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The genus *Phyllanthus* from the Tertiary of India with critical remarks on the nomenclature of fossil woods of Euphorbiaceae

U. Prakash, M. B. Bande & V. Lalitha

ABSTRACT

Prakash, Uttam, Bande, M.B. & Lalitha, V. (1986). The genus *Phyllanthus* from the Tertiary of India with critical remarks on the nomenclature of fossil woods of Euphorbiaceae. *Palaeobotanist*, **35**(1) : 106-114.

The paper deals with in detail the problem of nomenclature of fossil woods of the family Euphorbiaceae and describes two fossil woods showing a close similarity with the modern woods of *Phyllanthus emblica* from the Tertiary of India. While one of them belongs to the Tipam sandstones of Assam, the other was collected from the Deccan Intertrappean beds of Nawargaon in Wardha District of Maharashtra. The present findings thus indicate a continuous existence of the modern genus *Phyllanthus* in India from the early Tertiary till today. Speciation of fossil woods similar in structure and resembling the modern wood of *Phyllanthus emblica*, from widely separated continents belonging to different ages, has also been discussed.

Key-words—Xylotomy, Nomenclature, *Phyllanthus*, Euphorbiaceae, Tipam Sandstones, Deccan Intertrappean beds, Tertiary (India).

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सारांश

भारत के तृतीयक कल्प से फ़ाइलेन्थस प्रजाति तथा यूफ़ोर्बिएसी कुल के काष्ठाश्मों की नामपद्धति पर समीक्षात्मक टिप्पणियाँ

उत्तम प्रकाश, मोहन बलवंत बाँडे एवं वी. ललिथा

इस शोध-पत्र में यूफ़ोर्बिएसी कुल के काष्ठाश्मों की नामपद्धति की समस्या तथा भारत के तृतीयक कल्प से फ़ाइलेन्थस अँम्बलिका के वर्तमान काष्ठों से घनिष्ठ समानता प्रदर्शित करने वाले दो काष्ठाश्मों का विस्तृत विवेचन किया गया है। इनमें से एक असम के तिपम बालुपत्थरों से सम्बद्ध है तथा अन्य महाराष्ट्र के वर्धा जनपद में नवरगाँव के दक्खिन अन्तर्ट्रेपी संस्तरों से एकत्र किया गया था। अतएव प्रस्तुत अन्वेषण से भारत में प्रारम्भिक तृतीयक कल्प से आज तक वर्तमान फ़ाइलेन्थस प्रजाति की निरन्तर विद्यमानता इंगित होती है। फ़ाइलेन्थस अँम्बलिका की वर्तमान काष्ठ से मिलते-जुलते एवं संरचना में सदृश काष्ठाश्मों का जाति-उद्भवन विवेचित किया गया है, विभिन्न आयु के ये काष्ठाश्म पृथक-पृथक महाद्वीपों से सम्बन्धित हैं।

INTRODUCTION

IN palaeobotany it is always interesting to build up the fossil history of a taxon in space and time. Although it is usually from the Neogene onwards that the fossils can be identified with any particular species, sometimes this becomes possible even in the earlier strata. Thus, it becomes even more remarkable when fossils showing similarities with a single modern species are discovered in the rocks of widely separated areas belonging to different ages. The authors came across one such case while working on the fossil woods from the Tipam sandstones of Assam and the Deccan Intertrappean beds of Nawargaon in Maharashtra. From both these beds fossil woods showing a close similarity with the modern woods of *Phyllanthus emblica* were discovered. As the age of Tipam sandstones is considered to be Upper Miocene and that of the Deccan Intertrappean beds as early Tertiary, the present findings establish a continuous existence of the genus *Phyllanthus* in India since the early Tertiary.

FAMILY—EUPHORBIACEAE

Genus—*Paraphyllanthoxylon* Bailey, 1924

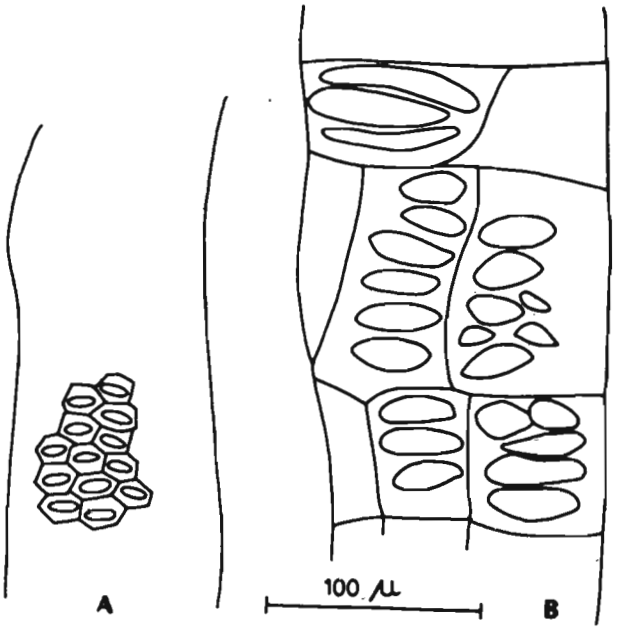
Paraphyllanthoxylon palaeoemblica sp. nov.

