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Global diversity and distribution of fossil *Dictyosporae*

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ABSTRACT

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Encounter with dispersed fossil fungi is a common phenomenon in palynological studies. These are generally found in the form of spores, mycelia, sporocarps and symbiotic associations. Fungal spores exhibit a variety of morphological variations in number and nature of cells, apertures and spore wall characters, e.g. unicellate, dicellate, tricellate, multicellate, muriform, filiform, spirally coiled, star-like, etc. According to number and arrangement of cells, spores are divided into: *Amerosporae*, *Didymosporae*, *Phragmosporae*, *Dictyosporae*, *Helicosporae*, *Staurosporae* and *Scolecosporae.* The present paper deals with *Dictyosporae* only, recorded so far from the world over. These spores (conidia) are divided into cells by longitudinal and transverse septa. Altogether, 11 genera and 60 species have been dealt here, including 10 fossil genera with 53 fossil species and one extant genus (*Alternaria*) with seven fossil species. These are: *Alternaria* Nees 1816 (7 spp.), *Centonites* Peppers 1964 (1 sp.), *Ctenosporites* Elsik & Janson. 1974 (2 spp.), *Dictyosporites* Félix 1894 (15 spp.), *Dictyosporiuminites* Debi Mukh. 2012 (1 sp.), *Kutchiathyrites* R.K. Kar 1979 (5 spp.), *Lirasporis* R. Potonié & S.C.D. Sah 1960 (2 spp.), *Octosporites* Sal.-Cheb. & Locq. 1980 (1 sp.), *Papulosporonites* Schmied. & A. J. Schwab 1964 (7 spp.), *Polyadosporites* Hammen 1954 (3 spp.) and *Staphlosporonites* Sheffy & Dilcher 1971 (16 spp.). The dominant genera, both in number and variety, are *Staphlosporonites*, *Dictyosporites*, *Alternaria*, *Papulosporonites* and *Kutchiathyrites*. Dictyospores have been recorded from Australia, Azerbaijan, Cameroon, Canada, China, Colombia, Germany, India, Spain, Turkey and U.S.A. In India, these have been recorded from many areas, e.g. Arabian Sea, Gujarat (Kutch and Cambay basins), Haryana, Himachal Pradesh, Kerala, Madhya Pradesh, Meghalaya-Assam, Mizoram, Tamil Nadu, Tripura and West Bengal. Fungal spores are useful in the evaluation of the palaeoenvironments, particularly those that can be related to modern taxa.

Keywords: Fossil fungi, fungal spores, *Dictyosporae*, global diversity, distribution.

INTRODUCTION

Studies on fossil fungi gained importance all over the world during the last fifty years. Kalgutkar and Jansonius (2000) published a synopsis of fossil fungi and tried to streamline taxonomic status of almost all fossil fungal genera and species published till then. Lakhanpal et al. (1976) and Saxena (1991, 2006) published catalogues in order to document all records of fossil fungal remains from the Indian Tertiary sediments. Saxena and Tripathi (2011) published a monographic study with the objective to synthesize the available information on Indian fossil fungi. 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. Saxena and Wijayawardene (2022) attempted to establish fossil-extant relationship in *Fungi* and their significance in palaeoenvironmental interpretation.

In the present paper, fossil fungal spores have been treated according to Saccardoan system of grouping the spores (e.g. *Amerosporae*, *Didymosporae*, *Phragmosporae*, *Dictyosporae*, *Helicosporae*, *Staurosporae* and *Scolecosporae*). This is based mainly on number and arrangement of cells. Here, in this paper, only *Dictyosporae* are dealt with, which includes conidia divided into cells by longitudinal and

transverse septa. This group is represented by the following genera: *Alternaria* Nees 1816, *Centonites* Peppers 1964, *Ctenosporites* Elsik & Janson. 1974, *Dictyosporites* Félix 1894, *Dictyosporiuminites* Debi Mukh. 2012, *Kutchiathyrites* R.K. Kar 1979, *Lirasporis* R. Potonié & S.C.D. Sah 1960, *Octosporites* Sal.-Cheb. & Locq. 1980, *Papulosporonites* Schmied. & A.J. Schwab 1964, *Polyadosporites* Hammen 1954, and *Staphlosporonites* Sheffy & Dilcher 1971.

