# On the Indian origin of *Ocimum* (Lamiaceae) : a palynological approach

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Hexacolpate pollen grains recovered from a bore hole core no.K 12, drilled by the MECL at Kuchaur-Benia area, Bikaner District, Rajasthan closely resemble the extant pollen of *Ocimum* spp. by their size range, shape, pluricolumellate reticulation and presence of columella in lumina. The palynological assemblage from where these grains were recovered indicates an Early Eocene age. Since this is the oldest record of fossil *Ocimum* pollen known so far it is postulated that the genus *Ocimum* originated in India.

**Key-words**—Palynology, *Ocimum*, Origin, Early Eocene (India).

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**सारांश**

***ओसिमम्* (लेमिएसी) की भारतीय उत्पत्ति : एक परागाणविक दृष्टिकोण**

रंजीत कुमार कर

राजस्थान में बिकानेर जनपद में कुचौर-बेनिया क्षेत्र में वेध-छिद्र क्रोड़ के०-12 से उपलब्ध षटविदरकी परागकण *ओसिमम* प्रजाति के वर्तमान परागकणों से सजातीयता व्यक्त करते हैं। इस वेध-छिद्र से उपलब्ध परागाणविक समुच्चय की आयु प्रारम्भिक आदिनूतन आँकी गई है। चूंकि *ओसिमम्* के अश्मित परागकणों का यह सबसे पुराना अभिलेख है अतः यह प्रस्तावित किया गया है कि *ओसिमम्* की उत्पत्ति भारत में ही हुई थी।

THE family Lamiaceae (Labiatae) consists of about 180 genera and 3500 species. It is mostly concentrated in the Mediterranean region but according to Willis (1973) some groups have localised distribution in Australia, Tasmania, India, etc. Some of the genera of Lamiaceae like *Mentha* and *Lycopus* are marshy plants, some are climbers (*Stenogyne*). Most of them are herbs, but few like *Hyptis* are small trees; while *Gomphostemma* excels in the rain forest.

Mukerjee (1940) remarked that of the Indian Lamiaceae, the most common genera are *Leucas, Nepeta, Plectranthus, Pogostemon, Salvia, Scutellaria* and *Gomphostemma*. *Ocimum* is a small genus and only 9 species are found in India. Of which, three are exotic. All the species of *Ocimum* have hexacolpate pollen grains. Polycolpate pollen are common in the Early Tertiary sediments of India and reported by many a palynologists. Sahni, Sitholey and Puri (1947) were the first to report a polycolpate pollen from the Early Miocene sediments of Assam. Rao and Vimal (1950, 1952), Bose (1952), Vimal (1952, 1953) and many others described various types of polycolpate grains from different Tertiary sediments of India (see Saxena, 1982). These pollen are accommodated in more than 30 genera. Saxena (1982) observed that a number of these genera were proposed on minor differences, while in others pollen having distinguishing characters were clubbed together into one genus.

At present polycolpate pollen are found in a number of families, viz., Bruniaceae, Chloranthaceae, Ctenolophonaceae, Didiereaceae, Euphorbiaceae, Lamiaceae, Papaveraceae, Pedalliaceae, Polygalaceae, Saxifragaceae, Scrophulariaceae, etc. It leads to a logical assumption that the fossil polycolpate pollen were also produced by diverse families. These groups of plants are, however, difficult to

identify by studying the pollen alone in the dispersed condition, because in most of the cases they are devoid of any special morphological feature.

The pollen of *Ctenolophon* of the family Ctenolophonaceae is an exception. It has ring like, occasionally branched exinal thickenings, one in each apocolpium and are interconnected by meridional thickenings. By this character it could be traced from Maestrichtian to present day. According to Muller (1981), many of the polycolpate pollen described by Baksi (1962), Mathur (1966), Sah and Dutta (1968, 1974), Venkatachala and Kar (1969), Venkatachala and Rawat (1972), Rawat *et al.* (1977) could be accommodated in *Ctenolophon parvifolius* type. The parentage of rest of the polycolpate pollen could not be definitely ascertained.

