

Size correlations among cambial initials and their derivatives in some Himalayan trees

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Three species of Himalayan trees viz. *Aesculus indica* Colebr., *Quercus leucotrichophora* Camus ex Bahadur and *Rhododendron arboreum* Linn. were investigated to find out the correlation between cambium and its derivatives. Of these *A. indica* is deciduous and *Q. leucotrichophora* and *R. arboreum* are evergreen. Although these taxa grow in identical climatic and edaphic conditions, yet they show considerable variations in the length of fusiform initials and their derivatives.

Key-Words—Fusiform initials, Phloem, Xylem, Himalayan trees.

INTRODUCTION

The literature dealing with the size variations of the xylem elements in relation to the cambial initials has been reviewed by Spurr and Hyvarinen (1954), Dinwoodie (1961), Philipson *et al.* (1971) and Butterfield (1973). During recent years, a number of tropical trees, growing in the Indian environment have been studied in respect to the size correlation between cambium and its derivatives (Ghouse & Yunus 1975; Ghouse & Hashmi 1978; Anand *et al.*, 1978, 1981 Sharma *et al.*, 1979; Paliwal G.S. *et al.* 1979; Paliwal, *et al.*, 1981, in press) and it has been observed that all the derivatives experience variable size changes during their differentiation and maturation.

Knowledge on the cambial structure and its derivatives as also its relationship to plant development is still fragmentary and several questions remain to be answered as yet. Keeping this in view, some temperate tree species, growing in the Himalayan region of Uttaranchal, India, were selected for exploring the relationship between various climatic factors *vis-a-vis* the cambial activity and differentiation into components of phloem and xylem.

MATERIAL AND METHOD

The samples for the present survey were drawn from the trees growing in the mixed forest range, under natural climatic and edaphic conditions of Kandolia forest (Pauri Garhwal), at an elevation of 1,800 m.

above mean sea level. Two fully grown specimens of each species viz. *Aesculus indica* Colebr. (Hippocastanaceae), *Quercus leucotrichophora* Camus ex Bahadur (Fagaceae), and *Rhododendron arboreum* Linn. (Ericaceae) were marked out from the population. Later, monthly collections were made from the twigs (2 cm diameter) and main trunks (3 cm³) in the 3rd week of each month for two consecutive years. Subsequently these large pieces were cut into smaller ones and fixed in FAA For 24 hours. These were finally preserved in 70% ethyl alcohol for processing at a later stage. Sections of the materials from twigs as well as the main trunks were cut in transverse and tangential longitudinal planes at 15-25 μ m on a Spencer's sliding microtome. Staining was done with tannic acid-ferric chloride-lacmoid combination (Cheadle *et al.*, 1953). After dehydrating the sections in an ethyl alcohol series, mounting was done in canada balsam.

The dimensions of the fusiform initials, ray initials, and their derivatives except the treachery elements, phloem and xylem fibres were recorded from tangential and transverse sections. The measurements for the treachery elements and fibres were recorded from the macerated material owing to the difficulty of discerning their ends in the sections.

OBSERVATION

Of the three investigated trees, *Aesculus indica* is a fast-growing and deciduous form, whereas

Quercus leucotrichophora and *Rhododendron arboreum* exhibit slow growth and evergreen nature. These are the important constituents of angiospermic flora at the Kandolia forest range. The leaf-fall in all the three species starts in the month of September and the trees of *Aesculus indica* become completely leafless in December, whereas in *Quercus leucotrichophora* and *Rhododendron arboreum*, leafless condition was not noticed due to their evergreen habit. New leaves appeared in *Aesculus indica* at the beginning of February whereas sprouting of new leaves started slightly later in the other two taxa.

Vascular Cambium – The vascular cambium in all the three taxa is non-storied type and is composed of medium-sized, pointed fusiform initials with overlapping ends, coupled with more or less isodiametric rectangular ray initials (Pl. 1, figs 1-3). The latter are interspersed amongst radial rows of fusiform initials, located in the radial, continuation with the xylem and phloem rays. The ray initials are exclusively uniseriate and homogeneous in *Aesculus indica* and *Quercus leucotrichophora*, although a few biseriate ones have also been seen in the latter species whereas these are uni-, bi- and multiseriate and heterogeneous in *Rhododendron arboreum*. The fusiform initials possess dense cytoplasmic contents and give a characteristic beaded appearances on their tangential walls during dormancy. An average length of fusiform initials is 396.36 ± 39.75 μ m in *Aesculus indica*, 427.41 ± 59.58 μ m in *Quercus leucotrichophora* and 457.03 ± 61.83 μ m in *Rhododendron arboreum*. The dimension of their derivatives in the respective tree are given in the Histogram.

