by the cambial age, while in older rings the effects of growth conditions become predominants.

As shows in Tab.II, between the three density values measured (Dmin, Dmean, Dmax), minimum density has shown the highest correlation with ring age, whereas the ones relative to the other values of density resulted quite low, particularly which relative to maximum density.

The low values of the correlation coefficients also for minimum density (Tab.II), evidenced that a large variability has to be explain yet, and more consideration should be probably assign to both stems and stools genetics'.

Minimum density shows also high correlation with the mean density of the ring, let to suppose that, being less affect by the growth effects or the climatic ones, earlywood density is probably the component which more independently determines the density value of the ring (similar conclusion were reported by Fonseca for *Pinus pinaster*[1989]).

Except the lowest height near the base, the radial pattern of density within the stem remains almost constant (see Graph 5), and small

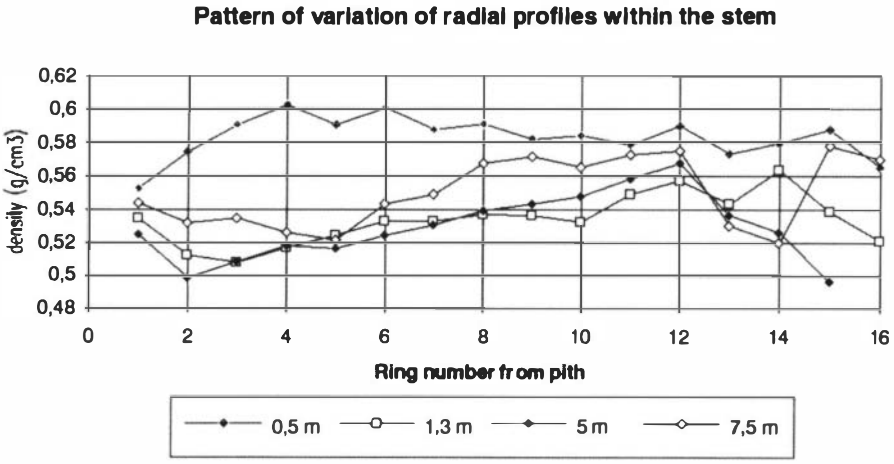
[4] In the observed samples tension wood cells, identifiable because of the presence of the G layer, resulted always located in the middle of the ring and never in early or in late latewood.

Stem height	Dmin	Dmean	Dmax
0,5 m	- 0,217 ***	- 0,146 *	- 0,146 *
1,3 m (DBH)	0,297 ***	0,198 *	- 0,02 ns
3,5 m	0,339 ***	0,219 *	0,174 *
5 m	0,336 ***	0,222 *	0,034 ns
6,5 m	0,317 ***	0,127 *	0,16 ns

Tab. II : Correlation matrix between density and ring age at the different levels of sampling - (*) Level of significance

	Dmean	Dmax
Dmin-0,5	0,86 ***	0,48 ***
Dmin-1,3	0,79 ***	0,48 ***
Dmin-3,5	0,78 ***	0,32 *
Dmin-5	0,73 ***	0,27 *
Dmin-6,5	0,70 ***	0,23 *

Tab.III : Correlation matrix of Dmin versus Dmean and Dmax
(*) Level of significance



Graph 5 : Density variation within the stem.

Analysis of Variance for AVER.den - Type III Sums of Squares

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS					
A:AVER.sam-lev	.0093830	3	.0031277	13.694	.0000
B:AVER.Rin-num	.0058282	13	.000448	1.963	.0522
RESIDUAL	.0089073	39	2.28391E-004		
TOTAL (CORRECTED)	.0241184	55			

All F-ratios are based on the residual mean square error.

Multiple range analysis for AVER.den by -.sam- lev

Level		Count	LS Mean	Homogeneous Groups
3	(3,5 m)	14	.5314045	X
2	(1,3 m	14	.5344264	X
4	(5 m)	14	.5465131	X
1	(0,5 m)	14	.5643400	X

contrast	difference	+/- limits
1 - 2	0.0299	0.01156 *
1 - 3	0.03294	0.01156 *
1 - 4	0.01783	0.01156 *
2 - 3	0.00302	0.01156
2 - 4	-0.01209	0.01156 *
3 - 4	-0.01511	0.01156 *

* denotes a statistically significant difference.

Tab.IV : Statistical analysis of density observations

variations have been recorded in the average values of density at the differents levels (see Tab. III). At bottom level the values resulted higher and statistically different from those at the upper heights. Up from DBH the radial pattern becomes more constant and also differences in average values are smaller. Nevertheless values belonging to the highest levels (6,5 m) show statistically significant differences (Tab. IV) which indicate that also for density a dependence with the processes of meristem's longitudinal maturation has to be consider (probably as direct consequence of the transformations undergoes by wood cells).