The present study deals with a type of hexacolpate pollen recovered from a bore core (no. K 12) drilled by the MECL at Kuchaur-Benia area, about 30 km south west of Bikaner on Bikaner-Nagaur road, Rajasthan. The area covered by alluvium is also presently investigated by the Geological Survey of India for lignite exploration. The thickness of the lignite is about 1- 2 m thick and is roughly found 80 m below the surface. In all, 10 samples from the bore core no. K 12 were collected at the depth of 134 m, 125 m, 122 m, 121 m, 98 m, 97 m, 95 m, 90 m, 85 m and 80 m, respectively. The lithology of the bore hole core and location of samples are provided in Text-figures 1 and 2. All the samples yielded spores and pollen grains. The palyno-assemblage is dominated by the angiospermic pollen; the pteridophytic spores are rare and the gymnospermic pollen are absent. The common taxa are *Neocouperipollis kutchensis* Venkatachala & Kar 1969, *Tricolpites reticulatus* Cookson 1947, *Margocolporites tsukadai* Ramanujam 1966, *Lakiapollis ovatus* Venkatachala & Kar 1969, *Proxapertites operculatus* van der Hammen 1956, *Proxapertites cursus* van Hoekken-Klinkenberg 1966, *Calophyllumpollenites rotundus* Sah & Kar 1974, etc. On the basis of palynoflora an Early Eocene age is ascribed to the assemblage. Rao and Vimal (1950), Sah and Kar (1974) and others worked on the Early Tertiary palynofossils of Rajasthan. Besides, some new forms are also present in the assemblage. The hexacolpate form, described here, are first encountered at 134 m depth and very common at 80 m. The slides of the concerning palynomorphs have been deposited at the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

## GEOLOGY

The 'West Rajasthan Shelf', according to Das Gupta (1973), is made up of a number of sedimentary basins separated from each other by basement ridges. The Bikaner-Nagaur Basin is one of these basins while the others are Jaisalmer Basin, Barmer Basin and Sanchore Basin. The major part of these basins is, however, covered by sand and sand dunes making correlation and mapping an uphill task. Bhola (1940), Jacob and Sastri (1950), Singh (1951, 1952, 1953, 1971), Ghosh (1962), Khosla (1967, 1968), Shrivastava (1971), Das Gupta (1977), Pareek (1981), Singh (1984) and others studied the geology of this shelf. Shrivastava (1971) proposed a rock stratigraphic classification of Bikaner-Nagaur area as under:

| | | |
|---|---|---|
| Quaternary | Mar Formation | Dirty white, brown ferruginous, medium to coarse grained, gritty and conglomeratic, current bedded sand with minor variegated shale and clay (560 ft thick). |
| | Jogira Formation | Nummulitic yellow limestone, marl, test beds, foraminiferal limestone and grey to yellow Fuller's earth (520 ft thick). |
| Tertiary | Palana Formation | Variegated clays, interbedded nummulitic limestone and marls with dark to grey sticky clays and minor sandstones : lignite at places (700 ft thick). |
| Triassic | Mayakor Formation | Dark coloured ferruginous and interbedded sandstones and conglo-merates (100 ft thick). |
| Palaeozoic | Badhaura Formation | Yellow to red coloured gritty sandstone, interbedded ferruginous and variegated clays. Bap boulders contain boulders of igneous and metamorphic rocks (100 ft thick). |

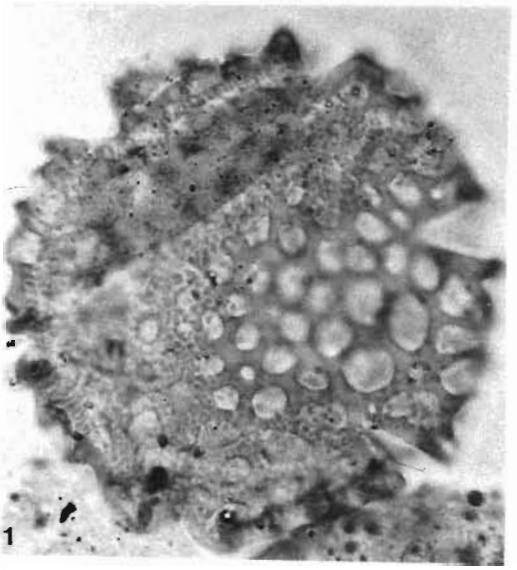
## PLATE 1

(All photomicrographs are enlarged *ca.* x 1000, unless otherwise mentioned)