Pl. 1, figs 1, 2, 9, 11; Text-fig. 1a, 1b

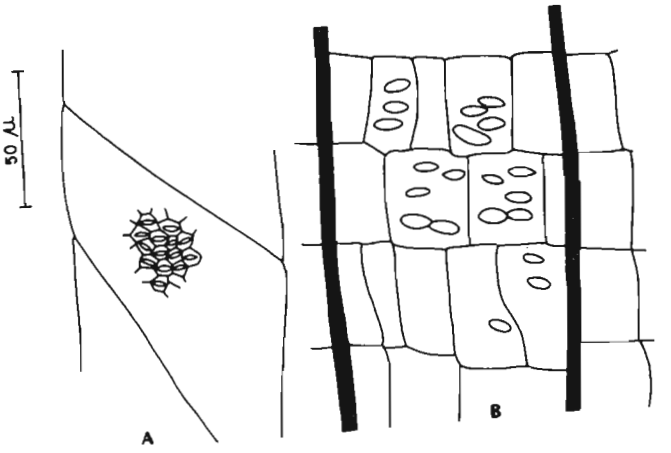
Material—A single piece of well preserved mature secondary wood measuring 6 cm in length and 4 cm in width.

Topography—*Wood* diffuse porous. *Growth rings* absent. *Vessels* small to medium-sized, solitary and mostly in radial multiples of 2-5, rarely in tangential rows and irregular clusters, 5-9 per sq mm (Pl. 1, fig. 1); tyloses absent, reddish gum deposits present in some vessels. *Parenchyma* scanty paratracheal with occasional cells touching the vessels (Pl. 1, fig. 1). *Xylem rays* 1-7 (rarely up to 9) seriate, 30-195 μm wide, 6 per mm; ray tissue heterogeneous (Pl. 1, fig. 2) rays of two types according to size and composition: (a) uniseriate rays homocellular composed of upright cells only, 3-12 cells and up to 850 μm in height (Pl. 1, fig. 2); (b) multiseriate rays heterocellular consisting of procumbent cells in the median thickened portion with distinct sheath cells on both the flanks and 1-7 rows of marginal upright cells at one or both the ends, 6-43 cells and up to 2500 μm in height (Pl. 1, fig. 2). *Fibres* aligned in radial rows.

Elements—*Vessels* anglular to circular in cross section, t.d. 75-90 μm, r.d. 120-165 μm; vessel members 164-675 μm in length with truncate or tapering ends; perforations simple; intervessel pit-pairs bordered, alternate, 8-12 μm in diameter, round to polygonal in shape with linear to lenticular apertures (Pl. 1, fig. 11; Text-fig. 1a); vessel-ray pits large, simple, usually horizontally elongated, 20-32 μm in diameter (Text-fig. 1b). *Ray cells* thin-walled, procumbent cells 28-36 μm in tangential height and 110-130 μm in radial length; upright cells 48-140 μm in tangential height 40-48 μm in radial length. *Fibres* polygonal in cross section, semilibriform to libriform, septate, about 15 μm in diameter and up to 1500 μm in length; interfibre pits could not be seen.



Text-fig. 1—*Paraphyllanthoxylon palaeoemblica* from Tipam sandstones, (**A**) intervessel pit-pairs, and (**B**) vessel-ray pits.



Text-fig. 2—*Paraphyllanthoxylon palaeoemblica* from Deccan Intertrappean beds, (**A**) intervessel pit pairs, and (**B**) vessel ray pits.

AFFINITIES AND DISCUSSION

From the above description it is clear that the fossil is characterised by important anatomical features such as small to medium-sized vessels without tyloses; simple perforations; large, alternate intervessel pit-pairs with linear to lenticular apertures; simple, large, usually horizontally elongated vessel-ray pits; scanty paratracheal parenchyma; broad heterogeneous rays with sheath cells and septate fibres. All these characters indicate the affinities of this fossil to the family Euphorbiaceae with a close resemblance with the members of the *Glochidion* group of the sub-family Phyllanthoideae.

The family Euphorbiaceae is extremely heterogeneous in wood structure. It shows a great variation of vascular tissues with no diagnostic characters which are constant in the family as a whole. This family has been divided into two sub-families, viz., Phyllanthoideae and Crotonoideae. Phyllanthoideae has been further divided into two groups; Group A—*Aporosa* Type and Group B—*Glochidion* Type (Metcalfe & Chalk, 1950, pp. 1208, 1219-1227). According to Metcalfe and Chalk (1950, p. 1221), the *Glochidion* Type includes the woods of *Antidesma* Burm. ex Linn., *Aporosella* Chodat, *Hymenocarida* Wall. (Antidesminae), *Bischofia* Bl., (Bischofinae), *Glochidion* (Glochidiinae), *Phyllanthus* L., *Securinega* Comm. ex. Juss. (Phyllanthinae), *Bridelia* Willd. and *Cleistanthus* Hook. (Brideliae) of the sub-family Phyllanthoideae and *Acalypha* Linn. (Acalypheae) of the sub-family Crotonoideae.

