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Permineralized fungal remains in the fossil wood of *Barringtonia* from the Deccan Intertrappean sediments of Yavatmal District, Maharashtra, India

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ABSTRACT

Srivastava R, Kapgate DK & Chatterjee S 2009. Permineralized fungal remains in the fossil wood of *Barringtonia* from the Deccan Intertrappean sediments of Yavatmal District, Maharashtra, India. The Palaeobotanist 58(1-3): 11-19.

Fungal infection (parasitism and saprophytism) in the fossil flora of Deccan Intertrappean sediments is well documented from Chhindwara, Dindori, Mandla, Nagpur and Seoni areas of central India. In the present communication, a well preserved dicotyledonous fossil wood showing resemblance with the extant genus *Barringtonia* Forster & G. Forster of the family Lecythidaceae is recorded for the first time from the Yavatmal District, Maharashtra. The anatomical study of wood reveals that it is endogenously infected with saprophytic fungus *Epicoccum* Link. ex Schlecht and fungal conidia are profusely distributed in the vessels of the fossil wood. Very fine, ill preserved mycelium is also seen at places. Presence of the genus *Barringtonia*, as well as fungus *Epicoccum* is indicative of warm and humid conditions in the area during the time of deposition of intertrappean sediments.

Key-words—Fungal remains, Fossil wood, Lecythidaceae, Deccan Intertrappean beds, Maharashtra, Saprophyte, Climate.

भारत में महाराष्ट्र के यवतमाल जिले के दक्कन अंतःट्रेपी अवसादों से प्राप्त बैरिंगटोनिया के काष्ठ जीवाश्म में पर्मिनीकृत कवक अवशेष

रश्मि श्रीवास्तव, डी.के. कपगटे एवं शांतनु चटर्जी

सारांश

मध्य भारत के छिंदवाड़ा, डिंडोरी, मांडला, नागपुर एवं सिवनी क्षेत्रों से प्राप्त दक्कन अंतःट्रेपी अवसादों के पेड़-पौधों के जीवाश्मों में कवक संक्रमण (परजीविता एवं मृतजीविता) सुप्रलेखित किया गया है। इस संप्रेषण में, महाराष्ट्र के यवतमाल जिले से प्राप्त सुपरिरक्षित द्विबीजपत्री काष्ठ जीवाश्म लेसीथिडेसी कुटुंब के वंश *बैरिंगटोनिया* फार्स्टर एवं जी. फॉर्स्टर से समानता दर्शाती हुई पहली बार अंकित की गई है। काष्ठ का शारीरीय अध्ययन सुझाता है कि यह मृतजीवी कवक *एपिकोकम* लिंक से अंतःप्रवर्धी रूप से संक्रमित है तथा काष्ठ जीवाश्म की वाहिका में कवक कोनिडिया प्रचुरता में विद्मान हैं। अत्यन्त महीन कवक जाल भी कई

स्थानों पर मिलते हैं। क्षेत्र में *बैरिंगटोनिया* वंश के साथ-साथ *एपिकोकम* कवक की विद्यमानता अंतःट्रेपी अवसादों के निक्षेपण के दौरान कोष्ण एवं आर्द्र स्थितियों की द्योतक है।

संकेत-शब्द—कवक अवशेष, काष्ठ जीवाश्म, लेसीथिडिएसी, दक्कन अंतःट्रेपी संस्तर, महाराष्ट्र, मृतजीवी, जलवायु।

