Palaeobotanist 52(2003) . 73-79
0031-0174/2003/73-79 $2.00

Unisexual flowers from the Deccan Intertrappean Bed of Madhya Pradesh, India

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(Received 06 February 2002; revised version accepted 18 December 2002)

ABSTRACT

Kar RK, Ambwani K, Sahni A & Sharma P 2003. Unisexual flowers from the Deccan Intertrappean Bed of Madhya Pradesh, India. Palaeobotanist 52(1-3) : 73-79.

Unisexual flowers are described for the first time from the Deccan Intertrappean Bed of Mohgaon-Kalan, Chhindwara District, Madhya Pradesh, India. The female flower viz., *Flosfemina intertrappea* is sessile with perianth and unilocular, superior ovary with many ovules. The male flower viz., *Flosvirulis deccanensis* has six perianth parts and six pairs of anther lobes reflecting six stamens. The anthers contain tricolporate, anguloaperturate, laevigate pollen.

Key-words—Unisexual flowers, Deccan Intertrappean, Maastrichtian, India, Angiosperm.

भारत के मध्य प्रदेश प्रान्त के दक्खिनी अन्तर्ट्रेपीय संस्तर से प्राप्त एकलिंगी पुष्पों का अध्ययन

रंजीत कुमार कर, कृष्ण अम्बवानी, अशोक साहनी एवं पूनम शर्मा

सारांश

भारत के मध्य प्रदेश प्रान्त के छिंदवाड़ा जिले के मोहगाँव कलाँ के दक्खिनी अन्तर्ट्रेपीय संस्तर से प्रथम बार एकलिंगी पुष्प अभिवर्णित किए गए हैं। मादा पुष्प, जैसे—*फ्लॉसफेमिना इण्टरट्रेपिया* परिदलपुंज तथा एकको ठकी, अनेक बीजाण्डों युक्त ऊर्ध्ववर्ती अण्डाशय से युक्त अवृन्त है। नर पुष्प, जैसे—*फ्लॉसवाइरूलिस डेक्केनेन्सिस* मे छह परिदलपुंज भाग तथा परागकोशकों के छह जोड़े हैं, जो छह पुंकेसर प्रदर्शित करता है। परागकोशकों में त्रिकॉल्पसी, कोण. द्वारकी, चिकने परागकण विद्यमान हैं।

संकेत शब्द—एकलिंगी पुष्प, दक्खिनी अन्तर्ट्रेपीय, मास्ट्रिशियन, भारत, आवृतबीजी।

INTRODUCTION

THE Deccan Trap in the opinion of Deshmukh (1990) is one of the most extensive and largest flood basalt provinces in the world. It covers roughly an area of 5,00,000 sq km, in central, western and southern India. The lava mass consists of compound and simple flows with a particular pattern of spatial and temporal distribution. The lower 1,200 m thick lava mass of the Western Ghats are made up of compound flows with slow rate of effusion whereas the overlying sequence of flows are of simple nature and were deposited in a quick succession.

The Deccan volcanism is thought to have been a major Cretaceous-Tertiary Boundary event by Courtillot *et al.* (1986, 1988, 1990), Baksi (1987), Duncan & Pyle (1988), Hallam 1988), Sahni & Bajpai (1988), Sahni *et al.* (1996). Sahni (1990) remarked that on the basis of Ar ^{40}/Ar ^{39} dates, it is now presumed that Deccan volcanism was an event of unprecedented magnitude

