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Research Article

AILANTHOXYLON (TREE OF HEAVEN) FROM THE UPPER CRETACEOU DINOSAURIAN SEDIMENTS OF PISDURA MAHARASHTRA INDIA

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ABSTRACT
Significant recovery of a fossil wood, *Ailanthoxylon* Prakash,1959(=*Ailanthus*) from the dinosaurian sediments of Lameta Formation (Maastrichtian) at Pisdura, Maharashtra, India indicates the development of angiosperms in the area earlier than Maastrichtian time.Occurrence of dinosaurian coprolites in the sediments containing partly digested/ degraded plant tissues reflects that the herbivore dinosaurs (*Titanosaurid sauropods)* were consuming the plants growing around them.In situ occurrence of other fragmentary mega and micro-fossils e.g. *Araucaria* (wood, cones and pollen), Palms (wood, seeds and pollen) and dicotyledonous plants referable to Capparidaceae, Arecaceae and the pteridophytes remains in the coprolites reflect the presence of green forests and the fresh water lacustrine ecosystem around the dwelling sites of these animals. A large number of plant fragments recovered from different types of dinosaurian coprolites by earlier workers corroborates similar environmental conditions. Evidence of grasses in dinosaurian coprolites suggests the development of hypsodonty in the Upper Cretaceous animals. As regards the extinction of Upper Cretaceous dinosaurs, apart from the impact of meteoritic actions and other drastic environmental changes, the toxicity of *Ailanthus* plants in this area possibly also added a cause to their demise. These investigations suggests that the Lameta formation as sub-tropical -tropical and landscape dominated by plants associated with deltaic environment and sub aquatic environments associate to delta-like palaeochannels.Presence of *Ailanthus* along with spores of aquatic ferns (*Azolla & Salvinia*), support the flood plane where these plants were able to grow in association with the algae and diatoms (eg. *Aulacosiera*).

***Key words**: Ailanthoxylon Lametai Sp. Nov., Lameta Formation (Maastrichtian), Dinosaurs, Coprolites, Pisdura, Maharashtra, India*

INTRODUCTION

The Maastrichtian sediments of Lameta Formation are well exposed around Nand Dongargaon (79° 05': 20° 10') in Maharashtra, India (Figure 1). The formation contains well known dinosaurian evidences in form of skeleton fragments as well as coprolites. In addition the plant representatives of Upper Cretaceous are also associated in these sediments. Plant mega and microfossils has been reported by various workers: Ambwani *etal*.(2003) found the diatoms (*Aulacosiera*) in the dinosaurian coprolites (Type-A; as classified by Matley, 1921), Mohabey & Samant (2003), Samant & Mohabey(2003) reported fragmentary evidences of the plants (pteriodophytes, gymnosperms and angiosperms), Ghosh *et. al.* (2004) carried out detailed analysis of different types of dinosaurian coprolites and revealed that the herbivorous dinosaurs (*Tititanosaurid sauropods*) consumed C3 plants in their diet. Kar *etal.* (2004) reported silicified woods belonging to the family Lecythidaceae; Ambwani & Debi Dutta (2005) recovered arecoid seed-like structure referable to *Phoenix* and a few seeds of Capparidaceae embedded in the coprolites. Evidences of grass phytoliths in all the four types(A,B,Ba&C) of dinosaurian coprolites, was brought forward by Prasad *et al.* (2005), they opined that the dinosaurs consumed the grasses and evolved grazing habit.Apart from the above investigations, recovery of a fossil gymnosperm wood showing affinities with present day

