ISSN 0376-5156
Geophytology 50(1&2): 95–126
May 2022

Fossil-extant relationship in *Fungi* and its palaeoenvironmental significance: Indian perspective

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Manuscript received: 22 February 2022
Accepted for publication: 18 March 2022

ABSTRACT

Saxena R.K. & Wijayawardene N.N. 2022. Fossil-extant relationship in *Fungi* and its palaeoenvironmental significance: Indian perspective. Geophytology 50(1&2): 95–126.

Fossil fungal remains are commonly found in macerated residues prepared for palynological studies and occur in the form of spores, hyphae, sporocarps and mycorrhiza. In pre-Tertiary sediments of India, these are poorly represented but are abundant and highly diversified in Tertiary and Quaternary sediments. Sporocarps of epiphyllous fungi, recovered from the Indian Tertiary, can be compared with extant forms with greater accuracy than the spores. These are variously shaped, ostiolate or non-ostiolate bodies made up of radiating rows of mycelia giving an appearance of tissues arranged in a radiating fashion. It has been observed that except for some distinctive Tertiary forms, fossil fungal remains cannot be generally ascribed to extant taxa, hence they are often described as form genera under the Artificial System of Classification which is based on morphological characters. However, their affinities with extant genera or with taxon of higher rank are provided, wherever possible. In quite a good number of cases, fossil fungal species have been ascribed to extant genera. Three cases of fossil–extant relationship, e.g. *Mediaverrunites* Jarzen & Elsik ex Nandi & A. Sinha 2007 vs. *Potamomyces* K.D. Hyde 1995, *Polycellaesporonites* Anil Chandra et al. 1984 vs *Alternaria* Nees 1816 and *Frasnacritetrus* Taug. 1968 vs *Tetraploa* Berk. & Broome 1850, have been discussed in this paper. Tracing relationship of fossil forms with their extant counterparts is of utmost importance in placing them in the classification of *Fungi*. This is also indispensable in the interpretation of environment. Fossil epiphyllous fungi are more reliable and advantageous for palaeoclimatic interpretations and their occurrence reflects moist and humid climate of tropical to subtropical belts.

Keywords: Ascocarps, Fungal spores, fossil vs. extant fungi, palaeoenvironment, India.

INTRODUCTION

Fossil fungi are highly diversified. These are reported in the form of spores, mycelia, sporocarps and mycorrhiza. Fungal remains, commonly observed in the palynological preparations, have been sporadically recorded since long (e.g. Williamson 1878, 1880, Kidston & Lang 1921, Edwards 1922) but their study received more attention with the amplification of palynological studies since the 1950s. A great spurt in the fungal diversity is witnessed in Tertiary Period, suggesting that their proliferation is linked with diversification of angiosperms. The fossil records suggest that *Ascomycota*, the largest and most diversified group of modern fungi, got well established during the Cretaceous Period and became conspicuously abundant in the Tertiary Period (Jain 1974, Jansonius 1976, Jain & Kar 1979, Ramanujam 1982, Kalgutkar & Jansonius 2000, Tripathi 2009, Saxena & Tripathi 2011). The majority of dispersed fungal spores found in palynological preparations are produced by taxa belonging to *Ascomycota*.

Ascospores are produced, usually in groups of four or eight, inside a sac (ascus) by the so-called "perfect morph" (teleomorph or sexual morph) of these fungi. The "imperfect morph" (anamorph or asexual morph or conidial stage or mitosporic fungi) may produce several types of asexual spores, named as conidiospores (or conidia). The *Fungi* Imperfecti also, comprising a large group of fossil fungi with septate hyphae, reproduce by conidia and other asexual spores. Although their conidia are similar to those found in *Ascomycota*, the lack of a sexual (perfect) stage and also of DNA based phylogenetic analyses prevent linking them to the latter class (i.e. *Ascomycota*). Saprophytic *Ascomycota* may produce ascocarps of macroscopic size and definite shape. These occur above the ground, e.g. the cup fungi, or may remain subterraneous, as in truffles (e.g. some taxa in *Leotiomycetes*).

Based on characters, such as size, symmetry, pores and septa, the spores are described under different morphologic groups. Besides, sporocarps of epiphyllous fungi can be compared with extant forms with greater accuracy than the spores and are more reliable and advantageous for palaeoclimatic interpretations. The fructifications or the ascocarps are variously shaped, ostiolate or non-ostiolate bodies made up of radiating rows of mycelia, giving an appearance of tissues arranged in a radiating fashion. The ascocarps contain asci. Besides, studies particularly focusing the host-fungus relationship are of great significance in attempting the palaeoenvironmental interpretations.

During the last four decades or so, serious efforts have been made on the study of fossil fungi laying emphasis on their phylogenetic, stratigraphic and environmental aspects. In order to include all records of fossil fungal remains from the Indian Tertiary sediments, published till 2005, three catalogues were published (Lakhanpal et al. 1976, Saxena 1991, 2006). Data generated on fossil fungi are significant but a large number of fossil fungal forms needed taxonomic revision, as these were either not validly published or their diagnoses and status were not properly defined. Hence, many species of different genera were recombined with some other suitable genera (Saxena & Tripathi 2011).

CENOZOIC SEDIMENTS OF INDIA

As stated above, fossil fungi are most abundant in the Cenozoic sediments (Saxena & Tripathi 2011, Saxena et al. 2021), hence their brief account in India is given ahead. Cenozoic sediments are exposed in both

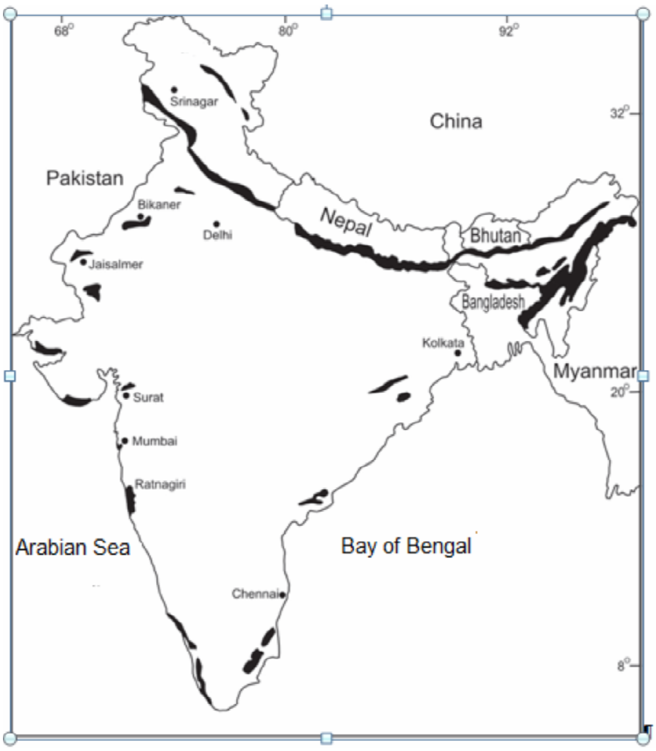

Figure 1. Map of India showing areas of Tertiary exposures from where fossil fungi have been recorded (Modified after Saxena & Tripathi 2012).

peninsular and extra-peninsular parts of India (Figure 1). In peninsular region, these sediments occur in eastern, north-eastern, southern and western parts of India. In extra-peninsular region, these rocks are distributed in wide geographical areas of Himalayan Foothills, Lesser as well as Tethys Himalayas. Early Tertiary rocks in Lesser Himalayas are characterized by marine sequences but those of the later part of this period are estuarine or fresh-water deposits. Collectively, these sediments are recognized as Subathu-Murree-Siwalik succession and range in age from Eocene to Early Pleistocene. Tertiary rocks of eastern India range in age from Palaeocene to Pliocene and are found in Andaman and Nicobar Islands and as subsurface sediments in Bengal Basin. Tertiary sediments are also extensively exposed in north-eastern part of India covering Assam, Meghalaya, Arunachal Pradesh and adjoining states. In Assam and Meghalaya, these are developed in the form of geosynclinal and shelf facies and are named differently. In south, Tertiary sediments occur along the eastern coastal strip of Cauvery Basin and Malabar and Coromandal coasts on the western side. In western part of India, Tertiary sediments are found in Rajasthan and Gujarat states. These sequences are known for extensive Tertiary deposits embodying many workable lignite seams. Complete sequence of Palaeocene to Pliocene sediments is developed in western and southern parts of the Kutch Basin, Gujarat. Tertiary sequence of Rajasthan and Cambay basins are largely covered with alluvium. In Rajasthan, these rocks range in age from Palaeocene to Early Eocene. The Cambay Basin sediments are of Palaeocene to Pliocene age.

FOSSIL-EXTANT RELATIONSHIP IN FUNGI

Wijayawardene et al. (2020a) published an outline of the classification of the Kingdom *Fungi* (including fossil fungi. i.e. dispersed spores, mycelia, sporophores, mycorrhizas) and placed all fungal genera at phylum-, class-, order- and family-level. This work was updated by Wijayawardene et al. (2022). Wijayawardene et al. (2020b) published details of the website http://outlineoffungi.org, which was launched to provide a continuous update of the above mentioned Outline of *Fungi* and presents an important platform for researchers, industries, government officials and other users. Saxena and Tripathi (2011) synthesized the available information on Indian fossil fungi published till then. Saxena et al. (2021) presented diversity in dispersed fossil fungal spores recorded so far and attempted to trace affinity of fossil fungi with the living ones. Needless to say that establishing relationship of fossil fungal remains with their extant counterparts is extremely useful in studies on evolution and environmental interpretation. A summary of Indian fossil fungal taxa and their affinities with extant fungal taxa of suprageneric ranks is presented in Table 1.

FOSSIL SPECIES DESCRIBED UNDER EXTANT GENERA

It has been observed that in most cases, fossil fungal remains cannot be ascribed to extant taxa, hence they are often described as form taxa under the Artificial System of Classification which is based on morphological characters only. However, their affinities with extant genera or with taxon (or taxa) of higher rank are provided, wherever possible. On the other hand, when it is possible to allocate fossil fungal specimens to extant taxa, they are described under extant species, e.g. *Annellophora mussaendae* M.B. Ellis., *Entophlyctis lobata* Willoughby & Townley, *Tetraploa aristata* Berk. & Broome, *T. ellisii* Cooke (Gupta 1970) or under extant genera, e.g. *Alternaria* sp. (Rao & Menon 1970, Sharma 1976, Mallesham et al. 1989), *Chaetomium* sp. (Banerjee & Nandi 1992), *Isthmospora* sp. (Ramanujam & Srisailam 1980), *Meliola* sp. (Ramanujam & Rao 1978, Prasad & Ramesh 1983, Varma & Patil 1985, Saxena & Rao 1996) and *Periconia* sp. (Sarkar & Singh 1994, Mandaokar et al. 2008). In yet other cases, when specimens are ascribed to an extant genus but cannot be placed in any of its known species, new fossil species is proposed under the extant genus. Such species are called fossil species because of their types being fossil. Information about such species recorded from the Indian sediments is summarized in Table 2.

Table 1. Fossil fungal sporocarps, mycelia and other fungal remains from India and their relationship with extant counterparts.

Phylum	Class	Order	Genus	Species recorded from India	Indian records
Ascomycota Caval.-Sm.	*Dothideomycetes* O.E. Erikss. & Winka	*Asterinales* M.E. Barr ex D. Hawksw. & O.E. Erikss.	*Palaeoasterina* S. Mitra et al. 2002	*P. siwalica* S. Mitra et al. 2002	Mitra et al. 2002, p. 286, figures 2A–I, 3, Siwalik sediments (Middle Miocene), Darjeeling foothills, West Bengal.
		Botryosphaeriales C.L. Schoch et al.	*Ascochytites* Barlinge & Paradkar 1982	*A. intertrappeus* Barlinge & Paradkar 1982	Barlinge and Paradkar 1982, p. 169, plate 1, figure D, text-figures F–G, Deccan Intertrappean Series (?Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Deccanodia Singhai 1974	*D. eocena* Singhai 1974	Singhai 1974, p. 100, plate 1, figures 9-10, Deccan Intertrappean Beds (Late Cretaceous, Maastrichtian), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Diplodites D.N. Babajan & Tasl. ex Kalgutkar et al. 1993	*D. mohgaoensis* (Barlinge & Paradkar) Kalgutkar et al. 1993	Barlinge and Paradkar 1982, p. 168–169, plate 1, figure G, text-figures A–E, Deccan Intertrappean Series (?Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
				D. rodei (Mahabale) Kalgutkar et al. 1993	Mahabale 1969, p. 295, plate 1, figures 1-6, Deccan Intertrappean Series (Early Tertiary), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
				D. sahnii (Singhai) Kalgutkar et al. 1993	Singhai 1974, p. 97, plate 1, figures 5–8, Deccan Intertrappean Beds (Late Cretaceous, Maastrichtian), Mohgaon Kalan, Chhindwara District, Madhya Pradesh, India.
				D. sweetii Kalgutkar et al. 1993	Kalgutkar et al. 1993, p. 111, plate 1, figure 3, Deccan Intertrappean beds (Late Cretaceous, Maastrichtian), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Guignardiacarpites Debi Mukh. 2012	*G. sphaerioides* Debi Mukh. 2012	Mukherjee 2012, p. 8, figure 2.12, Neyveli Lignite Mine–I, Cuddalore District, Tamil Nadu, Miocene (Neyveli Lignite).
			Mohgaonidium Singhai 1974	*M. deccani* Singhai 1974	Singhai 1974, p. 97, Late Cretaceous, Maastrichtian, Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Palaeocytosphaera R.B. Singh & G.V. Patil 1980	*P. intertrappeana* R.B. Singh & G.V. Patil 1980	Singh and Patil 1980, p. 17, plate 1, figures 1–2, text-figures 1–4, Deccan Intertrappean beds (Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Palaeophoma Singhai !974	*P. intertrappea* Singhai 1974	Singhai 1974, p. 94, Late Cretaceous, Maastrichtian, Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Phomites Fritel 1910	*P. ebenoxyloni* Chitaley & G.V. Patil 1972	Chitaley and Patil 1972, p. 103–104, plate 1, figures 4–7, text-figures 2, 8–13, Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
		Capnodiales Woron.	*Mycosphaerellascoidetes* Debi Mukh. 2012	*M. radiatus* Debi Mukh. 2012	Mukherjee 2012, p. 9, figure 3.15, Neyveli Lignite Mine–I, Cuddalore District, Tamil Nadu, Miocene (Neyveli Lignite).