Phloem - The secondary phloem of *Aesculus*

indica and *Quercus Leucotrichophora*, consists of the sieve-tube elements, companion cells, phloem parenchyma cells, and the phloem fibres in the axial system and ray parenchyma cells in the radial system. In addition to these elements, crystalliferous parenchyma cells were also noticed closely associated with the fibres in *Rhododendron arboreum*. These parenchyma strands have more than 10 compartments and each have a single rhomboidal crystal of calcium oxalate. The other type of parenchyma strand contains 3-6 compartments, filled with starch grains in *Aesculus indica* and *Quercus leucotrichophora* and tanniferous material in *Rhododendron arboreum*, especially at the time of cambial dormancy. The sieve-tube elements in the living phloem are clearly evidenced by open sieve pores and the presence of slime (p-protein), in the vicinity of the sieve plates. Callose deposition and lateral sieve areas are also seen at variable positions which are recognizable owing to the bluish stain with lacmoid (Pl.1, figs 4-6). The sieve plates are compound with oblique end walls containing 3-8 sieve areas upon them in *Aesculus indica* and *Quercus leucotrichophora*, whereas these are simple, transverse or slightly oblique in *Rhododendron arboreum*. The phloem fibres are arranged in banded pattern in *Aesculus indica* and *Quercus leucotrichophora* whereas these are uniformly distributed in *Rhododendron arboreum*. The fibres are aseptate, thick-walled with narrow lumen. The phloem ray system in *Aesculus indica* and *Quercus leucotrichophora* is uniseriate, homogeneous although a few tri-seriate ray strands are also seen towards the periderm. In *Rhododendron arboreum*, these are uni-, bi- or multiseriate and heterogeneous. The height of individual ray strands is also

PLATE-1

Structure and organization of cambium, phloem and xylem in the stems of *Aesculus indica*, *Quercus leucotrichophora* and *Rhododendron arboreum*. (fi, fusiform initials; pf, phloem fibres; pps, phloem parenchyma strands, prc, phloem ray cells; ri, ray initials; ste, sieve-tube elements; tr, trachieds; ty- tyloses; ve, vessel elements; xf, xylem fibres; xps, xylem parenchyma strands; xrc, xylem ray cells.)

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| <p>1-2. Tangential longitudinal sections showing non-storeyed cambium, uni-seriate and homogeneous ray initials in <i>Aesculus indica</i> (1X120) and <i>Quercus leucotrichophora</i> (2x195).</p> <p>3. Tangential longitudinal section showing non-storeyed cambium, uni-bi, multiseriate and heterogeneous ray initials in <i>Rhododendron arboreum</i> X 70.</p> <p>4-6. Tangential longitudinal sections showing oblique and compound</p> | <p>sieve-plates in <i>A. indica</i> (4x190); <i>Q. leucotrichophora</i> (5x110) and simple, transverse sieve-plate in <i>Rhododendron arboreum</i> (6x150).</p> <p>7-9. Tangential longitudinal sections of xylem showing its organization and distribution of vessels, fibres, xylem rays and tyloses in <i>Aesculusindica</i> (7x60), <i>Quercus leucotrichophora</i> (8x110) and <i>Rhododendron arboreum</i> (9x140).</p> |
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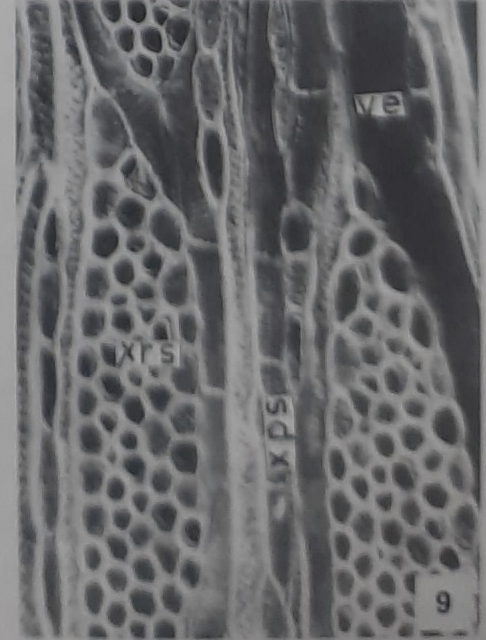
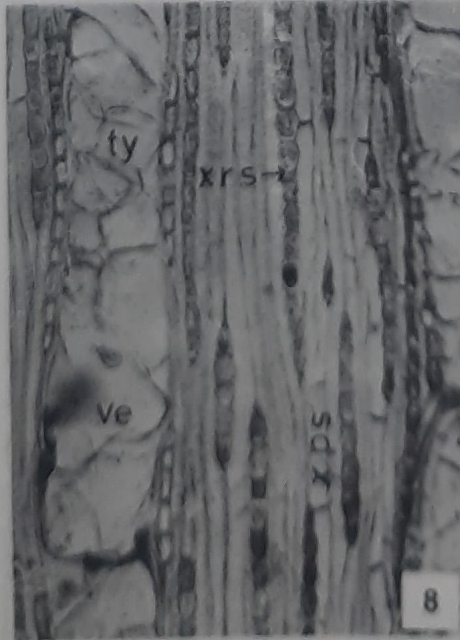
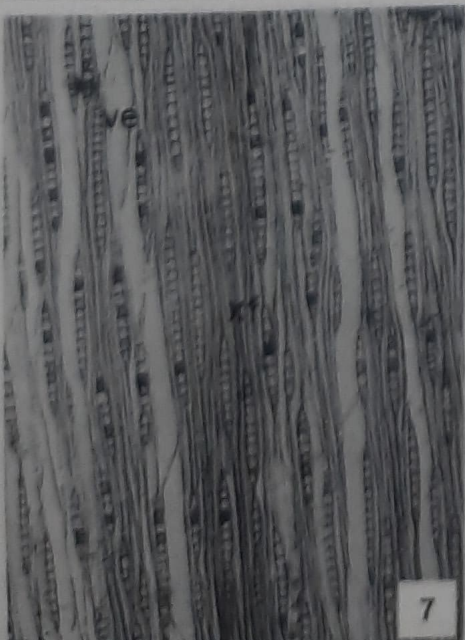