Félix (1894) instituted the genus *Dictyosporites* (Type: *D. loculatus* Felix) from the Eocene sediments of Perekeschkul, near Baku, Azerbaijan. According to Kalgutkar and Jansonius (2000), *Arbusculites* Paradkar 1976, *Dactylosporites* Paradkar 1976, *Pleosporonites* R.T. Lange & P.H. Sm. 1971 and *Ravenelites* Ramanujam & Ramachar 1980 are later synonyms of *Dictyosporites.* Van der Hammen (1954) instituted the genus *Polyadosporites* (Type: *P. suescae* Hammen) from the Maastrichtian sediments of Magdalena Valley, Eastern Cordillera, Colombia, South America, for fungal spores composed of several grains or cells that are united along several axes or in a more or less irregular manner. Kalgutkar and Jansonius (2000) emended the generic diagnosis as follows: "Spores (sub)spherical, loosely aggregated in clusters, with individual cells not connected to others by shared walls; clusters (colonies?) more or less regularly spherical to subspherical." Potonié and Sah (1960) proposed the genus *Lirasporis (*Type: *L. intergranifer* R. Potonié & S.C.D. Sah) from the Miocene or Pliocene sediments of Cannanore Beach, Kerala, India and diagnosed it as follows: "Size varies from 69 × 103 µm to 116 × 134 µm; outline oval, longitudinal ends broadly rounded or somewhat tapering, sometimes showing irregular protuberances which form a jumbled mass; *extrema lineamenta* somewhat smooth except the longitudinal ends which are always nearly notched; following the longer axis exist perhaps 20–30 parallel but narrow ribs showing between them spaced grana. Jain and Kar (1979) emended the generic diagnosis as follows: "Fungal bodies oval-elliptical with equal or unequal, broad, generally notched ends. Mycelia, long, septate, parallel to one another, extending from one end to other; wall generally laevigate, sometimes granulose." Jain and Kar (1979) observed that the parallel ribs seem to be septate fungal mycelia arranged in longitudinal direction. Kalgutkar and Jansonius (2000), however, had reservations about the fungal nature of these forms. Schmiedeknecht and Schwab (1964) proposed the genus *Papulosporonites* (Type: *P. sphaeromorphus* Schmied. & A.J. Schwab) from the Middle Eocene sediments of Zwischenflöz, Tagebau des Braunkohlenwerkes Nachterstedt, Germany with the following diagnosis: "Fungal remains of globular to elongate shape, consisting of numerous more or less polygonal cells that are firmly fused into mulberry-shaped aggregates. Cells without any regular order, or concentrically arranged. No differentiation of an outer wall layer; however, one to three of the innermost cells commonly much larger. Occasionally individual aggregates fused together." Peppers (1964) described the genus *Centonites* (Type: *C. symmetricus* Peppers) from the Late Pennsylvanian sediments of Illinois, U.S.A. Elsik (1992) indicated that the spore wall of *Centonites* appears to be not exclusively fungal; thus, an algal affinity cannot be ruled out. Sheffy and Dilcher (1971) described the genus *Staphlosporonites* (Type: *S. conoideus* Sheffy & Dilcher) from the Middle Eocene sediments of Puryear clay pit, 800 m south of Puryear, Henry County, Tennessee, U.S.A. for inaperturate, psilate to punctate fungal or algal bodies of four or more irregular cells. Cells in clusters, shape variable along more than one axis. Kalgutkar and Jansonius (2000) emended the generic diagnosis as follows: "Inaperturate multicellate fungal spores, with muriform architecture (cells internally dividing without a regular pattern), lacking a plane or axis of symmetry. Cells rounded or rounded polygonal, septa may be depressed where they intersect the amb. Overall shape generally more or less elongate; sometimes oval to ellipsoidal, rarely subspherical. Always with a distinct proximal hold-fast cell and/or a hilar scar." According to Kalgutkar and Jansonius (2000), *Transeptaesporites* Ediger 1981 is a later synonym of *Staphlosporonites.* Elsik and Jansonius (1974)