Dothideales Lindau	*Cucurbitariaceites* R.K. Kar et al. 1972	*C. bellus* R.K. Kar et al. 1972	Kar et al. 1972, p. 148, plate 1, figures 11–15, Tura Formation (Palaeocene), Garo Hills, Meghalaya; Varma and Patil 1985, p. 156, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Tripathi 1989, p. 73, plate 2, figure 8, Therria Formation (Palaeocene), Jowai-Sonapur Road Section, Jaintia Hills District, Meghalaya; Mandaokar 1991, p. 26, Early Miocene, north of Maibong Railway Station, North Cachar Hills District, Assam; Mandaokar 1993, p. 139, Tikak Parbat Formation (Late Oligocene), Dangri Kumari Colliery, Dibrugarh District, Assam; Mandal et al. 1996, p. 80, age not mentioned, mud volcano in Baratang Island, Andaman and Nicobar Islands; Saxena et al. 1996, p. 21, plate 3, figure 13, Tura Formation (Palaeocene), Nongwal Bibra area, East Garo Hills District, Meghalaya; Mandaokar 2000a, p. 320, Bhuban Formation (Early Miocene), Ramrikawn near Chandmari, Aizawl District, Mizoram; Mandaokar 2000b, p. 181, plate 1, figures 20, 24, Tikak Parbat Formation (Late Oligocene), Jeypore Colliery, Dilli-Jeypore Coalfields, Dibrugarh District, Assam; Mandaokar 2000c, p. 38, Tikak Parbat Formation (Late Oligocene), Namchik River Section, Changlang District, Arunachal Pradesh; Mandaokar 2002a, p. 116, Dulte Formation (Early Miocene), 2 km from Dulte Village on Dulte-Keifang Road, Aizawl District, Mizoram; Mandaokar 2002b, p. 21, Tikak Parbat Formation (Late Oligocene), Borjan Coalfield, Nagaland; Mandaokar 2003, p. 187, Middle Bhuban Formation (Early Miocene), Lawngtlai, Chhimtuipui District, Mizoram; Chakraborty 2004, p. 116, Lakadong Sandstone (Late Palaeocene), around Bhalukurung, North Cachar Hills, Assam; Mandaokar 2005, p. 55, Tikak Parbat Formation (Late Oligocene), Ledo Colliery, Makum Coalfield, Assam; Kar et al. 2010, p. 242, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
		C. keralensis Y.N.R. Varma & R.S. Patil 1985	Varma and Patil 1985, p. 155, plate 1, figure 29, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala.
	Palaeoleptosphaeria Barlinge & Paradkar 1982	*P. intertrappeana* Barlinge & Paradkar 1982	Barlinge and Paradkar 1982, p. 166, plate 1, figure I, Late Cretaceous, Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
	Perisporiacites Félix 1894	*P. varians* Sahni & H.S. Rao 1943	Sahni and Rao 1943, p. 45, plate 2, figures 11–12, text-figure 6, Deccan Intertrappean Series (Early Tertiary), Sausar, Chhindwara District, Madhya Pradesh.
Microthyriales G. Arnaud	*Appendicisporonites* R.K. Saxena & S. Khare 1992	*A. typicus* R.K. Saxena & S. Khare 1992	Saxena and Khare 1992, p. 40, plate 1, figure 1, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu; Rao and Nair 1998, p. 52, Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala
	Asterothyrites Cookson 1947	*A. edvensis* (K.P. Rao & Ramanujam) Kalgutkar & Janson. 2000	Rao and Ramanujam 1976, p. 100, plate 1, figure 7, Quilon Beds (Miocene), Edavai, Kerala.
		A. konkanensis (R.K. Saxena & N.K. Misra) Kalgutkar & Janson. 2000	Saxena and Misra 1990, p. 270, plate 2, figure 9, Sindhudurg Formation (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra.
		A. menonii (K.P. Jain & R.C. Gupta) Kalgutkar & Janson. 2000	Jain and Gupta 1970, p. 179, plate 1, figure 10, Quilon Beds (Early Miocene), Kollam, Kerala; Singh et al. 1986, p. 96, plate 1, figure 4, Barail and Surma groups (Oligocene-Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam; Rao 1995, p. 233, plate 1, figure 2, Tertiary, Alleppey and Kannur districts, Kerala.

Callimothallus Dilcher ex Janson. & L.V. Hills 1976	*C. assamicus* R.K. Kar et al. 1972	Kar et al. 1972, p. 151, plate 2, figures 19–20, Tura Formation (Palaeocene), Garo Hills, Meghalaya; Sah and Kar 1974, p. 182, Palana lignite (Early Eocene), Palana, Bikaner District, Rajasthan; Saxena et al. 1984, p. 188, plate 2, figure 35, Lower Siwalik (Middle-Late Miocene), Bhakra-Nangal Section, Bilaspur District, Himachal Pradesh; Singh et al. 1985, p. 36, Barail Group (Oligocene), Assam and Meghalaya; Sarkar and Singh 1988, p. 60–61, plate 6, figure 22, Subathu Formation (Early Eocene), Banethi-Bagthan area, Sirmaur District, Himachal Pradesh; Saxena and Misra 1990, p. 265, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Saxena and Khare 1992, p. 37, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu; Sarkar et al. 1994, p. 201, Middle Siwalik (Late Miocene), Bagh Rao, Dehradun District, Uttarakhand; Saxena 2000, p. 163, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra; Saxena and Sarkar 2000, p. 257, Siju Formation (Middle Eocene), Simsang River Section near Siju, South Garo Hills District, Meghalaya.
	C. dilcheri K.P. Rao & Ramanujam 1976	Rao and Ramanujam 1976, p. 99, plate 2, figure 13, Quilon and Warkalli Beds (Miocene), Kerala.
	C. pertusus Dilcher 1965	Ramanujam and Rao 1973, p. 205, plate 2, figures 15–18, Warkalli Formation (Miocene), Varkala, Kerala; Phadtare and Kulkarni 1980, p. 166, plate 2, figure 4, Ratnagiri Beds (Miocene), Ratnagiri-Pawas Road near Third Dharamshala stop 10 km south of Ratnagiri, Ratnagiri District, Maharashtra; Reddy et al. 1982, p. 114, plate 1, figures 10–11, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu; Singh and Sarkar 1984b, p. 48–49, plate 2, figure 32, Kasauli Formation (Early Miocene), Banethi, Sirmaur District, Himachal Pradesh; Singh et al. 1985, p. 36, Barail Group (Oligocene), Assam and Meghalaya; Varma 1987, p. 167, plate 1, figure 8, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Patil and Ramanujam 1988, p. 263, plate 1, figure 3, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Mallesham et al. 1989, p. 15, plate 1, figure 1, Miocene, Godavari-Krishna Basin, Andhra Pradesh and Palk Bay area in Cauvery Basin, Tamil Nadu; Tripathi 1989, p. 72, plate 2, figure 3, plate 3, figure 8, Therria and Kopili formations (Palaeocene-Eocene), Jowai-Sonapur Road Section, Jaintia Hills District, Meghalaya; Saxena and Khare 1992, p. 37, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu; Tripathi 1995, p. 47, subsurface Palaeocene-Eocene sediments near Kapurdi, Barmer District, Rajasthan; Samant and Phadtare 1997, p. 66, plate 14, figure 18, Tarkeshwar Formation (Early Eocene), Rajpardi, Cambay Basin, Gujarat; Samant 2000, p. 16, Kharsalia Clay Formation (Early Eocene), near Bhavnagar, Cambay Basin, Gujarat; Sarkar and Prasad 2000b, p. 147, Subathu Formation (Late Ypresian-Middle Lutetian), west bank of Ghaggar river near Kharak village, Morni Hills, Haryana; Tripathi et al. 2000, p. 243, Tura Formation (Early Eocene), Tura-Dalu Road, West Garo Hills District, Meghalaya.
	C. quilonensis K.P. Jain & R.C. Gupta 1970	Jain and Gupta 1970, p. 180, plate 1, figures 15–16, Quilon Beds (Early Miocene) Kollam District, Kerala.
	C. ramanujamii (R.K. Saxena & H.P. Singh) Kalgutkar & Janson. 2000	Saxena and Singh 1982, p. 294, plate 2, figures 24–25, Upper Siwalik (Pliocene), Hoshiarpur-Una Road Section, Hoshiarpur District, Punjab and Una District, Himachal Pradesh; Saxena and Bhattacharyya 1990, p. 112, plate 2, figure 4, Dharmsala Group (Oligocene-Early Miocene), Manjhi Khad Section near Dharmsala, Kangra District, Himachal Pradesh.
	C. raoi Ramanujam & K.P. Rao 1973	Ramanujam and Rao 1973, p. 205–206, plate 3, figures 19–20, text-figure 1, Warkalli Formation (Miocene), Varkala, Kerala.
	C. senii (Venkatach. & R.K. Kar)	Venkatachala and Kar 1969, p. 181, plate 1, figures 6–7, Naredi Formation (Early Eocene), Matanomadh, Kutch District, Gujarat.

Euthythyrites Cookson 1947	*E. bifidus* R. Kar et al. 2010	Kar et al. 2010, p. 247, plate 2, figure 8, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
	E. keralensis Ramanujam & K.P. Rao 1973	Ramanujam and Rao 1973, p. 207, plate 1, figures 10–11, plate 2, figures 12–14, Warkalli Formation (Miocene), Varkala, Kerala; Phadtare and Kulkarni 1980, p. 167, plate 1, figure 3, Ratnagiri Beds (Miocene), Ratnagiri-Pawas Road near Third Dharamshala stop, 10 km south of Ratnagiri, Ratnagiri District, Maharashtra.
	E. morenoinitis Selkirk 1975	Reddy et al. 1982, p. 117, plate 2, figures 2–4, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu; Varma 1987, p. 167, plate 1, figure 7, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Patil and Ramanujam 1988, p. 264, plate 2, figure 7, Miocene, Tonakkal, Thiruvananthapuram District, Kerala.
Haplopeltis Theiss. 1914	*H. mucoris* Dilcher 1965	Rao and Ramanujam 1976, p. 102, plate 1, figure 6, Quilon and Warkalli Beds (Miocene)), Kerala.
	H. neyveliensis Reddy et al. 1982	Reddy et al. 1982, p. 118, plate 2, figures 7–9, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu.
Kalviwadithyrites M.R. Rao 2003	*K. saxenae* M.R. Rao 2003	Rao 2003, p. 118, plate 1, figures 1–3, text-figure 2, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra; Rao 2004, p. 124, plate 2, figures 11–12, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra.
Koshalia S. Sarkar & V. Prasad 2003	*K. enigmata* S. Sarkar & V. Prasad 2003	Sarkar and Prasad 2003, p. 114–115, plate 1, figures 1–4, Subathu Formation (Late Ypresian), Koshalia Nala near Koti, Shimla Hills, Himachal Pradesh.
Microthyriacites Cookson 1947	*M. cooksoniae* Rao 1958	Rao 1958, p. 45, plate 1, figures 12-13, Palana lignite (Early Eocene), Palana, Bikaner District, Rajasthan; Warkalli lignite (Miocene), Warkalli, Thiruvananthapuram District, Kerala.
	M. ramanujamii R.K. Saxena & N.K. Misra 1990	Saxena and Misra 1990, p. 268, plate 2, figure 13, Miocene, Amberiwadi Section, Sindhudurg District, Maharashtra; Rao 2004, p. 124, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra.
	M. sahnii Rao 1958	Rao 1958, p. 44, plate 1, figures 3–6, Palana Lignite (Early Eocene), Palana, Bikaner District, Rajasthan.
Parmathyrites K.P. Jain & R.C. Gupta 1970	*P. indicus* K.P. Jain & R.C. Gupta 1970	Jain and Gupta 1970, p. 178, plate 1, figures 1–2, Early Miocene, Padappakkara, Kollam District, Kerala; Jain and Kar 1979, p. 107, plate 1, figure 13, Neogene, around Kollam and Varkala, Kerala; Singh and Sarkar 1984b, p. 49, plate 2, figure 24, Kasauli Formation (Early Miocene), Banethi, Sirmaur District, Himachal Pradesh; Varma 1987, p. 167, plate 1, figure 6, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Bhattacharya 1987, p. 120, Early Eocene, Rajpardi, Broach District, Gujarat; Mallesham et al. 1989, p. 15, plate 1, figure 4, Miocene, Godavari-Krishna Basin, Andhra Pradesh and Palk Bay area in Cauvery Basin, Tamil Nadu; Rajendran et al. 1989, p. 42, plate 1, figures 7, 16, plate 2 figure 22, Miocene, Padappakkara, Kerala; Kar 1990b, p. 232, plate 2, figure 19, Disang Formation (Palaeocene-Eocene), Silchar-Haflong Road Section, Assam; Kumaran et al. 1995, p. 1024, figure 3m, Warkalli Formation (Miocene), Bharathi and Kundra Clay Mines, Kerala; Rao 1995, p. 233, plate 1, figure 3, Tertiary, Alleppey and Kannur districts, Kerala; Rao 1996, p. 156, Early Miocene, Turavur Borehole near Panchayat L.P. School, west of N.H. 47 between 380 and 381 km, Alleppey District, Kerala; Chandra and Kumar 1998, p. 62, plate 1, figure 17, Late Tertiary, Site 218, Deep Sea Drilling Project Leg 22, Bengal Fan, Indian Ocean; Rao and Nair 1998, p. 52, Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala; Rao 2000, p. 295, Kherapara Formation (Oligocene), Tura-Dalu Road Section near Kherapara, West Garo Hills District, Meghalaya; Saxena and Sarkar 2000, p. 257, plate 1, figure 3, Middle Siju Formation (Eocene), Simsang River Section near Siju, South Garo Hills District, Meghalaya; Mandaokar 2002b, p. 21, plate 2, figure 16, Tikak Parbat Formation (Late Oligocene), Borjan Coalfield, Nagaland; Rao 2004, p. 124, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra; Kar et al. 2010, p. 242, Bhuban Formation (Miocene), Tlangsam, Mizoram.

