The Journal of the Indian Botanical Society

Vol. XXXIX 1960 No. 2

VARIATION IN VESSEL LENGTH WITHIN ONE GROWTH RING OF CERTAIN ARBORESCENT DICOTYLEDONS

By B. G. L. Swamy, N. Parameswaran and E. Govindarajalu

Department of Botany, Presidency College, Madras-5

(Received for publication on March 2, 1959)

Bisset *et al.* (1950 *a*, *b*) have recently demonstrated that the length of the imperforate tracheary cells within the limits of one growth ring is subject to significant variability under certain conditions of growth of the secondary xylem. They have shown that in gymnospermous and dicotyledonous woods characterized by the presence of distinct growth rings, the fibres generally undergo a progressive increase in length from the first-formed early wood to the last-formed late wood; on the other hand, in those secondary xyla where the formation of distinct growth rings is absent, the fibres fail to exhibit any significant kind of mode even when considerable quantum of wood representing the growth of several years is analysed.

In hard woods with storeyed cambia and distinct growth rings, Chalk *et al.* (1955) observed that the length of the fibres rose to a maximum in the middle of the ring and dropped abruptly on the ring boundary; the length of the parenchyma strands, on the contrary, remained constant throughout the ring. The other cell type of the secondary xylem that has not been studied from the point of view of size variability within one growth ring is the vessel. The present contribution deals with the results obtained in course of exploratory investigations on the range of size variations of vessel members within a growth ring.

Investigations along these lines on vessels present certain difficulties as a result of which the choice of species becomes limited. Woods with very wide vessels and those with sparse pore distribution cannot possibly yield the adequate number of observations needed in connection with studies involving reasonably accurate average values. Thus, the selection of material of woods with definite growth ring becomes further confined to those with relatively smaller-lumened vessels and denser pore distribution. Data have been obtained from the following species:—

A. Woods showing definite growth rings

1. Ring porous (including graded arrangement)
   Acanthopanax ricinifolia Sieb. and Zucc.
   Alangium chinense (Loureiro) Harms
   Cipadessa baccifera Miq. (vessels and rays storeyed)
   Gilibertia trifida Makino
   Sassafras officinale Nees. and Eberm.
   Tectona grandis L.

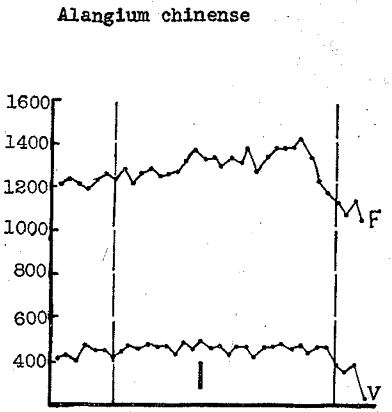
2. Diffuse porous
   Alangium kurzii Craib
   Alangium rotundifolium (Hasskarl) Bloemb.
   Platanus occidentalis Hook. and Arn.

B. Woods without definite growth rings
   Alangium javanicum (Bl.) Wangerin
   Alangium salvifolium (Linn. f.) Wangerin
   Pancheria ternata Brongn. and Gris.

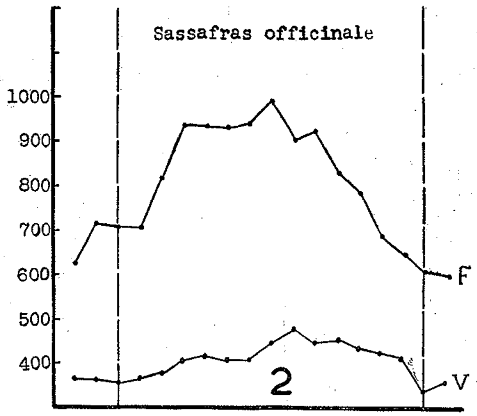
The techniques employed for the preparation of materials were in essential similar to those adopted by Bisset *et al.* (1950 *b*). In all cases, fairly mature and more or less comparable specimens were utilized, taking particular care to avoid structural defects. In the case of woods with relatively narrow-lumened vessels, serial tangential sections varying in thickness between 80 and 120 μ were taken, while for woods with much larger diameters the thickness was adjusted between 100 and 200 μ. The sections were macerated in Jeffrey's reagent at 60° C. Optimum maceration was obtained at the end of three to four hours. The macerated tissues were squashed by gentle shaking in water in a glass tube. The suspension thus obtained was transferred on to slides with the help of a medicine dropper. One hundred vessel members and the same number of fibres were measured for length values from each tangential section; vessel diameter, wherever taken, has been measured from the corresponding vessel member which was utilized for obtaining the linear dimension. All measurements were taken directly under the microscope with calibrated lens combination. In the graphs reproduced as text-figures the average length values for fibres at corresponding distances as of the vessels are also given for comparison.