instituted *Ctenosporites* (Type: *C. eskerensis* Elsik & Janson.) from the Paleogene sediments of the Pacific Northwest. Kar (1979) proposed the genus *Kutchiathyrites* (Type: *K. eccentricus* Kar) from the Maniyara Fort Formation (Oligocene) exposed along Barkhana nala cutting, near the village Sarangwara, Kutch District, Gujarat. India. Kar (1979) identified it as a non-ostiolate microthyriaceous asco-stromata with radially arranged thick hyphae. Kalgutkar and Jansonius (2000) emended the generic diagnosis as follows: "Hilate conidia, fan-shaped, formed by numerous linear filaments radiating out from the hilum; conidia may be flattened (i.e. two-) or three-dimensional; filaments may be joined to their neighbors, or partially free, and may branch towards the periphery; hilum may or may not show the stipe from which it developed". Salard-Cheboldaeff & Locquin (1980) described *Octosporites* (Type: *O. stauroides* Sal.-Cheb. & Locq.) from the Early Miocene sediments of Coast of Equatorial Africa, Gulf of Guinea, Cameroon and diagnosed it as "monohilate, octocellate murospores, globular, the middle partitions forming a cross; 15 μm". Chandra et al. (1984) instituted the genus *Polycellaesporonites* (Type: *P. bellus* Chandra et al.) from the Quaternary sediment cores in Arabian Sea and diagnosed it as "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 modern *Alternaria*." Saxena et al. (2022) considered this genus a later synonym of extant *Alternaria* Nees and transferred seven species allocated to it to *Alternaria* Nees 1816. Mukherjee (2012) instituted *Dictyosporiuminites* (Type: *D. intermedius* Debi Mukh.) from the lignite deposits (Miocene) of Neyveli Lignite Mine–I in Cuddalore District, Tamil Nadu, India. and compared it with the extant *Dictyosporium* in having sporodochium-like structure with multiseptate conidiophores (united together).

FOSSIL *DICTYOSPORAE*

1. Genus: ***Alternaria*** Nees

Index Fungorum Registration Identifier: 7106.

Type species: *Alternaria tenuis* Nees, Index Fungorum Registration Identifier: 211928.

Heterotypic synonym: *Polycellaesporonites* Anil Chandra et al. 1984, Index Fungorum Registration Identifier: 25604.

Classification: Phylum: *Ascomycota*, Class: *Dothideomycetes*, Order: *Pleosporales*, Family: *Pleosporaceae*.

Number of fossil species known: Seven.

Remarks: Chandra et al. (1984) proposed *Polycellaesporonites* (Type: *P. bellus* Anil Chandra et al. 1984) and diagnosed the genus as follow: "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) and Gupta (2002) emended the diagnosis of the genus, as follows: Muriform spores with a hilum, and distally with an elongated, knob-like or beaked, extension; overall structure as that in the modern *Alternaria* (Kalgutkar & Jansonius 2000); 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 (Gupta 2002). Altogether, seven species have been assigned to this genus (Saxena et al. 2021). Saxena et al. (2022) considered *Polycellaesporonites* a synonym of *Alternaria* Nees and transferred all the species of the former to the latter.

1.1. Species: ***Alternaria acuminata*** (Rouse & Mustard) R.K. Saxena et al. 2022

Figure 1

Index Fungorum Registration Identifier: 843345**.**

Basionym: *Multicellaesporites acuminatus* Rouse & Mustard, Palynology 21: 208. 1997, Index

Fungorum Registration Identifier: 463998.