	P. ramanujamii H.P. Singh et al. 1986	Singh et al. 1986, p. 96, plate 1, figures 8–9, Umkiang Member, Bhuban Formation (Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam; Saxena and Misra 1990, p. 265, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Rao 1995, p. 233–234, plate 1, figure 9, Tertiary, Alleppey and Kannur districts, Kerala; Saxena and Rao 1996, p. 46, Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya; Rao and Nair 1998, p. 52, Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala; Mandaokar 2000a, p. 320, Bhuban Formation (Early Miocene), Ramrikawn near Chandmari, Aizawl District, Mizoram; Rao 2000, p. 295, Kherapara Formation (Oligocene), Tura-Dalu Road Section near Kherapara, West Garo Hills District, Meghalaya; Mandaokar 2002b, p. 21, Tikak Parbat Formation (Late Oligocene), Borjan Coalfield, Nagaland; Rao 2004, p. 124, plate 2, figure 8, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra.
	P. robustus K.P. Jain & R.K. Kar 1979	Jain and Kar 1979, p. 107, plate 1, figure 14, plate 2, figure 34, Neogene, around Kollam and Varkala, Kerala; Bhattacharya 1987, p. 120, Early Eocene, Rajpardi, Broach District, Gujarat; Rajendran et al. 1989, p. 41, 43, 44, plate 1, figure 1, Miocene, Tonakkal, Kundra, Edavai, Paravur, Kannur, Palayangadi, Kerala; Kar 1990a, p. 179, Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura; Kar and Bhattacharya 1992, p. 251, Early Eocene, Rajpardi lignite, Bharuch District, Gujarat.
	P. tonakkalensis R.S. Patil & Ramanujam 1988	Patil and Ramanujam 1988, p. 264, plate 1, figure 6, Miocene, Tonakkal, Thiruvananthapuram District, Kerala.
	P. turaensis R.K. Kar et al. 1972	Kar et al. 1972, p. 149, plate 2, figure 17, Tura Formation (Palaeocene), Garo Hills, Meghalaya; Mandaokar 2005, p. 55, Tikak Parbat Formation (Late Oligocene), Ledo Colliery, Makum Coalfield, Assam.
Phragmothyrites W.N. Edwards 1922	*P. cooksoniae* (K.P. Rao & Ramanujam) Kalgutkar & Janson. 2000	Rao and Ramanujam 1976, p. 100, plate 1, figure 10, Quilon and Warkalli Beds (Miocene), Kerala; Pathak and Banerjee 1984, p. 250, plate 2, figure 24, Geabdat Sandstone (Neogene), Darjeeling District, West Bengal.
	P. edwardsii (Rao) R.K. Kar et al. 1972	Rao 1958, p. 45, plate 1, figures 7–10, Warkalli lignite (Miocene), Varkala, Thiruvananthapuram District, Kerala; Kar et al. 1972, p. 150, plate 2, figure 22, Tura Formation (Palaeocene), Garo Hills, Meghalaya; Dutta and Singh 1980, p. 620, plate 1, figures 9–10, Siwalik Group-Units B-C (Late Miocene-Pliocene), Bhalukpong-Bomdila Section, Kameng District, Arunachal Pradesh; Mehrotra 1983, p. 17, plate 4, figure 4, Mikir Formation (Palaeocene-Early Eocene), Garampani, North Cachar Hills, Assam; Singh and Tripathi 2010, p. 12, plate 1, figure 20, Akli Formation (Early Palaeogene), Borehole near Barakha, Barmer District, Rajasthan.
	P. eocaenicus W.N. Edwards 1922	Venkatachala and Kar 1969, p. 179, plate 1, figures 1–5, Naredi Formation (Early Eocene), Matanomadh, Kutch District, Gujarat; Kar and Saxena 1976, p. 9, plate 3, figure 20, Matanomadh Formation (Palaeocene), Matanomadh, Kutch District, Gujarat; Kar 1979, p. 31, Maniyara Fort Formation (Oligocene), Barkhana Nala Cutting near Sarangwara, Kutch District, Gujarat; Jain and Kar 1979, p. 107, plate 1, figures 1–7, plate 2, figure 19, Neogene, around Kollam and Varkala, Kerala; Dutta and Singh 1980, p. 620, Siwalik Group-Units B-C (Late Miocene-Pliocene), Bhalukpong-Bomdila Section, Kameng District, Arunachal Pradesh; Kar and Saxena 1981, p. 106, Middle-Late Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat; Mehrotra 1983, p. 17, plate 4, figure 11, Mikir Formation (Palaeocene-Early Eocene), Garampani, North Cachar Hills, Assam; Singh and Sarkar 1984a, p. 98, plate 2, figure 30, Miocene, Ramshahr Well–1, Solan District, Himachal Pradesh; Saxena et al. 1984, p. 187, plate 2, figure 34, Lower-Middle Siwalik (Middle Miocene-Early Pliocene), Bhakra-Nangal Section, Bilaspur District, Himachal Pradesh; Kar 1985, p. 130, Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat; Singh et al. 1986, p. 94,

plate 1, figures 1–2, plate 2, figure 15, Barail-Surma Groups (Oligocene-Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam; Siddhanta 1986, p. 64, plate 5, figure 48, Neyveli Formation (Palaeocene-Eocene), Neyveli, South Arcot District, Tamil Nadu; Saxena et al. 1988, p. 276, plate 2, figure 26, Pinjor Formation (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana; Bhattacharya 1987, p. 120, Early Eocene, Rajpardi, Broach District, Gujarat; Sarkar and Singh 1988, p. 60, plate 6, figures 19–20, Subathu Formation (Eocene), Banethi-Bagthan area, Sirmaur District, Himachal Pradesh; Rajendran et al. 1989, p. 41, 42, 43, 44, plate 1, figure 6, plate 2, figure 39, Miocene, Tonakkal, Kundra, Padappakkara, Varkala, Edavai, Paravur, Kannur, Palayangadi, Kerala; Tripathi 1989, p. 72, plate 2, figure 14, plate 3, figure 13, Therria and Kopili formations (Palaeocene-Eocene), Jowai-Sonapur Road Section, Jaintia Hills District, Meghalaya; Kar 1990a, p. 179, plate 8, figure 119, Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura; Kar 1990b, p. 232, 233, 236, 238, 240, plate 1, figure 13, plate 2, figures 7, 11, Disang, Laisong, Jenam, Renji and Bhuban formations (Palaeocene-Early Miocene), Silchar-Haflong Road Section, Assam; Saxena and Misra 1990, p. 265, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Mandaokar 1991, p. 26, Early Miocene, north of Maibong Railway Station, North Cachar Hills District, Assam; Kar and Bhattacharya 1992, p. 251, Rajpardi lignite (Early Eocene), Bharuch District, Gujarat; Saxena and Khare 1992, p. 37, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu; Ambwani 1993, p. 153, Palaeocene-Early Eocene, Rekmangiri Coalfield, Garo Hills, Meghalaya; Kar et al. 1994, p. 187, Tertiary, subsurface sediments in Upper Assam; Sarkar et al. 1994, p. 201, Middle Siwalik (Late Miocene), Bagh Rao, Dehradun District, Uttarakhand; Singh and Sarkar 1994, p. 52, plate 1, figure 25, Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh; Kumaran et al. 1995; p. 1024, Warkalli Formation (Miocene), Bharathi and Kundra Clay Mines, Kerala; Rao 1995, p. 233, plate 1, figure 1, Tertiary, Alleppey and Kannur districts, Kerala; Tripathi 1995, p. 47, Palaeocene-Eocene, subsurface sediments near Kapurdi, Barmer District, Rajasthan; Kumar 1996, p. 114, Tarkeshwar Formation (Early Eocene), Rajpardi, Bharuch District, Gujarat; Mandal et al. 1996, p. 80, age not mentioned, mud volcano in Baratang Island, Andaman and Nicobar Islands; Rao 1996, p. 156, Early Miocene, Turavur Borehole near Panchayat L.P. School, west of N.H. 47 between 380 and 381 km, Alleppey District, Kerala; Saxena and Rao 1996, p. 46, Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya; Samant and Phadtare 1997, p. 68, plate 14, figure 17, Tarkeshwar Formation (Early Eocene), Rajpardi, Cambay Basin, Gujarat; Sarkar 1997, p. 102, 104, 108, Subathu Formation (Eocene), 20 km southeast of Bilaspur on Shimla-Bilaspur Highway, Bilaspur District, Himachal Pradesh; Chandra and Kumar 1998, p. 56, plate 3, figure 5, Late Tertiary, Site 218, Deep Sea Drilling Project Leg 22, Bengal Fan, Indian Ocean; Rao and Nair 1998, p. 52, plate 1, figure 24, Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala; Mandaokar 1999, p. 241, Disang Group (Late Eocene), Tirap River Section, Tinsukia District, Assam; Mandaokar 2000a, p. 320, Bhuban Formation (Early Miocene), Ramrikawn near Chandmari, Aizawl District, Mizoram; Mandaokar 2000b, p. 181, Tikak Parbat Formation (Late Oligocene), Jeypore Colliery, Dilli-Jeypore Coalfields, Dibrugarh District, Assam; Mandaokar 2000c, p. 38, plate 1, figure 9, Tikak Parbat Formation (Late Oligocene), Namchik River Section, Changlang District, Arunachal Pradesh; Rao 2000, p. 295, Kherapara Formation (Oligocene), Tura-Dalu Road Section near Kherapara, West Garo Hills District, Meghalaya; Samant 2000, p. 16, plate 1, figure 20, Kharsalia Clay Formation (Early Eocene), near Bhavnagar, Cambay Basin, Gujarat; Samant and Tapaswi 2000, p. 29, figure 2.14, Cambay Shale (Early Eocene), Cambay Basin, Gujarat; Sarkar and Prasad 2000a, p. 171, Subathu Formation (Late Ypresian-Middle Lutetian), Koshalia Nala Section near Koti, Shimla Hills, Solan District, Himachal Pradesh; Sarkar and Prasad 2000b, p. 147, Subathu Formation (Late Ypresian-Middle Lutetian), west bank of Ghaggar river near Kharak village, Morni Hills, Haryana; Saxena 2000, p. 163, plate 2, figure 13, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra;