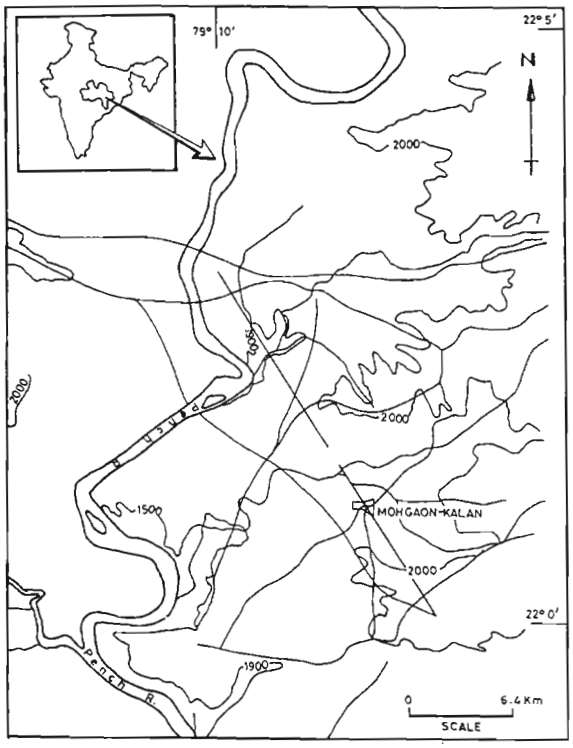


Fig. 1—Showing the village of Mohgaon-Kalan from where the material was collected.

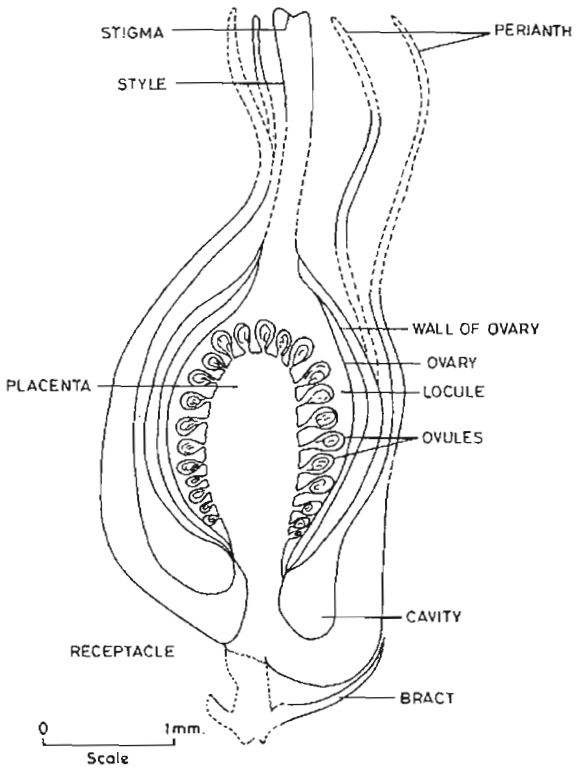


Fig. 2—Showing the various parts in longitudinal section of *Flosfemina intertrappea* sp. nov.

bordering the Cretaceous-Tertiary boundary. The ejection of several thousand tonnes of CO_2, NO_2 and SO_2 should have had a major effect on the biosphere.

According to Sahni (1990), the initial flows of the Deccan exposures, spreading from the west coast marginal basins of Kutch through the central Indian exposures of Madhya Pradesh to those occurring at Krishna-Godavari Basin around Rajahmundhry and marginal offshore deposits of Narsapur, were supposed to be of the quieter, intermittent type with a regional hiatus in which drainage was dammed and lakes developed leading to the abundance of flora and fauna.

Outside India, many fossil angiospermic flowers from Cretaceous are also known. Dilcher & Crane (1984) recovered *Archaeanthus*—an early angiospermic flower from the Cenomanian of the western interior of North America. Takahashi *et al.* (1999a, b) described angiospermic flowers, fruits, seeds, leaf fragments and woods from Ashizawa Formation (Upper Cretaceous) of Japan. The assemblage shows strong similarity to the northern hemisphere flora. Mohr and Friis (2000) noted early angiosperms from the Aptian of Brazil. Friis *et al.* (2001) reported the Nymphaeales from the Early Cretaceous of Portugal. Sun *et al.* (2002) reported Archaefructaceae, a new basal angiosperm family from the Upper Jurassic-Lower Cretaceous of China. They advocate it as an aquatic plant, their reproductive axes lack petals and sepals, the stamens are in pairs below the conduplicate carpels.