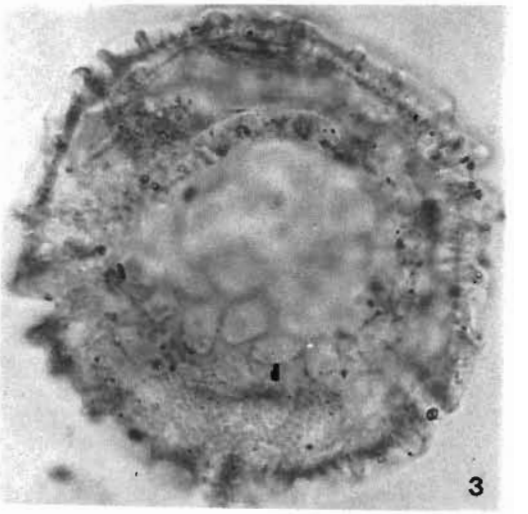
1-6,8. *Ocimumpollenites indicus* gen. et sp. nov., Slide nos. 11285, E27/1; 11275, K29/1; 11286, E26/1; 11275, M18/2; 11286, D28/3; 11275, K29/1.

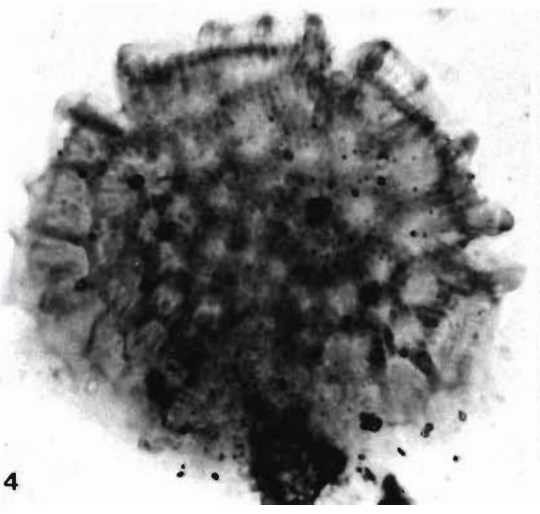
2-5. Parts of exine showing pluricolumellate reticulation.