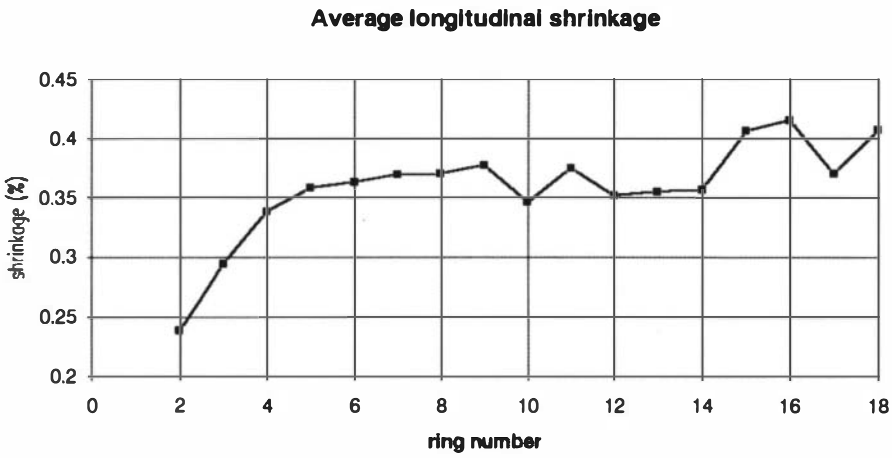
3.2.3 - Relation between density and ring width

Many experimental researches performed on softwood species have shown the strong correlation existing in many species between ring width and density (density decrease as ring width increase).

More contrasting are the data about hardwood species and particularly the ring porous ones, where often, especially within the same stand, is possible to find fast growing trees, characterised by big annual increments, with low value of density [Polge-Keller-1973] (in ring porous species density should increase as ring with increases).

The results obtained in this research indicate for chestnut the absence of a strong correlation between ring width and density, as has been already found by Chanson [1988].

Results show that normally, after a period of slow growth (very small ring), as ring width increases also density increases. Nevertheless within the same ring width class a large variability in density values is present, which means that a strong influence on cell elongation and cell wall thickness also depend on the growing conditions. This behaviour could be explain considering that in chestnut, and in ring porous species in broad sense, hormones, (which control the process of both cell division and cell elongation), are produce not only by the shoots, as in conifer, but by leaves as well [Ciampi-1951]. Therefore within the ring it is possible to find cells with large lumen and small cell wall until the late latewood, which determine a lower value in density.



Graph 6 - Variation of longitudinal shrinkage along the radius.

3.3 - Shrinkage

3.3.1 - Longitudinal shrinkage

As shown in Graph 6 on the average the value of longitudinal shrinkage (LS) is quite small (not greater than 0,5%), even in rings closest to the pith.

Along the radius from pith to bark LS shows the pattern of variation illustrated in Graph 6: it increases until ring 5-6 from pith, keeping almost constant after this point.

The increment measured in the first rings should be probably correlated with the maturation of the porous vessels which occupy a progressively larger portion of the earlywood zone, and that are characterised as, reported below, by a large microfibril angle.

In accordance with results from other authors [Chanson 1988], within the growth ring LS resulted higher in the earlywood then in latewood. this behaviour can be explain considering the influences exerted on shrinkage by both microfibrill angle and relative thickness of the secondary wall layers:

- as reported in previous paragraphs (§ 3.1.2) measurements performed in this work have evidenced the systematic presence of large microfibril angle in earlywood fibres, to which has to be add the effect produced by the microfibril organisation of ring porous vessels which can present angle as large as 45° [Harada, Wardrop].

- At fibres level another important role is probably played by the thickness of the S_1 and S_2 layers. As attested by Quirk and Marioux infact, in thin wall cells (typical of earlywood) the S_2 lamellas are very few in number, and the longitudinal shrinkage is mostly determined, because of its large micro fibril angle, by the S_1 layer.

3.3.2 - Tangential shrinkage

The pattern of variation of the tangential shrinkage (TS) has been studied within the growth ring, along the radius and within the stem.

In graphic 7 is reported the variation of tangential shrinkage within a structurally normal ring (without tension wood). The dependence, at ring level, of TS from density results quite obvious: it increases from earlywood to latewood, the difference ranging around 1%[5].

When tension wood occurred some collapse phenomena were recorded within the growth ring.

No particular patterns of variation have been found along the radius (see Graph 8), where TS values showed small variations around an average value of 10 % (a little higher as compare to the values reported in literature, probably because of the lower content in tannins of materials from the cited provenance. This behaviour can be explain considering the small entity of density variation in radial direction, which are normally limited in a range of 40-50 kg/m³ , and that are not enough for producing significant differences in shrinkage. Furthermore, some part of the potential differences is also limited by the fact that in the specimen growth rings interact each other conditioning what would otherwise be the behaviour of individual rings.