GEOLOGICAL SETTING

The volcano-sedimentary exposures of the Deccan Trap are either found below the trap (infratrappean) or in between the two traps (intertrappean). The number of intertrappean/ infratrapppean beds vary from locality to locality. At Mohgaon-Kalan only one Intertrappean Bed is observed, whereas at

PLATE 1

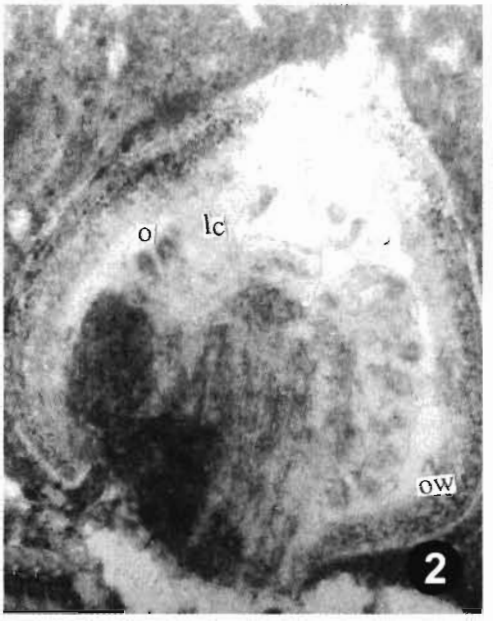
1-2. *Flosfemina intertrappea* sp. nov. in longitudinal sections showing perianth (p), style (st), stigma (g), ovary wall (ow), ovule (o) and the locule (lc). *ca.* x 10.

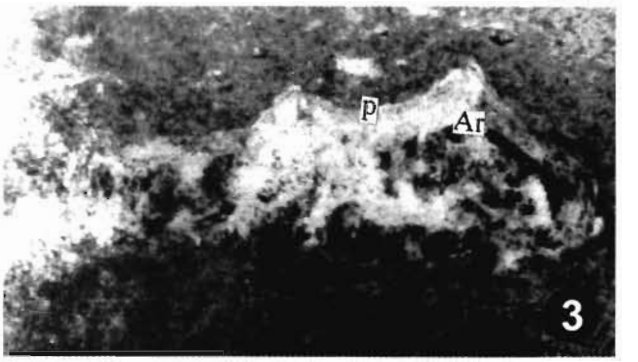
3. *Flosvirulis deccanensis* sp. nov. showing perianth lobe (p) and anther (ar). *ca.* X 12.

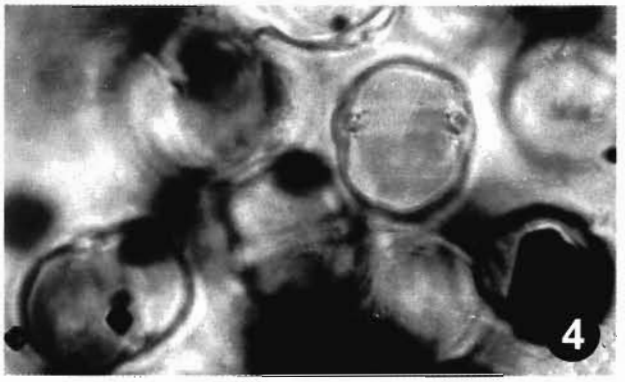
4. Tricolporate pollen in the anther. *ca.* X 300.

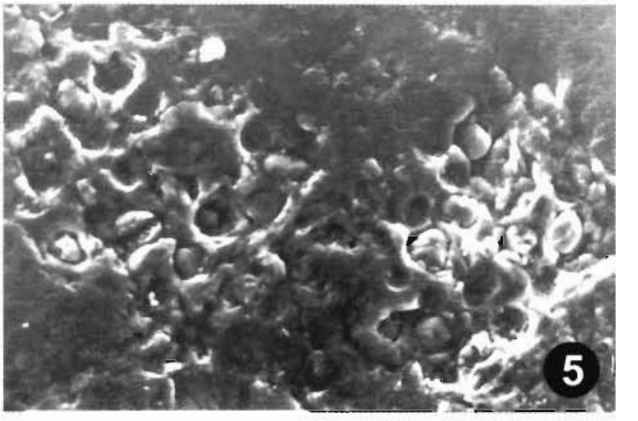
5,7 Showing the anther sacs in transverse section (SEM).