INTRODUCTION

A large number of fossil woods are known from the Deccan Intertrappean sediments of India (Bande *et al*., 1988; Srivastava, 1991; Srivastava & Guleria, 2006). A perusal of the literature shows that most of the woods have been reported from central India. The present wood is described from the Deccan Intertrappean sediments of Yavatmal District, Maharashtra (Collected by DK Kapgate). The wood was collected from Jhargad (Lat. 20° 17' 19" N: Long.78° 33'10" E), about 3 km west of the village Jhadgaon . The area lies on a hillock where cherts are flooded with gastropods and plant material along with fossil woods (both dicots and palms). The area has not been explored properly for the plant remains. The only fossil *Oxygiocarpon jhargadi*, a capsular fruit has been described from Jhargad area by Yawale and Channe (1998) while Dahegaonkar (2004) reported a palm root, viz. *Rhizopalmoxylon shiblaii* from there. Thus, the present report forms the first record of a dicotyledonous wood along with saprophytic fungus from the area. The fossil wood and slides along with saprophytic fungus are deposited in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow, India.

SYSTEMATICS

Family—LECYTHIDACEAE

Genus—BARRINGTONIOXYLON Shallom, 1960

Barringtonioxylon deccanense Shallom, 1960

(Pl. 1.1-6; Pl. 2.1)

Material—The description is based on a single piece of fossil wood measuring 10.5 cm in length and 11.2 cm in diameter. The preservation is good revealing all the xylotomical characters.

Description—Wood diffuse-porous. *Growth rings* indistinct, marked by smaller vessels and denser fibres. *Vessels* solitary and mostly in radial multiples of 2-4 (sometimes up to 8), rarely into small clusters (Pl. 1.1); 18-30 per sq. mm; small to medium (mostly small) sized, tangential diameter 35-150 µm, radial diameter 30-160 µm; circular to oval when solitary, flattened at the place of contact when in multiples (Pl. 1.1); mostly open, few seem to be tylosed; vessel members 192-575 µm in length with oblique or tailed end walls; perforations simple (Pl. 1.3); intervessels pits alternate,

PLATE 1
Barringtonioxylon deccanense Shallom

1. Cross section of fossil wood showing distribution of vessels, parenchyma and degraded tissue marked with arrow. Museum no. BSIP 39550-I.
2. Tangential longitudinal section showing multiseriate rays and conidia marked with arrow. Museum no. BSIP 39550-III.
3. Tangential longitudinal section showing alternate bordered intervessel pits as well as fungal mycelium. Museum no. BSIP 39550-III.
4. Tangential longitudinal section showing multiseriate rays and cluster of conidia marked with arrow. Museum no. BSIP 39550-III.
5. Radial longitudinal section showing procumbent and upright ray cells and degradation of walls of ray cells at places marked with arrow. Museum no. BSIP 39323-II.
6. Tangential longitudinal section showing cluster and solitary distribution of conidia in the vessel segment. Museum no. BSIP 39550-III.