		Saxena and Sarkar 2000, p. 257, Siju Formation (Middle Eocene), Simsang River Section near Siju, South Garo Hills District, Meghalaya; Tripathi et al. 2000, p. 243, Tura Formation (Early Eocene), Tura-Dalu Road, West Garo Hills District, Meghalaya; Kumar et al. 2001, p. 244, Barail Group (Oligocene), Tinali Well-7, Upper Assam; Tripathi 2001, p. 567, figure 3D, Rajmahal Formation (Early Cretaceous), Borehole RJNE-32, depth 95.50 m, Rajmahal Basin, Bihar; Singh and Kar 2002, p. 214, plate 1, figure 9, Deccan Intertrappean Beds (Palaeocene), 3 km northeast of Papro village, Latitpur District, Uttar Pradesh; Mandaokar 2002a, p. 116, Dulte Formation (Early Miocene), 2 km from Dulte village on Dulte-Keifang Road, Aizawl District, Mizoram; Mandaokar 2002b, p. 21, Tikak Parbat Formation (Late Oligocene), Borjan Coalfield, Nagaland; Mandal et al. 2003, p. 102, 104, Baratang Formation (Eocene), Baratang Island, Andaman and Nicobar Islands; Singh and Kar 2003, p. 219, plate 2, figure 5, Deccan Intertrappean Beds (Palaeocene), northeast of Papro, Lalitpur District, Uttar Pradesh; Chakraborty 2004, p. 116, Lakadong Sandstone (Late Palaeocene), around Bhalukurung, North Cachar Hills, Assam; Rao 2004, p. 124, plate 3, figure 14, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra; Mandaokar 2005, p. 55, Tikak Parbat Formation (Late Oligocene), Ledo Colliery, Makum Coalfield, Assam Kar et al. 2010, p. 245, Bhuban Formation (Miocene), Tlangsam, Mizoram.
	P. lutosus (Dilcher) R.K. Kar & R.K. Saxena 1976	Kar and Saxena 1976, p. 9, Bhuj-Lakhpat Road, Matanomadh Village, Kutch District, Gujarat; Saxena and Ranhotra 2009, p. 692, figure 3.22, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
	P. ramanujamii B. Samant in Saxena 2009	Samant 2000, p. 15, plate 1, figure 21, Kharsalia Clay Formation (Early Eocene), near Bhavnagar, Cambay Basin, Gujarat.
	P. serratus R.K. Saxena & S. Khare 1992	Saxena and Khare 1992, p. 39–40, plate 1, figure 5, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu.
	P. suratensis B. Samant & Tapaswi 2000	Samant and Tapaswi 2000, p. 29, figure 2.15, Cambay Shale (Early Eocene), Surat District, Gujarat.
Plochmopeltinites Cookson 1947	*P. cooksoniae* Ramanujam & K.P. Rao 1973	Ramanujam and Rao 1973, p. 207, plate 3, figures 22–23, Warkalli Formation (Miocene), Varkala, Kerala; Reddy et al. 1982, p. 116–117, plate 1, figure 17, plate 2, figure 1, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu; Patil and Ramanujam 1988, p. 265, plate 2, figure 8, Miocene, Tonakkal, Thiruvananthapuram District, Kerala; Singh and Kar 2003, p. 219, plate 2, figure 7, Deccan Intertrappean Beds (Palaeocene), northeast of Papro, Lalitpur District, Uttar Pradesh.
	P. keralensis R.S. Patil & Ramanujam 1988	Patil and Ramanujam 1988, p. 265, plate 2, figure 9, Miocene, Tonakkal, Thiruvananthapuram District, Kerala.
Polyhyphaethyrites R. Srivast. & R.K. Kar 2004	*P. giganticus* R. Srivast. & R.K. Kar 2004	Srivastava and Kar 2004, p. 866–867, figure 2, Deccan Intertrappean Beds (Palaeocene), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
Ratnagiriathyrites R.K. Saxena & N.K. Misra 1990	*R. hexagonalis* R.K. Saxena & N.K. Misra 1990	Saxena and Misra 1990, p. 270, plate 2, figure 14, plate 3, figure 11, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Saxena 2000, p. 163, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra; Rao 2004, p. 124, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra.

Spinosporonites R.K. Saxena & S. Khare 1992	*Spinosporonites indicus* R.K. Saxena & S. Khare 1992	Saxena and Khare 1992, p. 40, plate 1, figures 18–19, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu.
Trichopeltinites Cookson 1947	*T. folius* R.K. Kar et al. 2010	Kar et al. 2010, p. 247, plate 2, figure 7, Bhuban Formation (Miocene), Tlangsam, Mizoram.
	T. fusilis Dilcher 1965	Rao and Ramanujam 1976, p. 101, plate 2, figure 14, Quilon and Warkalli Beds (Miocene), Kerala; Tripathi 2001, p. 566, figures 3G-I, Rajmahal Formation (Early Cretaceous), Borehole RJNE-32, depth 95.50 m, Rajmahal Basin, Bihar.
	T. kiandrensis Selkirk 1975	Reddy et al. 1982, p. 117–118, plate 2, figures 5–6, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu; Patil and Ramanujam 1988, p. 265–266, plate 2, figure 10, Miocene, Tonakkal, Thiruvananthapuram District, Kerala; Chandra and Kumar 1998, p. 60, plate 1, figure 18, Late Tertiary, Site 218, Deep Sea Drilling Project Leg 22, Bengal Fan, Indian Ocean.
Trichothyrites F. Rosend. 1943	*T. airensis* (Cookson) Kalgutkar & Janson. 2000	Ramanujam and Rao 1973, p. 205, plate 1, figure 9, Warkalli Formation (Miocene), Varkala, Kerala.
	T. amorphus (R.K. Kar & R.K. Saxena) R.K. Saxena & N.K. Misra 1990	Kar and Saxena 1976, p. 9, plate 4, figures 44–45, Matanomadh Formation (Palaeocene), Matanomadh, Kutch District, Gujarat; Jain and Kar 1979, p. 108, plate 2, figures 21–22, Neogene, around Kollam and Varkala, Kerala; Phadtare and Kulkarni 1980, p. 166, plate 1, figure 2, Ratnagiri Beds (Miocene), Ratnagiri-Pawas Road near Third Dharamshala stop 10 km south of Ratnagiri, Ratnagiri District, Maharashtra; Kar and Saxena 1981, p. 106, Middle-Late Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat; Singh and Saxena 1984, p. 624, plate 2, figure 33, Girujan Clay (Neogene), Jorajan Well-3, Assam; Singh and Sarkar 1984b, p. 50, plate 2, figures 28–29, Kasauli Formation (Early Miocene), Banethi, Sirmaur District, Himachal Pradesh; Saxena et al. 1984, p. 188, plate 2, figure 39, Lower Siwalik (Middle-Late Miocene), Bhakra-Nangal Section, Bilaspur District, Himachal Pradesh; Kar 1985, p. 130, Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat; Singh et al. 1986, p. 96, plate 1, figure 10, Dona Member, Bhuban Formation (Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam; Rajendran et al. 1989, p. 43, plate 1, figure 15, Miocene, Edavai, Kerala; Sarkar et al. 1994, p. 201, Middle Siwalik (Late Miocene), Bagh Rao, Dehradun District, Uttarakhand; Saxena and Misra 1990, p. 270, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Saxena 2000, p. 163, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra; Saxena and Sarkar 2000, p. 257, Siju Formation (Middle Eocene), Simsang River Section near Siju, South Garo Hills District, Meghalaya.
	T. denticulatus (Ramanujam & K.P. Rao) Kalgutkar & Janson. 2000	Ramanujam and Rao 1973, p. 204–205, plate 1, figures 7–8, Warkalli Formation (Miocene), Varkala, Kerala; Rao and Ramanujam 1976, p. 98, plate 1, figures 1–2, Quilon and Warkalli Beds (Miocene), Kerala; Phadtare and Kulkarni 1980, p. 166, plate 1, figure 1, Ratnagiri Beds (Miocene), Ratnagiri-Pawas Road near Third Dharamshala stop 10 km south of Ratnagiri, Ratnagiri District, Maharashtra.
	T. echinatus (K.P. Rao & Ramanujam) Kalgutkar & Janson. 2000	Rao and Ramanujam 1976, p. 99, plate 1, figures 3–4, Quilon and Warkalli Beds (Miocene), Kerala.

T. keralensis (K.P. Rao & Ramanujam) Kalgutkar & Janson. 2000	Rao and Ramanujam 1976, p. 100–101, plate 2, figures 11–12, Quilon and Warkalli Beds (Miocene), Kerala; Singh and Sarkar 1994, p. 52, Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh.
T. ovatus (Venkatach. & R.K. Kar) Kalgutkar & Janson. 2000	Venkatachala and Kar 1969, p. 182, plate 1, figures 9–11, Naredi Formation (Early Eocene), Bore-hole No. 14, Matanomadh, Kutch District, Gujarat; Rawat et al. 1977, p. 187, Kadi Formation (Early Eocene), Cambay Basin, Gujarat.
T. padappakkarensis (K.P. Jain & R.C. Gupta) Kalgutkar & Janson. 2000	Jain and Gupta 1970, p. 178, plate 1, figures 13–14, Quilon Beds (Early Miocene), Kollam District, Kerala; Rao and Ramanujam 1976, p. 99, plate 1, figure 5, Quilon and Warkalli Beds (Miocene), Kerala; Dutta and Singh 1980, p. 620, plate 1, figure 6, Siwalik Group-Units A-C (Late Miocene-Pleistocene), Bhalukpong-Bomdila Section, Kameng District, Arunachal Pradesh; Reddy et al. 1982, p. 114, plate 1, figure 8, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu; Varma 1987, p. 167, plate 1, figure 9, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Singh et al. 1986, p. 96, plate 1, figure 7, Bhuban Formation (Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam.
T. sastryi R.S. Patil & Ramanujam 1988	Patil and Ramanujam 1988, p. 262–263, plate 1, figure 2, Miocene, Tonakkal, Thiruvananthapuram District, Kerala; Samant and Tapaswi 2000, p. 29, figure 2.16, Cambay Shale (Early Eocene), Cambay Basin, Gujarat.
T. setifer (Cookson) R.K. Saxena & N.K. Misra 1990	Rajendran et al. 1989, p. 41, 42, 44, Miocene, Tonakkal, Padappakkara, Kannur, Palayangadi, Kerala; Kar 1990a, p. 179, plate 8, figure 118, Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura; Kar 1990b, p. 232, 236, 240, plate 2, figure 6, Disang, Jenam and Bhuban formations (Palaeocene-Eocene, Middle Oligocene and Early Miocene), Silchar-Haflong Road Section, Assam; Saxena and Misra 1990, p. 270, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Kar and Bhattacharya 1992, p. 251, Rajpardi lignite (Early Eocene), Bharuch District, Gujarat; Saxena and Khare 1992, p. 37, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu; Ambwani 1993, p. 153, Palaeocene-Early Eocene, Rekmangiri Coalfield, Garo Hills, Meghalaya; Kar et al. 1994, p. 187, Tertiary, subsurface sediments in Upper Assam; Rao 1995, p. 233, Tertiary, Alleppey and Kannur districts, Kerala; Kumar 1996, p. 114, Tarkeshwar Formation (Early Eocene), Rajpardi, Bharuch District, Gujarat; Rao 1996, p. 156, Early Miocene, Turavur Borehole near Panchayat L.P. School, west of N.H. 47 between 380 and 381 km, Alleppey District, Kerala; Saxena and Rao 1996, p. 46, Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya; Samant and Phadtare 1997, p. 68, plate 14, figure 16, Tarkeshwar Formation (Early Eocene), Rajpardi, Cambay Basin, Gujarat; Rao and Nair 1998, p. 52, plate 1, figure 26, Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala; Mitra et al. 2000, p. 126, plate 1, figure 1, Siwalik Group (Neogene), Darjeeling Foothills, Eastern Himalaya; Rao 2000, p. 295, Kherapara Formation (Oligocene), Tura-Dalu Road Section near Kherapara, West Garo Hills District, Meghalaya; Saxena 2000, p. 163, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra; Tripathi et al. 2000, p. 243, Tura Formation (Early Eocene), Tura-Dalu Road, West Garo Hills District, Meghalaya; Chakraborty 2004, p. 116, Lakadong Sandstone (Late Palaeocene), around Bhalukurung, North Cachar Hills, Assam; Rao 2004, p. 124, plate 3, figure 16, Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra; Kar et al. 2010, p. 242, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.