6. Showing the basal vascular supply of the flower (SEM).









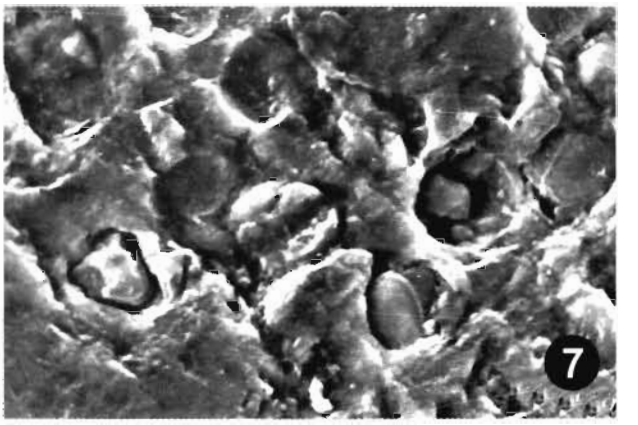


PLATE 1

Padwar and Ranipur in Jabalpur District at least two intertrappean beds are detected. At Anjar in Kutch District, several intertrappean beds were reported by Ghevariya (1988) and Ghevariya & Srikarni (1990).

The overlying trap flow covers the intertrappean sediments with a sharp contact without evidence of lava having flowed into a water body or even over a wet ground. Deshmukh (1990) remarked that in many intertrappean sediments number of palm fossils were preserved, but no where a mould of fossil palm was observed. He presumed that this provides a suggestion that the intertrappean sediments prior to the deposition of overlying lava flows were completely desiccated with total extinction of biota caused due to extremely hot volcanic effusion.

MATERIAL AND METHODS

A number of chert samples were collected from the village Mohgaon-Kalan (79°11'E : 22°1'N) (Fig. 1). The cherts are well exposed around this village and also at Paladon, Paratwara and Rajalwari covering approximately 10 km. The cherts are hard, compact, cryptocrystalline and consist predominantly of quartz less than 30 μm in size. They are tough, splintery and variously coloured. The chert is found only at the basal part of the intertrappean bed. The thickness of the intertrappean bed is roughly 1 m and this could be ascertained in a number of unlined water wells around the village. The basalmost sediment consists of variegated hard chert of 0·25 m thick containing fresh water pelecypod shells. The topmost unit is carbonaceous and is roughly 0·30 m thick. This has a variety of dinosaur/avian egg shell fragments, ostracodes, molluscs, fishes and wood fragments. The intertrappean sediments are sandwiched between the two basaltic flows.

The chert collected from Mohgaon-Kalan was cut into pieces and fixed on to glass slides by means of Canada Balsam. When dry, the slides were polished using Carborundum powder to the required thinness. The slides were finally mounted with cover glass in Canada Balsam. All the slides are deposited at the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

EARLIER RECORD OF FOSSIL FLOWER

Shukla (1944) described *Sahnianthus*—a bisexual angiosperm flower from the chert of Mohgaon-Kalan, Chhindwara District, Madhya Pradesh. Chitaley (1955), Dwivedi and Shukla (1958), Paradkar and Senad (1984) contributed further to the knowledge of *Sahnianthus*. Shukla (1950) instituted *Sahnipushpam*—another bisexual flower from the chert of Mohgaon-Kalan. Verma (1956) proposed *Sahnipushpam shuklai*—the type species for the genus followed by *S. glandulosum* by Prakash (1956) from the same locality. Prakash and Jain (1964) reinvestigated *Sahnipushpam* and made *S. glandulosum* a junior synonym of *S. shuklai*. Chitaley and Kate (1974) described *Deccanthus savitrii*—a bisexual flower from the same locality. Paradkar (1971) proposed *Chitaleypushpam mohgaoense* from Mohgaon-Kalan. Chitaley and Patel (1975) described a new bisexual flower and named it as *Raoanthus*. Lakhanpal *et al.* (1975, 1982), Bande (1993) investigated a monocotyledonous inflorescence. Bonde (1996) reported *Arecoideostrobus*—a palm rachilla from the intertrappean bed.

SYSTEMATICS

Genus—FLOSFEMINA gen. nov.

Type Species—FLOSFEMINA INTERTRAPPEA sp. nov.

Generic Diagnosis—Flowers bracteate, unisexual, 2-5 mm long, 1·8-2 mm broad, with two perianth whorls, perianths extend up to apex of the ovary, probably fused at base. Gynoecium 2-4 mm long, ovary superior, unilocular, ovules many, anatropous, placentation free central, placenta present up to half length of ovary, style long, stigma bifid.

Description—Two bracts observed in L.S. below the base of perianth extending for roughly one third length of flower. Perianth arising from basal part of ovary, lower part swollen, stalk free, some tissue made up of arenchymatous cells could be observed, same cellular structure was also seen as remnant parts of perianth at apical region. Vascular supply extends from basal part of ovary to perianth (Fig. 2).