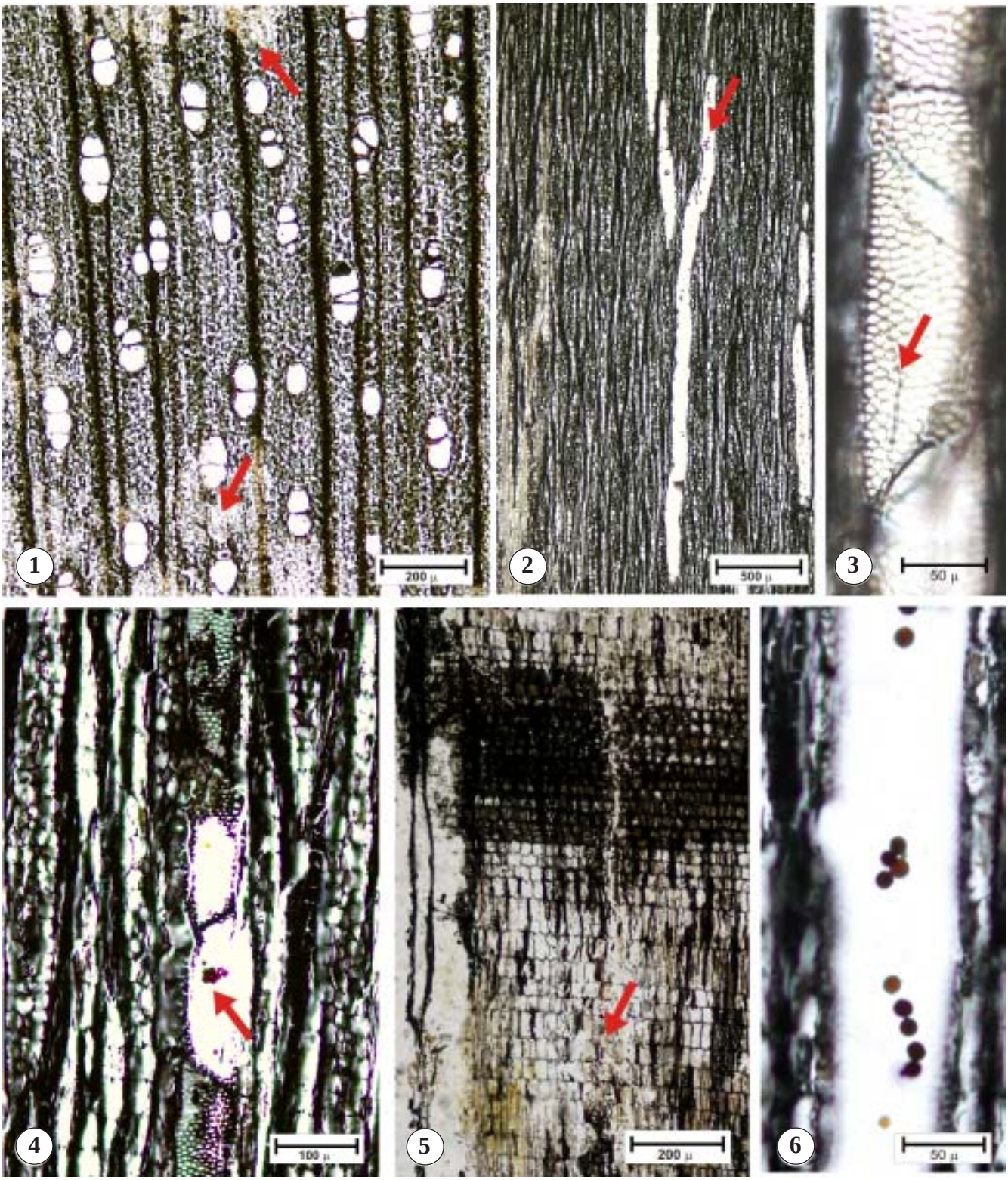

PLATE 1

hexagonal, large, about 11-13 µm in diameter with lenticular apertures (Pl. 1.3; Pl. 2.1). *Parenchyma* abundant, both apotracheal and paratracheal; paratracheal scanty, few cells associated with vessels, sometimes vasicentric, forming uniseriate sheath round the vessels; apotracheal abundant, diffuse to diffuse-in-aggregate forming 1-2 seriate broken lines among fibres forming reticulum (Pl. 1.1); parenchyma lines are separated by 2-4 cells of fibres; parenchyma cells 22-33 µm in diameter and 44-77 µm in length. *Fibres* aligned in radial rows between two consecutive rays, angular, 11-22 µm in diameter; nonseptate. *Rays* 1-5 (mostly 3-4) seriate (Pl. 1.2, 4), 10-13 rays per mm; heterocellular; uniseriate few, made up of upright cells only, 2-10 cells or 100-500 µm long; multiseriate 2-5 cells in width, made up of procumbent cells in the centre with sheath cells on the flank of multiseriate portion and 2-4 or more marginal rows of upright cells at one or both the ends (Pl. 1.2, 4-5), 4-45 cells or 160-1100 µm long; end to end ray fusion present; ray cells large, filled with some dark coloured deposits; procumbent cells with tangential height 11-27.5 µm and radial length 27.5-57.5 µm; upright cells 33-82.5 µm in tangential height and 11-27.5 µm in radial length; vessel-ray pits present, many per cell, half bordered, 12-14 µm in diameter.