7. Pollen of *O. basilicum* showing the disposition of colpi.

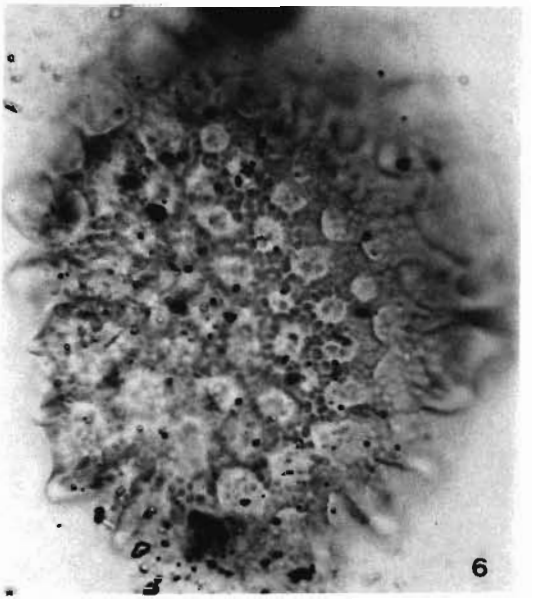


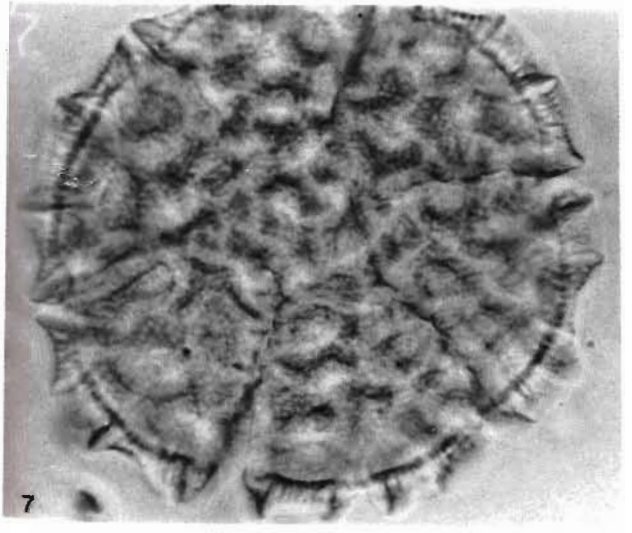








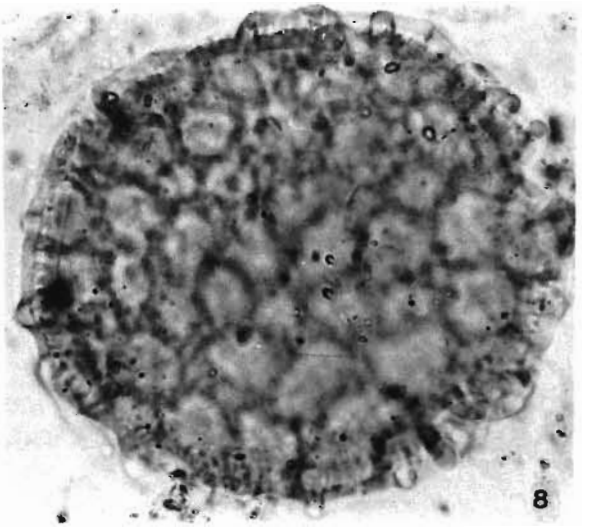




**PLATE 1**

## SYSTEMATIC DESCRIPTION

**Genus—*Ocimumpollenites* gen. nov.**

Type species—*Ocimumpollenites indicus* sp. nov.

*Generic diagnosis*—Pollen grains subcircular-circular in polar view, size range 56-72 µm, 6 colpate, brevicolpate, colpi slit-funnel shaped in polar view. Exine 2-4 µm thick, sexine thicker than nexine. Tectate, columellate, some columella fused at top but free at base, reticulation broad, muri pluricolumellate, columella also present in lumina.

*Comparison*— *Retistephanocolporites* van der Hammen & Wijmstra 1964 is distinguished from the present genus by its colporate nature. Similarly, *Psilastephanocolporites* Leidelmeyer 1966 is differentiated by its colporate condition and laevigate exine and *Stephanocolporopollenites* Thomson & Pflug 1953 is mostly porate. *Ocimumpollenites* proposed here is distinguished from all the polycolpate forms by its thick exine, pluricolumellate reticulation and presence of columella in lumina.

*Ocimumpollenites indicus* sp. nov.
Pl. 1, figs 1-6, 8

*Holotype*—Pl. 1, fig. 4, size 65x60 µm, Slide no. 11275, M 18/2.

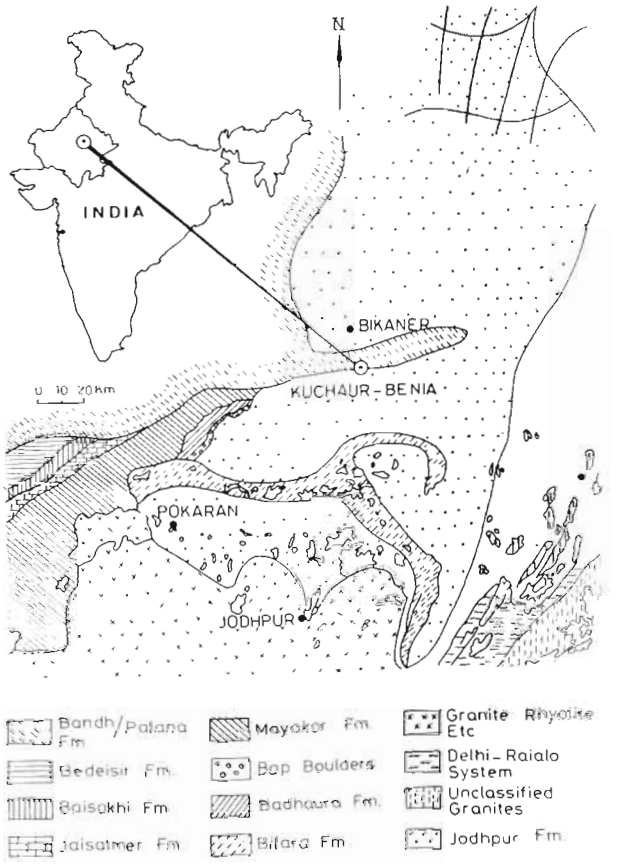
*Type locality*—Bore hole core no. K 12, depth 80 m, Palana Formation, Early Eocene, Bikaner District, Rajasthan.

