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EVOLUTIONARY TRENDS IN THE SECONDARY XYLEM OF WOODY DICOTYLEDONS FROM THE TERTIARY OF INDIA

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ABSTRACT

A large number of dicotyledonous woods have so far been described from the various Indian Tertiary formations. Based on their published data an attempt has been made to trace the evolutionary trends in the anatomical features of the secondary xylem of woody dicotyledons. The studies have shown that there is a gradual increase in the percentage of woods with advanced type of characters, especially in the axial parenchyma and the xylem rays, from the Palaeogene onwards to the successive younger floras.

Key-words — Dicotyledonous woods, Xylotomy, Evolutionary trends, Tertiary, India.

साराँश

भारत के तृतीयक युग से उपलब्ध द्विबीजपत्री काष्ठाश्मों की द्वितीयक दारू में विकासात्मक प्रवृत्तियाँ – मोहन बलवंत बाँडे एवं उत्तम प्रकाश

भारतीय तृतीयक युगीन विभिन्न शैल-समूहों से अभी तक बृहत् संख्या में द्विबीजपत्रीय काष्ठाश्मों का वर्णन किया जा चुका है। प्रकाशित आँकड़ों पर आधारित द्विबीजपत्री काष्ठाश्मों की द्वितीयक दारू के शारीरीय लक्षणों में विकासात्मक प्रवृत्तियों के अन्वेषण का एक प्रयास किया गया है। इस अध्ययन से स्पष्ट होता है कि तृतीयक-पूर्व कल्प से लेकर अल्पायु वाले क्रमिक वनस्पतिजातों तक उन्नत प्रकार के लक्षणों से युक्त काष्ठों की, विशेषतया अक्षीय दृढ़ोतक एवं दारू-किरणों में, प्रतिशतता उत्तरोत्तर बढ़ती है।

INTRODUCTION

IN the study of evolution of higher plants the role of wood anatomy cannot be overlooked. Development of a well organized wood structure, along with the evolution of reproductive organs, has played a vital role in deciding the struggle of dominance in favour of angiosperms against other contemporary plant groups.

Although there is a lot of controversy regarding the earliest record of the angiosperms, it is beyond doubt that by the end of the Cretaceous they were surely a conspicuous element of the flora and became dominant from the Tertiary onwards. If the injunction that the existing forms are the products of this evolutionary process, is accepted, then it can also be suggested that the earliest angiosperms represent the primitive stock and during the succeeding geological eras, evolution has been going on in them so as to reach the present forms. Thus, in case of evolution of the secondary xylem in angiosperms, especially the dicotyledons, it is logical to presume that the forms of earlier ages should possess a primitive type of secondary xylem with more specialized types appearing in the succeeding ages (B.S.I.P. Ann. Rep. 1973-74, pp. 17-18).

The Indian Tertiary flora is very rich in fossil woods, both in the Palaeogene as well as in the Neogene. Because a considerable data is now available regarding the dicotyledonous fossil woods of this flora, it is desirable to analyse it and compare it with the observations made on modern woods so as to have an understanding of the lines of evolution of secondary xylem in the Indian Tertiary dicotyledons. However, before the actual analysis of the Indian Tertiary dicot woods is taken up, it is advisable to classify the advanced and the primitive characters in the secondary xylem of the dicotyledons. Wood anatomists have reached, entirely independently, to certain conclusions in this respect which can be summarized as follows:

1. The vessel member with a scalariform perforation plate is more primitive than the one with a simple perforation plate (Bailey & Tupper, 1918; Bliss, 1921; Thompson, 1923; Frost, 1930a,b).

2. The vessel element with scalariform perforation plates having many bars (over 15) to a plate is primitive, the type with intermediate bars (5 to 15) comes next, and the type with few (five or fewer) bars is highly evolved amongst these (Frost, 1930b).

3. The length of vessel elements decreases as they become specialized (Bailey & Tupper, 1918; Bailey, 1920; Frost, 1930a) and there is a definite trend in some groups toward widening of vessels with increasing specialization (Carlquist, 1961). Consequently, their endwalls become less oblique until a transverse wall is formed (Bailey & Tupper, 1918; Bailey, 1920; Frost, 1930 a, b).

4. Vessels with angular cross sections are primitive while those with round outlines are advanced (Bailey, 1924; Frost, 1930a). Important exceptions to this trend occur in some highly advanced groups where the angular characteristic may be attained secondarily (Carlquist, 1958, 1961; Bailey, 1957).

5. The evolutionary development of intervascular pitting proceeds from scalariform to transitional to opposite to alternate type (Bailey & Tupper, 1918; Brown, 1918; Frost, 1930a, 1931).

6. Diffuse-porous woods usually precede ring-porous woods (Frost, 1930a). However, the degree to which ring porosity is environmentally modifiable needs investigation. Formation of ring porosity represents an evolutionary adjustment to highly seasonal climatic conditions that has occurred many times independently in groups with primitive wood as well as in groups with specialised xylem (Carlquist, 1961).

7. The solitary pores are more primitive than those in various aggregate arrangements like pore multiples, pore clusters, and pore chains.

8. Evolution has taken place from tracheids to fibretracheids to libriform wood fibres (Bailey & Tupper, 1918; Bailey, 1924, 1936).

9. According to Bailey (1920, 1924) and Bailey and Tupper (1918) the nonseptate fibrous tracheary elements precede the septate elements whose length decreases as they become more and more specialized. However, the evolutionary interpretation of septation in fibres is not very clear. Obviously the statistical studies (Metcalfe & Chalk, 1950) show that fibre septation is not related to the major trends of xylem evolution (Carlquist, 1961, p. 51).

10. Heterogeneous rays are more primitive than homogeneous rays. Kribs (1935, 1959) has classified the xylem rays of dicotyledons into following types:

Type I — Heterogeneous

(a) Uniseriate rays composed of vertically elongated cells which are unlike the cells of the multiseriate part of the multiseriate rays.

(b) Multiseriate rays with uniseriate tails or wings as long or longer than the multiseriate portion of the ray and composed of vertically elongate cells similar to those of the uniseriate rays; cells of the multiseriate portion are round to oval and radially elongated.

Type II — Heterogeneous — (Heterogeneous Type IIa of Kribs, 1935).

(a) Uniseriate rays composed of vertically elongate cells which are unlike those of the multiseriate portion of the multiseriate rays.

(b) Multiseriate rays with one large vertically elongate marginal cell or with uniseriate tails or wings shorter than the multiseriate portion of the ray and composed of vertically elongate cells similar to those of the uniseriate rays; the cells of the multiseriate portion are round to oval and radially elongated.

Type III-Heterogeneous — (Heterogeneous Type II-B of Kribs, 1935).

(a) Uniseriate rays usually of two types, some of the uniseriates are composed of vertically elongate cells and some are composed of cells which are nearly identical to those of the multiseriate portion of the the multiseriate rays.

(b) Multiseriate rays with square marginals (not vertically elongate) usually a single row; cells of the multiseriate portion are round to oval and radially elongated.

Type IV-Homogeneous

(a) Uniseriate rays composed of cells which are identical to those of the multiseriate rays.

(b) Multiseriate rays without square or vertically elongate marginal cells; the cells are all round or oval and radially elongate with or without tails.

Type V-Heterogeneous

Rays uniseriate only composed of radially and vertically elongate cells.

Type VI-Homogeneous

Rays uniseriate only.

Kribs (1935) has also shown that the evolutionary sequence is from heterogeneous type I, the most primitive through transitional heterogeneous type II (type IIA) and type III (type IIB) to homogeneous type VI. The homogeneous type IV rays are more highly specialised than uniseriate heterogeneous type V rays which are regarded as derivatives of either heterogeneous type I, II or type III. Homogeneous type VI may have evolved from any of the other types. It appears that the uniseriate types are highly specialised structures owing to the elimination of multiseriate rays (Kribs, 1935; Tippo, 1938).

Kribs' conclusions on the relative evolutionary status of the ray types may be summarized in the following way as done by Carlquist (1961). Rays in the most primitive woods exhibit the following features:

1. Both multiseriate and uniseriate rays are present.
2. Both types of rays are high (of marked vertical length).
3. Both types of rays are heterocellular.
4. Multiseriate rays have long uniseriate wings.

With advancement, the following changes occur in rays:

(a) Multiseriate rays or uniseriate rays are lost.
(b) There is a tendency for loss of heterogeneity in ray cells, particularly loss of erect cells. Thus, homocellular rays are advanced.
(c) Multiseriate rays are reduced in size and number.
(d) Uniseriate wings on multiseriate rays are reduced, ultimately to a single cell.

11. In the axial parenchyma, two main groups can be demarcated: (a) apotracheal, in which parenchyma is distributed without specific relation to vessels, and (b) paratracheal, in which parenchyma shows a close association with vessels. Based on the observations of earlier workers (Bailey, 1924; Jeffery, 1917; Kribs, 1937; Carlquist, 1961) the evolution of the axial parenchyma types may be broadly summarised as follows:

(a) Absence of parenchyma is primitive at least in some dicotyledons (Carlquist, 1961, p. 63). However, axial parenchyma is absent in a number of families having specialised types of vessels (Carlquist, 1976, p. 20).
(b) Diffuse parenchyma represents the primitive type.
(c) Diffuse-in-aggregate is slightly advanced over diffuse.
(d) Apotracheal banded parenchyma represents the most advanced type of apotracheal parenchyma. Wide bands are more advanced than narrow bands.
(e) Vasicentric, abundant parenchyma is the most highly specialised type.