Since the present fossil wood belongs to the *Glochidion* type, the anatomy of the members showing this type of wood structure has been studied here in

detail. The woods belonging to *Glochidion* type are distinguished mainly by the presence of septate fibres and the absence of parenchyma or its limitation to a few cells around the vessels. From a detailed comparison of the present wood with the woods of the extant genera of *Glochidion* type at the Xylaria of the Forest Research Institute, Dehra Dun and the Birbal Sahni Institute of Palaeobotany, Lucknow it has been found that the present fossil wood closely resembles the wood structure of the modern genus *Phyllanthus* Linn. and differs from all others in a number of characters.

Antidesma, *Aporosella* and *Hymenocardia* can be differentiated from the fossil under discussion in having both simple and scalariform perforation plates. Further, the intervessel pit-pairs are small in *Acalypha* and *Hymenocardia* and minute in *Aporosella*, whereas they are large in the present fossil. *Bischofia* differs from this fossil in having usually large vessels with abundant tyloses and 1-5 seriate xylem rays. *Glochidion* also differs from it in having large vessels, minute intervessel pits and 1-3 (—4) seriate xylem rays. While *Securinega* can be distinguished by its scalariform performation plates which are absent in the fossil; in *Bridelia* the growth rings are distinct, delimited by a line of parenchyma in some species and the rays are only 1-5 seriate. Moreover, intervessel pits are small in *Bridelia* and minute in *Cleistanthus* and are vestured in both (Janssonius, 1930, pp. 483-486; Bailey, 1933, p. 265, pl. 63, fig. 14) which further separate them from the wood under discussion.

When compared with all the available species of the genus *Phyllanthus*, viz., *Phyllanthus emblica* Linn., *Phyllanthus indicus* Muell., *Phyllanthus polyphyllus* Willd. and *Phyllanthus reticulatus* Poir., it was found that the fossil is almost identical to *Phyllanthus emblica* Linn. (B.S.I.P. slide no. W 493; F. R. I. slide no. A5552/C3539; Pearson & Brown, 1932, pp. 877-880, fig. 274). In both the extant wood of *Phyllanthus emblica* as well as the present fossil wood the growth rings are absent, vessels are small to medium-sized, open with simple perforations, intervessel pits are medium to large and vessel-ray pits are large and usually horizontally elongated, parenchyma is sparse, restricted to occasional cells around the vessels, xylem rays are 1-9 seriate with strongly heterogeneous ray tissue and the fibres are semilibriform or libriform and septate. However, the ray cells and vessel-ray pits of *Phyllanthus emblica* are slightly smaller than the fossil. But this is a variable feature.

So far a number of fossil woods belonging to the family Euphorbiaceae have been described under different generic names from many parts of the world. These genera are being listed below in Table 1.

It was Bailey who in 1924 instituted the fossil genus *Paraphyllanthoxylon* for the reception of dicotyledonous woods having combinations of anatomical characters which occur in mature stems of *Phyllanthus emblica* L. and other structurally similar representatives of the Phyllanthoideae. However, in 1932, Ogura, being unaware of the fossil genus *Paraphyllanthoxylon* Bailey (1924), also created a new genus *Phyllanthinium* for the fossil woods of Phyllanthoideae, although he himself was not clear about the affinities of his fossil. He has mentioned in his paper that, "it is, of course, impossible to determine the exact affinity of the fossil now in question only from the structure of the wood, but the writer considers it to be one of the Euphorbiaceae, especially of the tribe Phyllanthoideae, which is however, different from any of the living species, so that it will be a new representative of this or a related family" (Ogura, 1932, p. 189). In 1956, Ramanujam instituted another genus *Glochidioxylon* for the fossil woods which resemble the extant woods of *Glochidion* group. He says that, "Bailey (1924) while describing a fossil wood from the Cretaceous of Arizona; which according to him shows resemblance with *Phyllanthus* and other structurally similar representatives of Phyllanthoideae, instituted a new name *Paraphyllanthoxylon* for the fossil woods showing apparent similarities to the section Phyllanthoideae. Ogura (1932) created a new generic name *Phyllanthinium* for his fossil wood resembling according to him genera like *Antidesma*, *Glochidion*, *Bischofia* and *Bridelia*. Our fossil too, it is obvious, resembles these genera which by virtue of their anatomical characters fall under the wood type of the *Glochidion* group. Since the section Phyllanthoideae