*Description*—Pollen grains mostly found in polar view, subcircular-circular, 56-68 x 54-65 µm, hexacolpate, brevicolpate, colpi generally slit like, distinct. Exine 2-4 µm thick, sexine thicker than nexine; tectate, columellate, columella closely placed, some columellae fused at top but free at base. Reticulate, reticulum broad, square-rhomboidal in shape, muri pluricolumellate, few columella also present in lumina.

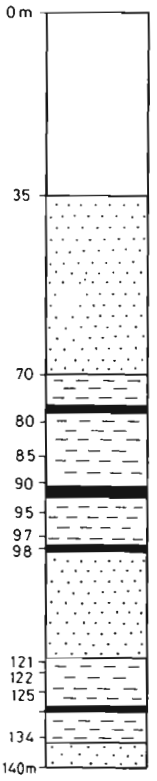
*Remarks*—Muller (1981) thinks that there are only few fossil records of undoubted Lamiaceous pollen. Embolden (1964) described fossil *Salvia* pollen from the Late Miocene of Alaska. Van Campo (1976) reported some Lamiaceous pollen from the Late Miocene of Spain while Menke (1976) reported same type of pollen from the Pliocene of Germany. Boltenhagen (1976a, 1976b) reported some pollen resembling *Salvia* as *Hexacolpites mitchedlichvilii* from the Coniacian of Gabon. Muller (1981), in view of the similar pollen occurring in other genera of Lamiaceae and considerable stratigraphic hiatus between his and other records kept this finding as pending.

According to Erdtman *et al.* (1961) Lamiaceae is basically a stenopalynous family having either 3 or 6 colpi. Ikuse (1956) in his treatise on the pollen grains of Japan also included some Lamiaceous pollen. Embolden (1964), Nair (1965), Henderson *et al.* (1968), Varghese and Verma (1968), Vij and Kashyap (1975), Markgraf and d'Antoni (1978), Bir and Saggoo (1981), Forlani (1981), Saggoo and Bir (1983), Gupta and Sharma (1986) investigated pollen grains of Lamiaceae. Gupta and Sharma (1990) worked on the polymorphism in pollen of *Salvia leucantha*.

A comparative study of pollen morphology and cytology investigated by Leitner (Erdtman, 1952) in-




**Text-figure 1**—Geological map of the area showing the locality.




**Text-figure 2**—Showing the litholog of the bore-hole core.

dicates that tricolpate pollen are shed in 2 nucleate stage and hexacolpate pollen in 3 nucleate stage. This led Erdtman to divide Lamiaceae into two broad groups. In the group with 2 nucleate stage having 3-4 colpi he included Ajugoideae (except Rosmarineae), Prostantheroideae, Prasinoideae, Scurtellarioideae and Stachyoideae (in parts). In the other group, he placed Rosamarineae of Ajugoideae, Lavanduloideae, Stachyoideae (*Salvia* and others), Ocimoideae and Catopherioideae.

Varghese and Verma (1968) worked on the pollen grains of some Indian Lamiaceae (Labiatae). They observed hexacolpate pollen grains in different species of *Salvia, Elsholtzia, Micromeria, Origanum, Calamintha, Thymus, Ocimum, Plectranthus* and *Coleus*. Of all these genera, *Ocimum* pollen described and illustrated by them resemble the fossil pollen described here by thick exine, pluricolumellate, broad reticulation and presence of columella in the lumina. The pollen grains of *Salvia coccinea* (Varghese & Verma, 1968, fig. 5) and *Plectranthus gerardinus* (Varghese & Verma, 1968, figs 11-12) have also pluricolumellate reticulation but the columella are absent in lumina. Erdtman (1952, fig. 130C, p. 218) illustrated the pollen of *Catopheria chiapensis*. Here the reticulation is simplibaculate and the colpi margin is provided with granulate membrane.

*Ocimum basalicum* pollen illustrated by Reille (1992, p. 171) closely resemble *Ocimumpollenites* by its hexacolpate condition and ornamentational pattern. Reille (1992) described several species of *Polygonum*. Most of them are either tricolporate (e.g., *P. bistoria, P. aviculare*) or periporate (viz., *P. hydropiper, P. minus*) and only *P. amplexicaule* is pentacolpate.

