

# RELATIONSHIP BETWEEN FIBER CELL-WALL DEFORMATIONS AND LONGITUDINAL GROWTH STRAIN: A RESEARCH NOTE

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(Received July 1988)

## ABSTRACT

The relationship between fiber cell-wall deformations and longitudinal growth strain is investigated in trees of *Eucalyptus pilularis* Sm. (blackbutt) and *Eucalyptus grandis* W. Hill ex Maiden (rose gum).

In *E. pilularis* a weak correlation ( $r = 0.39$ ) was observed between the number of cell-wall deformations in fiber walls adjacent to the second marginal ray cell and field measurements of longitudinal growth strain. However, a similar relationship could not be found in *E. grandis*.

*Key words:* Growth stress, cell-wall deformation, slip plane.

## INTRODUCTION

Australian trees, particularly eucalypts, are frequently subject to high levels of growth stress (Chafe 1979). This often results in productivity losses during conversion of logs to timber. A practical method of estimating growth stress would provide a valuable means of resource assessment for forest planners.

To date, all methods of growth stress determination measure strain that is produced by stress release. The majority of these methods severely damage the tree being studied. In view of this, an alternative nondestructive, anatomical method for approximating growth stress levels is desirable.

Fiber cell-wall deformations, commonly known as slip planes (Wilkins 1986a), form in response to longitudinal compressive stress (Dinwoodie 1968). They are known to occur more frequently in the fiber walls adjacent to rays (Wilkins 1986b). Longitudinal growth stress near the pith may be a source of the compressive stress that causes these deformations (Dadswell and Langlands 1934, 1938). Hence, the abundance of deformations in the fiber walls adjacent to rays near the pith may indicate the maximum level of longitudinal growth stress that a tree experienced during its lifetime.

This investigation examines the relationship between the abundance of cell-wall deformations in the fiber walls adjacent to rays and measurements of longitudinal growth strain obtained by destructive testing. Trees of *Eucalyptus pilularis* Sm. (blackbutt) and *Eucalyptus grandis* W. Hill ex Maiden (rose gum) were used.

## PROCEDURE

Samples of *E. grandis* (discs of 10-cm thickness) were taken at 20-cm height from twelve, nine-year-old plantation trees in winter. Trees selected had an average diameter of 22 cm (including bark) and were not obviously leaning. Dom-

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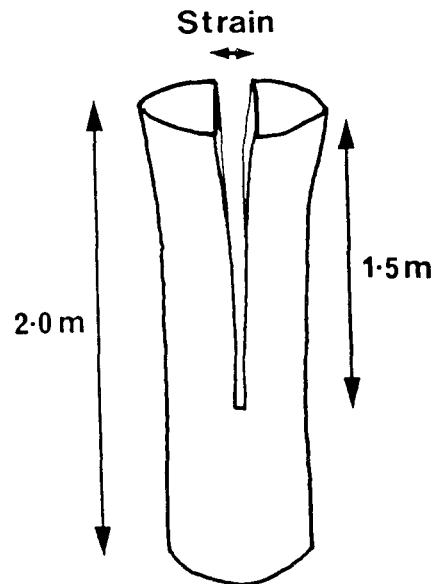


Fig. 1. Diagram showing the method of strain determination using a saw cut to release stresses. The radial displacement of the split end was recorded as a measure of growth strain.

inant trees were not sampled so as to reduce the influence of wind stress. Because of the young age of the trees, severe decay was not found near the pith. From each of the discs, 2-cm cubes were removed at a position two-thirds of the way between cambium and pith. This sampling position was chosen so as to avoid decayed wood that might be present near the pith, while at the same time ensuring that samples had a history of longitudinal compressive stress. The change from longitudinal tension to longitudinal compression has been found to occur at about one-third of the way along the radius from cambium to pith (Boyd 1950). Therefore, wood at a position inside this may be expected to have been subjected to some longitudinal compression from growth stress.

To obtain samples of *E. pilularis*, discs of 30-cm average diameter were taken at stump height (50–100-cm height) from twenty-seven trees in an uneven aged stand in winter. Leaning trees and trees with severe decay near the pith were excluded from the study. Because of a greater level of decay in these older trees, 2-cm cubes were removed at the mid-position between cambium and pith from each of the discs.

The 2-cm cubes were fully saturated and microtomed to produce four serial tangential longitudinal sections of 10- $\mu$ m thickness. Production of slip planes as artifacts of microtomy was minimized by careful orientation of the knife and specimen angle (Dinwoodie 1966; Keith and Côté 1968). This principally involves keeping the fiber axis parallel to the knife edge, with a low attack angle (angle between knife edge and direction of travel) and cutting angle (angle between knife edge and horizontal).

Tangential longitudinal sections were then examined, and slip planes were observed, using polarized light, and were counted in the fiber walls adjacent to rays using the method described by Wilkins (1986b). In the counting procedure, ray cells were numbered progressively from the ray margin. Slip planes occurring in

the fiber wall adjacent to the marginal cell were recorded as occurring at ray cell position 1. Slip planes occurring in the fiber wall adjacent to the ray cell next to the marginal cell of the ray were recorded as occurring at ray cell position 2. Similarly ray cell position 3 is adjacent to position 2. As it has been shown (Wilkins 1986b) that there is no difference in the abundance of cell-wall deformations at ray cell positions 2 and 3 in *E. pilularis*, only results from the first two ray cell positions were recorded for this species. Since this has not been confirmed in *E. grandis*, cell-wall deformations were counted at ray cell positions 1, 2, and 3. Counts were performed at both ends of twenty-five rays that intersected a random line drawn on the microscope slide cover glass.