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PLATE 1

1. *Paraphyllanthoxylon palaeoemblica* sp. nov.—Cross section showing radial rows of vessels, scanty paratracheal parenchyma and broad xylem rays. × 25 B.S.I.P. slide no. 8008.
2. *Paraphyllanthoxylon palaeoemblica* sp. nov.—tangential longitudinal section showing uni-to multiseriate xylem rays with sheath cells. × 30 B.S.I.P. slide no. 8009.
3. *Paraphyllanthoxylon palaeoemblica*—Cross section showing distribution of vessels and broad xylem rays. × 30 B.S.I.P. slide no. 8011.
4. *Phyllanthus emblica*—Cross section. × 30.
5. *Paraphyllanthoxylon palaeoemblica*—Cross section magnified to show vessels, broad xylem rays and scanty paratracheal parenchyma. × 80. B.S.I.P. slide no. 8011.
6. *Phyllanthus palaeoemblica*—Cross section magnified. × 80.
7. *Paraphyllanthoxylon emblica*—Tangential longitudinal section showing broad, heterogeneous xylem rays. × 30 B.S.I.P. slide no. 8012.
8. *Phyllanthus emblica*—Tangential longitudinal section. × 30.
9. *Paraphyllanthoxylon palaeoemblica* sp. nov. Radial longitudinal section. × 150 B.S.I.P. slide no. 8010.
10. *Phyllanthus emblica*—Radial longitudinal section. × 80.
11. *Paraphyllanthoxylon palaeoemblica* sp. nov.—Intervessel pit pairs × 500. B.S.I.P. slide no. 8009.