Results and Discussion

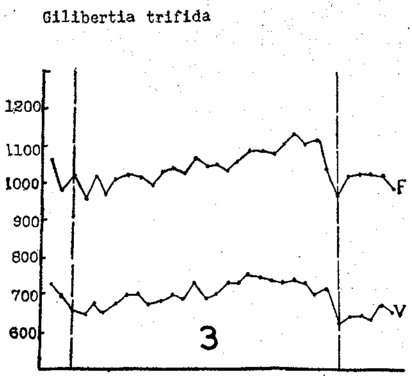
In ring porous woods the average vessel length in the later-formed region of a growth ring is always greater than that in the earlier-formed part (Text-Figs. 1–5). This trend is in accordance with that obtained for the fibres of the corresponding species as also for the fibres of other species by Bisset *et al.* (1950 *b*). In most instances the peak for vessel length lies somewhere in the later-formed region of the growth ring. In *Cipadessa baccifera* (Text-Fig. 6) the vessel members retain more



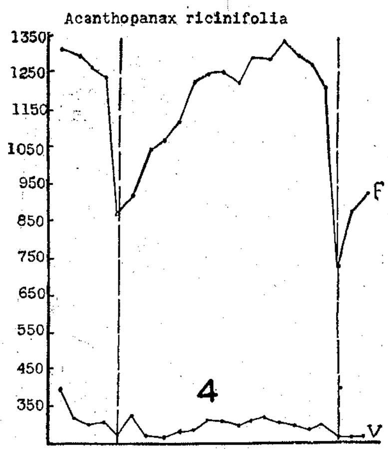
TEXT-FIG. 1



TEXT-FIG. 2



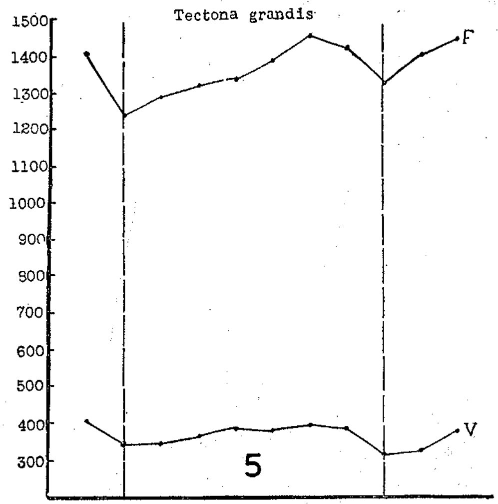
TEXT-FIG. 3



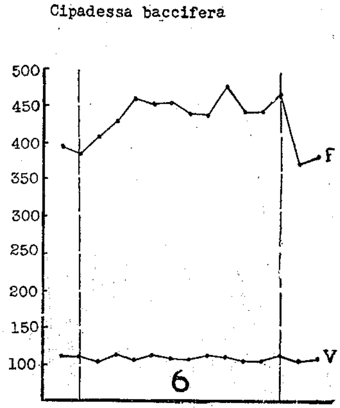
TEXT-FIG. 4

or less the same length values throughout the growth ring, although the curve for the fibres exhibits a trend similar to that shown by many other woods with distinct growth rings. This situation appears to be just what is to be expected in view of the storeyed nature of the cambium, wherein the feature is particularly well established in relation to the vessel member. Incidentally, it may also be noted that in woods with storeyed cambia the length of the vessel remains relatively constant from the earlier-formed to the later-formed secondary wood along the entire diameter of the stem (Bailey and Tupper, 1919) and recently a parallel trend has been established for storeyed wood parenchyma strands also (Chalk *et al.*, 1955).