Homotypic synonyms: 1. *Piriurella acuminata* (Rouse & Mustard) M.G. Parsons & G. Norris 1999, Index Fungorum Registration Identifier: 483924. 2. *Polycellaesporonites acuminatus* (Rouse & Mustard) Kalgutkar & Janson. 2000, Index Fungorum Registration Identifier: 483526.

Original description: Fusiform fungal spores, consisting of 5–6 thin septa in each half; each septum with a small central pore; septa supporting an inner membranous body that is closely appressed to the outer wall in central regions, but contracted away from the outer wall towards the two pointed extremities; wrinkles occur sporadically on the inner wall that appear as elongate irregular plicae. Dimensions: range of length 62–68 µm; of diameter 17–25 µm.

Figure 1. *Alternaria acuminata* (Rouse & Mustard) R.K. Saxena et al. 2022. Scale Bar = 20 µm.

Location: Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, Canada and the Northwestern Washington State, U.S.A.

Age: Late Palaeocene.

1.2. Species: ***Alternaria alternariata*** (Kalgutkar & Sigler) R.K. Saxena et al. 2022

Figure 2

Index Fungorum Registration Identifier: 843343.

Basionym: *Piriurella alternariata* Kalgutkar & Sigler, Mycological Research 99(5): 518, figure 14. 1995, Index Fungorum Registration Identifier: 413840.

Homotypic synonym: *Polycellaesporonites alternariatus* (Kalgutkar & Sigler) Kalgutkar & Janson. 2000, Index Fungorum Registration Identifier: 483527.

Original description: Conidia arising singly or in clusters; multicellate, muriform, solitary, ovoid to obclavate, rostrate, cicatrized or not, pale brown to brown, smooth. Conidia with a short conical beak and 8–12 transverse and several longitudinal or oblique septa; transverse septa more prominent and thicker than the longitudinal or oblique septa; terminal [apical] conical beak about 9–11 µm broad, with a conspicuous dark thickened tip that probably represents the point of origin (attachment scar) of the next apical spore in the succession of a conidial chain. Conidia, when cicatrized, with a scar at the proximal end at the point of attachment to the conidiophore. Conidia 42–74 µm long, 18–27 µm wide in the broadest part.

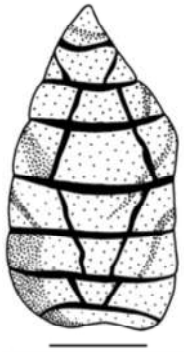

Figure 2. *Alternaria alternariata* (Kalgutkar & Sigler) R.K. Saxena et al. 2022. Scale Bar = 15 µm.

Location: Kanguk Peninsula, Axel Heiberg Island, Northwest Territories, Canada.

Age: Late Palaeocene or Early Eocene (Iceberg Bay Formation).

Remarks: This species has also been recorded from the intertrappean beds (Early Palaeocene) exposed at about 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat, India (Saxena & Ranhotra 2009).

1.3. Species: ***Alternaria bella*** (Anil Chandra et al.) R.K. Saxena et al. 2022

Figure 3

Index Fungorum Registration Identifier: 843342.

Basionym: *Polycellaesporonites bellus* Anil Chandra et al., Biovigyanam 10(1): 49, plate 2, figure 20. 1984, Index Fungorum Registration Identifier: 107183.

Original description: Fungal spore with a capsular body and a tube-shaped unicellular appendage emerging from one end; size range 45–68 × 13–15 µm; main body of spore 33–48 × 13–15 µm; tube-like projection hyaline, 12–20 µm long, multicellate individual cells rectangular, not arranged along one axis; inaperturate; spore wall 1–1.5 µm thick, psilate.

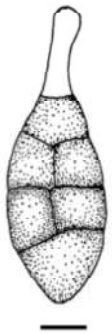

Figure 3. *Alternaria bella* (Anil Chandra et al.) R.K. Saxena et al. 2022. Scale Bar = 15 µm.