				T. siwalikus Phadtare 1989	Phadtare 1989, p. 128, figure 5, Middle Miocene, Kali River Section near Thuli Gad, about 18 km NE of Tanakpur, Uttarakhand.
		Patellariales G. Arnaud	*Rhytidhysteriumites* Debi Mukh. 2012	*R. lunatum* Debi Mukh. 2012	Mukherjee 2012, p. 9, figure 3.14, Neyveli Lignite Mine-I, Cuddalore District, Tamil Nadu, Miocene (Neyveli Lignite).
		Pleosporales	*Dictyosporiumites* Debi Mukh. 2012	*D. intermedium* Debi Mukh. 2012	Mukherjee 2012, p. 5, figure 2.5, Neyveli Lignite Mine-I, Cuddalore District, Tamil Nadu, Miocene (Neyveli Lignite).
	Eurotiomycetes O.E. Erikss. & Winka	*Eurotiales* G.W. Martin ex Benny & Kimbr.	*Memnonillasporonites* Debi Mukh. 2012	*M. stellatus* Debi Mukh. 2012	Mukherjee 2012, p. 5, figure 2.6, Neyveli Lignite Mine-I, Cuddalore District, Tamil Nadu, Miocene (Neyveli Lignite).
	Leotiomycetes O.E. Erikss. & Winka	*Helotiales* Nannf.	*Lithouncinula* N. Sharma et al. 2005	*L. lametaensis* N. Sharma et al. 2005	Sharma et al. 2005, p. 76, plate 2, figure 2, Lameta Formation (Maastrichtian), Pisdura, Maharashtra, India.
			Protoerysiphe N. Sharma et al. 2005	*P. indicus* N. Sharma et al. 2005	Sharma et al. 2005, p. 76, plate 2, figure 4, Lameta Formation (Maastrichtian), Pisdura, Maharashtra.
	Sordariomycetes O.E. Erikss. & Winka	*Meliolales* Gäum. ex D. Hawksw & O.E. Erikss.	*Meliolinites* Selkirk ex Janson. & L.V. Hills 1975	*M. anfractus* (Dilcher) Kalgutkar & Janson. 2000	Jain and Kar 1979, p. 109, plate 3, figure 51, Neogene, around Kollam and Varkala, Kerala; Varma and Patil 1985, p. 156, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala.
				M. nivalis Selkirk 1975	Reddy et al. 1982, p, 112, plate 1, figures 1–3, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu; Patil and Ramanujam 1988, p. 262, plate 1, figure 1, Miocene, Tonakkal, Thiruvananthapuram District, Kerala.
				M. spinksii (Dilcher) Selkirk 1975	Chandra and Kumar 1998, p. 60, plate 1, figure 7, Late Tertiary, Site 218, Deep Sea Drilling Project Leg 22, Bengal Fan, Indian Ocean.
			Meliostroma Kar et al. 2010	*M. tlangsamensis* Kar et al. 2010	Kar et al. 2010, p. 246, plate 1, figures 10–11, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
		Sordariales Chadef. ex D. Hawksw & O.E. Erikss.	*Palaeosordaria* Sahni & H.S. Rao 1943	*P. lagena* Sahni & H.S. Rao 1943	Sahni and Rao 1943, p. 46, plate 2, figure 13, plate 3, figures 22–23, text-figure 5, Deccan Intertrappean Series (Early Tertiary), Sausar, Chhindwara District, Madhya Pradesh.
		Xylariales Nannf.	*Diploneurospora* K.P. Jain & R.C. Gupta 1970	*D. tewarii* K.P. Jain & R.C. Gupta 1970	Jain and Gupta 1970, p. 180, plate 1, figure 21, Early Miocene, Padappakkara, Kollam District, Kerala, India.
Basidiomycota R.T. Moore	*Pucciniomycetes* R. Bauer et al.	*Pucciniales* Caruel	*Aeciosporonites* Debi Mukh. 2012	*A. peridionum* Debi Mukh. 2012	Mukherjee 2012, p. 11, figure 3.18, Neyveli Lignite Mine-I, Cuddalore District, Tamil Nadu, Miocene (Neyveli Lignite).
			Hapalophragmites Ramanujam & Ramachar 1980	*H. cumminsii* Ramanujam & Ramachar 1980	Ramanujam and Ramachar 1980, p. 82–83, plate 1, figures 7–9, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu.

			Pucciniasporonites Ramanujam & Ramachar 1980	*P. arcotensis* Ramanujam & Ramachar 1980	Ramanujam and Ramachar 1980, p. 82, plate 1, figures 4–6, Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu.
			Shuklania J.N. Dwivedi 1968	*S. enigmocarponae* J.N. Dwivedi 1968	Dwivedi 1968, p. 9–10, plate 1, figures 1–7, text-figures 1–7, Intertrappean Beds (Eocene). Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Rabenhorstinidium R.B. Singh & G.V. Patil 1980	*R. intertrappeum* R.B. Singh & G.V. Patil 1980	Singh and Patil 1980, p. 17–18, plate 1, figures 5, 8, text-figures 7–8, Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
	Ustilaginomycetes R. Bauer et al.	*Ustilaginales* G. Winter	*Chlamydosporites* Paradkar 1975	*C. gramineus* Paradkar 1975	Paradkar 1975, p. 96–97, plate 1, figure 4, Deccan Intertrappean Series (?Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
			Teliosporites R. Kar et al. 2010	*T. globatus* R. Kar et al. 2010	Kar et al. 2010, p. 246, plate 2, figure 1, Bhuban Formation (Miocene), Tlangsam, Mizoram.
				T. hirsutus R. Kar et al. 2010	Kar et al. 2010, p. 246, plate 2, figure 3, Bhuban Formation (Miocene), Tlangsam, Mizoram.
Glomeromycota C. Walker & A. Schüßler	*Glomeromycetes* Caval.-Sm.	*Diversisporales* C. Walker & A. Schüßler	*Palaeogigaspora* R. Kar et al. 2010	*P. excellensa* R. Kar et al. 2010	Kar et al. 2010, p. 245, plate 1, figure 4, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
Mucoromycota Doweld	*Endogonomycetes* Doweld	*Endogonales* Jacz. & P.A. Jacz.	*Chlamydospora* R. Kar et al. 2010	*C. dichotoma* R. Kar et al. 2010	Kar et al. 2010, p. 245, plate 1, figure 9, Bhuban Formation (Miocene), Tlangsam, Mizoram.
			Palaeomycites Mesch. 1902	*P. acinus* (Sat. K. Srivast.) Kalgutkar & Janson. 2000	Saxena and Ranhotra 2009, p. 692, figure 3.20, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
				P. bharwainensis (H.P. Singh & R.K. Saxena) Kalgutkar & Janson. 2000	Singh and Saxena 1981, p. 175, plate 1, figures 17–18, Upper Siwalik (Plio-Pleistocene), Gagret-Bharwain Road Section, Una District, Himachal Pradesh; Saxena and Singh 1982, p. 292, Upper Siwalik (Pliocene), Hoshiarpur-Una Road Section, Hoshiarpur District, Punjab and Una District, Himachal Pradesh.
				P. butleri (F. Rosend.) Kalgutkar & Janson. 2000	Saxena and Ranhotra 2009, p. 691, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
				P. dichotomus (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi 2011	Kar et al. 2010, p. 245, plate 1, figure 9, Bhuban Formation (Miocene), Tlangsam, Mizoram.
				P. excellensus (R. Kar et al.) R.K. Saxena & S.K.M.	Kar et al. 2010, p. 245, plate 1, figure 4, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.

		P. globatus (Sharma et al.) R.K. Saxena & S.K.M. Tripathi 2011	Sharma et al. 2005, p. 76, plate 2, figure 5, Lameta Formation (Maastrichtian), Pisdura, Maharashtra; Kar et al. 2010, p. 245, plate 1, figure 2, Bhuban Formation (Miocene), Tlangsam, Mizoram.
		P. horneae (Kidst. & W.H. Lang) Kalgutkar & Janson. 2000	Saxena and Ranhotra 2009, p. 692, figure 3.25, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
		P. minnesotensis (F. Rosend.) Kalgutkar & Janson. 2000	Saxena and Ranhotra 2009, p. 692, figure 3.17, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
		P. minutus (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi 2011	Kar et al. 2010, p. 245, plate 1, figure 3, Bhuban Formation (Miocene), Tlangsam, Mizoram.
		P. robustus (R.K. Kar) Kalgutkar & Janson. 2000	Kar 1979, p. 36, plate 3, figures 58–62, Maniyara Fort Formation (Oligocene), nala cutting near Ber Mota, Kutch District, Gujarat; Singh and Saxena 1980, p. 278, Upper Siwalik (Plio-Pleistocene), Gagret-Bharwain Road Section, Una District, Himachal Pradesh; Singh and Saxena 1981, p. 175, plate 1, figure 3, Upper Siwalik (Plio-Pleistocene), Gagret-Bharwain Road Section, Una District, Himachal Pradesh; Saxena et al. 1984, p. 188-189, plate 2, figure 40, Lower-Middle Siwalik (Middle Miocene-Early Pliocene), Bhakra-Nangal Section, Bilaspur District, Himachal Pradesh; Kar 1985, p. 201, Maniyara Fort Formation (Oligocene), near Ber Mota, Kutch District, Gujarat; Kar 1990a, p. 204, Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura.
	Udaria A. Gupta 1996	*U. saxenae* A. Gupta 1996	Gupta 1996, p. 104, figures 9–14, Subathu Formation (Early Tertiary), Jamtah Road Section, Sirmaur District, Himachal Pradesh.
		U. singhii A. Gupta 1996	Gupta 1996, p. 104, figures 1–8, Dagshai Formation (Early Tertiary) Jamtah Road Section, Sirmaur District, Himachal Pradesh.
Mucoromycota genera incertae sedis	*Lithomucorites* R. Kar et al. 2010	*L. miocenicus* R. Kar et al. 2010	Kar et al. 2010, p. 245, plate 1, figure 1, Bhuban Formation (Miocene), Tlangsam, Mizoram.
		L. tripuraensis Mand. & R.K. Saxena 2014	Mandaokar and Saxena 2014, p. 26, Plate 1, figures 1–9, Bhuban Formation (Early Miocene), Maharanicherra, South Tripura District, Tripura.
Mycelia Sterilia	*Dendromyceliates* K.P. Jain & R.K. Kar 1979	*D. rajmahalensis* A. Tripathi 2001	Tripathi 2001, p. 570, figures 4F–K, Rajmahal Formation (Early Cretaceous), Borehole RJNE-32, Rajmahal Basin, Bihar.
		D. splendus K.P. Jain & R.K. Kar 1979	Jain and Kar 1979, p. 112, plate 3, figures 45–46, Neogene, around Kollam and Varkala, Kerala; Varma and Patil 1985, p. 156, Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala; Saxena and Misra 1990, p. 265, Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra; Saxena 2000, p. 163, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra.
	Sclerotites A. Massal. 1859	*S. chitaleyae* Khubalkar 2003	Khubalkar 2003, p. 293–294, plate 1, figures 1–3, text-figure 1–9, Deccan Intertrappean Beds (Late Maastrichtian), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.

Fossil fungi incertae sedis	*Dictyomykus* R. Kar et al. 2010	*D. ellipticus* R. Kar et al. 2010	Kar et al 2010, p. 247, plate 2, figure 2, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
	Lithosporocarpia R. Kar et al. 2010	*L. cephala* R. Kar et al. 2010	Kar et al. 2010, p. 245, plate 1, figure 6, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
	Mycozygosporangia R. Kar et al. 2010	*M. laevigata* R. Kar et al. 2010	Kar et al. 2010, p. 246, plate 1, figure 5, Bhuban Formation (Miocene), Tlangsam, Mizoram, India.
	Netothyrites C.M. Misra et al. 1996	*N. paleocenicus* C.M. Misra et al. 1996	Misra et al. 1996, p. 19, plate 1, figures 14–15, text-figure 1B, Palaeocene, Boreholes EM-A, SM-79-A, B-66-A, B-163-A in Bombay Offshore, Boreholes Palakollu-Am, Modi-A, Razole-A, Elamanchalli-A, Peddapelam-A in Krishna-Godavari Basin and Boreholes An-42-A in Andaman Basin.
		N. vertistriatus C.M. Misra et al. 1996	Misra et al. 1996, p. 18–19, plate 1, figures 1–13, text-figure 1A, Palaeocene, Boreholes EM-A, SM-79-A, B-66-A, B-163-A in Bombay Offshore, Boreholes Palakollu-Am, Modi-A, Razole-A, Elamanchalli-A, Peddapelam-A in Krishna-Godavari Basin and Boreholes An-42-A in Andaman Basin.
	Palaeocercospora S. Mitra & M. Banerjee 2000	*P. siwalikensis* S. Mitra & M. Banerjee 2000	Mitra and Banerjee 2000, p. 8, figures 1–5, text-figure 2, Geabdat Sandstone Formation (Middle Miocene), N.H. 31 Road Section, Darjeeling Foothills, Eastern Himalaya.
	Palaeocolletotrichum S. Mitra & M. Banerjee 2000	*P. graminioides* S. Mitra & M. Banerjee 2000	Mitra and Banerjee 2000, p. 8, figures 6–9, text-figure 3, Geabdat Sandstone Formation (Middle Miocene), N.H. 31 Road Section, Darjeeling Foothills, Eastern Himalaya.
	Protocolletotrichum R.K. Kar et al. 2004	*P. deccanensis* R.K. Kar et al. 2004	Kar et al. 2004, p. 947, figures 3A, C–E, Deccan Intertrappean Bed (Maastrichtian, Mohgaon-Kalan, Chhindwara District, Madhya Pradesh; Kar et al. 2010, p. 245, Bhuban Formation (Miocene), Tlangsam, Mizoram.
	Stauromyca R. Kar et al. 2010	*S. radiata* R. Kar et al. 2010	Kar et al. 2010, p. 247, plate 2, figure 9, Bhuban Formation (Miocene), Tlangsam, Mizoram.
	Tetradigita R. Kar et al. 2010	*T. stellata* R. Kar et al. 2010	Kar et al. 2010, p. 247, plate 2, figure 4, Bhuban Formation (Miocene), Tlangsam, Mizoram.
	Tricellaesporonites Sheffy & Dilcher 1971	*T. granulatus* A. Gupta 2002	Gupta 2002, p. 135, plate 2, figure 11, Subathu Formation (Eocene), Dadahu Road Section (left bank of Giri River), Sirmaur District, Himachal Pradesh.

Table 2. Extant fungal genera to which fossil species have been assigned and their Indian records.