Ovary unilocular, marginal cells composed of 3-4 layers of thick walled cells, seems to be lignified, stalked, oval with a broad base, ovules many, placenta slender, a central vascular supply within parenchymatous tissue of placenta seen, vascular strands with annular and spiral thickenings, style short, almost surrounded by perianth lobes, style slender, upper part well preserved in one specimen, cells parenchymatous, rectangular in shape, a fine vascular strand observed running longitudinally. Stigma seems to be bifid perhaps due to mechanical injury. Vascular supply occasionally observed reaching up to stigma.

Comparison—Flosfemina is readily separated from all the fossil flowers of Deccan Intertrappean by its unisexuality and unilocular ovary with free central placentation. *Sahnianthus* Shukla (1944) is a bisexual, trimerous flower with a tubular calyx, 6-8 locular ovary and axile placentation. *Sahnipushpam* Shukla (1950) is also a bisexual flower in which the receptacle forms a cup like hypanthium enclosing the pentalocular ovary with basal placentation. *Deccananthus* Chitaley and Kate (1974) is bisexual with six perianth parts found in two whorls around a syncarpous, tricarpellary ovary. *Chitaleypushpam* Paradkar (1971) and *Raoanthus* Chitaley and Patel (1975) are also bisexual.

FLOSFEMINA INTERTRAPPEA sp. nov.

(Pl. 1·1-2)

Holotype—Pl. 1·1 Slide No. BSIP 12004.

Type Locality—Mohgaon-Kalan, Deccan Intertrappean, Maastrichtian, Chhindwara District, Madhya Pradesh.

Specific Diagnosis—As for the genus.

Remarks—Flowers observed so far only in L.S. Among dicots, unisexual flowers are present in many families e.g., Casuarinaceae, Piperaceae, Chloranthaceae, Salicaceae, Garryaceae, Leitneriaceae, Betulaceae, Moraceae, etc. So it would be difficult to compare the female flower described here by this character alone. However, unilocular, superior ovary with free central placentation are found mostly in Balanophorales and Primulales (Lawrence, 1951; Cronquist, 1988). Of the Balanophorales, Aristolochiaceae has got bisexual flowers and Rafflesiaceae is either dioecious or monoecious. But the flowers in Rafflesiaceae are very big in size.

The Primulales are generally gamopetalous with pentamerous flowers and are divided into Theophrastaceae, Myrsinaceae and Primulaceae. In Theophrastaceae, the flowers are either bisexual or unisexual but the unilocular ovary is 5 carpelled whereas in the present specimen there is only one carpel. Myrsinaceae has also bisexual or unisexual flowers but the carpels bear 4-6 locules. Primulaceae has only bisexual flowers and the carpels are 5 in number. So the flower described here is not assignable to any known families of angiosperms.

Genus—FLOSVIRULIS gen. nov.

Type Species—FLOSVIRULIS DECCANENSIS sp. nov.

Generic Diagnosis—Perianth lobes six with imbricate aestivation, one lobe overlapped by adjacent two lobes. Six pairs of anther chambers observed within perianth lobes. Pollen grains surrounded by parenchymatous anther wall. Pollen grains subtriangular-subcircular, tricolporate, anguloaperturate, exine up to 2 μm thick, laevigate.

Description—Specimen studied only in T.S., represented by perianth lobes and anthers. Perianth lobes in T.S. distinct, unequal in size, six lobes could be traced; aestivation seems to be imbricate, six pairs of pollen chamber confined within perianth lobes indicate perhaps dithecal nature of anthers, filaments, however not observed in T.S. Each anther lobe contains numerous mature and immature pollen surrounded by anther wall made up of parenchymatous cells. Pollen grains generally subtriangular, sometimes subcircular in shape, some pollen also observed in dyad and tetrad condition, size range 18-25 μm, anguloaperturate, tricolporate, colpi long, narrow, slit-like, pore distinct, less than 2 μm in diameter, exine 1·5-2 μm thick, laevigate.