In *Alangium chinense* (Text-Fig. 1) the attainment of maximum length of vessel members appears to become established at the beginning

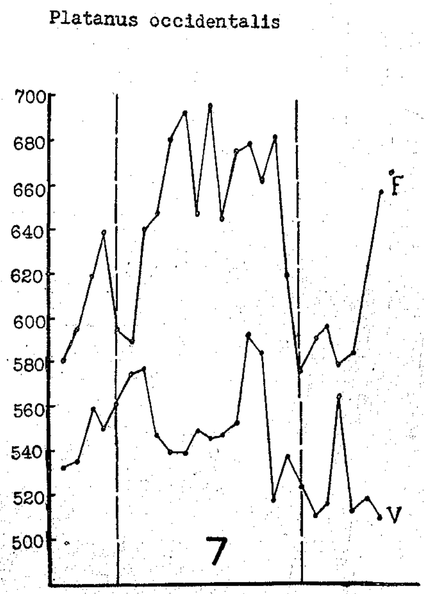


TEXT-FIG. 5

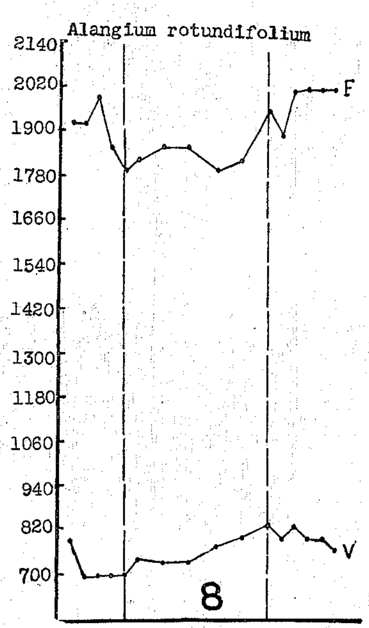


TEXT-FIG. 6

TEXT-FIGS. 1–6. Length-on-age curves for fibres and vessel members in woods with distinct growth rings (F and V respectively). The numbers along the vertical axis are in microns. Limits of growth rings are represented in vertical broken lines. Ring porous woods.

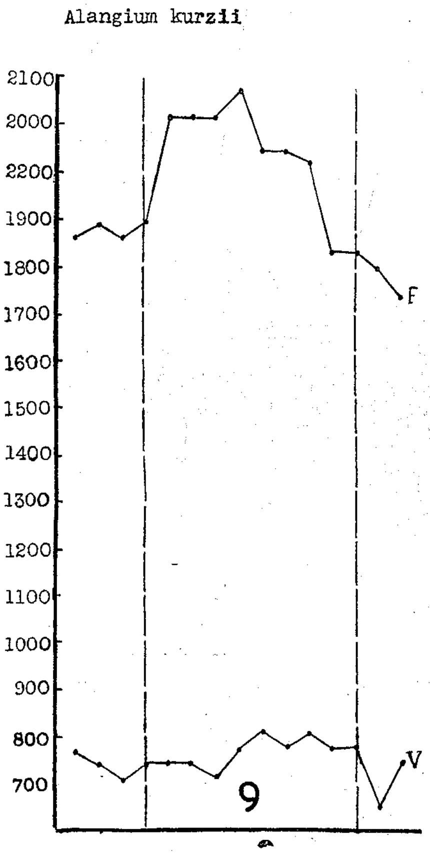


TEXT-FIG. 7

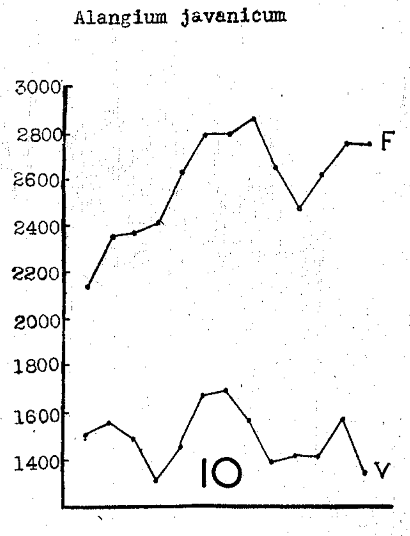


TEXT-FIG. 8

of the growth period itself and this acquired length remains relatively constant at successive distances within the ring, finally dropping down abruptly at the junction region of the next growth ring as in other ring porous species. In woods which possess distinct growth rings and diffuse pattern of distribution of pores, the mode shown by the average length of vessel member parallels the one described for ring porous woods (Text-Figs. 7–9). In contrast to these two categories of woods in which the growth increments are clearly defined, woods in which growth rings are