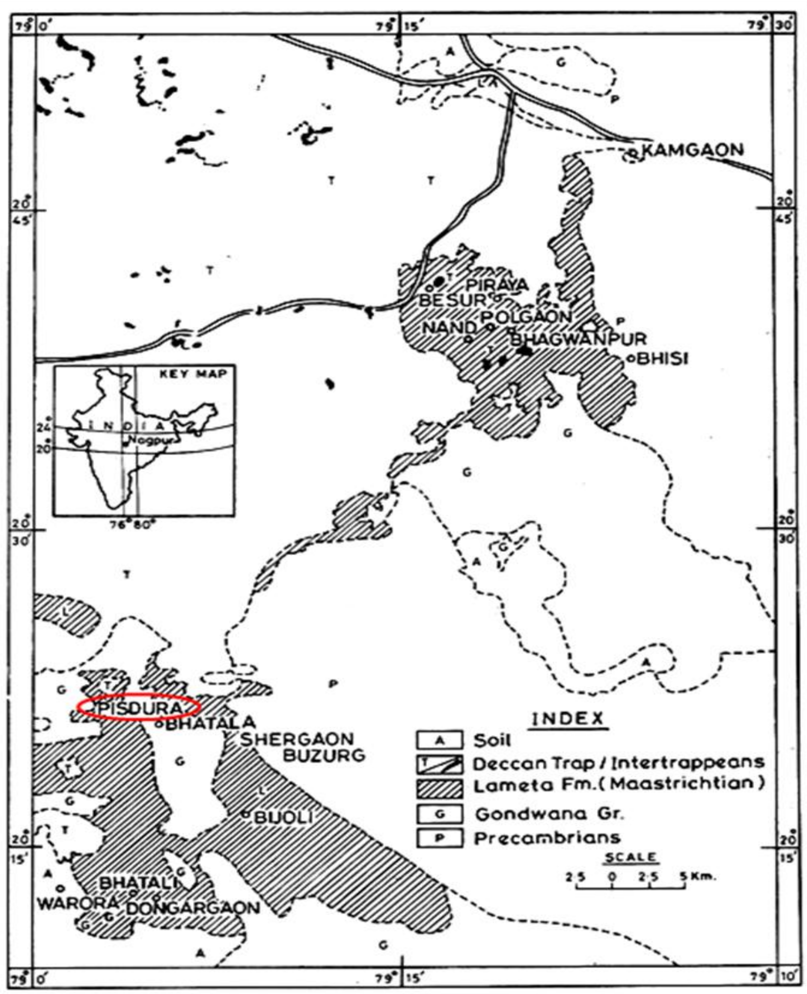

Figure1: *Ailanthoxylon* (Tree of Heaven) from the Upper Cretaceous dinosaurian sediments of Pisdura, Maharashtra, India-Map showing locality from where the fossil wood was collected (After Mohabey, 1996).

Araucaria has been reported by Debi Dutta & Ambwani (in press). Occurrence of the plant remains in the dinosaurian coprolites and association of the megafossils in the sediments representing both monocots & dicots reflects that the ecosystem in which the animals dwelled provided substance to their diet. Presence of diatoms (*Aulacosiera, Synedra* and *Pinnularia*) in the coprolites are presumed to have been injested while consuming water (Thulborn ,1991); Ambwani *et.al.*(2003), Kar *et al.*(2003), Mohabey & Samant (2003),Ambwani & Dutta (2005)and Dutta&Ambwani,(in Press).Reports of some dicotyledonous woods from the Lameta sediments of Rajulwari and Polgaon of Nand-Dongargaon inland basin of Nagpur district, Maharashtra, India were reported by Kar *et. al.* 2005. Occurrence of the genus *Ailanthoxylon* has also been reported from the contemporary sediments of the Deccan Intertrappean beds of India by Prakash (1959), Shallom (1961) and Khare *et al.* (2000). Recently *Ailanthoxylon* (*A. indicum,* Prakash) has been reported from the Deccan Intertrappean sediments of Yeotmal District, Maharashtra by Prasad *et al.* (2008), whereas from the younger horizons (Cuddalore Series) of South India Ramanujam(1960); Navale(1964) also reported this genus. Finding of *Ailanthoxylon* (cf. *Ailanthus* Desf.) belonging to the family Simaroubaceae at Pisdura, Maharashtra is important from view point of the dinosaurian habitat and palaeoecology.

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Geology of the area

The Lameta Formation (Late Cretaceous) Pisdura is overlain by the Deccan volcanic rocks. It comprises basal red and green silty non-laminated clays, which rest over the Precambrian granites and schists with a pronounced unconformity over the Kamthi Formation (Gondwana). Here the clays generally attain up to 6 m thickness associated with less frequently occurring sandstones of vertical and lateral accretion types. Sometimes pockets of grey and yellow marls are also present in the clays. These clays are overlain and overlapped by yellow and cream laminated clays and shales interbedded with thin limestones and marlites (Figure2).