12. The storied structure of various elements, namely rays, wood fibres, parenchyma, and the vessel members indicate highly specialised condition (Record, 1919, 1934; Carlquist, 1961, p. 65).

Thus it can be seen that a substantial information is now available regarding the primitive or advanced nature of a particular anatomical character. However, all the anatomical characters mentioned above were not found useful while dealing with the fossil dicotyledonous woods mainly due to the lack of uniformity in describing fossil woods by different authors. Besides, all the characters are not always available for their comparative analysis. Thus, within the limitations of the available data, the anatomical characters which were found suitable for analysis are (i) nature of perforation plates, (ii) type of intervessel pit-pairs, (iii) vessel end walls, (iv) axial parenchyma, and (v) the xylem rays.

For this analysis only those fossil genera and species have been taken into consideration whose description and identification appear to be reasonably correct. Moreover, when more than one species of a particular genus are known in a fossil assemblage the anatomical data of only well differentiated species have been taken into account.

The different Indian Tertiary strata from where the fossil dicotyledonous woods have been analysed are:

1. The Deccan Intertrappean beds of Central India (Palaeocene-Eocene — Tables 1 & 2).
2. The Lower Siwalik beds of the Himalayan foot-hills (Middle Miocene, Krishnan, 1968, p. 428 — Table 3).
3. Tipam Series of North-east India (Upper Miocene, Krishnan, 1968, p. 430 — Table 4).
4. The Neogene of West Bengal (Miocene, equivalent to the Tipams, Hunday, 1954; Hunday & Banerjee, 1967 — Table 5).
5. The Cuddalore Series of South India (Upper Miocene to Pliocene, Krishnan, 1968, p. 494 — Table 6).
6. The Dupitila Series of North-east India (Mio-Pliocene, Krishnan, 1968, p. 490 — — Table 7).

It is a well known fact that the ecological conditions quite often affect the anatomical structures. Therefore, it would be desirable to broadly consider the ecological conditions of the above mentioned Tertiary floras which form the basis of this analysis. Lakhanpal (1970), Prakash (1972) and Bande and Prakash (1982) have recently given their views regarding the past environments of these floras. Bande and Prakash (1982), while reconstructing the palaeoecology and palaeoclimate of the Deccan Intertrappean flora, concluded that this flora was growing under a warm, humid, tropical to subtropical climate. Almost similar type of climates have also been suggested for the Lower Siwalik, Cuddalore, Tipam and Deomali floras. In the West Bengal flora most of the forms are common to the different Neogene floras so far known from the Indian subcontinent. Thus, it can be said that all these floras were growing under more or less similar type of warm, humid, tropical to subtropical climatic conditions.

ANATOMICAL ANALYSIS

Dicotyledonous Woods from the Deccan Intertrappean Beds

In the Deccan Intertrappean flora a good number of fossil dicotyledonous woods are known from the following areas:

(a) Mandla District (Parapani, Samnapur Mohgaon, Ghughua, etc.).
(b) Nagpur-Chhindwara-Nawargaon area (Mohgaon Kalan, Keria, Mahurzari & Nawargaon).

Although the Deccan Intertrappean flora is usually considered as a single unit but on the evidence of fossil woods described from the above two areas it appears that these two assemblages constitute two distinct florules which may represent different geological ages and therefore, they have been treated here separately.

(a) *Fossil woods from Mandla District* — Seventeen fossil woods comparable with 16 extant genera belonging to 15 dicotyledonous families have been analysed anatomically. Their important anatomical characters have been classified in Table 1. A study of this table indicates that the perforation plates are mostly simple but scalariform with more than 10 bars in two species. Intervessel pits are bordered and alternate in most of the species with scalariform pits seen occasionally in one wood. The distribution of parenchyma is definitely of primitive type. Parenchyma is totally absent in one species, diffuse to diffuse-in-aggregate plus some vasicentric in four species, in thin apotracheal lines in two species, scanty paratracheal to 1-2 seriate, vasicentric in six species, and a well-developed aliform to aliform confluent or banded parenchyma is present in only four species.

Xylem rays also show a great deal of primitiveness. Of the 17 woods examined, heterogeneous rays occur in as many as 16 woods being heterogeneous type I in two woods, type II in twelve, and type III in two. Homogeneous type IV rays occur in only one wood.

(b) *Fossil woods from Nagpur-Chhindwara-Nawargaon area* — In all, 17 fossil woods comparable to 15 genera belonging to 14 families have been analysed (Table 2).

The perforation plates are simple in all the woods and the intervessel pits are bordered and alternate in 16 woods and scalariform in one wood. Parenchyma is absent in one wood, apotracheal diffuse to diffuse-in-aggregate with some scanty paratracheal in three, only scanty paratracheal in five, and well-developed vasicentric, aliform confluent and rarely banded in eight woods.

The xylem rays are mostly heterogeneous, being heterogeneous type I in one wood, type II or type III in 11 woods, type V in one wood, homogeneous type IV in three woods and homogeneous type VI in one wood.

Dicotyledonous Woods from the Lower Siwalik Beds of the Himalayan Foot-hills

In all, 19 fossil woods comparable to 17 extant genera belonging to eight families have been anatomically analysed (Table 3). Out of them 16 woods possess bordered and alternate intervessel pits and four vasicentric tracheids. Perforation plates are simple in all the woods. Vessel elements are storied in one.

As far as parenchyma is concerned, it is apotracheal diffuse to diffuse-in-aggregate or arranged in uniseriate, tangential apotracheal lines alongwith some scanty paratracheal parenchyma in eight out of 19 woods analysed here. Scanty paratracheal parenchyma is present only in one wood, apotracheal banded with paratracheal vasicentric parenchyma is present in four woods and a well-developed paratracheal aliform-confluent to banded parenchyma is present in six woods. In one case the parenchyma strands are storied. The xylem rays are heterogeneous type II or type III in 11 woods, heterogeneous type V in three woods and homogeneous type IV in five woods.

Dicotyledonous Woods from the Tipam Series of North-East India

Thirtyfour fossil woods representing 33 living genera belonging to 19 dicotyledonous families have been analysed (Table 4). All of them possess simple perforations except in one wood where they are scalariform with 8-10 bars. Inter-vessel pits are bordered and alternate in 32, and alternate to subopposite in two woods. Vasicentric tracheids are present in four woods.

Parenchyma shows a wide range of development. It is scanty paratracheal in five woods, scanty paratracheal to vasicentric alongwith apotracheal diffuse to diffuse-in-aggregate forming thin lines in eight woods, apotracheal banded in two, paratracheal vasicentric to aliform to confluent alongwith apotracheal diffuse-in-aggregate to banded in six, and well-developed paratracheal, aliform to confluent to banded in 13 woods. The xylem rays are heterogeneous in majority of the woods. They are heterogeneous type II in 16, type III in seven, type V in three, weakly heterogeneous in one, homogeneous type IV in six and homogeneous type VI in one wood. Storied rays occur in two woods.

Fossil Woods from the Neogene of West Bengal

In this case 22 woods representing 21 extant genera belonging to seven families have been analysed from these beds (Table 5). Their anatomical analysis clearly shows an advancement towards specialization. All of them possess simple perforations and bordered, alternate intervessel pit pairs. However, vasicentric tracheids occur in at least four woods.

Scanty paratracheal to vasicentric parenchyma occurs in three woods, paratracheal vasicentric parenchyma alongwith apotracheal diffuse to diffuse-in-aggregate or short tangential lines or bands occurs in three woods, and a well-developed apotracheal banded parenchyma is present in four woods. Out of 22 woods, 12 show a well-developed paratracheal aliform, aliform-confluent to banded parenchyma. Parenchyma cells are storied in four woods. Xylem rays are heterogeneous in 11 species and homogeneous in 11 species. Heterogeneous type II is seen in nine woods and type V in two. Similarly, homogeneous type IV occurs in nine and type VI in two woods. Storied rays are present in five woods.

TABLE 1 — FOSSIL WOODS FROM THE DECCAN INTERTRAPPEAN BEDS (MANDLA DISTRICT)

Fossil wood with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
ANONACEAE						
Polyalthioxylon paraniense Bande, 1973	*Polyalthia simiarum*	Simple	Bordered, alternate	Horizontal to oblique	Apotracheal, 1-2 seriate tangential lines and 1-2 seriate vasicentric	Heterogeneous Type II
FLACOURTIACEAE						
Homalioxylon mandlaense Bande, 1974	*Homalium tomentosum*	Simple	Bordered, alternate	Truncate	Scanty paratracheal	Heterogeneous Type II
Hydnocarpoxylon indicum Bande & Khatri, 1980	*Hydnocarpus wightiana*	Scalariform with 10-25 bars	Bordered, alternate to opposite sometimes scalariform	Oblique	Absent	Heterogeneous Type I
GUTTIFERAE						
Garcinioxylon tertiarum Bande & Khatri, 1980	*Garcinia* sp.	Simple	Bordered, alternate	Oblique to transverse	1-2 seriate small apotracheal tangential lines, small clusters or single cells. Paratracheal vasicentric, aliform to confluent	Heterogeneous Type I (Predominant) and Type II
STERCULIACEAE						
Sterculioxylon deccanensis Lakhanpal, Prakash & Bande, 1978	*Sterculia* sp.	Simple	Bordered, alternate to opposite	Oblique to horizontal	Apotracheal diffuse to diffuse-in-aggregate with short uniseriate lines, paratracheal 1-2 seriate vasicentric, cells showing storied tendency	Heterogeneous Type II. Sheath cells present
Sterculioxylon shahpurensis Bande & Prakash, 1980b, 1983a	*Sterculia* sp.	Simple	Bordered, alternate	Truncate	Apotracheal diffuse-in-aggregate and paratracheal 1-2 seriate vasicentric	Heterogeneous Type II. Sheath cells present
TILIACEAE						
Grewioxylon sp. Lakhanpal, Prakash & Bande, 1978	*Grewia* sp.	Simple	Bordered, alternate	Truncate	Paratracheal 1-2 seriate vasicentric	Heterogeneous Type III. Tile cells present
ELAEOCARPACEAE						
Elaeocarpoxylon mandlaensis Lakhanpal, Prakash & Bande, 1978	*Elaeocarpus* sp. *Echinocarpus sigun.*	Simple	Bordered, alternate to opposite	Oblique	Scanty paratracheal	Heterogeneous Type II. Sheath cells present
RUTACEAE						
Atalantioxylon indicum Lakhanpal, Prakash & Bande, 1978	*Atalantia monophylla-Limonia acidissima*	Simple	Bordered, alternate	Oblique	Paratracheal vasicentric to aliform and apotracheal diffuse	Homogeneous Type IV