Comparison—The earlier flowers described from the Deccan Intertrappean beds of India viz., *Sahnianthus* Shukla (1944), *Sahnipushpam* Shukla (1950), *Chitaleypushpam* Paradkar (1971), *Deccananthus* Chitaley and Kate (1974), *Raoanthus* Chitaley and Patel (1975) are all bisexual and hence are readily distinguished from the present unisexual male flower.

FLOSVIRULIS DECCANENSIS sp. nov.

(Pl. 1·3)

Holotype—Pl. 1·3. Slide No. BSIP 12004.

Type Locality—Mohgaon-Kalan, Deccan Intertrappean, Maastrichtian, Chhindwara District, Madhya Pradesh.

Specific Diagnosis—As for the genus.

Remarks—Anguloaperturate, tricolporate pollen grains are found in Apocynacee, Barbeyaceae, Clethraceae, Cneoraceae, Nyssaceae, Strasburgeriaceae, Theaceae, Tiliaceae, Trochodendraceae, Ulmaceae, Verbenaceae, Vitaceae and Vochysiaceae (Erdtman, 1952). However, the pollen grains of these families are not closely comparable to the present genus except *Clethra* of Clethraceae. The pollen of *Clethra* are also anguloaperturate, 15-30 μm in size, tricolporate and the exine is more or less laevigate. But the flowers in Clethraceae are bisexual, the calyx are 5 lobed, imbricate, polypetalous, petals distinct. stamens generally 10 in two whorls (Lawrence, 1951). Hence, *Flosvirulis* proposed here is readily distinguished from Clethraceae in having unisexual flower.

None of the dispersed pollen recovered and illustrarted from the various intertrappean and equivalent beds by Chitaley (1951), Baksi and Deb (1981), Mathur and Sharma (1990), Prakash *et al.* (1990), Bonde and Kumaran (1993), Sahni *et al.* (1996) and Kar and Srinivasan (1998) is comparable to the pollen of this male flower.

Presence of tricolporate pollen in the Maastrichtian of India shows that this type of aperture was prevalent in India, U.S.A. and other countries in that time. Doyle (1969) suggested that the evolution of angiospermic aperture from monosulcates (*Clavatipollenites* type) during Barremian-Aptian to tricolpate and tricolporoidate in Albian. According to him tricolporate with triangular amb evolved in the Cenomanian. Friis *et al.* (1997) reported *Anacostia*--an angiosperm from Early Cretaceous of North America and Portugal with trichotomocolpate/monocolpate pollen. Nair (1968, 1970) on the other hand assumed that trichotomosulcate pollen rather than sulcate pollen represents the basal, primitive pollen type in the Ranales. Walker (1974) advocated that in the ranalean complex, anasulcate pollen gave rise to zonasulcate, trichotomosulcate, ulcerate, catasulcate and inaperturate forms. He postulated that it is from this inaperturate type that the colpate, colporate and porate types evolved.

Acknowledgements—*Sincere appreciation is expressed to the Department of Science and Technology, Government of India, New Delhi for sanctioning a project entitled "Deccan Intertrappean*

palynoflora and its implication for the demarcation of K-T boundary" (ESS/CA/A4-16/96) under the auspices of which the present work was done. Thanks are also due to Professor Anshu Kumar Sinha, Director, Birbal Sahni Institute of Palaeobotany, Lucknow for providing the infrastructural facilities for the project.

REFERENCES

Baksi AK 1987. Critical evaluation of the age of the Deccan Traps, India : Implications for flood-basalt volcanism and faunal extinctions. Geology 15 : 147-150.

Baksi SK & Deb U 1981. Palynology of the Upper Cretaceous of the Bengal Basin, India. Review of Palaeobotany and Palynology 31 : 335-365.

Bande MB 1993. Further observations on the structure and affinities of *Monocotylostrobus bracteatus* Lakhanpal, Prakash & Bande from the Deccan Intertrappean beds of India. Palaeobotanist 42 : 78-85.

Bonde SD 1996. *Arecoideostrobus moarei* nov. a palm rachilla from Deccan Intertrappean beds of India. Palaeobotanist 43 : 102-109.

Bonde SD & Kumaran KPN 1993. A liliaceous inflorescence from the Deccan Intertrappean beds of India. Current Science 65 : 776-778.

Chitaley SD 1951. Fossil microflora from the Mohgaon Kalan beds of Madhya Pradesh, India. Proceedings of the National Institute of Sciences, India 17 : 373-381.