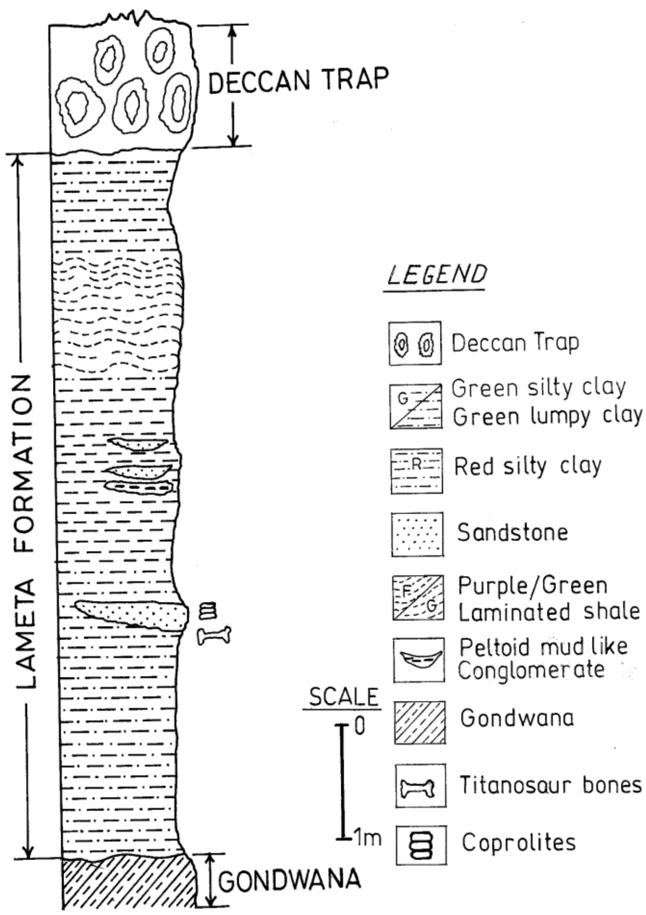

Figure 2: *Ailanthoxylon* (Tree of Heaven) from the Upper Cretaceous dinosaurian sediments of Pisdura Maharashtra India.
Litholog showing the detailed lithology of the area (After Mohabey 1996)

The Formation conventionally has been considered as fluvio-lacustrine deposit (Hislop, 1869; Medlicott & Blanford, 1994; Von-Huene and Matley, 1933). Based on the detailed litho-facies analysis of this area some views on their possible marine origin also emerged (Jain and Sahni,1985; Sahni, 1984; Mohabey *et al*., 1993) while(Mohabey and Udhoji,1990; Hensen, *et al*.1996,Mohabey,1996,2001) favoured the deposition as in alluvial-limnic environments under semi arid climate having seasonal fluctuations.
The Lameta sediments of Nand-Dongargaon at Pisdura have been known for their rich assemblage of fragmentary dinosaurs bones represented by *Titanosaurus indicus*, *T.blanfordi,Laplatosaurus*

medagascarensis, *Antarctosaurus septentrionalis* (Hislop,1869; Lydekker,1979; Matley, 1921, 1939; Von-Huene and Matley,1933; Berman and Jain,1982). As regards the age of the Lameta beds of Pisdura inland basin, Mohabey (1984,1990); Mohabey and Mathur (1989), Sahni (1984), Vianey-Liaud *et al.*(1987) and Prasad, Khajuria & Manhas (1995) assessed as the Late Cretaceous. According to Acharya and Lahiri, (1991) the separation of India from Africa and Madagascar gave rise the formation of inland basins around Nand-Dongargaon areas in Chandrapur district, Maharashtra and was a suitable habitat of the *Titanosaurus madagascarensis* as well as *Antarctosaurs septentrionals* (see.Heslop,1869;Lydekker,1979; Matley,1921;Von-Huene and Matley,1933; Berman and Jain, 1982; Sahni and Bajpai,1988).

MATERIALS AND METHODS

The fossil wood was collected from Lameta Formation Maastrachtian) exposed near Pisdura, Maharastra, India. Small piece of wood specimen is about 2.5 cm. long and 2 cm in diameter, silicified and shows marks of infection that could have occurred due to the activity of the borers (beetles) inhabiting in the surroundings (Figure 3A,B).