TABLE 1 — FOSSIL WOODS FROM THE DECCAN INTERTRAPPEAN BEDS (MANDLA DISTRICT) *Contd.*

Fossil wood with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
BURSERACEAE						
Burseroxylon preserratum Prakash & Tripathi, 1975; Bande and Prakash, 1983a	*Bursera serrata*	Simple	Bordered, alternate	Truncate to tailed	Paratracheal, scanty to 1-2 seriate vasicentric	Heterogeneous Type II
ICACINACEAE						
Gomphandroxylon samnapurensis Bande & Khatri, 1980	*Gomphandra tetrandra*	Scalariform with 10-15 bars	Bordered, alternate to opposite	Oblique	Apotracheal forming 1-2 seriate tangential lines	Heterogeneous Type II
MELIACEAE						
Heyneoxylon tertiarum Bande & Prakash, 1980b, 1983a	*Heynea trijuga*	Simple	Bordered, alternate to opposite	Truncate to tailed	Paratracheal banded	Heterogeneous Type III
ANACARDIACEAE						
Dracontomelumoxylon mangiferumoides Bande & Khatri, 1980; Bande and Prakash, 1982a	*Dracontomelum mangiferum*	Simple	Bordered, alternate	Truncate	Paratracheal, 1-3 seriate vasicentric to aliform	Heterogeneous Type II
MYRTACEAE						
Syzygioxylon mandlaense Ingle, 1973	*Syzygium cumuni*	Simple	Bordered, alternate, probably vestured	Oblique	Paratracheal vasicentric, aliform to aliform confluent and apotracheal diffuse	Heterogeneous Type II
LECYTHIDACEAE						
Barringtonioxylon mandlaensis Bande & Khatri, 1980	*Barringtonia* sp.	Simple	Bordered, alternate	Oblique	Apotracheal diffuse to diffuse-in-aggregate; paratracheal vasicentric	Heterogeneous Type II
LAURACEAE						
Laurinoxylon deccanensis Bande & Prakash, 1980b	Lauraceae	Simple	—	Truncate to transverse	Scanty paratracheal	Heterogeneous Type II
EUPHORBIACEAE						
Bischofinium deccanii Bande, 1974	*Bischofia javanica*	Simple	Bordered, alternate	Oblique	Scanty paratracheal	Heterogeneous Type II. Sheath cells present

TABLE 2 — FOSSIL WOODS FROM THE DECCAN INTERTRAPPEAN BEDS (MOHGAON KALAN, KERIA, MAHURZARI, NAWARGAON)

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
TILIACEAE *Grewioxylon mahurzariense* Prakash & Dayal, 1965	*Grewia laevigata*	Simple	Bordered, alternate	Tapering	1-3 seriate vasicentric sheath, irregularly storied	Heterogeneous Type II. Tile cells present, uniseriate rays partly storied
ELAEOCARPACEAE *Elaeocarpoxylon antiqum* Prakash & Dayal, 1964	*Elaeocarpus ferrugineus*	Simple	Bordered, alternate occasionally opposite	Tapering	Scanty paratracheal	Heterogeneous Type I
RUTACEAE *Evodinium indicum* Bande & Prakash, 1983b	*Evodia roxburghiana*	Simple	Bordered, alternate	Horizontal to inclined	Vasicentric to aliform confluent	Heterogeneous Type III
SIMAROUBACEAE *Ailanthoxylon indicum* Prakash, 1959b; Shallom, 1961; Saksena, 1963; Prakash, Verma and Dayal, 1967	*Ailanthus malabarica* and *A. grandis*	Simple	Bordered, alternate	Horizontal to inclined	Paratracheal vasicentric, aliform confluent to banded and apotracheal banded	Homogeneous Type IV
Simarouboxylon indicum Shallom, 1960; Prakash, 1964	*Simarouba* sp.	Simple	Bordered, alternate	Truncate or slightly tapering	Paratracheal aliform confluent to banded; storied tendency	Homogeneous Type IV
BURSERACEAE *Boswellioxylon indicum* Dayal, 1964, 1966	*Boswellia serrata*	Simple	Bordered, alternate	Truncate to tapering	Scanty paratracheal	Heterogeneous Type III
MELIACEAE *Amooroxylon deccanensis* Bande & Prakash, 1983b	*Amoora* sp.	Simple	Bordered, alternate to opposite	Horizontal to oblique	Paratracheal vasicentric, aliform confluent to banded; apotracheal diffuse to diffuse-in-aggregate	Heterogeneous Type III
VITACEAE *Leeoxylon multiseriatum* Prakash & Dayal, 1964	*Leea* sp.	Simple	Scalariform, rarely opposite	Tapering	Scanty paratracheal	Heterogeneous Type II. Sheath cells present

TABLE 2 — FOSSIL WOODS FROM THE DECCAN INTERTRAPPEAN BEDS (MOHGAON KALAN, KERIA, MAHURZARI, NAWARGAON)

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
SAPINDACEAE						
Sapindoxylon schleicheroides Dayal, 1965	*Schleichera* sp.	Simple	Bordered, alternate	Truncate to tapering	Scanty paratracheal	Homogeneous Type IV
ANACARDIACEAE						
Anacardioxylon semecarpoides Prakash & Dayal, 1965	*Semecarpus*	Simple	Bordered, alternate	Truncate or slightly inclined	Paratracheal, 1-3 seriate vasicentric to aliform	Heterogeneous Type III
LEGUMINOSAE						
Aeschynomenoxylon tertiarum Müller-Stoll, & Mädel, 1967; Prakash, 1963	*Aeschynomene* sp.	Simple	Alternate to opposite and scalariform	Horizontal to slightly inclined	Paratracheal, 1-4 seriate tangential bands and apotracheal diffuse	Homogeneous Type VI
LECYTHIDACEAE						
Barringtonioxylon eopterocarpum Prakash & Dayal, 1965	*Barringtonia pterocarpa*	Simple	Bordered, alternate	Truncate to tapering	Apotracheal narrow irregular tangential lines and scanty paratracheal	Heterogeneous Type II. Sheath cells present
SONNERATIACEAE						
Sonneratioxylon nawargaoensis Bande & Prakash, 1983b	*Sonneratia* sp.	Simple	Vestured, alternate to opposite	Vertical to oblique to tailed	Absent	Heterogeneous Type V
DATISCACEAE						
Tetrameleoxylon prenudiflora Lakhanpal & Verma, 1966	*Tetrameles nudiflora*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric to aliform confluent	Heterogeneous Type II or Type III
EUPHORBIACEAE						
Bridelioxylon krauseli Prakash, 1959a; Mädel, 1962	*Bridelia* sp.	Simple	Bordered, alternate	Truncate to tapering	Scanty paratracheal to vasicentric	Heterogeneous Type II
Paraphyllanthoxylon sahnii Prakash, 1959b; Mädel, 1962	*Phyllanthoideae*	Simple	Bordered, alternate	Truncate to inclined	Apotracheal diffuse and scanty paratracheal	Heterogeneous Type II and III
Mallotoxylon keriense Lakhanpal & Dayal, 1964	*Mallotus phillippinensis*	Simple	Bordered, alternate	Truncate or tailed	Apotracheal diffuse or forming short uniseriate lines and scanty paratracheal	Heterogeneous Type II