4 - Conclusion

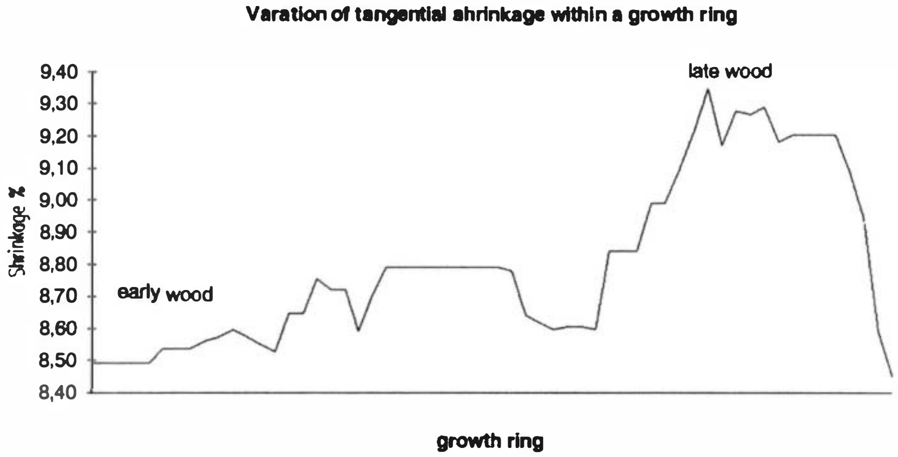
From the studies performed on the different features and properties, some general conclusions can be drawn.

Anatomical measurements have shown that both radial and tangential diameter of ring porous vessels increase until ring 8-10 from the pith, with a transition starting from ring number 5-6 from pith. In the same manner the ratio between the two diameters becomes almost constant after ring number 8-10 from pith, indicating it as a reasonable limit for juvenile wood.

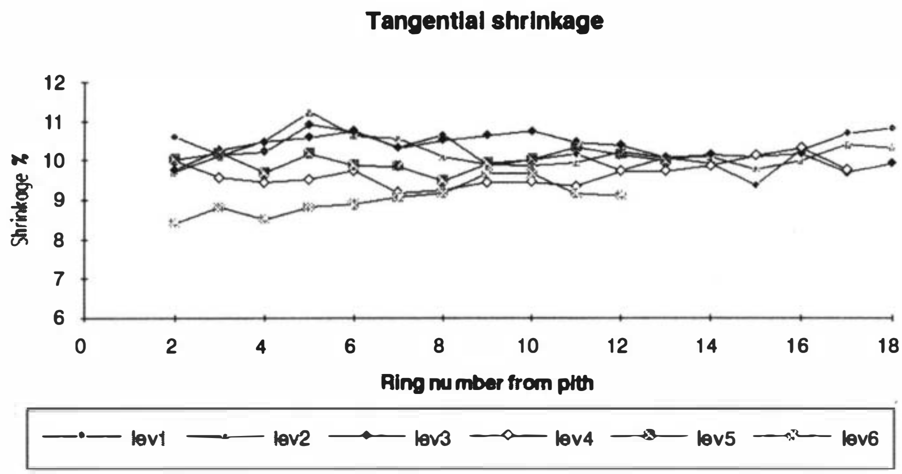
Both tangential diameter and diameters ratio may therefore used as a prompt parameters for estimating the limit of juvenile wood within a portion of stem.

Within the ring, mean microfibril

5 If earlywood had been isolated from the ring, it would have shown a lower tangential shrinkage. Infact, because of specimen continuity, earlywood remains linked to the latewood of the previous year, which forces it to shrink more than it would do on its own, given by both its anatomical structure and chemical composition.



Graph 7 - Example of the tangential shrinkage within a ring. Values are represented as measured in one ring.



Graph 8 - Radial variation of tangential shrinkage at the different heights of sampling

angle is higher in earlywood than in latewood, whereas decreases from pith to bark, and from base to the top of the stem. The angle values always range between 25 to 12°.

Densitometric profile in radial direction can be divided according to three characteristic tracts of which the first two are determined by the processes of cell maturation. From pith to bark density decreases until ring 4-6, increases until ring 8-10; the third tract is highly variable, since is mostly influenced by the so called "growth factors", rather than the cell maturation process..

Between the three different values measured (minimum, maximum and average density), minimum density resulted the component which shows best correlation with the density of the ring (but genetic influences maintain a large variability among individual trees), and is the best parameter to be used in order to represent the density variations along the radius.

Low correlation have been found between ring width and density, making not much efficient the use of this parameter for predicting ring density .

In rings close to the pith longitudinal shrinkage resulted smaller than is normally expected in juvenile wood of other species. A small but systematic increase has been evidenced until ring 5-6 from the pith.