TEXT-FIG. 9



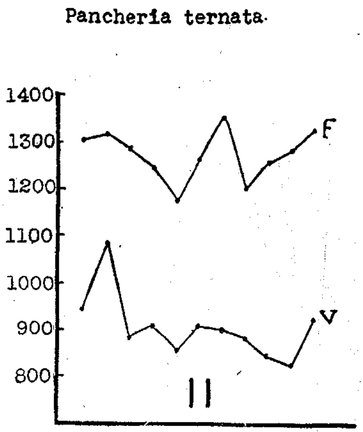
TEXT-FIG. 10

TEXT-FIGS. 7–10. Figs. 7–9. Length-on-age curves for fibres and vessel members in woods with distinct growth rings (F and V respectively). Diffuse porous woods. Fig. 10. Length-on-age curves for fibres and vessel members in woods without growth rings. Rest of the legend as in previous figures.

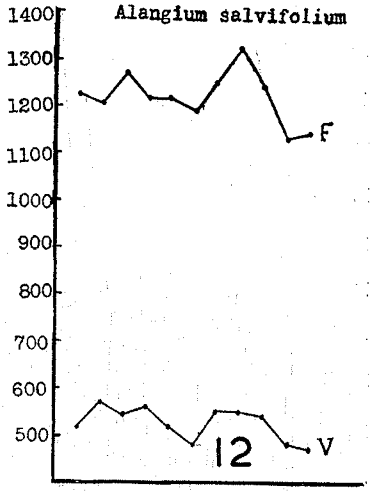
absent fail to exhibit specific curves in regard to the vessel length over stretches of xylem tissue formed during several years (Text-Figs. 10–12).

On the whole, it may be observed that although the trends shown both by fibres and vessels within a growth ring conform to the same basic kind the degree of expression of the feature is much more pronounced in the case of fibres than in vessel members of the same secondary xylem of any species. This difference is possibly a reflection of the inherent tendency of the fibre initial cell to undergo extensive apical elongation during maturation while such a feature is comparatively minimised in the ontogeny of a vessel member.

The trend shown by the vessel members and fibres, both in the diffuse porous and ring porous woods, as stated already, indicates a gradual increase from the beginning of the growth ring. In so far as the fibre length variation within a ring is concerned, it has been shown by Chalk *et al.* (1955) that shorter length at the beginning of a growth ring