PLATE-I

variable, depending upon the number of cells present per strand, throughout the year.

Xylem - The secondary xylem of *Aesculus indica* and *Rhododendron arboreum* is composed of vessel elements, parenchyma and fibres in the axial system and xylem ray parenchyma in the radial system (Pl. 1, figs. 7, 9). In addition to these, the tracheidal elements are also found in the axial system of *Quercus leucotrichophora* (Pl.1, figs 8). The former taxa possess diffuse porous wood whereas the latter shows diffuse to semi-ring porous condition. The vessels appear solitarily or in groups of 3-6, arranged in a row, forming pore-multiples in *Aesculus indica* and solitary or in small groups in *Rhododendron arboreum*. On the other hand, the larger vessels are conspicuously solitary at the beginning of the growth rings and later-formed smaller vessels are in long, oblique, diagonal radial or flame-like groups in *Quercus leucotrichophora*. The perforation plates are scalariform with several bars in *Aesculus indica* and *Rhododendron arboreum* whereas in *Quercus leucotrichophora* these are simple and their lateral walls are alternately pitted. The lumen of the large mature vessels are densely filled with tyloses. The vessel elements are long and narrow-lumened in *Aesculus indica* and *Rhododendron arboreum* as compared to *Quercus leucotrichophora* where these are short and with broad lumen. The parenchyma strand is made up of 2-6 cells in *Aesculus indica* and 4-5 cells in *Quercus leucotrichophora* and *Rhododendron arboreum*. These abound in starch grains in *Aesculus indica* and *Quercus leucotrichophora* whereas tannin was recognizable in the parenchymatous elements of *Rhododendron arboreum*. The xylem fibres in all the three taxa are aseptate, copiously thickwalled, with a narrow lumen and pointed apices. The xylem rays are exclusively uniseriate and homogeneous in *Aesculus indica* although a few biseriate rays have also been observed in the older trunks. In *Quercus leucotrichophora* these are homo- to heterogeneous and of two types: long, broad, aggregate and fine, small, uniseriate ones. The xylem rays in *Rhododendron arboreum*, on the other hand, are heterogeneous and uni-, bi-, multi-seriate. The ray cells are rectangular and their

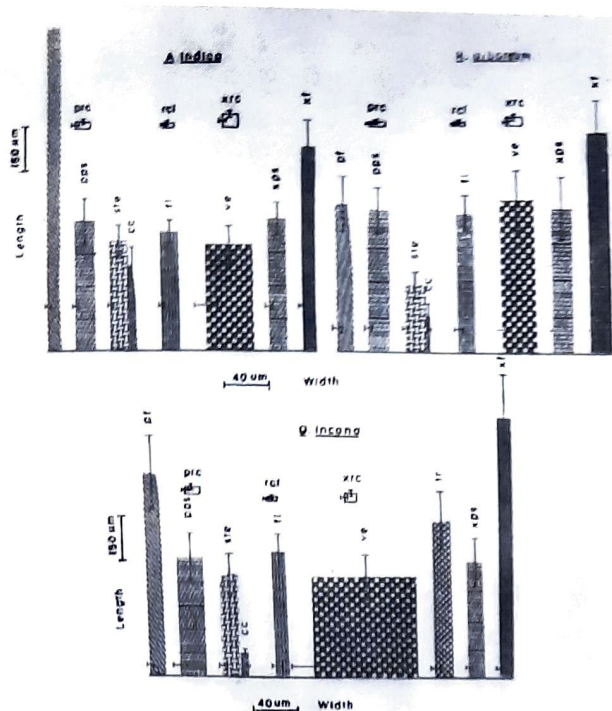
length undergoes minor alterations from one month to another throughout the year. The percentage of the uniseriate rays is higher as compared to the multi-seriate ones.