Phylum	Class	Order	Family	Extant genus	Fossil species recorded from India	Indian records
Ascomycota Caval.-Sm.	*Dothideomycetes* O.E. Erikss. & Winka	*Asterinales* M.E. Barr ex D. Hawksw. & O.E. Erikss.	*Asterinaceae* Hansf.	*Asterina* Lév.	*A. eocenica* Dilcher 1965	Ramanujam and Rao 1973, p. 206, plate 3, figure 21, Warkalli Formation (Miocene), Varkala, Kerala.
					A. indodeightonii Vishnu et al. 2017	Vishnu et al. 2017, p. 152, figure 4A–C, Upper Siwalik (Kimin Formation, Late Pliocene to Early Pleistocene), Road cuttings along the Itanagar-Banderdewa road in Papumpare district, Arunachal Pradesh.
					A. mioconsobrina Vishnu et al. 2017	Vishnu et al. 2017, p. 152, figure 4D–G, Upper Siwalik (Kimin Formation, Late Pliocene to Early Pleistocene), Road cuttings along the Itanagar-Banderdewa road in Papumpare district, Arunachal Pradesh.
					A. miosphaerelloides Vishnu et al. 2017	Vishnu et al. 2017, p. 155, figures 5A–F, Upper Siwalik (Kimin Formation, Late Pliocene to Early Pleistocene), Road cuttings along the Itanagar-Banderdewa road in Papumpare district, Arunachal Pradesh.
					A. neocombreticola Vishnu et al. 2017	Vishnu et al. 2017, p. 158, figures 6–7, Lower Siwalik (Dafla Formation, Middle to Late Miocene), Road cuttings to the south of Pinjoli area in West Kameng district, Arunachal Pradesh
					A. neoelaeocarpi Vishnu et al. 2017	Vishnu et al. 2017, p. 161, figures 8A–F, Lower Siwalik (Dafla Formation, Middle to Late Miocene), Road cuttings to the south of Pinjoli area in West Kameng district, Arunachal Pradesh
					A. presaracae Vishnu et al. 2017	Vishnu et al. 2017, p. 161, figures 9A–F, Middle Siwalik (Subansiri Formation, Pliocene), Road cuttings to the Bhalukpong area in West Kameng district, Arunachal Pradesh
		Botryosphaeriales C.L. Schoch et al.	*Botryosphaeriaceae* Theiss. & Syd.	*Diplodia* Fr.	*D. rodei* Mahab. 1969	Mahabale 1969, p. 295, plate 1, figures 1–6, Deccan Intertrappean Series (Early Tertiary), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
					D. sahnii Singhai 1974	Singhai 1974, p. 97, plate 1, figures 5–8, Deccan Intertrappean Beds (Late Cretaceous, Maastrichtian), Mohgaon Kalan, Chhindwara District, Madhya Pradesh, India.
		Dothideales Lindau	*Dothioraceae* Theiss. & Syd.	*Sarcophoma* Höhn.	*S. deccanii* R.B. Singh & G.V. Patil 1980	Singh and Patil 1980, p. 17–18, plate 1, figures 6–7, text-figures 9–10, Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.

		Pleosporales Luttr. ex M.E. Barr	*Didymellaceae* Gruyter et al.	*Epicoccum* Link	*E. deccanense* R. Srivast. et al. 2009	Srivastava et al. 2009, p. 16, plate 1, figures 1–6, plate 2, figures 1–7, Deccan Intertrappean Beds (Late Maastrichtian-Danian), Jhargad, near Jhadgaon village, Yavatmal District, Maharashtra, India.
	Leotiomycetes O.E. Erikss. & Winka	*Helotiales* Nannf.	*Mollisiaceae* Rehm	*Trimmatostroma* Corda.	*T. intertrappea* K.S. Patil & Datar 2002	Patil and Datar 2002, p. 32–34, plate 1, figures 1–4, text-figures 1–8, Deccan Intertrappean Beds (Late Cretaceous-Palaeocene), Nawargaon-Maragsur area, Wardha District, Maharashtra.
	Sordariomycetes O.E. Erikss. & Winka	*Diaporthales* Nannf.	*Incertae sedis*	*Botryodiplodia* Sacc.	*B. mohgaoensis* Barlinge & Paradkar 1982	Barlinge and Paradkar 1982, p. 168–169, plate 1, figure G, text-figures A–E, Deccan Intertrappean Series (?Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
		Sordariales Chadef. ex D. Hawksw. & O.E. Erikss.	*Incertae sedis*	*Monotosporella* S. Hughes	*M. doerfeltii* Sadowski et al. 2012	On degraded thallus of cladoniform lichen from Eocene amber, Gujarat.
	Incertae sedis	*Incertae sedis*	*Incertae sedis*	*Desmidiospora* Thaxt.	*D. willoughbyi* (W.H. Bradley) D.L.E. Glass et al. 1986	Jain and Gupta 1970, p. 180, plate 1, figures 3–5, Quilon Beds (Early Miocene), Kollam, Kerala.
				Potamomyces K.D. Hyde	*P. elsikii* (Nandi & A. Sinha) Nuñez Otaño et al. 2017	Nandi and Sinha 2007, p. 99, plate 1, figure 7, Text-figure 2B, Middle Miocene, Mizoram.
					P. mulleri (Nandi & A. Sinha) Nuñez Otaño et al. 2017	Nandi and Sinha 2007, p. 98, plate 1, figure 1–6, 8, 9, Text-figure 2A, Middle Miocene, Mizoram.
				Tetracoccosporium Szabó	*T. eocenum* Biradar & Mahab. 1974	Biradar and Mahabale 1974, p. 223–226, plate 1, figures 1–4, text-figures 1–4, Deccan Intertrappean Series (Maastrichtian), Mohgaon Kalan, Chhindwara District, Madhya Pradesh.
Basidiomycota R.T. Moore	*Ustilaginomycetes* R. Bauer, Oberw. & Vánky	*Urocystidales* R. Bauer & Oberw.	*Glomosporiaceae* Cif.	*Thecaphora* Fingerh	*T. mohgaoensis* (Chitaley & Yawale) R.K. Saxena et al. 2021]	Chitaley and Yawale 1978, p. 190, plate 1, figure 1, Late Cretaceous, Maastrichtian, Mohgaon Kalan, Chhindwara District, Madhya Pradesh; Saxena and Ranhotra 2009, p. 692, figure 3.33, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
			Urocystidaceae Begerow et al.	*Mundkurella* Thirum.	*M. mohgaoensis* Chitaley & Yawale 1978	Chitaley and Yawale 1978, p. 193, plate 1, figures 5–6, Late Cretaceous, Maastrichtian, Mohgaon Kalan, Chhindwara District, Madhya Pradesh.

FOSSIL VS. EXTANT: CASE STUDIES

Three cases of fossil vs. extant in fungi are discussed here. These are: **1.** *Mediaverrunites* Jarzen & Elsik ex Nandi & A. Sinha 2007 vs. *Potamomyces* K.D. Hyde 1995. **2.** *Polycellaesporonites* Anil Chandra et al. 1984 vs. *Alternaria* Nees 1816. **3.** *Frasnacritetrus* Taug. 1968 vs. *Tetraploa* Berk. & Broome 1850.

Case 1 – ***Mediaverrunites*** Jarzen & Elsik ex Nandi & A. Sinha 2007 versus ***Potamomyces*** K.D. Hyde 1995.

Muller (1959) recorded a characteristic unicellular fungal spore, having several verrucae at the equatorial region, from the Recent shelf sediments of the Orinoco

Delta, Venezuela. He, however, did not assign it to any named taxon. Elsik (1976) illustrated identical spores and informally named it *Mediaverrusporonites*. Jarzen and Elsik (1986) informally used the name *Mediaverrunites* to accommodate these spores but they neither proposed it as a genus nor assigned any species to it. They described *Mediaverrunites* as follows: "Fungal spores one-celled, with a single aperture (some specimens appear inaperturate), outline oval to elliptical, pore situated at one end of axis, 7 µm in diameter; spore colour medium brown; septum lacking, but with a shadow band, 10–12 µm wide; surface psilate except for shadow band which is ornamented with 8 (9?) large verrucae, 10–12 µm in diameter; verrucae dark brown to black; spore wall thin <1 µm thick; spore length 62–65 µm, spore width 33–35 µm." Nandi and Sinha (2007) were the first to formally describe *Mediaverrunites* as a genus and designated *Mediaverrunites mulleri* Nandi & A. Sinha 2007 as its type species. Nandi and Sinha (2007), however, considered Jarzen and Elsik (1986) as the author of the genus and proposed an emended diagnosis. Saxena et al. (2021) interpreted that Nandi and Sinha (2007) were the original authors (not the validating authors) of *Mediaverrunites* because earlier authors had no intention of proposing it as a genus nor they assigned any species to it. The original diagnosis of the genus, as given by Nandi and Sinha (2007), is as follow: "Spores aseptate, oval to elliptical, monoaperturate (or sometimes inaperturate), pore situated at the basal end of the axis, equatorial region ornamented with flat or slightly elevated verrucae that remain arranged either freely around the equator or merge to form a shallow, thin to wide, dark to light, shadow-like rim or band, verrucae large or small, apex of verrucae rounded or slightly connate, spore wall psilate to sculptured." The genus name is derived from the Latin *media* referring to the central position of the verrucae.

Based upon overall similarity, Nuñez Otaño et al. (2017) considered *Mediaverrunites* to be a later synonym of *Potamomyces*. They, therefore transferred seven species of *Mediaverrunites* (viz. *M. batii* Sancay 2014, *M. elsikii* Nandi & A. Sinha 2007, *M. fournieri* Elsik & Jarzen 2009, *M. invaginatus* Elsik & Jarzen 2009, *M. magnus* Elsik & Jarzen 2009, *M. mulleri* Nandi & A. Sinha 2007 and *M. pontidiensis* Sancay 2014) to *Potamomyces* K.D. Hyde 1995. However, only two species, viz. *M. elsikii* and *M. mulleri*, described by Nandi and Sinha (2007), have been recorded from India (Figure 2, Table 3).

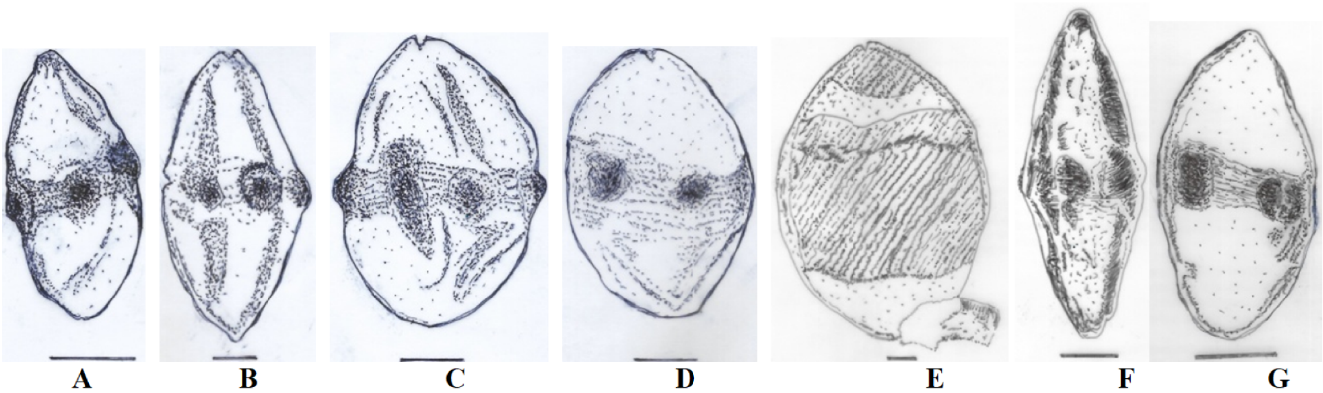

Figure 2. Showing various species of *Mediaverrunites* Nandi & A. Sinha 2007 (Current name: *Potamomyces* K.D. Hyde 1995). *A. *Potamomyces batii* (Sancay) ex Nuñez Otaño et al. 2017. Scale Bar = 20 µm. **B.** *Potamomyces elsikii* (Nandi & A. Sinha) Nuñez Otaño et al. 2017. Scale Bar = 10 µm. ***C.** *Potamomyces fournieri* (Elsik & Jarzen) Nuñez Otaño et al. 2017. Scale Bar = 10 µm. ***D.** *Potamomyces invaginatus* (Elsik & Jarzen) Nuñez Otaño et al. 2017. Scale Bar = 10 µm. ***E.** *Potamomyces magnus* (Elsik & Jarzen) Nuñez Otaño et al. 2017. Scale Bar = 10 µm. **F.** *Potamomyces mulleri* (Nandi & A. Sinha) Nuñez Otaño et al. 2017. Scale Bar = 10 µm. ***G.** *Potamomyces pontidiensis* (Sancay) ex Nuñez Otaño et al. 2017 Sancay 2014. Scale Bar = 20 µm (*not found in India).

Table 3. Showing fossil extant relationship and Indian records of various species allocated to *Mediaverrunites* Nandi & A. Sinha 2007 (Current name: *Potamomyces* K.D. Hyde 1995). Five species, not recorded from India, are marked with an asterisk (*) and their first occurrence is given here.