Chitaley SD 1955. A further contribution to the knowledge of *Sahnianthus*. Journal of the Indian Botanical Society 34 121-129.

Chitaley SD & Kate UR 1974. *Deccananthus savitrii*, a new petrified flower from the Deccan Intertrappean beds of India. Palaeobotanist 21 317-320.

Chitaley SD & Patel MZ 1975. *Raoanthus intertrappea* a new petrified flower from India. Palaeontographica 153B 141-149.

Courtillot V, Besse J, Vandamme D, Montingny R, Gaeger JJ & Cappetta H 1986. Deccan flood basalts at the Cretaceous/Tertiary Boundary. Earth and Planetary Science Letters 80 : 361-374.

Courtillot V, Feraud G, Malluski H, Vandamme D, Morean MG & Besse J 1988. Deccan flood basalts and the Cretaceous/Tertiary Boundary. Nature 333 . 843-846.

Courtillot V, Feraud G, Malluski H, Vandamme DJJ & Javoy M 1990. Deccan volcanism at the Cretaceous/Tertiary Boundary : data and inferences. Geological Society of America, Special Paper 247 : 401-409.

Cronquist A 1988. *The evolution and classification of flowering plants*. The New York Botanical Garden, Bronx, New York, USA.

Deshmukh SS 1990. Some aspects of Deccan volcanism in relation to biotic extinctions and Cretaceous-Tertiary Boundary. *In* . Sahni A & Jolly A (Editors)—Cretaceous event stratigraphy and the correlation of the Indian nonmarine stratigraphy. Contributions from the Seminar-cum-Workshop IGCP 216 & 245, Chandigarh : 115-117.

Dilcher DL & Crane PR 1984. *Archaeanthus* : an early angiosperm from the Cenomanian of the western interior of North America. Annals Missouri Botanical Garden 71 : 351-383.

Doyle JA 1969. Cretaceous angiosperm pollen of the Atlantic Coastal plain and its evolutionary significance. Journal of the Arnold Arboretum Harvard University 50 : 1-35.

Duncan RA & Pyle DG 1988. Rapid eruption of the Deccan flood basalts at the Cretaceous-Tertiary Boundary. Nature 333 : 841-843.

Dwivedi JN & Shukla RK 1958. On the pollen grains and pollination of *Sahnianthus parijai* Shukla from the Intertrappean beds of the Deccan. Journal of the Palaeontological Society of India 3 : 105-108.

Erdtman G 1952. Pollen morphology and plant taxonomy Angiosperms (An introduction to Palynology 1). Almqvist & Wiksell, Stockholm.

Friis EM, Crane PR & Pedersen KR 1997. *Anacostia*, a new basal angiosperm from the Early Cretaceous of North America and Portugal with trichotomocolpate/monocolpate pollen. Grana 36 225-244.

Friis EM, Pedersen KR & Crane PR 2001. Fossil evidences of water lilies (Nymphaeales) in the Early Cretaceous. Nature 410 357-360.

Ghevariya ZG 1988. Intertrappean dinosaurian fossils from Anjar area, Kutch District, Gujarat. Current Science 57 . 248-251

Ghevariya ZG & Srikarni C 1990. Anjar Formation, its fossils from Anjar area, Kachchh District, Gujarat. Current Science 57 : 248-251.

Hallam A 1988. A compound scenario for the end-Cretaceous mass extinction. Revista Espanola de Paleontologia no. Extraordinario 7-20.

Kar RK & Srinivasan S 1998. Late Cretaceous palynofossils from the Deccan Intertrappean beds of Mohgaon-Kalan, Chhindwara District, Madhya Pradesh. Geophytology 27 . 17-22.

Lakhanpal RN, Prakash U & Bande MB 1975. An angiospermous inflorescence from the Deccan Intertrappean Series of India. Geophytology 5 : 229-230.

Lakhanpal RN, Prakash U & Bande MB 1982. A monocotyledonous inflorescence from the Deccan Intertrappean beds of India. Palaeobotanist 30 : 316-324.

Lawrence GHM 1951 *Taxonomy of Vascular Plants*. The Macmillan Company, New York.