DISCUSSION

It is clear from the Plate 2, that the phloem and xylem fibres become 2.5 and 2 times long in *Aesculus indica* and 1.6 and 2 times long in *Quercus leucotrichophora* over their mother cells. In *Rhododendron arboreum*, however, the phloem fibres are nearly of the same length and the xylem fibres are more or less twice in length in comparison to their precursors. As early as 1920, Bailey had recorded that the fibres in *Ginkgo*, as well as, in the other members of coniferales are much longer than their initials. Chattaway (1936) also drew similar conclusions during the survey of the dicotyledonous woods and recorded that the fibres may elongate 1.1-9.5 times as compared to their initials. A more or less identical situation has been observed by Nanko *et al.* (1977), Sundarshivarao *et al.* (1973) Butterfield (1973), Anand *et al.* (1978) and Paliwal, S.P. *et al.* (1981). All the three taxa investigated by us also confirm these reports. The fusiform initials undergo considerable elongation during their differentiation into fibres, at first due to simplastic and later by intrusive growth. The degree of intrusive growth experienced by fibres varies in different species and is hardly a function or reflection of the size of the fusiform initials.

The length of the vessel elements was found to be slightly less (0.8 times) in *Aesculus indica* and *Quercus leucotrichophora*, but a little more or same (1.0 to 1.26 times) in *Rhododendron arboreum* as compared to their respective mother cells.

Such observations are in full agreement with the earlier reports of Bailey (1920) and Esau and Cheadle (1955). It would thus appear that the fusiform initials during their metamorphosis into vessel elements experience only minor size changes, due to shifting of their end walls. The length of the sieve-tube elements shows that it is slightly shorter (Histogram) than their respective fusiform initials in *Aesculus indica* and *Quercus leucotrichophora* whereas it is almost half the length of the fusiform initials in *Rhododendron arboreum*



Histogram- Size correlations among cambial initials and their derivatives in *Aesculus indica*, *Quercus leucotrichophora* and *Rhododendron arboreum*.

(cc, companion cells; fi, fusiform initials; pf, phloem fibres; pps, phloem parenchyma strands; prc, phloem ray cells; ri, ray initials; ste, sieve-tube elements; tr, trachieds; ve, vessel elements; xf, xylem fibres; xps, xylem parenchyma strands; xrc, xylem ray cells.)

(0.48 times). Zahur (1959) reported that the sieve tube elements in angiosperms have undergone a phylogenetic decrease in length similar to that of the vessel elements and concluded that the ontogenetic shortening of the sieve tube elements may be regarded as an advanced character. Carlquist (1961) has negated Zahur's conclusion and pointed out that the families listed by him, as having considerable septation, are by no means advanced in many respects. Evidently, both the conclusions of Carlquist (1961) and the findings of the present study, with regard to the septation in the phloem of all the three species, indicate that much more information on the phloem of a number of gymnospermous and angiospermous taxa is needed before giving any phylogenetic significance to the shortening of the sieve tube elements. Starch storing as well as the crystalliferous parenchyma strands in both the phloem and xylem either underwent slight elongation (*Aesculus indica* and *Rhododendron arboreum*) or remained more or less of the same length (*Quercus leucotrichophora*) as compared to their initials, sug-

gesting that these got differentiated directly from them without undergoing any divisions.

The fibres in the phloem and xylem region show decreased width in general as compared to their mother cells, except the xylem fibres in *Rhododendron arboreum* which experience widening along with their elongation. The width of the mature sieve-tube elements remains more or less same in comparison to the progenitors. The width of vessel elements, however, presents a different situation in all the three taxa. On an average, these are 3 times wider in *Aesculus indica*, 7 times in *Quercus leucotrichophora* and 2 times in *Rhododendron arboreum* than their initials. The ray cells of both phloem and xylem region experience a considerable increase in length while their width remain equal or slightly more as compared to ray cell initials. Similar conclusion have also been observed by Sharma *et al.*, (1979) and Paliwal *et al.* (1979).

Thus it can be concluded that the cambial initials undergo variable dimensional changes during their transformation into different elements of phloem and xylem. It is difficult to furnish any general idea of primitiveness or advancement on the basis of distribution and the dimensional changes during metamorphosis of the specific elements. Evidently, before any generalization can be presented, more and more trees should be explored for size correlation studies, as presented here.

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