Tangential shrinkage does not show any particular radial pattern of variation, and its values remain almost constant from pith to bark; this parameter is therefore not useful for the characterisation of juvenile wood in this specie.

According to these preliminary results juvenile wood in chestnut from coppice forest seems to be limited to the first 8-10 rings from pith, and its presence does not appear to influence significantly nor density characteristics nor shrinking behaviour of the timber.

M.F.

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Résumé

Présence et nature du bois juvénile de Châtaignier (*Castanea sativa*) issu de taillis

*Les propriétés physiques et anatomiques du bois juvénile de châtaignier (*Castanea sativa *Mill.) ont été étudiées dans le but d'estimer leur valeur ainsi que les limites de ce bois au niveau de la tige. 12 arbres codominants, âgés d'environ 20 ans ont été choisis à partir de différentes cépées d'un taillis ; des billons provenant de 6 hauteurs différentes de chaque tige ont été échantillonnés.*

L'étude a porté sur :

- Largeur de cerne, diamètre radial et tangentiel des vaisseaux de la zone poreuse, angle des microfibrilles, densité, retrait longitudinal et tangentiel.

Chaque caractéristique a été mesurée cerne par cerne de la moelle à l'écorce et aux différentes hauteurs de l'échantillonnage.

Les principaux résultats peuvent être résumés comme suit :

- La relation entre la largeur du cerne et sa position comptée depuis la moelle est représentée par un modèle linéaire avec un coefficient de corrélation R de - 0,54.

- Les diamètres radial et tangentiel des gros vaisseaux augmentent depuis la moelle jusqu'aux cernes n° 8-10.

- Au niveau du cerne, l'angle moyen des microfibrilles est plus grand dans le bois initial que dans le bois final, sachant qu'il diminue de la moelle vers l'écorce et de la base au sommet de la tige. La valeur de l'angle est toujours comprise entre 25 et 12°.

- Le profil densitométrique radial peut être divisé en 3 sections caractéristiques.

De la moelle à l'écorce la densité diminue jusqu'aux cernes 4-6, augmente jusqu'aux cernes 8-10, puis présente une forte variabilité après ce point, surtout influencée par ce que l'on appelle les "facteurs de croissance" plus que par le processus de maturation cellulaire.

- Le retrait longitudinal n'est jamais supérieur à 0,5 %. Une augmentation faible mais systématique a été mise en évidence depuis la moelle jusqu'aux cernes 5-6.

Le retrait tangentiel tourne autour de 10 % et ne présente pas de modèle particulier de variation, il reste pratiquement constant depuis la moelle jusqu'à l'écorce.

D'après les résultats de cette étude, le bois juvénile de Châtaignier provenant de taillis semble limité aux premiers 8 à 10 cernes en partant de la moelle, sa présence ne semble pas influencer significativement ni la densité ni le retrait du bois.

Mots clés : bois juvénile, *Castanea sativa* Mill., diamètres de gros vaisseaux, angle des microfibrilles, densité, retrait longitudinal.

Summary

Nature and occurrence of juvenile wood in Chestnut (*Castanea sativa*, Mill.) wood

*Physical and anatomical properties of juvenile wood of Chestnut (*Castanea sativa *Mill.) wood have been studied also with the aim of identifying its properties and limit within the stem. 12 codominant trees, aged about 20, were selected from different stools in a coppice forest, and small logs from 6 different heights in the stem were sampled. Studies have been focused on:*

- Ring width, radial and tangential diameter of ring porous vessels, microfibril angle, density, longitudinal and tangential shrinkage.

All the features were measured ring by ring from pith to bark at the different heights of sampling.

The main results can be summarised as follows:

- regression of ring width to ring position from the pith, varied according to a negative linear model with an R coefficient of -0,54.

- Radial and tangential porous vessels diameter increases until ring number 8-10 from pith, with transaction starting from rings number 5-6.

- Within the ring, mean microfibril angle is higher in earlywood than in latewood, whereas decreases from pith to bark and from base to the top of the stem. The angle values always range between 25 to 12°.

- Radial densitometric profile can be divide in three characteristic tracks. From pith to bark density decreases until ring number 4-6, increases until ring 8-10, remaining high variable after this point, since is mostly influenced by the so called "growth factors", rather than the cell maturation process.

- Longitudinal shrinkage was never greater than 0.5%. A small but systematic increase has been evidenced until ring 5-6 from pith.

Tangential shrinkage ranged around 10% and does not show any particular pattern of variation, remaining almost constant from pith to bark.

According to the results of this research the juvenile wood in Chestnut stem from coppice forest seems to be limited to the first 8-10 rings from pith, and its presence does not appear to influence significantly nor density nor shrinkage behaviour of the wood.

Key words : Juvenile wood, *Castanea sativa* Mill., porous vessels diameter, microfibrill angle, density, longitudinal shrinkage