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# False ring formation in teak (*Tectona grandis* L.f.) and the influence of environmental factors

P.B. Priya, K.M. Bhat*

*Wood Science Division, Kerala Forest Research Institute, Peechi, 680 653, India*

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**Abstract**

Seedling anatomy and cross sectional discs of 8- and 12-year-old (juvenile) teak trees were examined for tree ring analysis and determination of environmental factors responsible for false ring formation in teak. Based on the anatomy and location within the true annual rings, four types of false rings were identified. The results from both cross-dating of plantation grown trees and controlled experiments, including induced drought, showed that rainfall during dry period, drought during active growing season, (container) polybag/field transplantation of seedlings and juvenility are the important causative factors of frequent false rings in teak. No definite relationship could be established between insect defoliation and the incidence of false rings. False ring formation in teak appears to be mainly a resultant feature of tree ring responses to different environmental and physical factors. © 1998 Elsevier Science B.V.

*Keywords:* *Tectona grandis*; False ring; Wood anatomy; Rainfall; Drought; Defoliation; Dendrochronology

## 1. Introduction

Teak (*Tectona grandis* L.f.), a ring porous tropical hardwood which displays true annual rings, has been extensively planted almost throughout the tropics, in the recent massive commercial plantation programmes. Growth rings are useful tools for determination of age and growth rate of the trees in wood production of managed stands. Although it varies with locality, the season of wood formation in teak in India is generally during April–November with a peak period of growth being June–September (Chowdhury, 1939; Sudheendrakumar et al., 1993). According to Chowdhury (1939), initial growth is fast during the formation of early pores during June–July, then it slows down before the final rapid growth that occurs before the cessation of cambial activity sometime during the second week of November. The occurrence of false rings often misleads the task of age and growth rate determination as continuous or discontinuous false rings are more frequent in juvenile teak (Chowdhury and Rao, 1949). Although, false rings were first observed by Chowdhury as early as 1939, no adequate information is available on tree ring responses to changes in the environmental conditions particularly in the formation of false rings. The pertinent knowledge is useful to both dendrochronologists and plantation managers.

*Corresponding author. Fax: 0091 487 782249.


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The objectives of the present study are: (a) to determine the major environmental factors causing false ring formation in teak and (b) to characterise different types of false rings in teak based on their anatomy and location in the true annual rings.

## 2. Materials and methods

### 2.1. Study site

The study material consisted of cross sectional discs of 8- and 12-year-old juvenile trees grown in Nilambur (Kerala), India (11° 12′–11° 32′ N and 75° 82′–76° 32′ E). Monthly rainfall data were collected for the study sites corresponding to the growing period of the trees and presented in Table 1 (1976–1983). To study the possible effect of insect defoliation on false ring formation, discs of trees from 8-year-old plantations were examined. The plantations were raised in the year 1974 which extended over an area of 2500 ha of assorted age, part of which represented the second rotation plantations. When the trees were four years old, some of the experimental plots had been artificially protected against insect defoliation by spraying an insecticide (protected trees), while others (control trees) were left unprotected (Nair et al., 1985). At the end of the eighth year, the trees were felled. About 10 cm thick cross sectional discs were cut at breast height, from 102 trees representing the protected as well as the control populations of which thirty discs were selected at random from each treatment for the study.

### 2.2. Laboratory investigations

To study the pattern and formation of false rings, the cross sectional discs from sixty 8-year-old trees (30 protected and 30 control trees) and nine 12-year-old trees grown in Nilambur, were sanded and observed under stereo-microscope. 20 micrometer- thick transverse sections of each annual ring taken from two opposite radii of the discs, were cut on a Reichert sliding microtome. Most of the false rings were distinguished macroscopically from true annual rings and confirmed further by microscopic observation. The incidence of false ring formation was then correlated to the rainfall of the corresponding year.