Location: Sediment core no. 1 (Lat. 17°57.92' N: Long. 70°46.02' E), Arabian Sea.

Age: Late Quaternary.

Remarks: Chandra et al. (1984) suggested possible affinity of this species to *Alternaria* sp.

1.4. Species: ***Alternaria clavellata*** (Z.-C. Song & G.-X. Li in Song et al.) R.K. Saxena et al. 2022

Figure 4

Index Fungorum Registration Identifier: 843347.

Basionym: *Pluricellaesporites clavellatus* Z.-C. Song & G.-X. Li in Song et al., Early Tertiary Sporo-Pollen Assemblages from the Dongpu Region: 40, plate 2, figure 21. 1989, Index Fungorum Registration Identifier: 485254.

Homotypic synonym: *Polycellaesporonites clavellatus* (Z.-C. Song & G.-X. Li in Song et al.) Kalgutkar & Janson. 2000, Index Fungorum Registration Identifier: 483528.

Original description: Spores clavate with a long stipe and wide middle part, tapering toward both ends; about 100 µm in length, widest part about 18 µm in width. Spores multicellular, cells flat, some middle cells appear to be subdivided [by longitudinal septa]. Septa generally without septal folds and pores. Stipe of one cell, about 30 µm in length, with an attachment scar or pore at the [proximal] end. Spore wall less than 1 µm in thickness, surface smooth.

Figure 4. *Alternaria clavellata* (Z.-C. Song & G.-X. Li in Song et al.) R.K. Saxena et al. 2022. Scale Bar = 20 µm.

Location: Heze County and Shenxian County of Shandong Province, China.

Age: Middle-Late Oligocene (Shahejie and Dongying formations).

1.5. Species: ***Alternaria psilata*** (A. Gupta) R.K. Saxena et al. 2022

Figure 5

Index Fungorum Registration Identifier: 843341.

Basionym: *Polycellaesporonites psilatus* A. Gupta, Tertiary Research 21(1–4): 146, plate 4, figure 7. 2002, Index Fungorum Registration Identifier: 540760.

Original description: Spores multicelled, elongate, showing cells arranged in clusters along more than one axis at one end and a tube-like appendage at other, inaperturate, 37–78 µm long, number of cells

across its width of cell clusters ranges up to 3 or more, psilate, surface folded.

Figure 5. *Alternaria psilata* (A. Gupta) R.K. Saxena et al. 2022. Scale Bar = 10 μm.

Location: Dadahu Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Late Palaeocene to Early Oligocene (Subathu Formation).

Etymology: The species was named after its psilate spore wall.

1.6. Species: ***Alternaria saxenae*** **(**A. Gupta) R.K. Saxena et al. 2022

Figure 6

Index Fungorum Registration Identifier: 843340.

Basionym: *Polycellaesporonites saxenae* A. Gupta, Tertiary Research 21(1–4): 145, plate 4, figure 4, 2002, Index Fungorum Registration Identifier: 540761.

Original description: Spores multicelled, elongate, showing cells arranged in clusters along more than one axis at one side and a tube-like appendage at other, inaperturate, measuring 35–75 μm long, three or more cells across width, granulate, sculptural elements distinct at cell clusters but indistinct at appendage, surface folded.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Late Palaeocene to Early Oligocene (Subathu Formation).

Figure 6. *Alternaria saxenae* (A. Gupta) R.K. Saxena et al. 2022. Scale Bar = 5 μm.

Etymology: The species was named to honour Dr. Ramesh K. Saxena, Birbal Sahni Institute of Palaeosciences, Lucknow, India.

1.7. Species: ***Alternaria sirmaurensis*** **(**A. Gupta) R.K. Saxena et al. 2022

Figure 7

Index Fungorum Registration Identifier: 843339.

Basionym: *Polycellaesporonites sirmaurensis* A. Gupta, Tertiary Research 21(1–4): 145, plate 4, figure 3. 2002, Index Fungorum Registration Identifier: 540762.