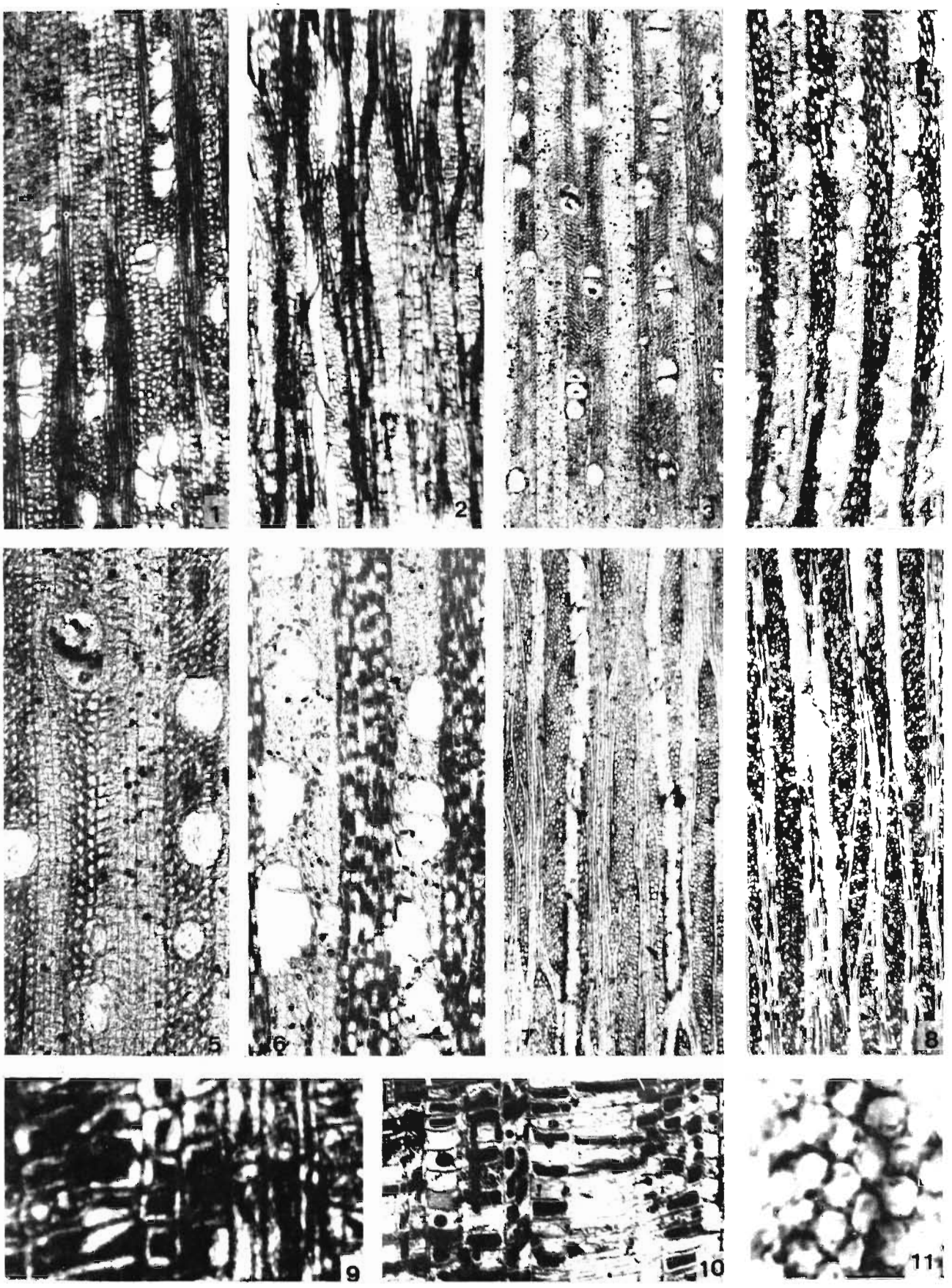

PLATE 1

Table 1

	Fossil Genus	*Author and year*	*Modern comparable taxa*
1.	*Euphorbioxylon*	Felix, 1887	Crotonoideae group (*Euphorbia, Jatropha*)
2.	*Paraphyllanthoxylon*	Bailey, 1924	*Phyllanthus emblica* and other structurally similar representatives of Phyllanthoideae
3.	*Phyllanthinium*	Ogura, 1932	Phyllanthoideae
4.	*Heveoxylon*	Kruse, 1954	*Hevea* Aubl.
5.	*Glochidioxylon*	Ramanujam, 1956	*Glochidion* type of woods
6.	*Putranjivoxylon*	Ramanujam, 1956	*Putranjiva* Wall.
7.	*Bridelioxylon* syn. Bischofioxylon	Ramanujam, 1956; Ramanujam, 1960	*Bridelia* Willd.
8.	*Aleuritoxylon*	Mädel, 1962	*Aleurites* Forst.
9.	*Securinegoxylon*	Mädel, 1962	*Securinega* Comm. ex. Juss.
10.	*Mallotoxylon*	Lakhanpal & Dayal, 1964	*Mallotus* Lour.
11.	*Bischofinium*	Bande, 1974	*Bischofia* Bl.

could be split up into two groups, *Glochidion* and *Aporosa* based on the wood anatomy, each group characterized by its own set of anatomical characters, it might be better and probably more natural, if the fossil woods showing affinities to these groups be named after these groups, unless they exhibit unmistakable resemblance with some particular genus, instead of grouping such woods under a single rather broad genus *Phyllanthinium* or *Paraphyllanthoxylon.*" However, he also added that the generic name "*Paraphyllanthoxylon* may be retained for the woods coming from the Cretaceous horizon" which seems quite unreasonable to us considering the origin and evolution in angiosperms.

In 1962, Mädel further classified the woods of the family Euphorbiaceae in a number of groups based on their wood anatomy. These are *Aporosa* group, *Putranjiva* group, *Glochidion* group, *Bridelia* group and *Crotonoideae* group (Mädel, 1962, pp. 285, 286, Table 1). All these are being listed in Table 2 with their anatomical characters and the fossil genera included under them. Among these, the woods of *Putranjiva* group and *Aporosa* group are anatomically quite similar except that the xylem rays are broader in the woods of *Aporosa* group than in *Putranjiva* group. She (Mädal, 1962, p. 307) also transferred all the *Glochidion*-type of fossil woods, which do not show affinity with any particular genus, to *Paraphyllanthoxylon* Bailey. All those assigned to this genus by her are: *Paraphyllanthoxylon arizonense* Bailey, 1924 syn. *Laurinoxylon arizonense* (Bailey) Berger, 1950; *P. pseudohobashiraishi* (Ogura) Mädel, 1962 syn. *Phyllanthinium pseudohobashiraishi* Ogura (Ogura, 1932; Watari, 1943); *P. tertiarum* (Ramanujam) Mädel, 1962 syn. *Glochidioxylon tertiarum* Ramanujam, 1956; *P. sahnii* (Prakash) Mädel, 1962 syn. *Glochidioxylon sahnii* Prakash, 1959; *P. pfefferi* (Platen) Mädel, 1962 syn. *Carpinoxylon pfefferi* Platen, 1908; and *P. capense* Mädel, 1962.

However, while critically analysing the above three closely related fossil genera, viz., *Paraphyllanthoxylon* Bailey, *Phyllanthinium* Ogura and *Glochidioxylon* Ramanujam, it appears that they need to be redefined in the light of our recent observations.

Although, the genus *Paraphyllanthoxylon* Bailey was established for the fossil woods of *Phyllanthus emblica* and structurally similar woods of Phyllanthoideae, a critical examination of the genotype *Paraphyllanthoxylon arizonense* shows unmistakable affinities with the modern woods of *Phyllanthus.* The wood of *Phyllanthus* is characterized by large horizontally elongated vessel-ray pits and broader rays showing strikingly heterogeneous ray tissue with long sheath cells. Consequently, it is proposed here to retain the genus *Paraphyllanthoxylon* Bailey for the fossil woods of *Phyllanthus* only. As Bailey (1924) has not given any generic diagnosis for his genus *Paraphyllanthoxylon*, this is being given here in the following pages.

Considering the other two genera *Phyllanthinium* Ogura and *Glochidioxylon* Ramanujam, it appears that the first was meant theoretically for the fossil woods of Phyllanthoideae as a whole, while the other was restricted to *Glochidion*-type of woods among Phyllanthoideae and Crotonoideae. However, a critical examination of their diagnoses and a review of their discussion indicate that their genotypes were compared with the modern woods of the same set of genera such as *Glochidion, Antidesma, Bischofia* and *Bridelia.* Therefore, it would be appropriate to merge and assign them to the *Glochidion*-type of woods in general. As *Phyllanthinium* Ogura has a priority over *Glochidioxylon* Ramanujam, being published earlier, *Phyllanthinium* Ogura becomes a valid name for the fossil woods of *Glochidion* group, while *Glochidioxylon* Ramanujam becomes its synonym. Further, as some of the characteristic features of the *Glochidion* group have not been given in the original diagnosis of *Phyllanthinium* Ogura, an emended generic diagnosis is being given below, so as to include all the fossil woods showing anatomical characters similar to the modern woods of this group except *Phyllanthus.*

EMENDED GENERIC DIAGNOSIS

Phyllanthinium Ogura emend.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels*

small to medium-sized; tyloses present or absent; vessel members with truncate or tailed ends; perforations simple; intervessel pits minute to large; vessel-ray pits mostly rounded. *Parenchyma* typically absent or scantly paratracheal to vasicentric. *Xylem rays* 1-4 seriate, ray tissue heterogeneous. *Fibres* non-libriform to libriform and septate.