### 2.3. Controlled experiments

To bring out the effect of drought on false ring formation, artificial drought was induced for ten 1-year-old seedlings maintained in a glass house, during the peak period of growth, without watering for 30 days. After the drought treatment, watering was resumed. A set of ten irrigated seedlings was used as control for comparison. After a period of 30 days, all of the treated as well as the control seedlings were cut and transverse sections were prepared for microscopic examination. In another experiment, 1-year-old nursery-raised seedlings were transferred to polybags (polyurethane containers) with an interval period of 15–24 h between uprooting and replanting to examine the effect of physiological disturbances suffered due to transplantation and partial defoliation. The polybagged seedlings were subsequently examined for the occurrence of false rings in response to the physiological disturbances due to transplantation.

Table 1
Monthly rainfall in mm at the study site during the years 1976–1983

| Years | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 0 | 0 | 3 | 77 | 20 | 215 | 748 | 529 | 121 | 123 | 217 | 61 |
| 1977 | 0 | 0 | 0 | 45 | 295 | 541 | 569 | 180 | 223 | 477 | 280 | 0 |
| 1978 | 0 | 0 | 0 | 24 | 102 | 635 | 821 | 724 | 54 | 151 | 243 | 8 |
| 1979 | 0 | 0 | 33 | 4 | 180 | 318 | 695 | 638 | 107 | 145 | 193 | 80 |
| 1980 | 0 | 0 | 0 | 59 | 83 | 1146 | 1094 | 435 | 159 | 210 | 128 | 1 |
| 1981 | 0 | 0 | 0 | 45 | 108 | 711 | 640 | 852 | 355 | 219 | 65 | 9 |
| 1982 | 0 | 0 | 0 | 4 | 53 | 340 | 527 | 284 | 59 | 16 | 105 | 0 |
| 1983 | 0 | 0 | 0 | 0 | 59 | 976 | 594 | 604 | 358 | 163 | 39 | 67 |

## 3. Results and discussion

### 3.1. Characterisation of false rings

From our observations in the samples of sixty trees of age 8 years, 73% displayed false rings in their second annual increment. No false rings were produced in the first and eighth year of growth, while some 5–10 trees exhibited false rings in the rest of the years (Fig. 1).

The false rings in the second annual increment were confined to the earlywood zone in all the trees (Fig. 2). Anatomically they resembled true annual rings in the sense that they were continuous and comprised of a zone resembling earlywood, which had one or two rows of parenchyma, large vessels and thin walled fibres which merged with the true latewood zone. This earlywood-like zone was preceded by thick walled fibres characteristic of latewood fibres but produced in the true earlywood zone. Yet another feature of interest was that some trees had even double and multiple rings in the earlywood zone of their second increment, which were mostly discontinuous (Fig. 3).

Some of the false rings produced in the rest of the increments had the same anatomy as mentioned above, while some others exhibited different features. In these increments the false rings were found to be produced either in the earlywood or the latewood zones. Some of them confined to the earlywood zone, consisted of an abrupt change from the usual thin walled fibres to a band of thick walled fibres with diffuse parenchyma and vessels (Fig. 4). Some false rings produced in the latewood zone were in the form

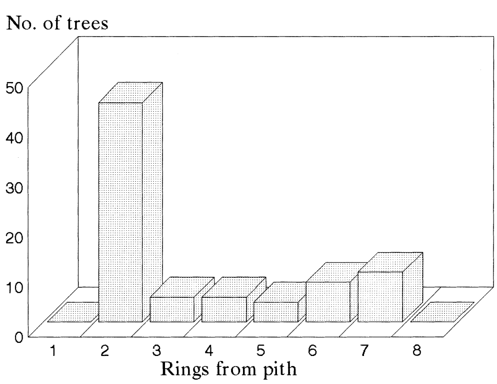


Fig. 1. Distribution of false rings in sixty 8-year-old trees.

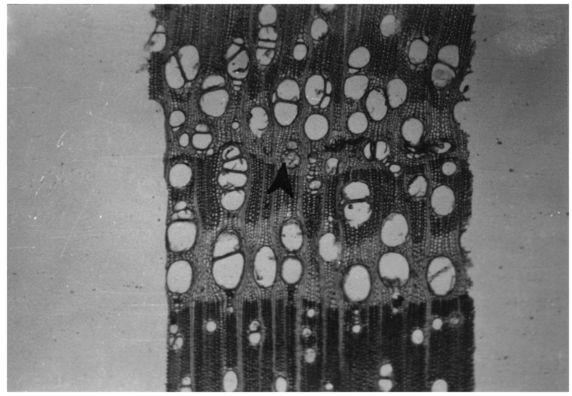

Fig. 2. Occurrence of 'Type I' false ring in the earlywood zone of second annual increment of 8-year-old teak, indicated by arrow mark (facing towards bark).