The wood with secondary tissues shows satisfactory preservation and reveals all the important anatomical characters. Thin sections of the were prepared wood in different planes (TS, TLS and RLS), the anatomical characters were observed under the high power microscope and photographs of important characters were prepare

Systematic decription

Order - Sapindales

Family - Simaroubaceae

Genus - *Ailanthoxylon* Prakash,1959

***Ailanthoxylon lametai* sp nov.**

(Figure 3 A-D,F,H-J)

Diagnosis

Wood diffuse porous; *growth rings* absent ; vessels small to medium,t.d.50-80µm r.d.70-120µm;6-12per sq mm, solitary, rarely multiples of 2-3 (Figure 3C,D), circular to oval sometimes filled with dark brown to black substance. Vessel segments 150-300µm long, ends truncate to oblique, nonstoried, perforations simple; intervessel pit pairs bordered, 8µm, alternate, openings circular to lenticular (Figure 3F,J),vessels filled with siliceous matters (Figure 3 H).*Parenchyma* paratracheal to apotracheal, paratracheal parenchyma scanty(some cells associated to vessels); apotracheal,1-2cells thick forming incomplete bands. Cells thin walled 20-28µm diameter and 40-165µm in length, strands nonstoried (Figure 3D, F)
Xylem rays 1-3 (mostly 2) seriate,30-45µm wide, up to 700µm long; ray tissues weakly heterogeneous, made up of usually procumbent cells (Figure 3F).*Fibres* thick walled, non-septate, 18-20 µm in diameter; 85-850 µm long.

Description

Fossil wood shows diffuse porous nature and absence of growth rings. The *vessels* are small circular to oval showing 50-80µm tangential diameter (td) and 70-120µm radial diameter (rd).The number of vessels ranges 6-12 per sq mm. Generally a solitary, very rarely multiple of two to three vessels can be seen (Figure 3-C& D) Sometimes the vessels are filled with brown to dark / black substance (probably resinous in nature). The vessel segments vary from 150-300µm in length with simple to oblique ends and simple perforation. The inter-vessel pits are generally bordered, alternating with lenticular to circular apertures (Figure 3-J).The vessels may be seen filled with siliceous matter (Figure 3-H).The *parenchyma* is usually paratracheal but scanty;1-2 cells in thickness (sometimes non-strioried bands of parenchyma can be observed at places (Figure 3 C&D).The xylem rays are generally 1-3(mostly 2 seriate),30-45µm wide ranging up to 700µm in height; ray tissues weakly heterogeneous, made up of usually procumbent cells (Figure 3F). *Fibres* thick walled, non-septate.