TABLE 3 — FOSSIL WOODS FROM THE LOWER SIWALIK BEDS

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
ANONACEAE						
Polyalthioxylon indicum Prakash, 1978	*Polyalthia simiarum*	Simple	Bordered, alternate	Truncate or tapered	Apotracheal, uniseriate, tangential lines	Heterogeneous Type II or III
DIPTEROCARPACEAE						
Dipterocarpoxylon sivalicus Prakash, 1978	*Dipterocarpus turbinatus*	Simple	Vasicentric tracheids present	Truncate to tailed	Scanty paratracheal, apotracheal diffuse to diffuse-in-aggregate and around gum canals	Heterogeneous Type II. Sheath cells present
Dipterocarpoxylon parabaudii Prakash, 1978	*Dipterocarpus baudii*	Simple	Vasicentric tracheids present	Truncate	Scanty paratracheal, apotracheal diffuse and around gum canals	Heterogeneous Type II. Sheath cells present
Anisopteroxylon kalagarhensis Prakash, 1978	*Anisoptera scaphula, A. glabra*	Simple	Vasicentric tracheids present	Truncate	Scanty paratracheal, apotracheal diffuse to diffuse-in-aggregate and around gum canals	Heterogeneous Type II. Sheath cells present
Shoreoxylon ornatum (Trivedi & Ahuja) Prakash & Bande, 1980a *syn. Pentacmeoxylon ornatum* Trivedi & Ahuja, 1979b	*Shorea* sp.	Simple	Bordered, alternate, vasicentric tracheids present	Truncate or tailed	Scanty paratracheal, apotracheal diffuse and around gum canals	Heterogeneous Type II. Sheath cells present
STERCULIACEAE						
Sterculioxylon kalagarhensis Trivedi & Ahuja, 1978a	*Sterculia* sp.	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric, apotracheal banded	Heterogeneous Type II. Sheath cells present
ANACARDIACEAE						
Dracontomelumoxylon mangiferumoides Ghosh & Roy; Prakash, 1979a, 1979b	*Dracontomelum mangiferum*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric, aliform to confluent	Heterogeneous Type II
Glutoxylon kalagarhense Trivedi & Ahuja, 1978b	*Gluta renghas*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric; apotracheal diffuse and banded	Heterogeneous Type V
LEGUMINOSAE						
Albizzinium eolebbekianum Prakash, 1975	*Albizzia lebbek*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal vasicentric, aliform to aliform confluent, apotracheal diffuse	Homogeneous Type IV

TABLE 3 — FOSSIL WOODS FROM THE LOWER SIWALIK BEDS — *Contd.*

FOSSIL SPECIES WITH FAMILY	COMPARABLE LIVING SPECIES	VESSELS			PARENCHYMA	XYLEM RAYS
		Perforations	Intervessel pits	End walls		
Cassinium prefistulai Prakash, 1975	*Cassia fistula*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal thick vasicentric, aliform to confluent forming broad undulating bands	Homogeneous Type IV
Cynometroxylon holdeni (Gupta) Prakash & Bande, 1980; Prakash, 1975	*Cynometra polyandra*, *C. ramiflora*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric, apotracheal banded	Heterogeneous Type III
Millettioxylon pongamiensis Prakash, 1975	*Millettia prainii*	Simple	Bordered, alternate, vestured	Truncate, elements storied	Apotracheal banded, strands storied	Homogeneous Type IV storied
Pahudioxylon indicum Prakash, 1978	*Afzelia-Intsia*	Simple	Bordered, alternate	—	Paratracheal aliform to aliform confluent	Homogeneous Type IV
Cassinium barooahii Prakash, 1978	*Cassia siamea*	Simple	Alternate to subopposite, vestured	—	Paratracheal aliform confluent to banded	Homogeneous Type IV
Hopeoxylon eosiamensis Prakash, 1981	*Sindora siamensis*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal vasicentric, aliform to aliform confluent, apotracheal banded enclosing gum canals	Homogeneous Type IV to heterogeneous type III
COMBRETACEAE						
Terminalioxylon palaeomanii Prakash, 1981	*Terminalia manii*	—	Alternate, vestured	Truncate	Scanty paratracheal	Heterogeneous Type V
LECYTHIDACEAE						
Careyoxylon pondicherriense Awasthi; Prakash, 1979b	*Careya arborea*	Simple	Bordered, alternate	—	Scanty paratracheal, apotracheal diffuse and in irregular uniseriate lines	Heterogeneous Type II Sheath cells present
EBENACEAE						
Ebenoxylon miocenicum Prakash, 1978	*Diospyros kurzii*	Simple	Bordered, alternate	Truncate to tailed	Scanty paratracheal, apotracheal forming 1-2 seriate tangential lines	Heterogeneous Type V
Ebenoxylon siwalicus Prakash, 1981	*Diospyros brandisiana*	Simple	Bordered, alternate	Truncate	Scanty paratracheal, apotracheal forming 1-2 seriate tangential lines	Heterogeneous Type II

TABLE 4 — FOSSIL WOODS FROM THE TIPAM SERIES

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
FLACOURTIACEAE						
Homalioxylon assamicum Prakash & Tripathi, 1974	*Homalium tomentosum*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal	Heterogeneous Type II
GUTTIFERAE						
Kayeoxylon assamicum Chowdhury & Tandon, 1949	*Kayea assamica*	—	Vasicentric tracheids present	Horizontal to slightly oblique	Apotracheal, 3-13 seriate continuous tangential bands	Heterogeneous Type III
Calophylloxylon eoinophyllum Prakash, 1966; Prakash and Awasthi, 1971	*Calophyllum inophyllum*	Simple	Vasicentric tracheids present	Truncate	Apotracheal, 2-4 seriate continuous or broken tangential bands	Heterogeneous Type V
DIPTEROCARPACEAE						
Dipterocarpoxylon chowdhurii Ghosh, 1956	*Dipterocarpus*	—	Vasicentric tracheids present	—	Paratracheal vasicentric, apotracheal diffuse to diffuse-in-aggregate and surrounding gum canals	Heterogeneous Type II
Anisopteroxylon garoense (Chowdhury) Prakash & Tripathi, 1970b	*Anisoptera* sp.	Simple	Bordered, alternate, vasicentric tracheids present	Truncate or tailed	Paratracheal vasicentric, apotracheal diffuse, in short tangential lines and surrounding gum canals	Heterogeneous Type II
Shoreoxylon tipamense Prakash & Awasthi, 1970	*Shorea* sp.	Simple	Bordered, alternate, vestured, vasicentric tracheids present	Truncate	Paratracheal vasicentric, aliform to aliform confluent; apotracheal diffuse or aggregate and surrounding gum canals	Heterogeneous Type II. Sheath cells present
STERCULIACEAE						
Sterculioxylon dattai Prakash & Tripathi, 1974	*Sterculia villosa*	Simple	—	Truncate or tailed	Paratracheal vasicentric; apotracheal diffuse to 1-2 seriate tangential lines and around gum canals	Heterogeneous Type II. Sheath cells present

TABLE 4 — FOSSIL WOODS FROM THE TIPAM SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels: Perforations	Vessels: Intervessel pits	Vessels: End walls	Parenchyma	Xylem rays
ELAEOCARPACEAE						
Elaeocarpoxylon hailakandiense Prakash & Tripathi, 1975	*Elaeocarpus, Echinocarpus*	Simple	Bordered, alternate to sub-opposite	Tapering	Scanty paratracheal	Heterogeneous Type II
BURSERACEAE						
Burseroxylon preserratum Prakash & Tripathi, 1975	*Bursera serrata*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal, vasicentric	Heterogeneous Type III
SAPINDACEAE						
Pometioxylon tomentosum Prakash & Tripathi, 1970a	*Pometia tomentosa*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal to vasicentric	Heterogeneous Type V
ANACARDIACEAE						
Mangiferoxylon assamicum Prakash & Tripathi, 1970a	*Mangifera indica*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric, aliform, aliform confluent; apotracheal banded	Heterogeneous Type II
Glutoxylon burmense (Holden) Chowdhury; Prakash and Tripathi, 1969b	*Gluta-Melanorrhoea*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric to aliform; apotracheal diffuse-in-aggregate and banded	Homogeneous Type IV
Swintonioxylon hailakandense Prakash & Tripathi, 1969a	*Swintonia floribunda*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric to aliform confluent, apotracheal banded	Heterogeneous Type III
Lanneoxylon grandiosum Prakash & Tripathi, 1969a	*Lannea grandis*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal	Heterogeneous Type III
Holigarnoxylon assamicum Prakash & Awasthi, 1970	*Holigarna beddomei*	Simple	Bordered, alternate	Truncate	Paratracheal, vasicentric to aliform confluent	Heterogeneous Type III
Melanorrhoeoxylon cacharense Prakash & Tripathi, 1976	*Melanorrhoea*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric and apotracheal banded	Homogeneous Type IV
Anacardioxylon shardai Prakash & Tripathi, 1976	—	Simple	Bordered, alternate	Truncate to tailed	Paratracheal vasicentric, aliform to aliform confluent	Heterogeneous Type II

TABLE 4 — FOSSIL WOODS FROM THE TIPAM SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
LEGUMINOSAE						
Adenantheroxylon pavoninium Prakash & Tripathi, 1969a	*Adenanthera pavonina*	—	Bordered, alternate and vestured	Truncate	Paratracheal vasicentric, rarely aliform to confluent, apotracheal diffuse sparse	Homogeneous Type IV
Peltophoroxylon cassioides Prakash & Awasthi, 1970	*Cassia fistula*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal, aliform to aliform confluent	Homogeneous Type IV
Cynometroxylon holdeni (Gupta) Prakash & Bande, 1980; Prakash, 1966c	*Cynometra* sp.	Simple	Bordered, alternate	Truncate or tapering	Paratracheal vasicentric, apotracheal banded	Heterogeneous Type III
Pahudioxylon assamicum Prakash & Tripathi, 1975	*Afzelia-Intsia*	Simple	Bordered, alternate, vestured	Truncate to tapering	Paratracheal vasicentric, aliform to aliform confluent	Homogeneous Type IV. Sometime storied
Ougeinioxylon tertiarum Prakash & Tripathi, 1977	*Ougeinia* sp.	Simple	Bordered, vestured	Truncate or tailed, members storied	Paratracheal aliform to aliform confluent, apotracheal diffuse	Homogeneous Type IV. Usually storied
Hopeoxylon assamicum Lalitha & Prakash, 1980	*Sindora* sp.	Simple	Bordered, alternate to sub-opposite, vestured	Truncate to oblique	Paratracheal vasicentric, aliform to aliform confluent	Weakly heterogeneous Type III
COMBRETACEAE						
Terminalioxylon tertiarum Prakash, 1966	*Terminalia tomentosa*	Simple	Bordered, alternate to sub-opposite, vestured	Truncate	Paratracheal vasicentric to aliform confluent, apotracheal diffuse	Heterogeneous Type V
LECYTHIDACEAE						
Barringtonioxylon assamicum Prakash & Tripathi, 1972	*Barringtonia acutangula*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal; apotracheal diffuse to diffuse-in-aggregate	Heterogeneous Type II. Sheath cells present
Careyoxylon kuchilense Prakash & Tripathi, 1972	*Careya arborea*	Simple	Bordered, alternate	Truncate	Scanty paratracheal, apotracheal diffuse and short uniseriate lines	Heterogeneous Type II