Growth strain determinations were based on the method of Krilov and Ades (1985), which used a 2-m log of 20-cm small end diameter cut from each sample tree. All logs were cut longitudinally from the small end through the pith to a depth of 1.5 m (Fig. 1). The radial displacement at the split end (strain) was recorded and gave a measure of the stress gradient.

Methanol-extracted basic density was determined for the remaining portion of each of the 2-cm wood cubes.

Pearson correlation coefficients were determined for all regressions. Independent *t*-tests were used to determine whether significant differences occurred between mean counts of cell-wall deformations at ray cell positions 2 and 3 in *E. grandis*. The 0.05 level was used in significance tests.

#### RESULTS AND DISCUSSION

At any particular location, the abundance of cell-wall deformations was expected to be related to the maximum compressive stress experienced at that position during the tree's lifetime. In the fiber walls of *E. pilularis*, adjacent to the second marginal cell of the rays (ray cell position 2), the abundance of cell-wall deformations was shown to be significantly related to strain ( $r = 0.39$ ). The weak nature of this relationship can be seen in Fig. 2. No similar relationship was found to occur in the samples of *E. grandis* examined ( $r = 0.06$ ).

In *E. grandis* no significant difference was found between counts of the number of cell-wall deformations at ray cell positions 2 and 3. As expected (Wilkins 1986b), no correlation was found between the number of cell-wall deformations adjacent to the marginal ray cell (ray cell position 1) and strain in either *E. pilularis* ( $r = 0.01$ ) or *E. grandis* ( $r = 0.15$ ). The number of deformations at ray cell position 1 may be complicated by factors such as the inflection of the fiber wall at the ray margin.

Several reasons may be suggested for the lack of a relationship between cell-wall deformations and strain in *E. grandis* and the weak relationship observed in *E. pilularis* at ray cell position 2. Possible factors could include: seasonal variation in the thickness of fiber walls, inter-tree variability, wind or gravity stress, and sampling location. These factors are discussed below.

It has been shown that the abundance of cell-wall deformations is influenced by density (Wilkins and Ghali 1987) and hence cell-wall thickness (Kitahara and Tsutsumi 1984). Although differences in overall density of sample blocks were not sufficient to be considered a source of error, seasonal changes in thickness may be sufficient to account for some differences in the abundance of cell-wall deformations in adjacent cells. It may be necessary to standardize measurements so that fiber walls of similar thickness are compared.

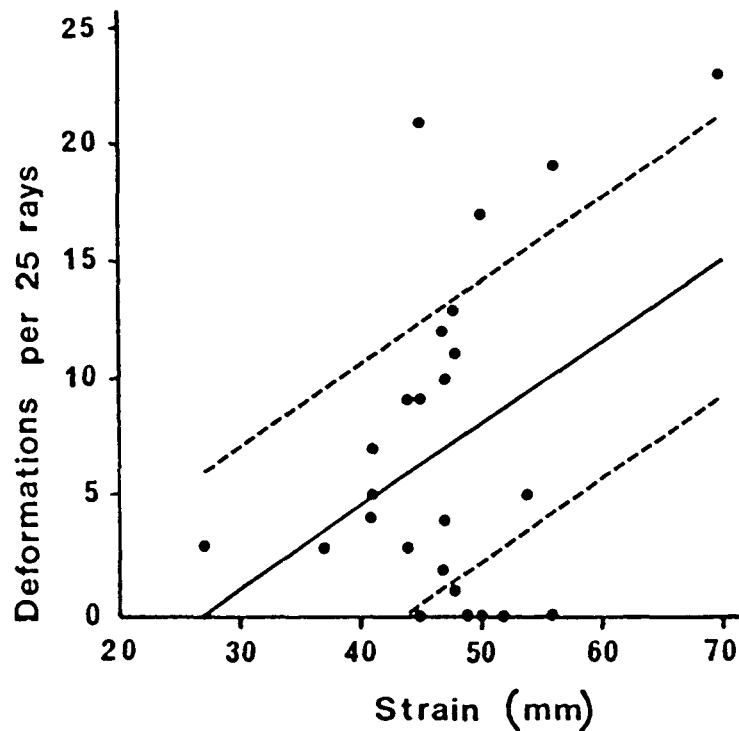


Fig. 2. Graph showing abundance of cell-wall deformations (at ray cell position 2) versus strain in *E. pilularis*. The least squares line of best fit is shown ( $R = 0.39$ ). Dotted lines show standard error ( $SE = 6.3$ ).

Wind or gravity stress acting on a leaning stem may provide sufficient compressive force to create fiber cell-wall deformations. The greatest stress from these sources would be generated at the periphery of the tree trunk rather than towards the pith. Therefore, if grossly leaning trees are avoided, it is considered that these factors would not introduce a significant source of error.

It is considered likely that the radial locations of sampling could not be realistically improved. Further toward the periphery, longitudinal tension from growth stress and significant compressive effects from wind stress may be present. Sampling from positions closer to the pith may theoretically give better correlations with strain measurements; however, such samples would rarely be free of decay.

#### CONCLUSION

A weak correlation was found between number of cell-wall deformations and strain in *E. pilularis* wood fiber cell walls adjacent to the second marginal ray cell. No such correlation was observed in *E. grandis*. As expected, no relationship was observed in either species in fiber walls adjacent to the marginal ray cell.

It is considered possible that variations in fiber wall thickness and/or inter-tree variability may explain the results obtained. Without further significant refinement, it appears that using the method investigated, cell-wall deformations cannot provide reliable estimates of growth strain.

## ACKNOWLEDGMENTS

The authors would like to thank Dr. J. Wilkes and Dr. A. Krilov for helpful comments, C. Mackowski and M. Freeman for assistance in various stages of this study.

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