Original description: Spores multicelled, elongate, showing cells arranged in clusters along more than one axis at one side and a tube-like appendage at other, inaperturate, measuring 26–58 μm long, number of cells across the width of cells cluster ranges up to 2, largely granulate, sculptural elements distinct at cluster but indistinct at appendage, surface folded.

Figure 7. *Alternaria sirmaurensis* (A. Gupta) R.K. Saxena et al. 2022. Scale Bar = 15 μm (* not found in India).

Location: Dadahu Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Late Palaeocene to Late Eocene (Subathu Formation).

Etymology: The species was named after Sirmaur District in Himachal Pradesh, India where its type locality is situated.

2. Genus: ***Centonites*** Peppers 1964

Index Fungorum Registration Identifier: 21032.

Type species: *Centonites symmetricus* Peppers 1964.

Original diagnosis: The microfossils are composed of 5 to approximately 15 polygonal segments joined to form radially or bilaterally symmetrical bodies, their symmetry depending upon their number and arrangement. Most of the microfossils are flatly compressed, but many are folded. Straight grooves are present on one side of the body where the segments are joined. Elevated, flattened ridges or folds occur adjacent to and along both sides of the grooves but are absent along the smooth outer margin of the microfossils. The microfossils usually are made up of an odd number of segments. The most common variation consists of five segments arranged in a boat-shaped pattern with two small, pointed segments at one end, two larger segments in the middle, and one pointed segment at the opposite end. In the largest specimens two to four segments in the center are almost completely bordered by other segments. Along the margins of the largest specimens three small indentations may occur, almost equal distances apart, where segments are absent. These indentations either have smooth edges and look almost like pores or they have uneven edges as if segments had been torn out. The microfossils are revealed under oil immersion objective as laevigate. They are 1 to 2 µm thick. The known size range is 50.2 to 123.2 µm in maximum diameter (Peppers 1964).

Number of species known: One.

Remarks: Elsik (1992) indicated that the spore wall of *Centonites* appears to be not exclusively fungal; thus, an algal affinity cannot be ruled out.

2.1. Species: ***Centonites symmetricus*** Peppers 1964

Figure 8

Index Fungorum Registration Identifier: 560969.

Figure: In Peppers 1964: 47, plate 8, figure 17.

Original description: The microfossils, of unknown origin, are composed of several polygonal segments joined to form radially or bilaterally symmetrical bodies, their symmetry depending upon the number and arrangement of the segments. The microfossils are usually in good, flattened compression, but many are folded. Straight grooves are present on one side of the body where the segments are joined, and adjacent to the grooves are elevated, flattened ridges or folds. These grooves and ridges are absent along the smooth margin of the microfossils. The number of segments in the specimens observed varies from 5 to 15, usually an odd number. The specimens having five segments are quite common and are probably the basic pattern. They are boat-shaped, with two segments at one end, one at the opposite more pointed end, and two in the middle. In the largest specimens two to four segments in the center are usually bordered by other segments. If some of the bordering segments are missing, the indentations (usually three) thus formed have smooth margins except where the segments appear to have been torn out. The microfossils are seen to be laevigate under oil immersion objective and are 1 to 2 µm thick. Dimensions (33 specimens): overall size range, 50.2 to 123.2 µm in maximum diameter, median, 68.1 µm; individual segments, 24.4 to 39 µm in maximum diameter, median, 29 µm.

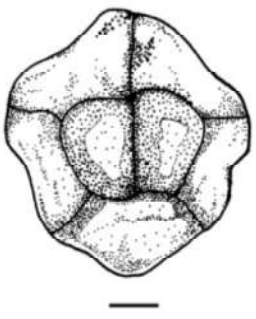

Figure 8. *Centonites symmetricus* Peppers 1964, Bar = 12 µm.

Location: Illinois, U.S.A.

Age: Late Pennsylvanian.