Affinities—The diagnostic features of the fossil wood are: vessels mostly in radial multiples with simple perforations and large intervessel pits; parenchyma abundant, paratracheal and apotracheal both, paratracheal vasicentric and apotracheal diffuse to diffuse-in-aggregate forming 1-2 seriate broken lines among the fibres; 1-5 seriate, heterocellular rays and nonseptate fibres. These characters collectively indicate its close resemblance with modern woods of *Barringtonia* Forster & G. Forster of the family Lecythidaceae. Thin sections as well as published descriptions and photographs of number of modern species of the genus *Barringtonia* reveal that the fossil wood shows closest resemblance with *B. acutangula* (Linn.) Gaertn (Moll & Janssonius, 1914; Metcalfe & Chalk, 1950; Desch, 1957; Kribs, 1959; Hayashi *et al*., 1973; Shahi & Taneja, 1982; Ilic, 1991).

Comparison with Fossil Woods—The genus *Barringtonioxylon* was instituted by Shallom (1960) to accommodate fossil woods showing affinities with the extant genus *Barringtonia* Forster & G. Forster. Earliest record of the genus is from Maastrichtian of Lameta Formation (Infratrappean beds) of Nand-Dongargaon area, Maharashtra (Kar *et al*., 2004). So far, its five species have been described from India and two species from Ethiopia and Bangla Desh. Amongst them, three species are reported from the Deccan Intertrappean beds of India. These are: *Barringtonioxylon deccanense* Shallom (1960) and *B. eopterocarpoxylon* Prakash and Dayal (1965) from Intertrappean sediments of Mahurzari, Nagpur, Maharashtra; *B. mandlaensis* Bande and Khatri (1980) from Intertrappean sediments of Parapani, Mandla (now Dindori), Madhya Pradesh and Wardha District, Maharashtra (Khare *et al*., 2000). Three species are reported from Neogene sediments of India, viz., *B. arcotense* Awasthi (1970) from Cuddalore Sandstone and Neyveli Lignite, Tamil Nadu (Reddy &

PLATE 2 →

Epicoccum deccanensis sp. nov.

1. Tangential longitudinal section of the fossil wood showing cluster and solitary distribution of conidia and mycelium showing branched hyphae. Museum no. BSIP 39550-III.
2. Same section enlarged showing conidia and branched septate hyphae. Museum no. BSIP 39550-III.
3. Radial longitudinal section showing degraded tissue and conidia. Museum no. BSIP 39550-II.
4. Tangential longitudinal section showing fungal hyphae and conidia. Museum no. BSIP 39550-IV.
5. Cross section showing mature conidium with small stalk and rough spore walls in vessels. Museum no. BSIP 39550-I.
6. Enlarged Tangential longitudinal section of the fossil wood showing mature conidia with varrucose spore wall. Museum no. BSIP 39323-IV.
7. Another section showing conidia. Museum no. BSIP 39323-III.
8. Living cultured specimen of *Epicoccum pupurascens* Ehrenberg (Synonym *E. nigrum* Link ex Schlechtendahl) showing similar type of conidia.