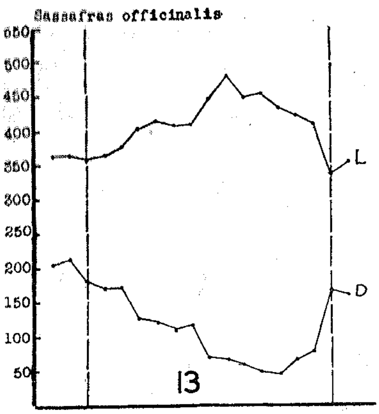


TEXT-FIG. 11

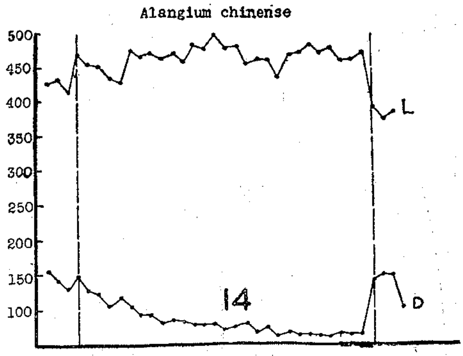


TEXT-FIG. 12

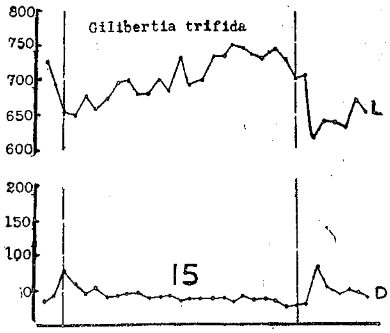
is correlated with a relatively rapid rate of pseudotransverse divisions of the fusiform initials, thereby inhibiting to some extent the phenomenon of apical elongation of the concerned fibres; on the other hand, towards the later-formed region, the frequency of such divisions slows down so that the derivative imperforate tracheary cells possess the required time to undergo maximum readjustment in terms of vertical elongation. This postulation appears to afford a logical explanation in the case of vessels of diffuse porous and ring porous woods as well. Although this factor may be operative in the case of vessels of ring porous woods, it is likely that the vessel diameter also could be a factor involved in the phenomenon. In typical cases of graded porous woods, the diameter of the vessel members is negatively correlated with their corresponding length within a growth ring (Text-Figs. 13–16); the *r*-values for the species investigated are of the order of $-\cdot 92$ for *Sassafras officinale* and *Acanthopanax ricinifolia*, $-\cdot 69$ for *Alangium chinense* and $-\cdot 68$ for *Gilibertia trifida*. From these data one is led to assume that the degree of lateral expansion of the vessel member may be regarded as an additional factor



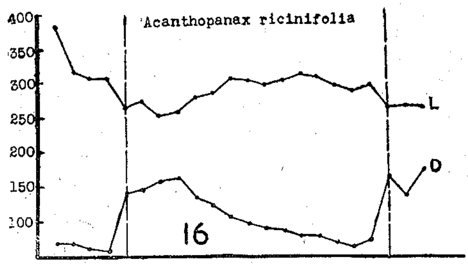
TEXT-FIG. 13



TEXT-FIG. 14



TEXT-FIG. 15



TEXT-FIG. 16

TEXT-FIGS. 11–16. Figs. 11–12. Length-on-age curves for fibres and vessel members in woods without growth rings. Rest of the legend as in previous figures. Figs. 13–16. Relationship between length and diameter of vessel members in graded porous woods (L = length, D = diameter).

influencing the formation of shorter vessel members at the beginning of the growth ring, at least in so far as the graded porous woods are concerned.

The results of this study raise an important consideration. Are the fluctuations seen in vessel length within one growth ring due to corresponding changes in the fusiform initials of the cambium that develop into vessels, or due to subsequent apical elongation of the vessel members during maturation ? It is proposed to discuss these and allied questions in a later contribution.

Summary

Size variations of vessel members within a growth ring of certain arborescent dicotyledonous woods have been studied. The average vessel length gradually increases from the earlier-formed to the later-formed part of the growth ring with the peak value lying towards the later half of the ring. This trend is similar in quality to that exhibited by the length of fibres; however, it is less pronounced quantitatively in the case of vessels. The rapidity of pseudotransverse divisions in the fusiform initials at the beginning of the growth ring appears to explain the formation of shorter vessel members both in diffuse and ring porous woods; the retarded rate of cell division toward the later-formed part of the growth ring appears to result in the differentiation of longer vessel members. In the case of certain ring porous woods, the vessel diameter is negatively correlated with its length within a growth ring. This behaviour also is suggested as a factor of some significance in controlling the vessel length within a growth ring of such woods.

References

Bailey, I. W. and Tupper, W. W. 1919. Size variation in tracheary cells. *Proc. Amer. Acad. Arts Sci.* **54**: 149–204.

Bisset, I. J. W., Dadswell, H. E. and Amos, G. L. 1950 *a*. Changes in fibre-length within one growth ring of certain angiosperms. *Nature, Lond.* **165**: 348–51.

——— and ——— 1950 *b*. The variation in cell length within one growth ring in certain angiosperms and gymnosperms. *Aust. Forester* **14**: 17–29.

Chalk, L., Marstrand, E. B. and De C. Walsh, J. P. 1955. Fibre length in storeyed hard woods. *Acta Neerl. Bot.* **4**: 339–47.