TABLE 4 — FOSSIL WOODS FROM THE TIPAM SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels: Perforations	Vessels: Intervessel pits	Vessels: End walls	Parenchyma	Xylem rays
LYTHRACEAE						
Lagerstroemioxylon eflosreginium Prakash & Tripathi, 1970a	*Lagerstroemia flosregine*	Simple	Bordered, alternate, vestured	Truncate or tailed	Paratracheal vasicentric aliform to aliform confluent apotracheal diffuse	Homogeneous Type VI
SONNERATIACEAE						
Duabangoxylon tertiarum Prakash & Awasthi, 1970	*Duabanga sonneratioides*	Simple	Bordered, alternate, vestured	Truncate or tailed	Paratracheal vasicentric to aliform	Heterogeneous Type II
SAPOTACEAE						
Madhucoxylon cacharense Prakash & Tripathi, 1977	*Madhuca butracea*	Simple	Bordered, alternate	Truncate or abruptly tailed	Scanty paratracheal; apotracheal in 1-3 seriate lines	Heterogeneous Type II
EBENACEAE						
Ebenoxylon kartikcherriense Prakash & Tripathi, 1970b	*Diospyros ehritioides*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal, apotracheal in 1-2 seriate tangential lines	Heterogeneous Type II
VERBENACEAE						
Viteoxylon miocenicum Prakash & Tripathi, 1974	*Vitex canescens*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric to aliform confluent	Heterogeneous Type II
LAURACEAE						
Laurinoxylon tertiarum Prakash & Tripathi, 1974	*Dehasia* and *Cinnamomum*	Simple and scalariform (8-10 bars)	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric, sometimes aliform confluent	Heterogeneous Type II
EUPHORBIACEAE						
Mallotoxylon assamicum Prakash & Tripathi, 1975	*Mallotus philippinensis*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal, apotracheal diffuse and in interrupted uniseriate lines	Heterogeneous Type II
MORACEAE						
Artocarpoxylon kartikcherraensis Prakash & Lalitha, 1978	*Artocarpus chapalasha*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric to mostly aliform, rarely aliform confluent	Heterogeneous Type II. Sheath cells present

TABLE 5 — FOSSIL WOODS FROM WEST BENGAL

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
DIPTEROCARPACEAE						
Dipterocarpoxylon bolpurensis Ghosh & Roy, 1979c	*Dipterocarpus* sp.	Simple	Vestured, alternate	Truncate to tailed	Paratracheal vasicentric and apotracheal banded	Heterogeneous Type II
Shoreoxylon tipamense Prakash & Awasthi; Bande and Prakash, 1980a	*Shorea assamica*	Simple	Bordered, alternate	Oblique	Paratracheal aliform to confluent; apotracheal forming short tangential lines and bands	Heterogeneous Type II
Anisopteroxylon santiniketanense Ghosh & Roy, 1980b	*Anisoptera* sp.	Simple	—	Truncate	Paratracheal scanty vasicentric, apotracheal diffuse	Heterogeneous Type II
GUTTIFERAE						
Calophylloxylon bengalense Ghosh & Roy, 1979e	*Calophyllum* sp.	Simple	—	Truncate	Apotracheal banded	Heterogeneous Type V
MELIACEAE						
Chisochetonoxylon bengalensis Ghosh & Roy, 1979d	*Chisocheton paniculatus*	Simple	Bordered, alternate	Tailed	Paratracheal, thick tangential bands	Heterogeneous Type II
ANACARDIACEAE						
Dracontomelumoxylon mangiferumoides Ghosh & Roy, 1979b	*Dracontomelum mangiferum*	Simple	Bordered, alternate	Tailed	Paratracheal vasicentric	Heterogeneous Type II
Glutoxylon burmense (Holden) Chowdhury, Roy & Ghosh, 1979b	*Gluta - Melanorrhoea*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric and apotracheal banded	Homogeneous Type IV
Mangiferoxylon assamicum Prakash & Tripathi; Ghosh and Roy, 1980a	*Mangifera indica*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric, aliform to aliform confluent, apotracheal banded	Heterogeneous Type II
Melanorrhoeoxylon garbetaense Ghosh & Roy, 1980c	*Melanorrhoea glabra* and *M. lacifera*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric and apotracheal banded	Homogeneous Type IV
Buchananioxylon indicum Ghosh & Roy, 1980d	*Buchnania latifolia*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric	Heterogeneous Type II

TABLE 5 — FOSSIL WOODS FROM WEST BENGAL — *Contd.*

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
BURSERACEAE						
Canarioxylon indicum Ghosh & Roy, 1978	*Canarium* sp.	Simple	Bordered, alternate	Truncate	Scanty paratracheal	Heterogeneous Type II or III
LEGUMINOSAE						
Pahudioxylon bankurensis Chowdhury; Ghosh and Kazmi, 1960	*Pahudia*	Simple	Bordered, alternate	Horizontal to slightly oblique	Paratracheal, aliform confluent, storied	Homogeneous Type IV tendency towards storied arrangement
Millettioxylon bengalensis Ghosh & Roy, 1979a	*Millettia pulchra*	Simple	Alternate, vestured	Truncate, members storied	Paratracheal banded bands 2-4 cells thick. Strands storied	Homogeneous Type IV to weakly heterogeneous, storied
Millettioxylon pongamiensis Prakash; Bande & Prakash, 1980a	*Millettia prainii*	Simple	Alternate, vestured	Vessel elements storied	Paratracheal banded, bands 4-8 cells thick; strands storied	Homogeneous Type IV, storied
Cassinium barooahii Prakash; Bande and Prakash, 1980a	*Cassia siamea*	Simple	Alternate vestured	—	Paratracheal tangential 4-8 seriate bands	Homogeneous Type IV
Cynometroxylon holdeni (Gupta) Prakash & Bande; Bande and Prakash, 1980a	*Cynometra ramiflora* and *C. polyandra*	Simple	Alternate, vestured	—	Apotracheal, 3-8 seriate, tangential bands	Heterogeneous Type II
Koompassioxylon elegans Kramer; Bande and Prakash, 1980a	*Koompassia malaccensis*	Simple	Bordered, alternate	Vessel elements storied	Paratracheal, aliform to confluent, cells storied	Homogeneous Type IV or weakly heterogeneous, storied
Ormosioxylon bengalensis Bande & Prakash, 1980a	*Ormosia robusta* and *O. watsonii*	Simple	Bordered, alternate to opposite	Transverse to oblique	Paratracheal aliform confluent to banded	Homogeneous Type IV to weakly heterogeneous, storied tendency present
Albizzinium eolebbekianum Prakash; Ghosh and Roy, 1981	*Albizzia lebbek*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal aliform to aliform confluent and apotracheal	Homogeneous Type IV
Peltophoroxylon ferruginoides Bande & Prakash, 1980a	*Peltophorum ferruginium*	Simple	Bordered, alternate	Transverse to oblique	Paratracheal vasicentric to aliform, also aliform confluent	Homogeneous Type VI
COMBRETACEAE						
Terminalioxylon tertiarum Prakash; Ghosh and Roy, 1980e	*Terminalia* sp.	Simple	Alternate, vestured	Truncate	Paratracheal vasicentric to aliform confluent	Homogeneous Type VI
Anogeissusoxylon bengalensis Roy & Ghosh, 1979	*Anogeissus acuminata*	Simple	Alternate, vestured	Truncate	Paratracheal vasicentric, aliform to aliform confluent	Heterogeneous Type V