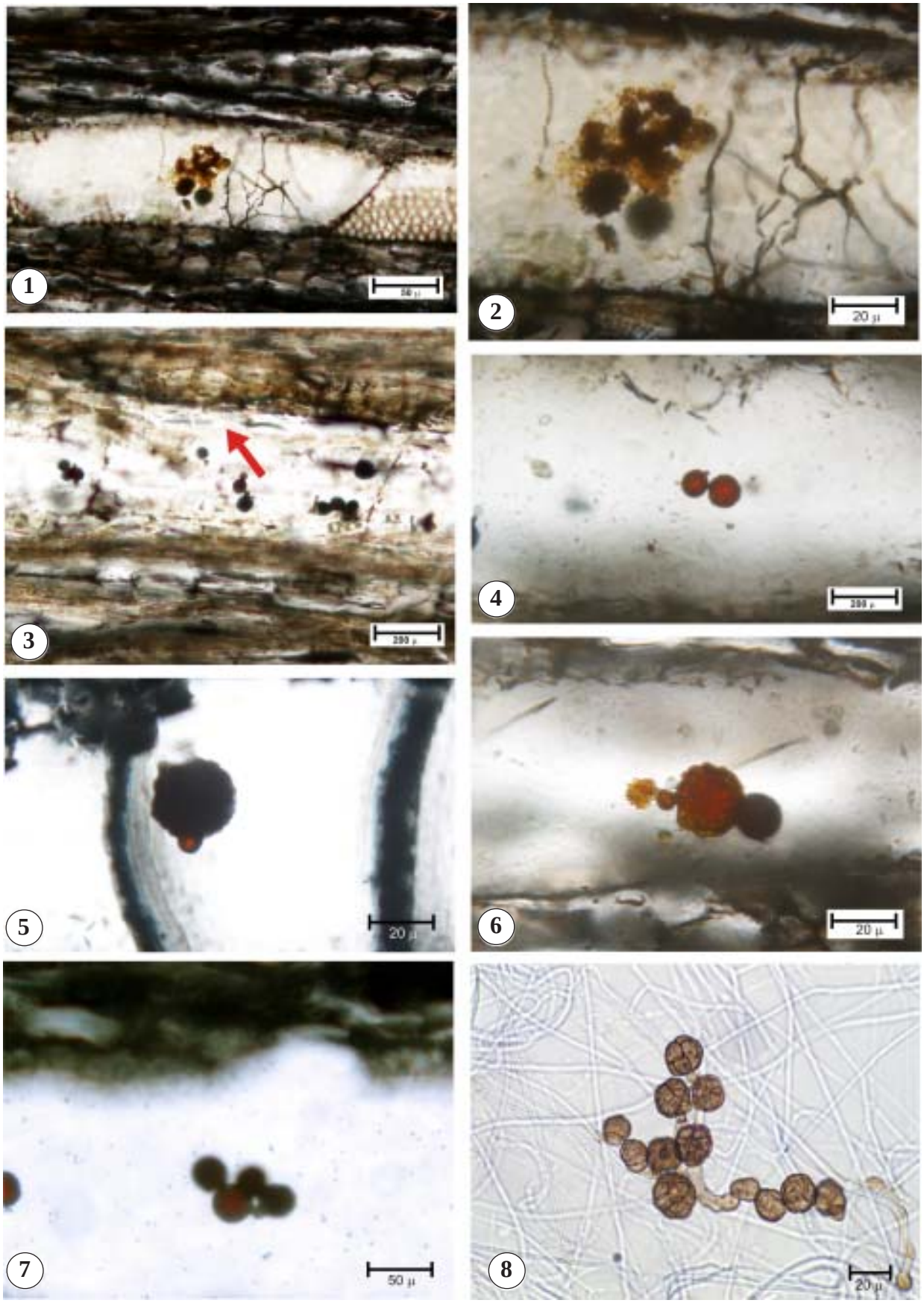

PLATE 2

Ramanujam, 1985), *B. assamicum* Prakash and Tripathi (1972) from Tipam Sandstone, Assam and *B. rajasthanense* Harsh *et al*. (1992) from Harsolav, Bikaner, Rajasthan. Besides these, *Barringtonioxylon deccanense* has subsequently been reported from Neogene sediments of Namsang Beds, Arunachal Pradesh (Awasthi & Mehrotra, 1993) and Tipam Sandstone, Assam (Prakash *et al.*, 1994) and also from Infratrappean sediments of Lameta Formation, Maharashtra. From abroad one species, *Barringtonioxylon allemblackioides* is reported by Lemoigne (1978) from the Tertiary of Ethiopia and *Barringtonioxylon assamicum* is reported from Bangla Desh (Agarwal *et al*., 2000).