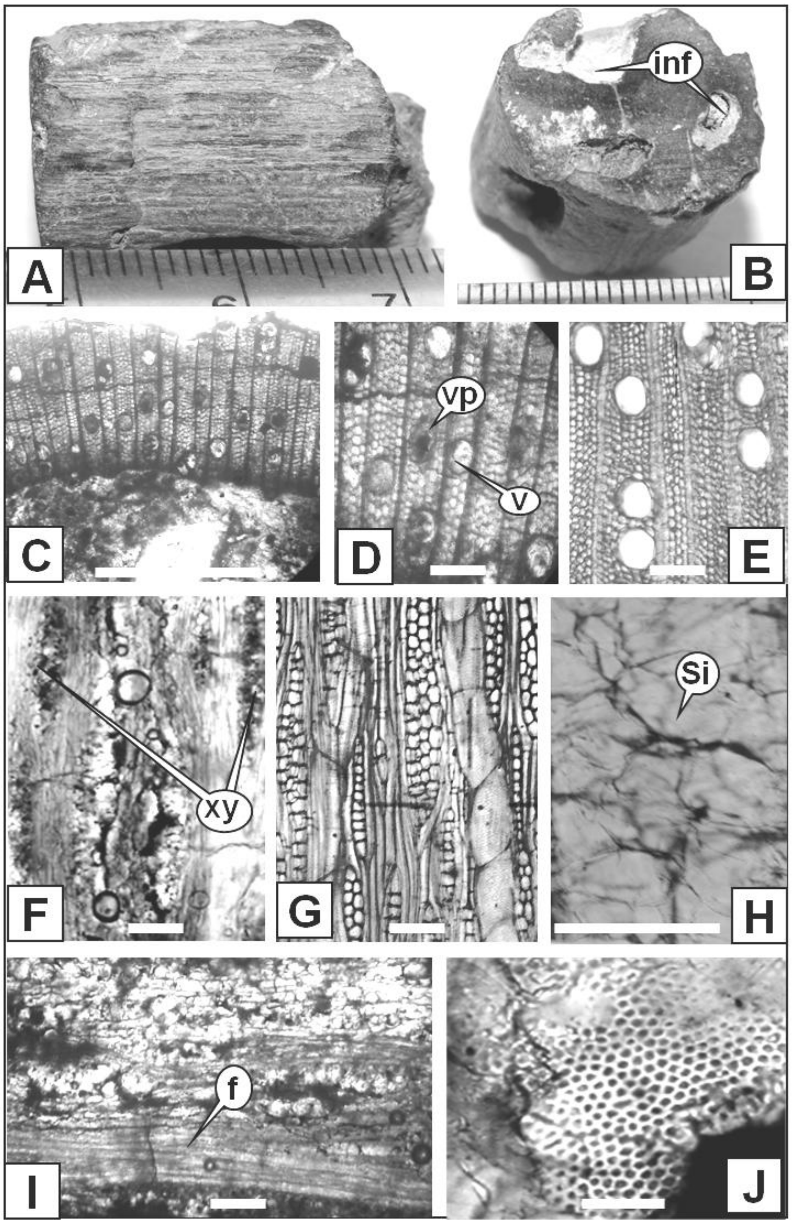

Figure 3: *Ailanthoxylon* (Tree of Heaven) from the Upper Cretaceous dinosaurian sediments of Pisdura Maharashtra India

A-Fossil wood specimen (*Ailanthoxylon*) showing woody texture,**B-**Cross section of the specimen showing decay in the wood as indicated by arrows, **C-** Cross section of the wood showing the nature of the vessels, rays and wood paranchyma, **D-**part of the wood enlarged to show vessels parenchyma, nature of the xylem rays and fibres, **E-**Cross section of mature wood of *Ailanthus excelsa* showing similar nature of vessels, xylem rays and paratracheal parenchyma, **F-**T.L.S. of fossil wood showing nature of xylem rays,**G-**L.S.of *Ailanthus excelsa* to show nature of xylem rays and non-septate fibres, **H**-Silica matter filled in xylem vessel, **I-**T.L.S.of fossil wood showing non-septate fibres, **J-**part of vessel to show wall pittings.

Abbreviations: (**F**=fibers; **inf** =infected areas in the wood; **Si**=siliceous matter;**V**=vessel;**vp**=vessel parenchyma, **xy**=xylem rays**)**

Bar value: Figure 3 **–(**C=1mm; D-G & I=100µm; E=500µm; H=50µm; J = 10µm.)

Affinity with modern plant

The diagnostic features of the present fossil wood such as small to medium size vessels, scanty paratracheal parenchyma and incomplete thin bands, apotracheal parenchyma 1-3(mostly 2) seriate,weakly heterogeneous; xylem rays composed mostly of procumbent cells, non-septate thick walled fibres collectively suggest its affinities with the extant wood of the genus *Ailanthus* Desf.of the family Simaroubaceae (Pearson&Brown,1932;Metcalfe& Chalk,1950;Kribs,1959; Ghosh,1963). In order to find out the specific affinity a critical examination of extant wood slides of available species as well as published literature pertaining to this genus have been carried out and it is concluded that out of above mentioned species the present fossil wood shows close affinity with the extant wood of *Ailanthus exelsa* Roxb.(Figure 3 E,G).

Fossil records and comparison

The fossil woods showing affinity with the genus *Ailanthus* Desf. have been described under the form genus *Ailanthoxylon* Prakash (1959). These are mostly reported from the Deccan Intertrappean (Palaeocene-Eocene) sediments of Central India and only few of them occur in Mio-Pliocene sediments of South India (Table-1). The present fossil wood has been compared with all the known species(listed in table-1) and concluded that it shows superficial resemblance with *Ailanthoxylon indicum* Prakash (Mehrotra,1990) but differs in being different nature of xylem rays and pattern of apotracheal parenchyma cells. In the present fossil wood, the xylem rays mainly are composed of procumbent cells and the apotracheal parenchyma bands are comparatively longer. In view of above differences, the present fossil wood has been assigned to new specific name, *Ailanthoxylon lametai*. The present finding constitutes the first record of the genus *Ailanthus* from the Lameta Formation (Upper Cretaceous) of India.

Table -1: Fossil woods of the genus *Ailanthus* Desf. from Tertiary sediments of India.