Suprageneric taxa	Extant genus/ Fossil genus	Fossil species	Indian/ *other records
Phylum: *Ascomycota* **Class:** *Incertae sedis* **Order:** *Incertae sedis* **Family:** *Incertae sedis*	*Potamomyces* K.D. Hyde 1995/ *Mediaverrunites* Jarzen & Elsik ex Nandi & A. Sinha 2007	**Mediaverrunites batii* Sancay 2014 [Current name: *Potamomyces batii* (Sancay) ex Nuñez-Otaño et al. 2017]	Not recorded from India. Original occurrence: Sancay 2014, p.35, plate 1, figures 1–3, Late Miocene, Turkey.
		Mediaverrunites elsikii Nandi & A. Sinha 2007 [Current name: *Potamomyces elsikii* (Nandi & A. Sinha) Nuñez-Otaño et al. 2017]	Nandi and A. Sinha 2007, p. 99, plate 1, figure 7, text-figure 2B, Neogene, Rengtekawn-Sherlui Road Traverse, Mizoram.
		**Mediaverrunites fournierii* Elsik & Jarzen 2009 [Current name: *Potamomyces fournierii* (Elsik & Jarzen) Nuñez-Otaño et al. 2017]	Not recorded from India. Original occurrence: Elsik and Jarzen 2009, 102, plate 1, figures 1–5, Early Miocene, Colombia, South America.
		**Mediaverrunites invaginatus* Elsik & Jarzen 2009 [Current name: *Potamomyces invaginatus* (Elsik & Jarzen) Nuñez-Otaño et al. 2017]	Not recorded from India. Original occurrence: Elsik and Jarzen 2009, p. 102, plate 2, figures 1–5, Early Miocene, Colombia, South America.
		**Mediaverrunites magnus* Elsik & Jarzen 2009 [Current name: *Potamomyces magnus* (Elsik & Jarzen) Nuñez-Otaño et al. 2017]	Not recorded from India. Original occurrence: Elsik and Jarzen 2009, p. 102, plate 2, figures 6–8, Early Miocene, Colombia, South America.
		Mediaverrunites mulleri Nandi & A. Sinha 2007 [Current name: *Potamomyces mulleri* (Nandi & A. Sinha) Nuñez-Otaño et al. 2017]	Nandi and Sinha 2007, p. 98, plate 1, figures 1–6, 8, 9, text-figure 2A, Neogene, Rengtekawn-Sherlui Road Traverse, Mizoram.
		**Mediaverrunites pontidiensis* Sancay 2014; [Current name: *Potamomyces pontidiensis* (Sancay) ex Nuñez-Otaño et al. 2017]	Not recorded from India. Original occurrence: Sancay 2014, p. 35, plate 2, figures 1–2; Late Miocene, Turkey.

Case 2 – *Polycellaesporonites* Anil Chandra et al. 1984 versus *Alternaria* Nees 1816.

Chandra et al. (1984) proposed *Polycellaesporonites* from the Late Quaternary sediment core, Arabian Sea and assigned *P. bellus* Anil Chandra et al. as its type species. They provided the following diagnosis for this genus: "Capsular fungal spores; inaperturate; one end of the spore is rounded while the other gives rise to a tube-like projection; multicellate; cells arranged in clusters, and not in a row or along a single axis; spore wall laevigate." Kalgutkar and Jansonius (2000) emended the generic diagnosis as follows: "Muriform spores with a hilum, and distally with an elongated, knob-like or beaked, extension; overall structure as that in the extant *Alternaria*". Later, Gupta (2002) emended the generic diagnosis as

Table 4. Showing fossil extant relationship and Indian records of various species allocated to *Polycellaesporonites* Anil Chandra et al. 1984 (Current name: *Alternaria* Nees 1816). Two species, not recorded from India, are marked with an asterisk (*) and their original occurrence is given here.

Suprageneric taxa	Extant genus/ Fossil genus	Fossil species	Indian/ *other records
Phylum: *Ascomycota* **Class:** *Dothideomycetes* **Order:** *Pleosporales* **Family:** *Pleosporaceae*	*Alternaria* Nees 1816/ *Polycellaesporonites* Anil Chandra et al. 1984	**Polycellaesporonites acuminatus* (Rouse & Mustard) Kalgutkar & Janson. 2000 [Current name: *Alternaria acuminata* (Rouse & Mustard) Saxena et al. 2022]	Not recorded from India. Original occurrence: Mustard and Rouse 1994, p. 142, plate 4, figure 15, Late Paleocene, Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, and the northwestern Washington State, USA.
		Polycellaesporonites alternariatus (Kalgutkar & Sigler) Kalgutkar & Janson. 2000 [Current name: *Alternaria alternariata* (Kalgutkar & Sigler) Saxena et al. 2022]	Saxena and Ranhotra 2009, p. 692, figure 3.30, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
		Polycellaesporonites bellus Anil Chandra et al. 1984 [Current name: *Alternaria bella* (Anil Chandra et al.) Saxena et al. 2022]	Chandra et al. 1984, p. 49, plate 2, figures 20–21, text-figure 2, Late Quaternary, Sediment core no. 1, Arabian Sea; Saxena et al. 1988, p. 277, plate 2, figure 30, Pinjor Formation (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana; Saxena and Bhattacharyya 1987, p. 189, Lower Siwalik-Nahan and Upper Siwalik (Middle Miocene-Pliocene), Kala Amb-Nahan Section, Sirmaur District, Himachal Pradesh; Saxena and Bhattacharyya 1990, p. 113, Dharmsala Group (Oligocene-Early Miocene), Churan Khad Section near Dharmsala, Kangra District, Himachal Pradesh; Saxena and Ranhotra 2009, p. 692, figure 3.31–32, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
		**Polycellaesporonites clavellatus* (Z.-C. Song & G.-X. Li) Kalgutkar & Janson. 2000 [Current name: *Alternaria clavellata* (Z.-C. Song & G.-X. Li) Saxena et al. 2022]	Not recorded from India. Original occurrence: Song and Li in Song et al. 1989, p. 40, plate 2, figure 21, Middle-Late Oligocene, Shahejie and Dongying Formations: Heze County and Shenxian County of Shandong Province, China.
		Polycellaesporonites psilata A. Gupta 2002 [Current name: *Alternaria psilatus* (A. Gupta) Saxena et al. 2022]	Gupta 2002, p. 146, plate 4, figure 7, Subathu Formation (Eocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh.
		Polycellaesporonites saxenae A. Gupta 2002 [Current name: *Alternaria saxenae* (A. Gupta) Saxena et al. 2022]	Gupta 2002, p. 145, plate 4, figure 4, Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh.
		Polycellaesporonites sirmaurensis A. Gupta 2002 [Current name: *Alternaria sirmaurensis* (A. Gupta) Saxena et al. 2022]	Gupta 2002, p. 145, plate 4, figure 3, Subathu Formation (Eocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh.

follows: "Capsular spore, one end of the spore gives rise to tube like projection, multicellate, inaperturate, cells arranged in clusters and not in a row or along a single axis, spore wall laevigate to ornamented" and proposed three new species. Altogether, seven species of *Polycellaesporonites* are known, viz. *P. acuminatus* (Rouse & Mustard) Kalgutkar & Janson. 2000, *P. alternariatus* (Kalgutkar & Sigler) Kalgutkar &

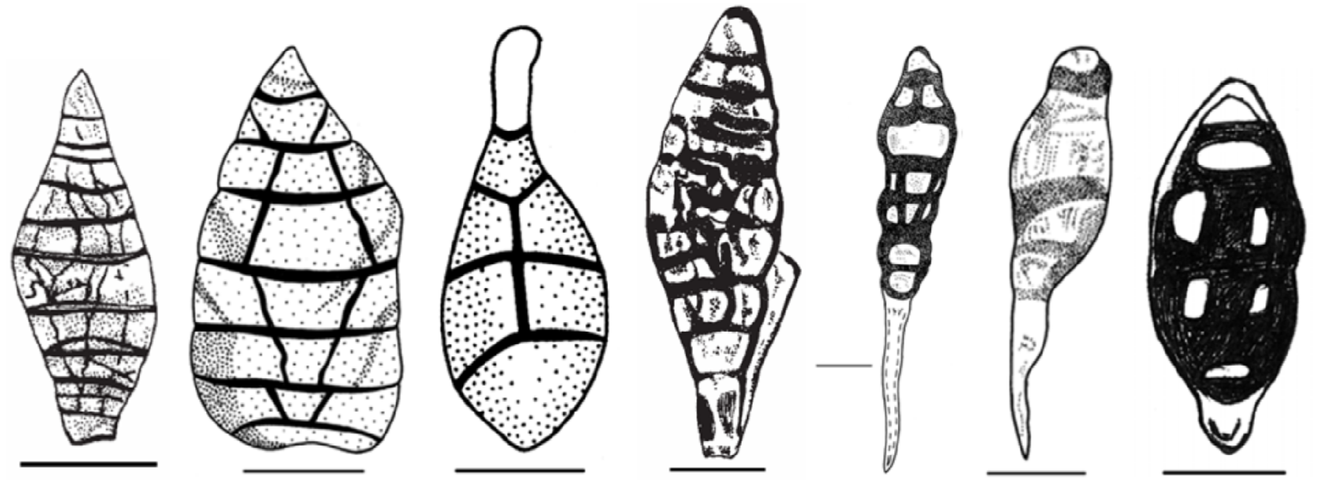

Figure 3. Showing various species of *Polycellaesporonites* Anil Chandra et al. 1984 (Current name: *Alternaria* Nees 1816).
*A. *Alternaria acuminata* (Rouse & Mustard) R.K. Saxena et al. 2022. Scale Bar = 20 µm. **B.** *Alternaria alternariata* (Kalgutkar & Sigler) R.K. Saxena et al. 2022. Scale Bar = 15 µm. **C.** *Alternaria bella* (Anil Chandra et al.) R.K. Saxena et al. 2022. Scale Bar = 15 µm. ***D.** *Alternaria clavellata* (Z.-C. Song & G.-X. Li in Song et al.) R.K. Saxena et al. 2022. Scale Bar = 20 µm. **E.** *Alternaria psilata* (A. Gupta) R.K. Saxena et al. 2022. Scale Bar = 10 µm. **F.** *Alternaria saxenae* (A. Gupta) R.K. Saxena et al. 2022. Scale Bar = 5 µm. **G.** *Alternaria sirmaurensis* (A. Gupta) R.K. Saxena et al. 2022. Scale Bar = 15 µm (* not found in India).

Janson. 2000, *P. bellus* Anil Chandra et al. 1984, *P. clavellatus* (Z.-C. Song & G.-X. Li) Kalgutkar & Janson. 2000, *P. psilatus* A. Gupta 2002, *P. saxenae* A. Gupta 2002 and *P. sirmaurensis* A. Gupta 2002. All the species, except *P. acuminatus* and *P. clavellatus*, have been recorded from India.

Based upon overall similarity, Saxena et al. (2022) considered *Polycellaesporonites* to be a later synonym of *Alternaria* and transferred all the seven species of former to the latter (Figure 3, Table 4).

Case 3 – *Frasnacritetrus* Taug. 1968 versus *Tetraploa* Berk. & Broome 1850.

Taugourdeau (1968) proposed *Frasnacritetrus* (Type species: *F. josettae* Taug. 1968) with following diagnosis: "Organic-walled microorganism, generally of cylindrical shape tending to a rounded slightly bell-shaped parallelepiped, in transversal section nearly circular at one pole, becoming rectangular with rounded corner at the opposite pole which carries four hollow horns (or "processes") that extend the ribs of the body." Taugourdeau (1968) stated that this single specimen does not resemble any microfossil already described. He also did not rule out possibility of contamination. He speculated possibility of this specimen being either a broken Diacrodian or half an organism of some *Conjugales* (*Desmidiales*) or linear colony such as certain *Desmochitina* or hydrozoans. But he rejected all the above possibilities and could not reach to any conclusion. Saxena and Sarkar (1986) emended the generic diagnosis, to allow inclusion of a number of fungal conidia that show a general similarity to the morphology of *Tetraploa*. This fungus generally grows on *Poaceae*, and the fossil species occur in association with grass pollen. Saxena and Sarkar (1986) adduced this to support their suggestion that *Frasnacritetrus* should not be considered an acritarch but a fossil genus with affinity to *Tetraploa*. Accordingly, they emended the generic diagnosis as follows: "Microfossils having two to four processes. Body subrectangular, unicellular or divided into chambers by septa, smooth or variously sculptured. Processes mostly smooth but may also be sculptured, unicellular or septate. Main body of the microfossils generally rectangular-subrectangular but variously shaped; either unicellular or divided into longitudinal chambers by vertical septa or multichambered, being divided by both vertical and transverse septa; septa may be complete or incomplete,

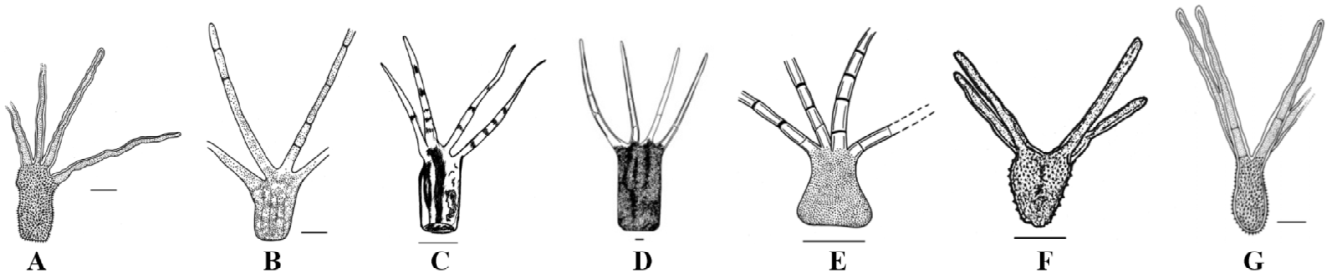

Figure 4. Showing various species of *Frasnacritetrus* Taug. 1968.
A. *Frasnacritetrus conatus* R.K. Saxena & S. Sarkar 1986. Scale Bar = 10 µm. **B.** *Frasnacritetrus indicus* R.K. Saxena & S. Khare 1992. Scale Bar = 10 µm. **C.** *Frasnacritetrus jamthaensis* A. Gupta 2002. Scale Bar = 15 µm. ***D.** *Frasnacritetrus josettae* Taug. 1968. Scale Bar = 5 µm. **E.** *Frasnacritetrus masolensis* R.K. Saxena & S.K.M. Tripathi 2011. Scale Bar = 20 µm. **F.** *Frasnacritetrus siwalikus* R.K. Saxena et al. 1988. Scale Bar = 10 µm. **G.** *Frasnacritetrus taugourdeaui* R.K. Saxena & S. Sarkar 1986. Scale Bar = 10 µm (* not found in India).