Amongst them, in having well developed paratracheal vasicentic, aliform to aliform-confluent parenchyma *Barringtonioxylon arcotense* Awasthi (1970) and *Barringtonioxylon mandlaensis* Bande and Khatri (1980) can be differentiated with the present fossil wood in which scanty paratracheal to uniseriate vasicentric parenchyma is present in addition to diffuse to diffuse-in-aggregate apotrachaeal parenchyma. While identification of *B. mandlaensis* reported by Khare *et al.* (2000) from the Wardha District is doubted by Kar *et al.* (2004), *B. arcotense* can be differentiated in having larger vessel diameter (up to 300 µm). Rest of the four species, namely, *Barringtonioxylon deccanense* Shallom, *B. eopterocarpum* Prakash and Dayal, *B. assamicum* Prakash and Tripathi and *B. rajasthanense* Harsh *et al.* exhibit resemblance with the fossil wood under consideration because these species were instituted on overlapping and variable characters. Since the present fossil wood resembles in all its characters with *Barringtonioxylon deccanense* Shallom which also has priority over others, it is placed under the same species.

Fungal Infection:

FUNGI

Class—ASCOMYCETES

Genus—EPICOCCUM Link 1815

Epicoccum deccanensis sp. nov.

(Pl. 1.1-6; Pl. 2.1-7)

Description—Fungal spores/conidia are profusely found endogenously in the vessels of the fossil wood (Pl. 1.1-4, 6; Pl. 2.1-7). Very fine mycelium is also seen at places but it is broken, ill preserved and difficult to reveal structural details. Hyphae septate, frequently branched, fine, 3-5 µm in diameter. In ground section they often appear flat and ribbon-like, but twists in the hyphae at places create the superficial appearance of change in diameter (Pl. 2.1, 2). Hyphal branches are sometimes narrower than the parent filament. Short conidiophores originate from hyphae in the form of clusters, conidiophores give rise to conidia. Conidia (spores) are dark coloured, circular, found as single grained or mostly in clusters, small, 10-30 µm in diameter, young conidia are round, smooth and without septation while mature conidia are multicellular (dictyoconidia), and have a funnel-shaped base and attachment scar (Pl. 2.5-7) that is formed from aggregated conidiophores on sporodochium (Pl. 2.1, 2). Conidial walls rough, verrucose to warty with dark pigmentation (Pl. 2.5, 6). Thinning and degradation of cell walls of fibres and ray cells seen at places (Pl. 1.1, 4; Pl. 2.3).

Comparison—The diagnostic features of the fossil fungus are: dark coloured spherical conidia (spores) which are multicellular with rough or verrucose cell walls. Conidia are globose pyriform, mostly l5-25 µm diameter with a funnel-shaped base and broad attachment scar, often detach with a protuberant basal cell; i.e. aleuric or rhexolytic dehescence of conidia. Among the modern analogs, they collectively indicates its affinity with the Ascomycetes, particularly with the genus *Epicoccum* Link., in which conidia become multicellular (dictyoconidia), darkly pigmented and have verrucose external surface on maturity. It is a very common invader of many different dead or dying plant types. *Epicoccum pupurascens* Ehrenberg (Synonym *E. nigrum* Link ex Schlechtendahl) is a saprophyte of worldwide distribution and partially parasitic on human skin (Barnett, 1962; Subramanian, 1971; Domsch *et al*., 1980; Barnett & Hunter, 1986).

Holotype—Museum No. BSIP 39550.

Locality—Jhargad, near Jhadgaon Village, Yavatmal District, Maharashtra.

Horizon—Deccan Intertrappean Beds.

Age—Upper Maastrichtian-Danian.