The fossil woods which have now been transferred to this newly circumscribed genus *Phyllanthinium* Ogura emend. are: *Phyllanthinium pseudohobashiraishi* Ogura, 1932 from Tertiary, Japan; *P. idahoense* (Spackman) comb. nov. syn. *Paraphyllanthoxylon idahoense* Spackman, 1948 from Upper Cretaceous, U.S.A.; *P. tertiarum* (Ramanujam) comb. nov. syn. *Glochidioxylon tertiarum* Ramanujam, 1956 from Mio-Pliocene, Cuddalore sandstones, South India; *P. sahnii* (Prakash) comb. nov. syn. *Glochidioxylon sahnii* Prakash, 1959 from Eocene, Deccan Intertrappean beds, Central India; *P. bengalamodense* Navale, 1962 from Mio-Pliocene, Cuddalore sandstones, South India; *P. keriense* (Dayal) comb. nov. syn. *Paraphyllanthoxylon keriense* Dayal, 1967 from Eocene, Deccan Intertrappean beds, Central India; *P. yvardi* (Koeniguer) comb. nov. syn. *Paraphyllanthoxylon yvardi* Koeniguer, 1970 from

TABLE 2

	PHYLANTHOIDEAE			CROTONOIDEAE	
Anatomical groups	*Aporosa* group	*Putranjiva* group	*Glochidion* group	*Bridelia* group	*Crotonoideae* group
Extant genus	*Aporosa, Baccaurea, Dicoelia, Maesobotrya, Protomegabaria, Richeria* (Antidesminae)	*Putranjiva* (Glochidienae), *Drypetes, Lingelsheimia* (Drypetinae)	*Antidesma, Aporosella, Hymenocardia* (Antidesminae), *Bischofia* (Bischoffiinae), *Glochidion* (Glochidiinae), *Phyllanthus, Securinega* (Phyllanthinae), *Acalypha* (Crotonoideae)	*Bridelia, Cleistanthus* (Brideliae)	All members of Crotonoideae except *Acalypha*
Fossil genus	Not known	*Putranjivoxylon* Ramanujam	*Paraphyllanthoxylon* Bailey, *Securinegoxylon* Mädel *Bichofinium* Bande	*Bridelioxylon* Ramanujam	*Euphorbioxylon* Felix *Heveoxylon* Kruse *Aleuritoxylon* Mädel *Mallotoxylon* Lakhanpal & Dayal
Wood	Diffuse-porous	Diffuse-porous	Diffuse-porous, seldom ring-porous	Diffuse-porous	Diffuse-porous, seldom ring-porous
Vessels	Radial groups; perforations scalariform (seldom simple and scalariform); intervessel pit-pairs small, alternate; vessel ray pits large.	Radial groups of 2-4; perforations scalariform or simple and scalariform; intervessel pit-pairs small, alternate; vessel ray pits large.	Radial groups of 2-4; tyloses may or may not be present; perforations simple or simple and scalariform; intervessel pitting alternate; vessel ray pits large or not large, seldom with spiral thickenings	Radial groups; perforations simple (seldom simple and scalariform); intervessel pits large or not large	Solitary and in radial groups of 2-4; perforations simple (seldom scalariform or simple and scalariform, intervessel pits alternate, opposite; vessel ray pits large or not large, sometimes with spiral thickenings
Fibres	Non septate, thick-walled with simple pitting	Non-septate, thick-walled with simple pitting	Septate, mostly thick-walled with simple pitting	Septate	Non-septate, mostly thick-walled with simple pitting
Parenchyma	Abundant as scattered cells and numerous short uniseriate bands; chambered crystals present	Abundant as scattered cells and numerous short uniseriate bands; chambered crystals present	Absent or as dead cells; scanty paratracheal	Spares to abundant paratracheal	Profusely diffuse, frequently one row thick or bands, sometimes paratracheal, aliform and confluent; cells crystaliferous
Xylem rays	Two types; uniseriate and broad (up to 17 cells typically 4-17 cells wide), height more than 1 mm, strongly heterogeneous	1-3 seriate, height more than 1 mm, strongly heterogeneous	Two types; uniseriates and up to 11 cells broad, height more than 1 mm, strongly heterogeneous	Moderately broad, height mostly less than 1 mm	Moderately broad, sometimes uniseriate height more than 1 mm, strongly heterogeneous

TABLE 3—FOSSIL WOODS OF *PARAPHYLLANTHOXYLON* BAILEY SHOWING IDENTITY WITH THE EXTANT GENUS *PHYLLANTHUS* LINN.