Mathur YK & Sharma KD 1990. Palynofossils and age of the Ranipur Intertrappean Bed, Gaur River, Jabalpur, M.P. *In* : Sahni A & Jolly A (Editors)—Cretaceous event stratigraphy and the correlation of the Indian nonmarine stratigraphy. Contributions from the Seminar-cum-Workshop, IGCP 216 & 245, Chandigarh : 115-117.

Mohr B & Friis EM 2000. Early angiosperms from the Aptian Crato Formation (Brazil), a preliminary report. International Journal of Plant Sciences Supplement 6 : 155-167.

Nair PKK 1968. A concept on pollen evolution in the "Primitive" angiosperms. Journal of Palynology 4 : 15-20.

Nair PKK 1970. Pollen morphology of angiosperms - a historical and phylogenetical study. Lucknow Publishing House, Lucknow.

Paradkar SA 1971. *Chitaleypushpam mohgaonense*, gen. et sp. nov. from the Deccan Intertrappean beds of India. Silver Jubilee Volume of the Birbal Sahni Institute of Palaeobotany, Lucknow : 77 (Abstract).

Paradkar SA & Senad VA 1984. *Sahnianthus parijai* Shukla - reinvestigated. Fifth Indian Geophytological Conference

Proceedings Symposium and Technical Sessions. The Palaeobotanical Society, Lucknow : 138-146.

Prakash U 1956. On the structure and affinities of *Sahnipushpam glandulosum* sp. nov. from the Deccan Intertrappean Series. Palaeobotanist 4 : 91-100.

Prakash U & Jain RK 1964. Further observations on *Sahnipushpam* Shukla. Palaeobotanist 12 : 128-139.

Prakash T, Singh RY & Sahni A 1990. Palynofloral assemblage from the Padwar Deccan Intertrappeans (Jabalpur), M.P. *In* : Sahni A & Jolly A (Editors)—Cretaceous event stratigraphy and correlation of the Indian nonmarine strata. Contributions from the Seminar-cum-Workshop IGCP 216 & 245, Chandigarh : 68-69.

Sahni A 1990. Recent advances and short-comings in understanding nonmarine Cretaceous basins of India. Proceedings of IGCP 216 & 245 Seminar-cum-Workshop (Chandigarh) : 18-21.

Sahni A & Bajpai S 1988. Cretaceous-Tertiary Boundary events; the fossil vertebrate, palaeomagnetic and radiometric evidences from peninsular India. Journal of the Geological Society of India 32 . 382-396.

Sahni A, Venkatachala BS, Kar RK, Rajanikanth A, Prakash T, Prasad GVR & Singh RY 1996. New palynological data from the Deccan intertrappean beds: implications for the latest record of dinosaurs and synchronous initiation of volcanic activity in India. *In* : Sahni A (Editor)—Cretaceous Stratigraphy and Palaeoenvironments. Memoir Geological Society of India 37 : 267-283.

Shukla VB 1944. On *Sahnianthus*, a new genus of petrified flowers from the Intertrappean beds at Mohgaon Kalan in the Deccan and its relation with the fruit *Enigmocarpon parijai* Sahni from the same locality. Proceedings of the National Academy of Sciences, India 14 : 1-39.

Shukla VB 1950. *Sahnipushpam* gen. nov. and other plant remains from the Deccan Intertrappeans. Palaeobotany in India. Journal of the Indian Botanical Society of India 29 : 29.

Sun G, Ji Q, Dilcher DL, Zheng S, Nixon KC & Wang X 2002. Archaefructaceae, a new basal angiosperm family. Science 296 : 899-904.

Takahashi M, Crane PR & Ando H 1999a. Fossil flower and associated plant fossil from Kamikitaba Locality (Ashizawa Formation, Futaba Group, Lower Coniacian, Upper Cretaceous) of northeast Japan. Journal of Plant Research 112 : 187-206.

Takahashi M, Crane PR & Ando H 1999b. *Esgueiria futabensis* sp. nov., a new angiosperm flower from the Upper Cretaceous (Lower Coniacian) of northeastern Honshu, Japan. Paleontological Research 3 : 81-87.

Verma JK 1956. On a new petrified flower, *Sahnipushpam shuklai* sp. nov. from the Intertrappean beds of Mohgaon-Kalan in the Deccan. Journal of the Palaeontological Society of India 1 131-141.

Walker JW 1974. Aperture evolution in the pollen of primitive angiosperms. American Journal of Botany 61 : 1112-1136.