*Pollen of Ocimum*—From the above discussion it is clear that the fossil pollen described here closely resemble the pollen of extant *Ocimum*. To ascertain the nearest resembling species, the pollen of *Ocimum basilicum, O. sanctum, O. americanum* and *O. kilimandscharicum* were examined at the French Institute, Pondicherry (courtsey of Dr C. Caratini). The pollen grains of these 4 species are very similar to each other in size range, hexacolpate nature, pluricolumellate reticulation and presence of columella in lumina. Thus it was very difficult to tag the fossil pollen with the pollen of any particular living species of *Ocimum*.

*Present distribution—Ocimum* is a genus of aromatic herbs, undershrubs or shrubs distributed generally in the tropics. Zaheer *et al.* (1966) remarked that the nomenclature of *Ocimum* species is complicated and confused. Mukerjee (1940) revised the Lamiaceae of the Indian subcontinent and remarked that the tribe Ocimoideae with the exception of *Lavandula* is confined to the East and tropical Africa and is almost entirely absent in other parts of the world. According to him, *Ocimum basalicum* is confined to India, Malay Peninsula, China, Formosa and Polynesia. *Ocimum sanctum* is found in India, Malay Peninsula, China, Pacific Islands, Australia, western Asia, Arabia and Japan. *O. americanum* flourishes in India, China, Japan, Western Asia, tropical Africa, Madagascar and America (cultivated). *O. kilimandscharicum* is originally a plant of tropical Africa but grows luxuriantly in the plains of India (Text-figure 3).


**Text-figure 3**—Showing the present day distribution of *Ocimum*.

*Homeland of Ocimum*—The distributional pattern of different species of *Ocimum* enumerated above points out that India occupies a central region from where the different species might have migrated towards east and west except *O. kilimandscharicum* which seems to be migrated to India from the tropical Africa. The occurrence of fossil *Ocimum* pollen in the Early Eocene of Rajasthan also substantiates this assumption. *Hexacolpites mitchedlichvilii* described by Boltenhagen (1976a, 1976b) from the Coniacian of Gabon is presumably Salviaceous pollen. The records of Embolden (1964), van Campo (1976) and Menke (1976) are from Late Miocene to Pliocene and supposed to be of *Salvia* and *Mentha* types of pollen. Since the present record happens to be the oldest record of *Ocimum* known so far it may be assumed that *Ocimum* originated in India and then migrated towards east and west.

Croizat (1952) observed that to investigate the *genorheitron* of Lamiaceae (Labiatae) is a difficult task as practically uninterrupted chain of intermediates could be aligned to associate Lamiaceae with Scrophulariaceae, Verbenaceae, Avicenniaceae, Acanthaceae, etc. He commented that the southern waters of the modern world are firmly held in the grip of Lamiaceous plants. So whether some plants are American or Asiatic in origin is nothing but mincing of words. However, since we are dealing only with

*Ocimum* which has rather a restricted distribution and undoubted fossil pollen record in the Early Eocene sediments of India we are rather forced to advocate its origin in India.

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## REFERENCES

Baksi SK 1962. Palynological investigation of Simsang River Tertiaries, South Shillong Front, Assam. *Bull. geol. Min. metall. Soc. India* **26**: 1- 22.

Bhola KL 1940. A short note on Fuller's earth deposits of Jodhpur State, Rajasthan. *Bull. geol. Min. metall. Soc. India* **12**: 83-96.

Bir SS & Saggoo MIS 1981. Cytopalynology of certain Acanthaceae and Labiatae. *J. Palynol.* **17**: 93-102.

Boltenhagen E 1976a. Pollen et spores Senoniennes du Gabon. *Cah. Micropaleont.* **3**: 1-21.

Boltenhagen E 1976b. La microflore Senoniennes du Gabon. *Rev. Micropaleont.* **18**: 191-199.

Bose MN 1952. Plant remains from Barmer District, Rajasthan. *J. Scient. Indian Res.* **11B**(5): 185-190.

Cookson IC 1947. Plant microfossils from the lignites of Kerguelen archipelago. *Rept. B.A.N.Z. Antarct. Exped.* Ser. A: 129-142.

Croizat L 1952. *Manual of Phytogeography on an account of plant dispersal throughout the world.* Uitgeverij Junk, The Hague.