Taxa	Horizon / Locality	Reference
Ailathoxylon indicum, Prakash	Deccan Intertrappean beds; Mohgaon Kalan, Chhindwara Distt. M.P., India	Prakash, 1967
A. indicum Prakash	Deccan Intertrappean beds, Shapura, Mandla Distt. M.P., India	Mehrotra,1990
	Deccan Intertrappean beds; Sibla,Yeotmal Distt. M.P..	Prasad, et.al., 2007
	Deccan Intertrappean beds; Nawargaon, Maharashtra, India	Khare,et.al., 2000
A.mahurzariense ,Shallom	Deccan Intertrappean beds; Mahurzari,Nagpur,Maharashtra, India.	Shallom,1961
A. pondichrriense Navale	Cuddalore Series, South India	Navale,1964
A.scantiporosus, Ramanujam	Tertiary of Mortandra, South India	Ramanujam, 1960
Ailanthoxylon sp. Verma	Deccan Intertrappean beds; Brangda, Madhya Pradesh,India	Udhoji& Verma,1990
	Deccan Intertrappean beds; Mandla Distt.M.P. India	----------;;---------------

DICUSSION

As regards the existence, development and proliferation of the Upper Cretaceous angiosperms (Doyle 1969; Muller,1970) on the basis of available fossil evidences inferred that angiosperms were not present anywhere in the world before Barremian (125my) assessing the Lower Cretaceous as the cradle of their divergence. On the other hand the earlier records of fossil angiosperms pollen that confidently be ascribed to the Early Cretaceous period (Doyle and Hickey, 1976).

According to Raven(1977) and Estrada Zuis (2007) there was a significant expansion of tropical climate during the Cretaceous period, it was this environment which allowed the early angiosperms to disperse as the land flora.In the Indian context, Mid-Late Cretaceous (Bagh Group) comprising Nimar and the Bagh, where Nimar Formation is essentially a coastal deposit with a dinosaur and the petrified woods bearing conglomerate at the base followed by sandstones.Some sandstones being intertidal facies(Khosla *etal*.2003,Sahni, 2006).The extensive sequences in western and central India represent Coniacian (Bardhan *et al.*, 2002) are capped in many places either by the Maastrichtian sediments referable to Lameta Formation or by Deccan volcanics (Sahni *et al*.1994,2006).Here the Nimar sandstone yields the remains of angiosperm woods (cf.*Rhizophora*) and sauropods, has been considered estuarine environment,a characteristic mangrove plant (Khosla *etal*.2003). As regards the Lameta Formation as a facies variant of the Intertrappean beds has similar flora to Deccan associated sedimentary beds (Courtillot *etal*.1986; Venkateshan *et al*.1993, 1996; Allerge *et.al*.1999; Sahni *et.al*.1994 and Widdowson *et al*.,2000).Taking an account of angiosperm evolution,the extent of availability of the fossil dicot woods in Lameta Formation at Pisdura, Nand-Dongargaon (Upper-Cretaceous) is very low as compared to the Deccan Intertrappeans, some of the large size (woody trees) appeared during the Lameta Formation and the families such as Capparidaceae,Simaroubaceae and Lceythidaceae along with Arecaceae and Araucariaceae are better known resulting the development of forests with higher canopies. Occurrence of *Ailanthus*-type plants in the dinosaurian habitat is important as the species of this genus are abundantly represented in tropical America from Mexico to Argentine. The largest gunus *Picramia* (40 spp.) the second in number of species being *Simaba* (22 spp.) with one endemics species (*S. africana* Baill) in the West Africa. One of the largest *Saulamia* (8-10 spp.) also occurs in Seychelles. *Ailanthus* (15 spp) ranges from India to New Guinea, N. E. Australia and Soloman Islands (Hutchinson, 1969,1973;Willis,1973). *Ailanthus excelsa* Roxb.is a large deciduous tree still growing in the northwords of, Chota Nagpur, North circars, Deccan and whole of Madhya Pradesh and Maharashtra, India(Gamble,1972)indicating its extensive occurrence in the tropical forests of the region since Late Cretaceous time. In Ganga planes *Ailanthus is* a prolific seed producer, grows rapidly and can overrun the native vegetation.Once established it can quickly take over a site and form an impenetrable thicket. The tree also produces toxins that prevent the establishment of other plant species. It can be visualized that intolerance of the toxins could have also acted one of the causes for the demise of the dinosaurs in the process of their extinction followed by the Deccan volcanism during the close of the Maastrichtian time in India.

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