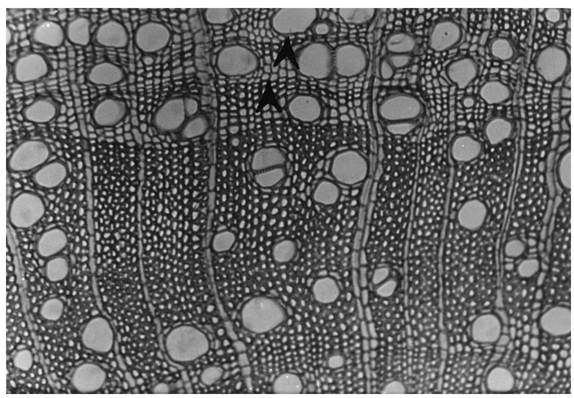

Fig. 3. Double ring in the second annual increment, indicated by arrow marks.

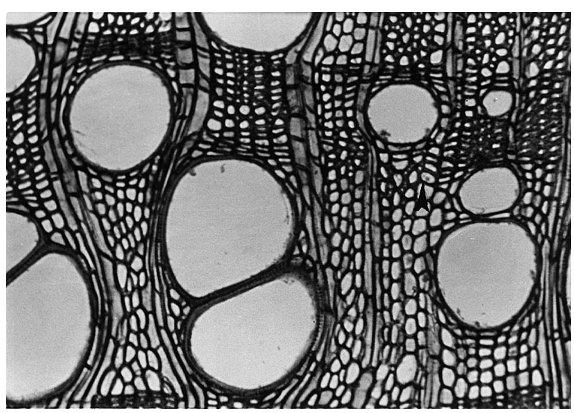

Fig. 4. False ring 'Type II', indicated by arrow mark.

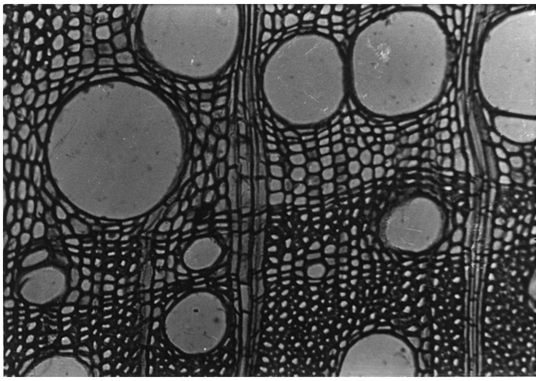

Fig. 5. False ring ‘Type III’, indicated by arrow mark.

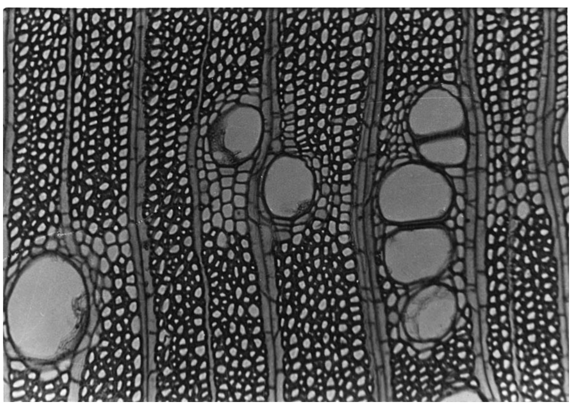

Fig. 6. False ring ‘Type IV’.

of one or two rows of parenchyma cells with small vessels scattered nearby (Fig. 5), or an aggregation of vessels in radial multiples with paratracheal parenchyma (Fig. 6). The former type of false rings were identified also by Chowdhury and Rao (1949). The latter was difficult to be distinguished macroscopically. Based on our observations on the anatomy and occurrence (location) in the true annual ring, false rings in teak could be classified into the following types:

#### *3.1.1. False rings occurring in the earlywood zone*

Type I. A zone resembling earlywood with one or more rows of parenchyma, large vessels and thin walled fibres which in turn, preceded by thick walled fibres (Fig. 2)

Type II. An abrupt change from the thin walled earlywood fibres to a band of thick walled fibres with diffuse parenchyma and vessels (Fig. 4)

#### *3.1.2. False rings occurring in the latewood zone*

Type III. One or two rows of parenchyma cells with small vessels scattered nearby (Fig. 5)

Type IV. Aggregations of vessels in radial multiples with paratracheal parenchyma cells (Fig. 6)

While the false rings (Types III and IV) which occur in latewood zone were found continuous, those which occur in earlywood zone (Types I and II) were often discontinuous as reported by Chowdhury and Rao (1949).

### *3.2. Factors influencing false ring formation*

#### *3.2.1. Rainfall*

Since 73% of the trees observed by us exhibited false rings in the earlywood zone of their second growth ring (as counted from pith), an attempt was made to correlate their formation with the rainfall of the corresponding year – 1976 (Fig. 7). It is to be noted that the first ring from pith at breast height level does not necessarily indicate the actual first year’s growth increment after seed germination. The cross-dating indicated that the trees must have commenced wood formation after a period of dormancy in April

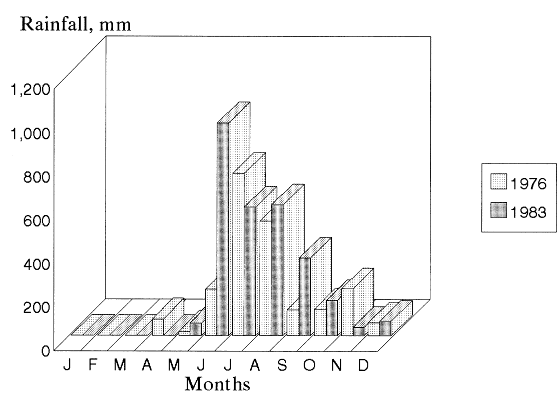


Fig. 7. Monthly rainfall in mm at the study site in the years 1976 and 1983.

soon after receiving the first pre-monsoon showers. Heavy rains in April must have logically rendered the formation of wide vessels in the earlywood zone. But unusually less rain witnessed in May was a probable cause of reduced pace or partial cessation of growth. This was evident in the earlywood zone of the growth increment in the form of thick walled fibres characteristic of latewood. Later with the advent of heavy rains in June, active growth must have resumed again, leading to the formation of wide vessels characteristic of earlywood which was depicted in the form of a 'Type I' false ring in the annual growth increment. The formation of double and multiple rings in some trees is reasonably attributable to successive resumption and cessation of growth due to some physiological disturbances apart from the fluctuations in rainfall. With regard to the formation of 'Type II' false rings in the earlywood zone, the probable reason is that the drought periods resulting in latewood type of cells, might not be followed by favourable conditions which were intense enough to produce the earlywood type of cells. Fluctuations in post-monsoon showers or unseasonably warm weather during the late growing season could cause the formation of 'Type III' and 'Type IV' false rings. Further, stem analysis of 12-year-old trees planted in 1981 revealed that, with the exception of four annual increments, all the trees exhibited false rings in any one of their annual rings (Fig. 8). Maximum number of trees had 'Type I' false rings in their third annual ring, which was again correlated with the rainfall of the corresponding year – 1983 (Fig. 7). Evidently, lack of rainfall during April, when seasonal wood formation normally resumes after the cambial

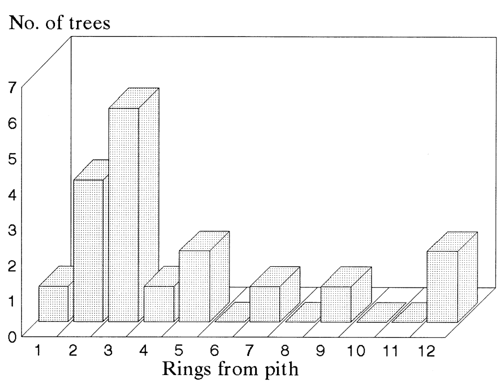


Fig. 8. Distribution of false rings in nine 12-year-old trees.