DISCUSSION

The genus *Barringtonia* is widely recorded in India during Maastrichtian as well as Tertiary (Palaeogene and Neogene) as evidenced by number of fossil woods from different localities of peninsular and extra-peninsular regions. Presently, the genus *Barringtonia* Forster & G. Forster consists of 39 species (Mabberley, 1997, p. 77). Small and medium sized trees of the genus are characteristic of beach forests of Polynesia, northwest Australia, Malaysia, Myanmar, Sri Lanka and India. Inland they occur along streams and swamps. Three species are reported to occur in India. *B. acutangula* (Linn.) Gaertn., the nearest modern counterpart of the present fossil wood is distributed in sub-Himalayan tract from Ganga eastwards to Bengal and Assam, also in Madhya Pradesh and coastal districts of the Peninsula along the banks of rivers and on swampy land, inland distribution is limited in Deccan and Karnataka (Shahi & Taneja, 1982, p. 20). The existence of the genus *Barringtonia* in India even at the present day speaks in volume about their adaptability and tolerance in different ecological conditions.

Fungal infection (parasitism and saprophytism) in the fossil flora of Deccan Intertrappean sediments of central India is well documented. Evidence of wood – fungal association/decay in fossil record is valuable for understanding palaeoecosystems. It not only provides an indirect method of documenting the existence of major groups of fungi in geological history, but also serves as a basis for characterizing the interaction between fungi and higher plants. The wood decay due to fungal infection is recorded as early as in Upper Devonian and the nature of infection in the fossil woods is almost similar to those found today (Stubblefield *et al*., 1985; Stubblefield & Taylor, 1988). The fossil records may provide valuable data concerning the time of origin of major groups and their eventual diversification.

There are many lignicolous fungi of Hyphomycetes (=Deuteromycetes) which occur on moist woods of various trees and shrubs. Since the genus *Epicoccum* is mainly saprophytic in nature, it might have attacked the dead or dying wood of *Barringtonia*. Fungal parasitism and saprophytism in fruits, seeds and woods as well as dispersed fungal spores from Deccan Intertrappean beds have been reported by many workers (Chitaley, 1950, 1957; Chitaley & Patil, 1970, 1972; Chitaley & Sheikh, 1971; Chitaley & Yawale, 1978; Barlinge & Paradkar, 1982; Lakhanpal *et al*., 1967; Patil & Singh, 1974; Singhai, 1972, 1974, 1978; Kalgutkar *et al*., 1993; Srivastava, 2008). However, due to the absence of fruiting bodies, most of them could not be identified up to generic level.

Epicoccum pupurascens Ehrenberg ex Schlechtendahl (Synonym *E. nigrum* link ex Schlechtendahl) is mainly a saprophytic fungus of worldwide distribution. It is very frequently found on dead parts of numerous plants, where the fungus is treated as secondary invader. Besides this, it is also known on seeds, mouldy paper, textile, insects, human skin and sputum (parasitic) and very frequently in the air. It has also been isolated from the varied soils, viz., common in forest soil, litter from deciduous trees and conifers, alpine soils, grassland salt marshes, heath land uncultivated and cultivated soils, saline sands, desert soil, sand dunes and many more substratum.

The fungus is adopted to grow on a wide range of temperature from -3° to 45°C, while optimum growth is found in between the range of 23-28°C with relative humidity of >90% and pH 5.0-6.0. It produces a good amount of pectinase and xylanase enzyme responsible for the decay of woody tissues. The thermal tolerance of this fungus is the reason for its cosmopolitan occurrence. Hence, it can be concluded from the above facts that presence of both *Barringtonia* as well as fungus *Epicoccum* indicates that warm and humid conditions were prevailing in the Yavatmal area during the time of deposition of Intertrappean sediments. The present material is also suggesting that the genus *Epicoccum*, which interacted with *Barringtonia* wood during Maastrichtian-Danian times in a manner similar to present day fungi.

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