Table 5. Showing fossil–extant relationship and Indian records of various species allocated to *Frasnacritetrus* Taug. 1968. One species, not recorded from India, is marked with an asterisk (*) and its original occurrence is given here.

Suprageneric taxa	Extant genus/ Fossil genus	Fossil species	Indian/ *other records
Phylum: *Ascomycota* **Class:** *Dothideomycetes* **Order:** *Pleosporales* **Family:** *Tetraplosphaeriaceae*	*Tetraploa* Berk. & Broome 1850/ *Frasnacritetrus* Taug. 1968	*Frasnacritetrus conatus* R.K. Saxena & S. Sarkar 1986	Saxena and Sarkar 1986, p. 215–216, plate 1, figures 4–5, text-figure 3, Kasauli Formation and Lower Siwalik (Miocene), near Banethi, Sirmaur District, Himachal Pradesh, and Nalagarh–Ramshahr Road Section, Solan District, Himachal Pradesh; Sarkar 1997, p. 102, 104, 108, Subathu Formation (Eocene), 20 km southeast of Bilaspur on Shimla-Bilaspur Highway, Bilaspur District, Himachal Pradesh; Saxena 2000, p. 163, Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra; Saxena and Ranhotra 2009, p. 692, figure 3.18, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
		Frasnacritetrus indicus R.K. Saxena & Khare 1992	Saxena and Khare 1992, p. 42, plate 1, figure 17, Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu; Saxena and Ranhotra 2009, p. 692, figure 3.23, Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat.
		Frasnacritetrus jamthaensis A. Gupta 2002	Gupta 2002, p. 148, plate 5, figures 1–3, Subathu and Dagshai formations (Late Palaeocene-Early Oligocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh.
		**Frasnacritetrus josettae* Taug. 1968	Not recorded from India. Original occurrence: Taugourdeau 1968, p. 3, plate 1, figures 1–4, Late Devonian (Frasnian), Boulonnais, Marquise, France.
		Frasnacritetrus masolensis R.K. Saxena & S.K.M. Tripathi 2011	Saxena et al. 1988, p. 278, plate 2, figure 34, Tatrot and Pinjor Formations (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana.
		Frasnacritetrus siwalikus R.K. Saxena et al. 1988	Saxena et al. 1988, p. 277, plate 2, figures 31–33, Tatrot and Pinjor Formations (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana; Kumar and Takahashi 1991, p. 609, plate 7, figure 6, plate 16, figure 11, Lower Bhuban and Bokabil formations (Early-Middle Miocene), Silchar-Haflong Road Section, Assam; Kumar 1994, p. 55, plate 27, figure 6, Lower Bhuban Formation (Early Miocene), Silchar-Haflong Road Section, Assam; Singh and Sarkar 1994, p. 52, Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh.
		Frasnacritetrus taugourdeaui R.K. Saxena & S. Sarkar 1986	Saxena and Sarkar 1986, p. 213–215, plate 1, figures 1–3, text-figure 2, Kasauli Formation and Lower Siwalik (Miocene), near Banethi, Sirmaur District, Himachal Pradesh and Ramshahr Well no.1, Solan District, Himachal Pradesh.

sometimes septa faintly developed; body either smooth or ornamented with grana, verrucae or coni, etc., sculpturing elements may be closely or sparsely or evenly distributed". Two to four processes arising from one end of the body (although in *Frasnacritetrus* sp. 4, three processes are attached at the end of the body while the fourth one comes out from the middle of the body); generally broader at the base and tapering towards the apices; cylindrical or ribbon-like; either aseptate-unicellular or septate, septa one to many in each process; apex of processes pointed or blunt. *Frasnacritetrus* is not comparable to any of the known fossil palynogenera".

Altogether, seven species of *Frasnacritetrus* are known, viz. *F. conatus* R.K. Saxena & S. Sarkar 1986, *F. indicus* R.K. Saxena & S. Khare 1992, *F. jamtahensis* A. Gupta 2002, *F. josettae* Taug. 1968, *F. masolensis* R.K. Saxena & S.K.M. Tripathi 2011, *F. siwalikus* R.K. Saxena et al. 1988 and *F. taugourdeaui* R.K. Saxena & S. Sarkar 1986. All the species, except *F. josettae*, have been recorded from India.

Based upon overall similarity, N.B. Nuñez Otaño and R.K. Saxena are making their detailed study. The work is in progress and soon the results will be published (Figure 4, Table 5).

PALAEOENVIRONMENTAL SIGNIFICANCE

Fungi, being heterotrophic in nature, are found in close association with specific plants and animals, and when found in fossil state are indicative of similar kind of situations during the geological past. Fossil fungi, therefore, may provide useful information about the palaeoenvironment, past habitats and their hosts. Fossil spororocarps of microthyriaceous taxa are generally considered to be reliable palaeoenvironmental indicators. Their occurrences are, generally, correlated with moist, humid climates and tropical to subtropical temperatures. Edwards (1922) reported the occurrence of this group on conifer needles. Microthyriaceous fungi grow best in rain forests, rain forest margins and along creek banks (Ramanujam 1982). Hence their presence is generally indicative of a wet tropical climate with heavy precipitation.

The palaeohabitat interpretations based on fossil epiphyllous microthyriaceous fungi and their germlings is well established through the studies on their modern equivalents growing on leaf litter from various Australian regions. These studies have shown the occurrence of microthyriaceous germlings in greater number on the plants growing in moist tropical habitats. Such studies have great potential in interpreting the palaeoclimate and should be undertaken for other geographical areas. However, the ecological interpretations based on epiphyllous fungi should be made with caution because some of these are reported to occur in wider latitudinal ranges (Dilcher 1965, Selkirk 1975). It is therefore, advisable to take into consideration the complete palynological assemblage for palaeoenvironmental interpretations. In most of the cases, coordinated studies on plant megafossils in association with palynological assemblages may provide more accurate information about the palaeoenvironmental conditions. Dilcher (1965) published an account of epiphyllous fungi from *Microthyriales*, *Erysiphales* (now *Helotiales*) and *Meliolales*, thriving on leaves of different plants, from the middle Eocene of Tennessee, U.S.A. Such studies bear great potential for determining the regional palaeoclimate by comparing the fossils with extant taxa of known habitats. Environmental interpretations based on the presence of *Microthyriaceae* may, however, sometimes be hampered due to the incorrect identification of the material. Their presence in dispersed fossil assemblages should, therefore, be ascertained before deciphering the past climate. The red alga *Caloglossa leprieurii*, generally found on grasses of brackish water marshes may be confused with *Trichopeltinites* due to morphological resemblance. Similarly, marine green alga *Ulvella lens* also resembles the fructifications of *Microthyriaceae*.

Studies, particularly focusing on host-fungus relationship, are also of great significance in attempting the palaeoenvironmental interpretations. Chitaley (1978) and Chitaley and Yawale (1978) provided valuable palaeoecological information based on the presence of fossil fungal spores in petrified plant materials from the Deccan Intertrappean beds of Central India.

Similar kinds of interpretations were published by Kar et al. (2003, 2004a, b, 2005, 2006) and Sharma et al. (2005). These studies emphasize the importance of some fungal spores in evaluation of palaeoenvironment. Kar et al. (2003) reported a sporocarp assignable to *Polyporaceae* (*Basidiomycota*) from the Lameta Formation (Late Cretaceous) exposed in Madhya Pradesh, India. This fossil, called *Lithopolyporales zeerabadensis*, resembles the extant *Fomes* (Fr.) Fr. 1849 which are saprobes on dead wood of various trees. Kar et al. (2004a) described a fossil fungus showing affinity to *Colletotrichum* Corda 1831 (*Glomerellaceae*), from an Intertrappean bed exposed at Mohgaon-Kalan Village, Chhindwara District, Madhya Pradesh, India. The modern species of this genus causes red rot in the economically important plants. The fossil of this fungus shows setae on the margins of the acervuli and was found to be preserved on a leaf cuticle. It was called *Protocolletotrichum deccanense* R.K. Kar et al. 2004 [as *deccanensis*] (Kar et al. 2004b). Kar et al. (2004a) described fossil parasitic fungi and epiphyllous fruiting bodies from the coprolite of dinosaurs. The coprolite yielding these fossils was collected from the Lameta Formation (Maastrichtian) of Central India. Occurrence of these fungi indicates that the plant leaves infected by the recovered fungi were part of dinosaurs' diet. Kar et al. (2006) reported two types of fossil Ingoldian aquatic fungi from the Miocene sediments of Mizoram, India. The first type, comparable to the extant *Tetrachaetum*, is needle-shaped and belongs to the scolicospores whereas the other type, comparable to the extant *Ceratosporella*, possesses globular to triangular body belongs to staurospores.

On the basis of fossil fungi, Kar and Saxena (1976) interpreted a warm and humid, tropical climate during the Palaeocene (Matanomadh Formation) of Kutch, western India with the support from spores and pollen of vascular plants. Ramanujam and Srisailam (1980) recorded a prevalence of *Palaeocirrenalia*, the helicoid spore, in Neogene sediments of Kerala, India and interpreted brackish to marine conditions by comparing them to the similar extant dematiaceous hyphomycete, *Cirrenalia*, which is commonly found in such an environment. The presence of other spores in the same strata, affiliated to *Grallomyces*, *Sporidesmium*, *Spegazzinia*, *Amphisphaerella* and *Isthmospora*, also supports this interpretation of a tropical climate. This conclusion was corroborated by pteridophytic spores and angiospermous pollen from the same strata and a tropical climate was concluded (Ramanujam & Rao 1978, Ramanujam & Srisailam 1980). A warm and humid environment has been interpreted by Kalgutkar and McIntyre (1991) in the Canadian Arctic due to the presence of helicosporous fungal types. Studies on certain fungal assemblages, sporomorphs and sporocarps, in coordination with micro- and megafossils of other groups, are used to infer the palaeoenvironment (Dilcher 1973). Pirozynski (1976a, b) and Ramanujam (1982) stressed the importance of coordinating the study of fossil fungi with their extant counterparts, in order to realize the full potential of fossil fungal spores as indicators of ancient environment. Ramanujam (1982) further urged that only those types, clearly related to extant taxa of which the environmental requirements are known, are relevant in such studies. These assessments are based on the assumption that the palaeoclimatic sensitivity of fossil taxa was similar to that of the comparable extant counterparts. In this regard, special stress was laid to explore the possibility of relating fossil fungal spores with those of modern fungi so as to realize their full potential in determining the ancient environment. However, only those types that could be related to the extant forms with certainty should be taken into account for this specific purpose.

CONCLUDING REMARKS

For palaeoclimatic and palaeoecological interpretations, 'Uniformitarian Principle' is applied which is based on the assumption that the same natural laws and processes that operate in our present-day scientific observations have always operated in the universe in the past and apply everywhere in the universe. This principle is largely accepted the world over and is simplified as 'The Present is the key to the Past'. The primary prerequisite for applying this principle is to relate fossils with their extant counterparts. Since habitats, climate and ecology of present day organisms is known, it can easily be suggested to be the same for their ancient fossil relatives. This prompts fossil workers, including palaeomycologists, to trace affinity of fossil taxa to their present day representatives. Sincere attempts must therefore be made by expert mycologists to standardize the morphotaxonomy and character evaluation of fossil fungal taxa and to trace the link of fossil fungal remains with modern fungi. This will also help to decipher evolutionary trends within this group.

Host-pathogen interaction is another aspect, which does not have basic information in the form of fossil evidence. The interaction of fungi with higher plants with reference to the palaeobotanical evidences need to be documented in appropriate manner by exploring more fossil fungi along with chemical and geological aspects. In biostratigraphic and environmental applications, it is always better to consider and apply data derived from all kind of microfossils. The inferences derived from multi-disciplinary cumulative data, i.e. a synergistic approach, are always more sound and reliable.

ACKNOWLEDGEMENTS

The authors are grateful to Kawmini D. Wickramanayake for formatting and cross-checking references. R.K.S. would like to thank authorities of the Birbal Sahni Institute of Palaeosciences, Lucknow, India for library facilities and N.N.W. to High-Level Talent Recruitment Plan of Yunnan Provinces ("Young Talents" Program and "High-End Foreign Experts" Program).

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