Das Gupta SK 1973. Hydrocarbon accumulation in the shelf sediments of Rajasthan. *Proc. Indo-Soviet Symp. Indian natn. Sci. Acad.*

Das Gupta SK 1977. The stratigraphy of the West Rajasthan Shelf. *Proc.4th Colloq.Indian Micropalaeont.Stratigr.*: 219- 233.

Embolden WA 1964. Pollen morphology of the genus *Salvia*, section Audibertia. *Pollen Spores* **6**: 527-536.

Erdtman G 1952. *Pollen morphology and plant taxonomy of Angiosperms: An introduction to palynology.* Almqvist & Wiksell, Stockholm.

Erdtman G, Berglund B & Praglowski J 1961 *An introduction to a Scandinavian pollen flora.* Almqvist & Wiksell, Stockholm.

Forlani L 1981. Atlas for Mediterranean pollen flora. *J. Palynol.* **17**: 3-36.

Ghosh PK 1962. Western Rajputana - its tectonics and mineral deposits including evaporites. *Proc. Symp. Rajputana Desert. Bull. natn. Inst. Sci. India* **1**: 101-130.

Gupta A & Sharma C 1990. Polymorphism in pollen of *Salvia leucantha* (Lamiaceae). *Grana* **29**: 277-284

Gupta HP & Sharma C 1986. *Pollen flora of north-west Himalaya.* Anuj Printers, Lucknow.

Henderson DM, Prentice H & Hedge IC 1968. Pollen morphology of *Salvia* and some related genera. *Grana Palynol.* **8** : 70-85.

Ikuse M 1956. *Pollen grains of Japan.* Hirokawa Publishing Co., Tokyo.

Jacob K & Sastri VV 1950. Some foraminifera from the Fuller's earth, Bikaner, Rajasthan. *Sci. Cult.***16**(2): 80-82.

Khosla SC 1967. A note on the stratigraphy and microfauna of the Kirthar beds of the Jaisalmer area. *Curr. Sci.* **36**(24): 670-671.

Khosla SC 1968. A note on the Eocene beds near Mudh village, district Bikaner. *Proc. 55 Indian Sci.Congr. (Abst.)*: 232-233.

Leidelmeyer P 1966. The Palaeocene and Lower Eocene pollen flora of Guyana. *Leid. geol. Meded.* **38**: 40-70.

Markgraf V & d'Antoni HL 1978. *Pollen flora of Argentina. Modern spore and pollen types of Pteridophyta, Gymnospermae and Angiospermae.* Univ. Arizona Press, Tuscon.

Mathur YK 1960. On the microflora in the Supra Trappeans of western Kutch, India *Q. J. Min. metall. Soc. India* **38**(1): 33-51.

Menke B 1976. Pliozane und altestquartare Sporen und Pollenflora von Schleswig - HoLstein. *Geol. Jahrb.* **32**(A): 3-197.

Mukerjee SK 1940. A revision of the Labiatae of the Indian Empire. *Rec. bot. Surv. India* **35**(1): 1-228.

Muller J 1981. Fossil pollen records of extant angiosperms. *Bot. Rev.* **47**(1): 1-142.

Nair PKK 1965. Pollen grains of Himalayan dephnes. *Palynol. Bull.* **1**: 52-54.

Pareek HS 1981. Basin configuration and sedimentary stratigraphy of western Rajasthan. *J. geol. Soc. India*. 22**(2)**: 517-528.

Ramanujam CGK 1966. Palynology of the Miocene lignite from South Arcot District, Madras, India. *Pollen Spores* **8**(1): 149-203.

Rawat MS, Mukherjee J & Venkatachala BS 1977. Palynology of the Kadi Formation, Cambay Basin, India. *Proc. 4th Colloq. Indian Micropalaeont. Stratigr., Dehradun*: 179-192.

Reille M 1992. *Pollen et spores d' Europe et d' Afreque du Nord. Lab. Bot. Hist. Palynol. Marseille* : 1-520.

Rao AR & Vimal KP 1950. Plant microfossils from Palana lignite (Eocene), Bikaner. *Proc. natn. Inst. Sci. India* **18**(6): 595-601.

Saggoo MIS & Bir SS 1983. Cytopalynological studies on Indian members of Acanthaceae and Labiatae. *J. Palynol.* **19**: 243-277.

Sah SCD & Dutta SK 1968. Palynostratigraphy of the Tertiary sedimentary formations of Assam-2.Stratigraphic significance of spores and pollen in the Tertiary succession of Assam. *Palaeobotanist* **16**(2): 177-195.