dormancy in teak, resulted in the production of a few layered earlywood followed by thick walled latewood type fibres. At the onset of rains in May, reactivation of cambium resulted in the production of a zone characteristic of earlywood which was evident as a false ring in the true earlywood zone of the corresponding annual increment. From our observations, it is clear that the intervention of a dry spell during active growing season, followed by favourable conditions is capable of producing a false ring, provided it is intense enough to cease or reduce the pace of growth for sometime prior to the resumption of active growth. No specific reasons other than some physiological disturbances could be attributed to the formation of false rings in the rest of the annual increments of 8- and 12-year-old trees. Our results support the recent findings of Pumijumnong et al. (1995) in teak grown in Northern Thailand that growth of teak in certain area is mainly controlled by rainfall from April to June.

*3.2.2. Drought*

The observations made in the previous section foreshadow the fact that intervention of a dry spell during active growing season, followed by favourable conditions, is capable of producing a false ring, provided it is intense enough to cease or reduce the pace of growth for some time, as reported in different coniferous species (Foote, 1954; Shepherd, 1964; Mon-Lin Kuo and Mc Ginnes, 1973; Fritts, 1976); This is reconfirmed by our drought induction treatment where 1-year-old teak seedlings, during active growing season, produced false rings as a response to artificial drought treatment. Since the drought period was imposed during an early growing season a 'Type I' false ring was induced in the earlywood region of the growth ring (Fig. 9). During the treatment period, growth was brought to a stand still, with the formation of thick walled fibres characteristic of latewood. On the resumption of watering, large vessels and parenchyma characteristic of the earlywood was produced, appearing as a false ring in the annual growth increment. Drought induction has already been found effective in producing false rings in seedlings of conifers. For instance, if Larson (1963) succeeded in producing false rings in 5-year-old *Pinus resinosa* by imposing varying periods of artificial drought during the growing season, Glerum (1970) produced drought rings in the seedlings of *Picea glauca* con-

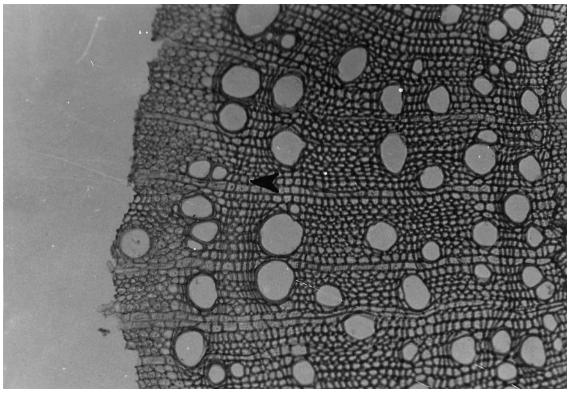

Fig. 9. False ring formation as a response to induced drought in 1-year-old seedling, indicated by arrow mark (facing towards bark).

sisting of fully lignified tracheids with reduced radial diameters.

### 3.2.3. Insect defoliation

As reported recently (Priya and Bhat, 1997), the trees which were given artificial protection against insect defoliation in Nilambur (India) also displayed false rings in the wood formed during the protection period of 4 years (Fig. 10). Similarly, microscopic examination of a growth ring formed in the corresponding year of five trees grown in another location (Peechi), which had lost their foliage soon after flushing due to acute insect defoliation and had resurgence of new foliage after a brief period of one week did not reveal any false ring. This implies that some physiological disturbance other than defoliation can cause false ring formation. In the above cases observed by us, the possible reason for lack of false rings is that either the cessation of radial growth resulted by the insect defoliation may not be of sufficient duration to produce cells characteristic of latewood or the resumption of growth may not be intense enough to produce an auxin gradient favourable for the formation of the earlywood type of cells. Here mention is to be made about Lobzhanidze's observation (1972), in Transcaucasian trees that, repeated leaf formation during one growing season did not always produce false rings unless there was an interval of at least three weeks enabling latewood formation. Another probable explanation for our observation is that, there might have been only slight resumption of radial growth which might have led to the formation of earlywood cells characteristic of a false ring only in the upper reaches of the crown without extending up to the base of the tree. However, several authors stated insect defoliation to be one of the causes of the incidence of false rings (Haygreen and Bowyer, 1989; Panshin and de Zeeuw, 1980). According to Chowdhury and Rao (1949) false rings were produced in response to heavy insect defoliation in teak clones of Burma origin though not in the clones of Indian origin growing in the same locality.