Fossil Species	Growth Rings	Vessels	Parenchyma	Xylem Rays	Fibres	Modern Equivalent	Locality and Age
Paraphyllanthoxylon arizonense Bailey, *1924*	Feebly differentiated	Solitary or grouped in radial clusters of 2-4, 8-14 per sq mm; tyloses present; perforations simple; intervessel pits bordered, alternate; vessel-ray pits transversely elongated	Scanty paratracheal	1-7 seriate; ray tissue heterogeneous	Thick walled, septate	*Phyllanthus emblica*	Arizona, U.S.A., Upper Cretaceous
Paraphyllanthoxylon capense Madel, 1962	Indistinct	Solitary and in radial rows of 2-5(-6), t.d. 35-100 μm, r.d. 60-135 μm 24-60 per sq mm; tyloses absent; perforations simple, intervessel pits large; vessel ray pits, simple, large, horizontally elongated	Absent or seldom scanty paratracheal	1-5 seriate; ray tissue heterogeneous	Libriform septate	*Phyllanthus discoideus*	South Africa; Upper Cretaceous
Paraphyllanthoxylon palaeoemblica' sp. nov.	Indistinct	Solitary and in radial multiples of 2-5 and in clusters, t.d. 75-90 μm r.d. 120-165 μm, 5-9 per sq mm; tyloses absent; perforations simple; intervessel pit-pairs large; vessel ray pits simple large, horizontally elongated	Scanty paratracheal	1-9 seriate; ray tissue strongly heterogeneous; sheath cells present	Semilibriform to libriform, septate	*Phyllanthus emblica*	Nailalung Railway station, Assam. Tipam sandstones (Upper Miocene)
Paraphyllanthoxylon palaeoemblica	Absent	Solitary and in radial multiples of 2-4, t.d. 60-160 μm, r.d. 80-175 μm 10-12 per sq mm; tyloses absent; perforations simple; intervessel pits-pairs bordered, alternate, 6-8 μm in diameter; vessel ray pits simple, large, horizontally elongated	Scanty paratracheal	1-9 seriate; ray tissue heterogeneous sheath cells present.	Semilibriform, septate	*Phyllanthus emblica*	Nawargaon near Wardha in Maharashtra; Deccan Intertrappean beds (early Tertiary)

Miocene, France; *P. alabamense* (Cahoon) comb. nov. syn. *Paraphyllanthoxylon alabamense* Cahoon, 1972 from Cretaceous, U.S.A.; and *P. utahense* (Thayn) comb. nov. syn. *Paraphyllanthoxylon utahense* Thayn in Tidwell *et al.*, 1976, Lower Cretaceous, U.S.A.

As the present fossil wood resembles the modern wood of *Phyllanthus emblica*, it is assigned to the redefined genus *Paraphyllanthoxylon* Bailey (1924). A critical examination of all the fossil woods belonging to *Glochidion* group indicates that only *Paraphyllanthoxylon arizonense* Bailey (1924) from the Cretaceous of Arizona and *Paraphyllanthoxylon capense* Mädel (1962) from the Upper Cretaceous of Africa belong to the genus *Phyllanthus*. Their anatomical characters have been summarized in Table 3. Of the two, *Paraphyllanthoxylon capense* which has been said to show similarities with *Phyllanthus discoideus* (Mädel, 1962, p. 295), differs from the present fossil in having greater frequency of vessels (24-60 vessels per sq mm) as against 5-9 vessels per sq mm in the present fossil and in possessing narrower, 1-5 seriate xylem rays which are up to 9 seriate in the wood under discussion. The other species *Paraphyllanthoxylon arizonense* Bailey, although very similar to the present fossil in its anatomical details, differs from it in having bigger vessels. While *Paraphyllanthoxylon arizonense* has been described from the upper Cretaceous of the Colorado group of Arizona, the fossil wood described here belongs to the Tipam sandstones (Upper Miocene) of Assam. Considering the occurrence of the above two fossil woods in widely separated continents of the Old and the New world, one in the United States of America and the other in north-east India, together with a vast difference in their ages, it becomes difficult to visualize that a single species of a genus could have existed in two such remote continents at different periods of time. As such the present fossil has been described under a new species *Paraphyllanthoxylon palaeoemblica*, the specific name suggesting that it might represent a form from which the modern species *Phyllanthus emblica* has evolved.

Present Distribution of Phyllanthus Linn.—The genus *Phyllanthus* consists of trees, shrubs and herbs which are mostly deciduous. These are widely distributed in the tropical and warm temperate regions of both the hemispheres except Europe and North Asia (Willis, 1973, p. 892). Over 600 species of this genus have been described of which 50 species occur in India. *Phyllanthus emblica* Linn. with which the fossil compares closely is a small to medium-sized timber tree having a wide range in India and Burma, and likewise extends to

Ceylon. In India, it is common in Uttar Pradesh, Bengal and stretches eastwards to Assam.