Sah SCD & Dutta SK 1974. Palynostratigraphy of the sedimentary formations of Assam-3. Biostratigraphic zonation of the Cherra Formation of South Shillong Plateau. *Palaeobotanist* **21**(1): 42-46.

Sah SCD & Kar RK 1974. Palynology of the Tertiary sediments of Palana, Rajasthan. *Palaeobotanist* **21**(2): 163-188.

Sahni B, Sitholey RV & Puri GS 1947. Palaeobotany in India - 6. Co- relation of Tertiary succession in Assam by means of microfossils. *J. Indian bot. Soc.* **26**: 261-263.

Saxena RK 1982. Taxonomic study of the palycolpate pollen grains from the Indian Tertiary sediments with special reference to nomenclature. *Rev. Palaeobot. Palynol.* **37**: 283-315.

Shrivastava BP 1971. Rock stratigraphic nomenclature for the sedimentaries of west central Rajasthan. *Bull. geol. Min. metall. Soc. India* **44**: 1-19.

Sigal J, Singh NP & Lys M 1971. The Palaeocene-Lower Eocene boundary in the Jaisalmer area (India). *J. Foram. Res.* **1**(4): 190-194.

Singh NP 1984. Addition to the Tertiary biostratigraphy of Jaisalmer basin. *Petr. Asia Jl.* :106-128.

Singh SN 1951. Kirthar foraminifera from Rajasthan *Curr. Sci.* **20**(9): 230.

Singh SN 1952. On the extension of Kirthar Sea to Rajasthan *Proc. natn. Acad. Sci. India* **22**(B): 7-10.

Singh SN 1953. Geology of the area WSW of Magh village near Kolyat, Bikaner, Rajasthan. *Proc. natn. Acad. Sci. India* **23**(1-111): 13-20.

Singh SN 1971. Planktonic foraminifera in the Eocene stratigraphy of Rajasthan, India. *Proc. II Plankt. Conf., Roma* : 1169-1181.

Thomson PW & Pflug H 1953. Pollen und sporen des Mitteleuropaischen Tertiars. *Palaeontographica* **94**: 1-138.

Van Campo E 1976. La flore sporopollenque du gisement Miocene terminal de Venta del Moro (Espagne). *Thesis.* Montpellier

Van der Hammen T 1956. A palynological systematic nomenclature. *Boln. geol. Bogota* **4**(2-3): 63-101.

Van der Hammen T & Wijmstra TH 1964. A palynological study on the Tertiary and Upper Cretaceous of British Guiana. *Leide geol. Meded.* **30**: 183-241

Van Hoekken-Klinkenberg PMG 1966. Maestrichtian Palaeocene and Eocene pollen and spores from Nigeria. *Leid. geol. Meded.* **38**: 37-48.

Varghese TM & Verma DPS 1968. Pollen morphology of some Indian Labiatae. *J. Palynol.* **4**: 77-83.

Venkatachala BS & Kar RK 1969. Palynology of the Tertiary sediments of Kutch 1. Spores and pollen from bore hole no. 14. *Palaeobotanist* **17**(2): 157-178.

Venkatachala BS & Rawat MS 1972. Palynology of the Tertiary sediments in the Cauvery Basin 1. Palaeocene Eocene palynoflora from the subsurface. *Proc. Sem. Palaeopalynol. Indian. Stratigr., Calcutta* : 292-335.

Vij SP & Kashyap SK 1975. Pollen grain studies in some Labiatae. *J. Palynol.* **11**: 29-42.

Vimal KP 1952. Spores and pollen from Tertiary lignites from Dandot. West Punjab (Pakistan). *Proc. Indian Acad. Sci.* **36**: 135-147

Vimal KP 1953. Tertiary spores and pollen from Warkalli Lignite, Travancore. *Proc. Indian Acad. Sci.* **38**: 195-210.

Willis JC 1973. *A dictionary of flowering plants and ferns (8th edition).* Cambridge Univ. Press, Cambridge.

Zaheer SH, Prasad B, Chopra RN, Santapau H, Krishnan MS & Deshaprabhu SB 1966. *The Wealth of India: a dictionary of Indian raw materials and industrial products. Raw Materials* **7**(N-Pe).C.S.I.R., New Delhi.