TABLE 6 — FOSSIL WOODS FROM THE CUDDALORE SERIES

FOSSIL SPECIES WITH FAMILY	COMPARABLE LIVING SPECIES	VESSELS			PARENCHYMA	XYLEM RAYS
		Perforations	Intervessel pits	End walls		
GUTTIFERAE						
Mesuoxylon arcotense Lakhanpal & Awasthi, 1964	*Mesua ferrea*	Simple	Tracheids present	—	Apotracheal, 2-5 seriate tangential bands	Heterogeneous Type V
Calophylloxylon cuddalorense Lakhanpal & Awasthi, 1965	*Calophyllum inophyllum* and *C. tomentosum*	Simple	Tracheids present, pits bordered, in vertical rows	Truncate	Apotracheal, 2-9 seriate tangential bands	Heterogeneous Type V
DIPTEROCARPACEAE						
Dryobalanoxylon holdeni (Ramanujam) Awasthi, 1971	*Dryobalanops*	Simple	Tracheids present, vessel — tracheid pits bordered, vestured	—	Paratracheal vasicentric to aliform confluent and apotracheal bands around gum canals	Heterogeneous Type II. Sheath cells present
Shoreoxylon arcotense Awasthi, 1974	*Shorea* sp.	Simple	Tracheids present, vessel — tracheid pits bordered, vestured	Truncate to tapered	Paratracheal vasicentric and apotracheal banded around gum canals	Heterogeneous Type II
Dipterocarpoxylon pondicherriense Awasthi, 1974	*Dipterocarpus indicus*	Simple	Tracheids present, vessel — tracheid pits vestured, in vertical rows	Truncate	Paratracheal vasicentric to aliform confluent and apotracheal bands around gum canals	Heterogeneous Type II. Sheath cells present
Anisopteroxylon cuddalorense Ramanujam, 1960	*Anisoptera*	Simple	Alternate, bordered	Truncate	Paratracheal, 1-2 seriate vasicentric, apotracheal diffuse to diffuse-in-aggregate	Heterogeneous Type II
Hopenium pondicherriense Awasthi, 1980	*Hopea* sp.	Simple	Tracheids present, pits alternate vestured	Truncate or tailed	Paratracheal vasicentric to aliform confluent; apotracheal parenchyma diffuse-in-aggregate to thin tangential lines	Heterogeneous Type II
SAPINDACEAE						
Sapindoxylon indicum Navale, 1957	—	Simple	Bordered, alternate	Tapering	Scanty paratracheal	Homogeneous Type IV
ANACARDIACEAE						
Glutoxylon cuddalorense Awasthi, 1966	*Gluta-Melanorrhoea*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric to aliform and apotracheal banded	Homogeneous Type IV
Mangiferoxylon scleroticum Awasthi, 1966	*Mangifera altissima*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric to aliform confluent	Heterogeneous Type III

TABLE 6 — FOSSIL WOODS FROM THE CUDDALORE SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels: Perforations	Vessels: Intervessel pits	Vessels: End walls	Parenchyma	Xylem Rays
LEGUMINOSAE						
Peltophoroxylon indicum Ramanujam 1955; Müller-Stoll and Mädel, 1967	*Peltophorum* and allied genera	Simple	Bordered, alternate	Truncate	Paratracheal aliform to aliform confluent; apotracheal diffuse and in irregular tangential bands	Homogeneous Type IV
Erythrophloeoxylon sitholeyi (Ramanujam) Müller-Stoll and Mädel, 1967	*Erythrophloem* and allied genera	Simple	Bordered, alternate	—	Paratracheal vasicentric, aliform confluent, storied	Homogeneous Type IV, storied tendency
Pterogynoxylon felexii (Navale) Müller-Stoll & Mädel, 1967	*Pteragyne* and allied genera	Simple	Bordered, alternate	—	Paratracheal vasicentric	Homogeneous Type IV to weakly heterogeneous, storied
Euacacioxylon bharadwajii (Navale) Müller-Stoll & Mädel, 1967	*Acacia*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal vasicentric, aliform and banded, apotracheal sparse, diffuse	Homogeneous Type IV
Millettioxylon indicum Awasthi, 1967, 1975a	*Millettia pendula*	Simple	Bordered, alternate, vestured	Truncate, elements storied	Paratracheal, 2-9 seriate tangential bands, strands storied	Homogeneous Type IV to weakly heterogeneous, storied
Tamarindoxylon antiqum Ramanujam, 1961	*Tamarindus*	Simple	Bordered alternate	Truncate or tailed	Paratracheal aliform to confluent	Heterogeneous Type V, storied tendency
Pahudioxylon sahnii Ghosh & Kazmi; Awasthi, 1975	*Afzelia-Intsia*	Simple	Vestured	—	Paratracheal, aliform to aliform confluent	Homogeneous Type IV
Cynometroxylon holdeni (Gupta) Prakash & Bande, 1980; Ramanujam and Rama Rao, 1966	*Cynometra*	Simple	Bordered, alternate to opposite	Tapering	Apotracheal banded	Heterogeneous Type III
Pterocarpoxylon arcotense Ramanujam, 1960	*Pterocarpus*	Simple	Alternate, vestured	Oblique	Paratracheal, aliform confluent; apotracheal 1-2 seriate tangential lines; storied	Homogeneous Type IV, storied

TABLE 6 — FOSSIL WOODS FROM THE CUDDALORE SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
Hopeoxylon arcotense Awasthi, 1977b	*Sindora* sp.	Simple	Alternate, vestured	Truncate to inclined	Paratracheal vasicentric, aliform to banded; apotracheal banded and associated with gum ducts	Heterogeneous Type II
Albizzinium pondicherriensis Awasthi, 1979	*Albizzia amara*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal vasicentric, aliform and confluent	Homogeneous Type IV
Cassinium arcotense Awasthi, 1979	*Cassia javanica*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal, aliform confluent and banded	Homogeneous Type IV
Pericopsoxylon indicum Awasthi, 1979	*Pericopsis mooniana*	Simple	Bordered, members storied	Truncate members storied	Paratracheal aliform to confluent, storied	Homogeneous Type IV storied
ROSACEAE						
Parinarioxylon cuddalorense Awasthi, 1969b	*Parinarium*	Simple	—	Truncate or tailed	Apotracheal banded	Heterogeneous Type V
COMBRETACEAE						
Terminalioxylon coromandelinum Ramanujam, 1966	*Terminalia*	Simple	Bordered, alternate	Truncate or tailed	Paratracheal aliform confluent; apotracheal diffuse	Heterogeneous Type V
Terminalioxylon traumaticum Ramanujam, 1966	*Terminalia*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal vasicentric and confluent; apotracheal around gum canals	Homogeneous Type V
Anogeissusoxylon indicum Navale, 1964	*Anogeissus*	—	Bordered, alternate	Truncate or tailed	asicentric aliform and confluent	Heterogeneous Type V
LECYTHIDACEAE						
Barringtonioxylon arcotense Awasthi, 1970a	*Barringtonia angusta*	Simple	Bordered, alternate	Truncate or tapered	Paratracheal vasicentric, aliform and aliform confluent; apotracheal diffuse and in small tangential rows	Heterogeneous Type II. Sheath cells present
Careyoxylon pondicherriense Awasthi, 1970a	*Careya arborea*	Simple	Bordered, alternate	Truncate	Scanty paratracheal and apotracheal short tangential lines	Heterogeneous Type I. Sheath cells present

TABLE 6 — FOSSIL WOODS FROM THE CUDDALORE SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels: Perforations	Vessels: Intervessel pits	Vessels: End walls	Parenchyma	Xylem rays
SONNERATIACEAE						
Sonneratioxylon preapetala Awasthi, 1969a	*Sonneratia apetala*	Simple	Bordered, alternate, vestured	Truncate to tapered	Absent	Heterogeneous Type V
ALANGIACEAE						
Alangioxylon scalariforme Awasthi, 1969c	*Alangium*	Scalariform	Bordered, alternate	Truncate or tailed	Apotracheal uniseriate tangential lines	Heterogeneous Type II. Sheath cells present
SAPOTACEAE						
Chrysophylloxylon pondicherriense Awasthi, 1977a	*Chrysophyllum roxburghii*	Simple	Bordered, alternate, tracheids present	Truncate to slightly tapered	Apotracheal tangential lines	Heterogeneous Type II or III
EBENACEAE						
Ebenoxylon arcotense Awasthi, 1970b	*Diospyros assimilis*	Simple	Bordered, alternate	Truncate or tapered	Scanty paratracheal, apotracheal uniseriate tangential lines	Heterogeneous Type VI
EUPHORBIACEAE						
Putranjivoxylon puratanam Ramanujam, 1956	*Putranjiva*	Simple and scalariform (4-8 bars)	Bordered, alternate	Truncate or tailed	Apotracheal diffuse and in uniseriate tengential lines	Heterogeneous Type II
Bridelioxylon cuddalorense Ramanujam, 1956	*Bridelia*	Simple	Bordered, alternate, vestured	Truncate or tailed	Paratracheal vasicentric; apotracheal diffuse	Heterogeneous Type III
Paraphyllanthoxylon tertiarum Ramanujam, 1956; Mädel, 1962	*Phyllanthoideae*	Simple	Bordered, alternate	Truncate or tailed	Scanty, apotracheal diffuse	Heterogeneous Type II
Phyllanthinium banglamodense Navale, 1962	*Phyllanthoideae*	—	Bordered, alternate	Truncate	Apotracheal diffuse or in short tangential lines	Heterogeneous Type I
ULMACEAE						
Holopteleoxylon indicum Awasthi, 1977a	*Holoptelea integrifolia*	Simple	Bordered, alternate	Truncate	Paratracheal vasicentric and aliform confluent and banded, storied	Homogeneous Type IV. Storied