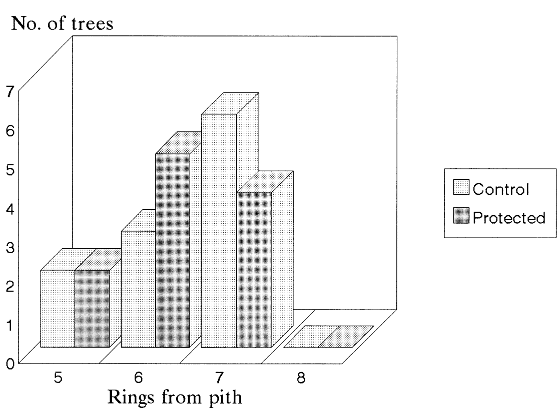


Fig. 10. Incidence of false rings in trees protected from insect defoliation in comparison with control.

### 3.2.4. Transplantation and defoliation

In one of our experiments, we transplanted nursery grown 1-year-old seedlings to polybags after giving an interval period of 15–24 h between uprooting and replanting. This was done during the active growing season in May which hindered the earlywood formation of the seedlings due to the partial defoliation suffered by them in consequence, which in turn was followed by favourable growing conditions. On observing sections of polybagged seedlings after two months it was noticed that a 'Type I' false ring was formed in the earlywood region in response to the transplantation. Thus the frequent incidence of false rings in the second or third annual growth increment of teak trees is attributed to the disturbances effected by the conventional practice of field transplantation of 1- or 2-year-old nursery-raised seedlings, apart from the effects of rainfall or periods of drought suffered, if any.

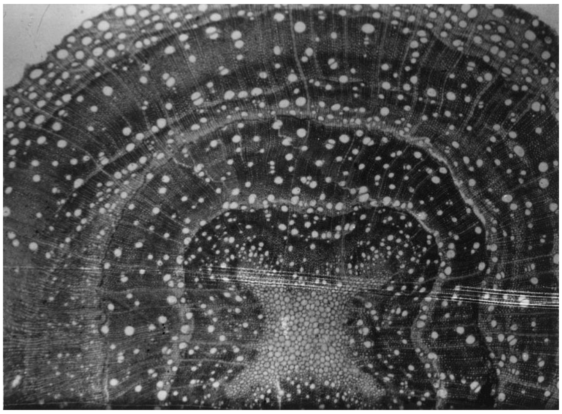

Fig. 11. False rings in teak seedling in response to transplantation and irregular irrigation.

*3.2.5. Juvenility*

The incidence of false rings appears to be more frequent in juvenile plants (seedlings) than in mature trees. During the vigorous growth of the juvenile plants any changes affecting their growing conditions had pronounced bearing on alteration of wood formation causing frequent false rings (Chowdhury and Rao, 1949; Lobzhanidze, 1972). They are more susceptible to partial or complete defoliation than in mature trees due to irregular irrigation (discontinuity in moisture availability and drought) and field or polybag transplantation (Fig. 11). This is evident from the observation that false rings were produced in 1-year-old seedlings with the physiological disturbances due to transplantation and partial defoliation for a short period of 24 hours in contrast to the lack of incidence of false rings, as reported elsewhere in this study, in older trees suffered from insect defoliation for longer periods.

## 4. Conclusions

From our observations, we conclude that rainfall during dry period, droughts of sufficient duration, field/polybag transplantation and juvenility are the major causes of false ring formation in teak as tree growth responds well to these factors. The sporadic incidence of insect defoliation, however, does not necessarily always induce false ring formation. The times when the intervention of these factors occurs during the growing season determine the location of false rings within the annual growth increment. For instance, pre-monsoon showers and early season droughts result in false rings in the earlywood of the corresponding growth ring. The intensity of drought and the following precipitation can also affect the anatomy of the false rings produced in response, as evidenced by the 'Types I and II'. These results will have practical implications in better management of teak plantations.

## Acknowledgements

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