GENERIC DIAGNOSIS

Paraphyllanthoxylon Bailey, 1924

Wood diffuse-porous. *Growth rings* indistinct or absent. *Vessels* small to medium-sized, solitary and in radial multiples; tyloses absent or present; perforations simple; intervessel pits bordered, alternate, medium to large. *Parenchyma* absent or scanty paratracheal. *Xylem rays* 1-10 or more seriate; ray tissue heterogeneous, sheath cells present. *Fibres* non-libriform to libriform and septate.

Genotype—Paraphyllanthoxylon arizonense Bailey, 1924.

SPECIFIC DIAGNOSIS

Paraphyllanthoxylon palaeoemblica sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to medium-sized, occasionally solitary, mostly in radial rows of 2-5, sometimes in tangential rows of 2-4 and in clusters, 5-9 per sq mm, t.d. 75-90 μm, r.d. 120-165 μm; vessel members 165-675 μm long; perforations simple; intervessel pit-pairs bordered, alternate, 8-12 μm in diameter, with linear to lenticular apertures; vessel-ray pits large, mostly elliptical and horizontally elongated. *Parenchyma* scanty paratracheal with occasional cells touching the vessels. *Xylem rays* 1-7 (—9) seriate and 30-190 μm in width, 6 per mm; ray tissue heterogeneous, uniseriate rays homocellular made up of upright cells, 3-7 cells or up to 600 μm in height, the multiseriate rays heterocellular with sheath cells on the flanks, 6-43 cells or up to 2500 μm in height. *Fibres* polygonal in cross section, semi-libriform to libriform, septate, about 15 μm in diameter and up to 1500 μm in length.

Holotype—B.S.I.P. Museum no. 35538.

Locality—Near Nailalung Railway Station, about 23 km from Lumding, Assam.

Besides the fossil wood described in these pages one more fossil wood, collected from the Deccan Intertrappean beds of Nawargaon in Wardha District of Maharashtra, was found to possess a close similarity with the modern wood of *Phyllanthus emblica* (Forest Research Institute, Dehra Dun slide no. 5969). It also resembles very closely the fossil species *Paraphyllanthoxylon palaeoemblica* described earlier except that the xylem rays in this wood are longer than in *P. palaeoemblica* and the intervessel and vessel-ray pits are slightly smaller. However, these variations have also been observed in different samples of *Phyllanthus emblica*. Therefore, it is being described here under the same species indicating the variations. The occurrence of this type of wood in the Deccan Intertrappean beds further extends the antiquity of fossil woods resembling *Phyllanthus emblica* to early Tertiary.

Paraphyllanthoxylon palaeoemblica

Material—A single piece of mature secondary wood measuring 10 cm in length and 6 cm in diameter. The preservation of anatomical features is quite satisfactory.

Topography—*Wood* diffuse-porous. *Growth rings* absent. *Vessels* small to medium-sized, solitary and in radial multiples of 2-4 or in small clusters, 10-12 per sq mm (Pl. 1, fig. 3); tyloses absent. *Parenchyma* scanty paratracheal as few cells around the vessels to uniseriate vasicentric (Pl. 1, fig. 5). *Xylem rays* fine to broad, 1-9 seriate, visible to the naked eye as dark coloured lines running radially on the cross-surface, uniformly distributed, 5-7 per mm (Pl. 1, fig. 3); ray tissue heterogeneous, rays of two distinct types; uniseriate rays less numerous than the multiseriates, homocellular made up of upright cells only, 3-7 cells or 145 to 320 μm in height (Pl. 1, fig. 7); multiseriate rays 2-9 seriate or 35-160 μm in width and 5 to 120 cells or 180-4000 μm in height, heterocellular made up of procumbent cells in the middle part and with or without 2-10 cells high uniseriate extensions of upright cells at one or both the ends; sheath cells present (Pl. 1, fig. 7); ray to ray fusion observed. *Fibres* aligned in radial rows in between the rays.

Elements—*Vessels* circular to oval when solitary, with flat contact walls when in groups, t.d. 60 to 160 μm, r.d. 80-175 μm, vessel members 200-400 μm long with oblique ends; perforations simple; intervessel pit-pairs bordered, alternate, angular due to crowding, with linear to lenticular apertures, 6-8 μm in diameter (Text-fig. 2a). *Parenchyma* cells thin-walled, 20-30 μm in width and 30-70 μm in length. *Ray cells* thin-walled, upright cells 20-40 μm in radial length and 40-60 μm in tangential height, procumbent cells 12-25 μm in tangential height and 25-40 μm in radial length; vessel-ray pits simple, large, horizontally elongated, 12-16 μm in diameter (Text-fig. 2b). *Fibres* semilibriform with broad lumen, circular to angular in cross section, septate, 15-25 μm in diameter and 400 to 1000 μm in length; interfibre pits could not be seen.

Specimen—B.S.I.P. Museum no. 35539.

Locality—Nawargaon, Wardha District, Maharashtra.

Horizon—Deccan Intertrappean beds.

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