TABLE 7 — FOSSIL WOODS FROM THE DUPITILA SERIES

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
GUTTIFERAE						
Calophylloxylon eoinophyllum Prakash, 1966; Prakash and Awasthi, 1971	*Calophyllum inophyllum*	Simple	Vasicentric, tracheids present	Truncate	Apotracheal banded	Heterogeneous Type V
DIPTEROCARPACEAE						
Shoreoxylon deomaliense Prakash & Awasthi, 1971	*Shorea* sp.	Simple	Bordered, alternate, vestured vasicentric tracheids present	Truncate	Paratracheal vasicentric to aliform confluent, apotracheal diffuse and enclosing gum canals	Heterogeneous Type II
STERCULIACEAE						
Sterculioxylon varmaii Lakhanpal, Prakash & Awasthi, 1981	*Sterculia alata*	Simple	Bordered, alternate	Truncate	Paratracheal aliform confluent; apotracheal banded; cells storied	Heterogeneous Type II. Sheath cells present
Heritieroxylon arunachalensis Lakhanpal; Prakash & Awasthi, 1981	*Heritiera fomes*	Simple	Bordered, small	Horizontal to oblique	Apotracheal diffuse and forming fine tangential lines	Heterogeneous Type II. Sheath cells present
BURSERACEAE						
Burseroxylon garugoides Lakhanpal, Prakash & Awasthi, 1981	*Garuga pinnata*	Simple	Bordered, alternate	Truncate	Scanty paratracheal	Heterogeneous Type II
ANACARDIACEAE						
Mangiferoxylon assamicum Prakash & Tripathi; Lakhanpal, Prakash and Awasthi, 1981	*Mangifera indica*	Simple	Bordered, alternate	Truncate or tailed	Scanty paratracheal to vasicentric, sometimes aliform to confluent, apotracheal banded	Heterogeneous Type V
LEGUMINOSAE						
Cynometroxylon holdeni (Gupta) Prakash & Bande, 1980; Prakash and Awasthi, 1971	*Cynometra polyandra*, *Cynometra ramiflora*	Simple	Bordered, alternate, vestured	Horizontal to oblique	Apotracheal banded	Heterogeneous Type III
Pahudioxylon deomaliense Prakash, 1965	*Afzelia-Intsia*	Simple	Bordered, alternate, vestured	Truncate or tailed	Paratracheal aliform to confluent	Homogeneous Type IV. Storied tendency

TABLE 7 — FOSSIL WOODS FROM THE DUPITILA SERIES — *Contd.*

Fossil species with family	Comparable living species	Vessels			Parenchyma	Xylem rays
		Perforations	Intervessel pits	End walls		
Albizinium eolebbekianum Prakash; Lakhanpal Prakash and Awasthi, 1981	*Albizia lebbek*	Simple	Bordered, alternate, vestured	Truncate	Paratracheal aliform to aliform confluent	Homogeneous Type IV
Millettioxylon palaeopulchera Lakhanpal, Prakash & Awasthi, 1981	*Millettia pulchera*	Simple	Bordered, alternate	Truncate, vessel members storied	Paratracheal banded, strands storied	Homogeneous Type IV, storied
COMBRETACEAE						
Terminalioxylon coriaceum Prakash & Awasthi, 1971	*Terminalia coriacea*	Simple	Bordered, alternate	Truncate	Paratracheal aliform confluent to banded; apotracheal irregularly banded	Homogeneous Type VI
Terminalioxylon tertiarum Prakash, 1966b	*Terminalia tomentosa*	Simple	Alternate to subopposite, vestured	Truncate	Paratracheal vasicentric, aliform to aliform confluent, apotracheal diffuse	Homogeneous Type VI
LYTHRACEAE						
Lagerstroemioxylon deomaliense Lakhanpal, Prakash & Awasthi, 1981	*Lagerstroemia villosa*	Simple	Bordered, alternate, vestured	Truncate or tailed	Paratracheal vasicentric, aliform confluent to banded	Homogeneous Type VI
SAPOTACEAE						
Siderinium deomaliense Prakash & Awasthi, 1970	*Sideroxylon grandifolium*	Simple	Bordered, alternate	Truncate	Apotracheal, uniseriate lines forming reticulum	Heterogeneous Type II or III
EBENACEAE						
Ebenoxylon indicum Ghosh & Kazmi, 1958	*Diospyros*	Simple	Bordered, alternate	—	Paratracheal vasicentric, apotracheal diffuse to diffuse-in-aggregate forming irregular uniseriate tangential lines	Heterogeneous
LAURACEAE						
Laurinoxylon namsangensis Lakhanpal, Prakash & Awasthi, 1981	—	Simple	Bordered, alternate to subopposite	Truncate	Scanty paratracheal	Heterogeneous Type III
Laurinoxylon deomaliensis Lakhanpal, Prakash & Awasthi, 1981	—	Simple	Bordered, alternate	—	Scanty paratracheal	Heterogeneous Type III

TABLE 8 — COMPARATIVE ANATOMICAL ANALYSIS OF DIFFERENT TERTIARY FLORAS

Deccan Intertrappean Beds		Lower Siwalik Beds	Tipam Series	Neogene of West Bengal	Cuddalore Series	Dupitila Series
Mandla District	Nagpur-Chhindwara-Nawargaon Area					
Woods analysed —17 Comparable genera —16 Families —15	Woods analysed —17 Comparable genera —15 Families —14	Woods analysed —19 Comparable genera —17 Families —8	Woods analysed —34 Comparable genera —33 Families —19	Woods analysed —22 Comparable genera —21 Families —7	Woods analysed —38 Comparable genera —36 Families —14	Woods analysed —17 Comparable genera —13 Families —11
Perforations	*Perforations*	*Perforations*	*Perforations*	*Perforations*	*Perforations*	*Perforations*
Simple —15 Scalariform —2	Simple in all	Simple in all	Simple —33 Scalariform —1	Simple in all	Simple —36 Scalariform —2	Simple in all
Intervessel pits	*Intervessel pits*	*Intervessel pits*	*Intervessel pits*	*Intervessel pits*	*Intervessel pits*	*Intervessel pits*
Bordered, alternate —17 Scalariform (partly) —1 —	Bordered, alternate —16 Scalariform —1 —	Bordered, alternate —16 Elements storied —1 *Vasicentric tracheids* —4	Bordered, alternate —32 Alternate to subopposite —2 *Vasicentric tracheids* —4	Bordered, alternate in all *Vasicentric tracheids* —4	Bordered, alternate —36 Alternate to opposite —2 *Vasicentric tracheids* —8	Bordered, alternate —16 Subopposite —1 —
Parenchyma	*Parenchyma*	*Parenchyma*	*Parenchyma*	*Parenchyma*	*Parenchyma*	*Parenchyma*
Absent —1 Diffuse to diffuse-in-aggregate +some vasicentric —4 Thin apotracheal lines —2 Scanty paratracheal to 1-2 seriate vasicentric —6 Paratracheal aliform confluent to banded —4 Storied —2	Absent —1 Apotracheal diffuse to diffuse-in-aggregate + scanty paratracheal —3 Scanty paratracheal —5 Vasicentric aliform confluent to banded —8	Apotracheal diffuse to diffuse-in-aggregate to thin lines + scanty paratracheal —8 Scanty paratracheal —1 Apotracheal banded + paratracheal vasicentric —4 Paratracheal aliform confluent to banded —6 Storied —1	Apotracheal diffuse to diffuse-in-aggergate or thin tangential lines + some paratracheal —8 Scanty paratracheal —5 Apotracheal banded —2 Paratracheal vasicentric to aliform confluent + apotracheal diffuse-in-aggregate to banded —6 Paratracheal aliform confluent to banded —13	Apotracheal diffuse to diffuse-in-aggregate or thin tangential lines or bands + some paratracheal —3 Scanty paratracheal to vasicentric —3 Apotracheal banded —4 Paratracheal, aliform confluent to banded —12 Storied —4	Absent —1 Apotracheal diffuse to diffuse-in-aggregate or tangential lines + some paratracheal parenchyma —11 Scanty paratracheal 1 Apotracheal banded with some paratracheal —8 Paratracheal vasicentric, aliform confluent to banded —17	Apotracheal diffuse to diffuse-in-aggregate or thin tangential lines —3 Scanty paratracheal —3 Apotracheal banded with or without some paratracheal —3 Paratracheal vasicentric, aliform, confluent to banded —8 Storied —2
Xylem rays	*Xylem rays*	*Xylem rays*	*Xylem rays*	*Xylem rays*	*Xylem rays*	*Xylem rays*
Heterogeneous Type I —2 Type II —12 Type III —2 Homogeneous Type IV —1	Heterogeneous Type I —1 Type II or III —11 Type V —1 Homogeneous Type IV —3 Homogeneous Type VI —1	Heterogeneous Type II or III —11 Type V —3 Homogeneous Type IV —5	Heterogeneous Type II —16 Type III —7 Type V —3 Weakly heterogeneous —1 Homogeneous Type IV —6 Type VI —1	Heterogeneous Type II —9 Type V —2 Homogeneous Type IV —9 Type VI —2 Storied —5	Heterogeneous Type I —1 Type II —12 Type III —3 Type V —8 Homogeneous Type IV —13 Type VI —1 Storied —5	Heterogeneous Type II or III —8 Type V —2 Unknown type —1 Homogeneous Type IV —3 Type VI —3 Storied —2

The number against each anatomical character indicates the number of woods in which that particular character is present.

Fossil Woods from the Cuddalore Series

From this area 38 fossil woods representing 36 modern genera belonging to 13 dicotyledonous families have been analysed (Table 6). The assemblage shows a well-marked structural specialisation. In almost all the woods the perforation plates are simple; scalariform perforations occur in only two. Similarly, only in two woods alternate to opposite pits have been observed, while in all other woods these are bordered and alternate. However, vasicentric tracheids are present in eight species.

Parenchyma is absent in one, scanty paratracheal in one, apotracheal diffuse to diffuse-in-aggregate or in tangential lines alongwith or without some paratracheal parenchyma in 11, apotracheal banded with or without some paratracheal parenchyma in eight, and a well-developed paratracheal vasicentric to aliform, aliform-confluent to banded parenchyma is present in as many as 17 woods.

Heterogeneous xylem rays are present in 24 woods, their distribution being heterogeneous type I in one, type II in 12, type III in three and type V in eight. However, the homogeneous rays are present in 14 woods; they are homogeneous type IV in 13 and type VI in one. Storied rays have been observed in seven woods.

Fossil Woods from the Dupitila Series

A total of 17 fossil dicotyledonous woods representing 13 living genera and 11 families have been anatomically analysed (Table 7). Perforations are simple in all the woods and intervessel pits are bordered and alternate in almost all of them. However, the pits are subopposite in one wood. Vasicentric tracheids are present in two woods.

Parenchyma is very well-developed. It is apotracheal diffuse to diffuse-in-aggregate or forming thin tangential lines in three woods, scanty paratracheal in three, apotracheal banded alongwith or without some paratracheal parenchyma in three and a well-developed paratracheal vasicentric, aliform, aliform-confluent or banded parenchyma occurs in eight woods. Parenchyma cells are storied in two species. Xylem rays are heterogeneous type II or III in eight, heterogeneous type V in two, heterogeneous of unknown type in one, homogeneous type IV in three and homogeneous type VI in three woods. Storied rays are present in two species.

DISCUSSION

A critical survey of the anatomical data accumulated from the Indian Tertiaries reveals some interesting facts regarding the evolution of anatomical characters from the oldest to the successively younger fossil floras. Two important characters, viz., axial parenchyma and xylem rays, show a marked specialisation in different fossil floras and have been dealtwith in detail (Table 8).

Considering the types of *axial parenchyma*, it is most primitive in the fossil woods described from Mandla District. Of the 17 woods analysed from this area, in as many as 13 (about 78%), the parenchyma is either absent, diffuse to diffuse-in-aggregate, in thin apotracheal lines, apotracheal narrow banded or scanty paratracheal to 1-2 seriate vasicentric. Only in four woods (about 22%), a well-developed paratracheal aliform to aliform-confluent parenchyma is known to occur. A well-developed vasicentric, aliform to aliform-confluent and rarely banded parenchyma is much more frequent in the fossil woods from the Nagpur-Chhindwara region. This type of parenchyma is present in as many as eight woods (about 48%) out of a total of 17 woods analysed from this area. In the remaining nine woods it is of primitive type.

However, coming to the Neogene floras of India, the woods of the Lower Siwalik beds (Middle Miocene) show a further increase in the percentage of woods with an evolved type of parenchyma. Of the 19 woods analysed from these beds, the parenchyma is paratracheal, aliform to aliform-confluent to banded in six of them (about 33%). In another four woods (about 21%) it is apotracheal banded with broad bands (considered to be most advanced amongst the apotracheal types) alongwith some paratracheal vasicentric type. In the remaining forms, the parenchyma is of primitive type.

The parenchyma shows further specialization in the woods from the Tipam Series (Upper Miocene) being paratracheal aliform, confluent to banded in about 39 per cent of woods, paratracheal vasicentric to aliform-confluent alongwith apotracheal diffuse to diffuse-in-aggregate to banded in about 18 per cent, apotracheal banded in about 6 per cent and it is of primitive type in the remaining woods.

In the fossil woods so far described from the Tertiary of West Bengal (considered to be equivalent to the Tipams) the percentage of woods with paratracheal aliform-confluent to banded parenchyma is further increased to about 54 per cent with another 18 per cent woods showing a well-developed apotracheal banded parenchyma. Another conspicuous feature is the occurrence of storied parenchyma in about 18 per cent of woods of this assemblage.

In the Cuddalore Series (Upper Miocene to Pliocene) about 48 per cent of woods show a well-developed paratracheal vasicentric, aliform, aliform-confluent to banded parenchyma. However, in about 20 per cent of woods, it is apotracheal banded but in the remaining woods, it is of primitive type.

Lastly, in the Dupitila Series (Mio-Pliocene) paratracheal vasicentric, aliform, confluent to banded parenchyma occurs in about 48 per cent of woods, apotracheal banded in about 18 per cent of woods and in the remaining it is of the primitive type. Storied parenchyma constitutes about 12 per cent of woods in this assemblage.

The *xylem rays* also show stages of specialization in the successive floras of the Indian Tertiaries. In Mandla assemblage heterogeneous rays of I, II, III and V types constitute as much as about 95 per cent of the total number of woods analysed, homogeneous type V rays occur in only one wood (about 5%). However, in the Nagpur-Chhindwara-Nawargaon region the percentage of woods with homogeneous rays is increased to about 23 per cent. The remaining 77 per cent woods show heterogeneous rays. In the Lower Siwalik woods, although the percentage of homogeneous rays is not substantially increased (about 25 per cent), the rays are of heterogeneous type V in about 18 per cent of woods. This is considered to be an advanced type evolved due to the elimination of multiseriate rays. In the Tipam Series there does not appear a marked specialization in the ray structure. In only about 21 per cent of woods, the rays are homogeneous and in the remaining ones they are heterogeneous. However, out of these the rays are of heterogeneous type V in about 9 per cent of woods.

The West Bengal flora, although considered to be equivalent to the Tipams in age, exhibits a high degree of specialisation in the ray structure. In 50 per cent of woods, the rays are homogeneous and in another 9 per cent they are of heterogeneous type V. Further, about 23 per cent of the woods have storied rays.

Fossil woods of the Cuddalore Series are also quite specialized. In about 38 per cent of woods the rays are homogeneous and in another 20 per cent they are heterogeneous type V. Storied rays occur in about 17 per cent of woods.

In the Dupitila Series about 36 per cent of woods show homogeneous rays while about 12 per cent woods are with heterogeneous type V rays. The remaining woods show either heterogeneous type II or III rays. Storied rays occur in about 12 per cent of woods. Thus, there is a well-marked increase in the percentage of advanced type of rays in the various Neogene floras as compared to the Palaeogene flora of the Deccan Intertrappean Series. However, this evolutionay tendency is not conspicuous in the Tipam Series.

In the remaining three Neogene floras, although there is not much difference in the specialization of ray structure, surprisingly, the most evolved type of rays are seen in the Neogene flora of West Bengal which is considered to be equivalent to the Tipams.

Thus, from the above studies it is evident that the Indian Tertiary dicotyledonous woods exhibit a general trend towards specialization in anatomical characters in their secondary xylem from geologically older to successively younger floras. These observations find further support from the studies of Wolfe, Doyle and Page (1975, p. 820) who analysed a number of dicot woods from the Cretaceous while discussing the palaeobotanical evidence for angiosperm phylogeny. According to them an assemblage of 70 entities from the late Campanian or early Maestrichtian of California and another assemblage of five entities from the Maestrichtian of Illinois " tend to substantiate that the supposedly advanced anatomical features are, in fact, geologically more recent than supposedly primitive features. Over half these wood patterns have solitary pores or solitary with a few short radial chains, and the majority also have diffuse, axial parenchyma only; the remainder have some vasicentric parenchyma in addition. Similarly, scalariform perforation plates are found in the majority and the rays are heterogeneous in almost all the woods. Two of the entities are dicotyledons lacking vessels. Some of the woods do have some specialized elements, such as short vessels and aggregate rays, but the overall pattern of these woods is not advanced. None of the woods possess supposedly advanced features such as storied elements, included parenchyma or elaborate pore distribution". Consequently, the observations made in the present paper along with those made by Wolfe, Doyle and Page (1975) help in the understanding and evaluation of the concept of relative primitiveness of anatomical features.

Another important conclusion which can be deduced from these studies is the fact that the Deccan Intertrappean flora was made up of a number of plant communities of different ages occurring in a wide area of Central India. This has already been suggested by Lakhanpal (1970), Prakash (1960, 1972) and Bande and Prakash (1982c) on the basis of their palaeobotanical studies of this flora. Recently Alexander (1981) has also given different ages for different Deccan Lava flows and their associated Intertrappean beds on the basis of his K-Ar studies. The present anatomical observations mark out two different plant assemblages, one in the Mandla District of Madhya Pradesh and the other in the Nagpur-Chhindwara-Nawargaon region. Of the two, the former appears to be more primitive than the latter with respect to parenchyma and xylem ray characters. Here it may be pointed out that the age of the Mohgaon Kalan beds of Chhindwara District has recently been suggested to be Palaeocene-Eocene by Bande, Prakash and Bonde (1981) due to the presence of the index fossil *Distichoplax* from this locality which has also been corroborated by Alexander (1981, p. 249) who has assigned it an age of 47 million years from his studies on Chhindwara traps.

Further, the fossil flora from the Neogene of West Bengal, usually considered equivalent to the Tipams (Hunday, 1954), is anatomically more advanced than the Tipams, especially in the structure of xylem rays. In fact, there does not appear to be any marked difference in the evolutionary status of the West Bengal flora, the Cuddalore flora (Miocene-Pliocene) and the Dupitila flora (Mio-Pliocene). The xylem rays in the Cuddalore and Dupitila woods appear to be somewhat less advanced than in the Neogene woods of West Bengal. However, some discrepancies are bound to occur in such comparisons as the number of woods available from all the different assemblages is not uniform. With the availability of more data a more correct picture can be obtained and the concepts of relative primitiveness of anatomical features and their general trends of specialization could be properly evaluated.

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