Remarks: The species epithet is in reference to the symmetrical arrangement of the segments.

3. Genus: ***Ctenosporites*** Elsik & Janson. 1974

Index Fungorum Registration Identifier: 21066.

Type species: *Ctenosporites eskerensis* Elsik & Janson. 1974.

Original diagnosis: Multicellular structures of fungal origin; one main stem of a few to several (commonly seven–nine) cells and lateral or secondary septate branches (cf. filaments) along one side of the main stem. Main stem and lateral branches are straight to slightly curved; apex of the main stem may be curved towards the side of the lateral branches; lateral branches are curved concave to the apex of the main stem. Basal cell of the stem is generally torn and may be thinner-walled than that portion of the stem bearing branches. Branches are of a few to several (commonly five–seven) cells. Branches may have incomplete septa but in all cases the apical branch has fewer septa (i.e., in most cases none) than the basal branches; the progression (with occasional exception) is one more septum with each additional branch counting from the apex to the base of the stem. Apical cell(s) of the stem may mimic the most apical branch or may be lacking altogether (Elsik & Jansonius 1974).

Number of species known: Two.

Remarks: The species epithet is derived from Greek *kteis*, *ktenos* = comb.

3.1. Species: ***Ctenosporites eskerensis*** Elsik & Janson. 1974

Figure 9

Index Fungorum Registration Identifier: 312369.

Synonym: *Ctenosporites wolfei* Elsik & Janson. 1974 fide Smith 1978 (named in honour of Dr. J.A. Wolfe), Index Fungorum Registration Identifier: 312370.

Original diagnosis: Multicellular structures of fungal origin; one main stem of a few to several (commonly seven–nine) cells and lateral or secondary septate branches (cf. filaments) along one side of the main stem. Main stem and lateral branches are straight to slightly curved; apex of the main stem may be curved towards the side of the lateral branches; lateral branches are curved concave to the apex of the main stem. Basal cell of the stem is generally torn and may be thinner-walled than that portion of the stem bearing branches. Branches are of a few to several (commonly five–seven) cells. Branches may have incomplete septa but in all cases the apical branch has fewer septa (i.e., in most cases none) than the basal branches; the progression (with occasional exception) is one more septum with each additional branch counting from the apex to the base of the stem. Apical cell(s) of the stem may mimic the most apical branch or may be lacking altogether.

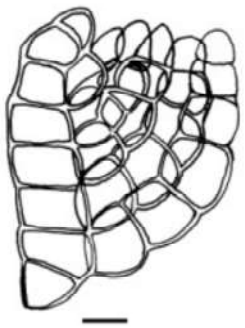

Figure 9. *Ctenosporites eskerensis* Elsik & Janson. 1974, Bar = 5 μm.

Location: Gulf of Alaska, Alaska (Elsik & Jansonius 1974), Lower Headon deposits, Hordle Cliff, Hampshire, England (Smith 1978).

Age: Late Eocene-Early Oligocene.

Remarks: Smith (1978) considered differences in *Ctenosporites eskerensis* and *C. wolfei* as morphological variations produced by the same mycelium and placed *Ctenosporites wolfei* in synonymy with *Ctenosporites eskerensis.*

3.2. Species: ***Ctenosporites sherwoodiae*** Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483290.

Figure: In Clarke 1965: 93, plate 1, figure 8; holotype marked on slide OPC 833 M-1, in a numbered black India ink ring (#11).

Original description: Fungal spores multicellular, individuals divergent uniseriate, occurring in colonies; septa simple, cells 3.0–10.0 µm in diameter, cell wall 0.5 µm thick, wall between lineages thickened to [as much as] 3 µm; overall dimensions 51–56 µm.

Emended description Comb-shaped, multicellular fungal (conidio) spores; individual spores divergent uniseriate, occurring in pairs; septa simple, with slightly thickened septal bases; cells 3–10 µm in diameter, cell walls ca. 0.2–0.5 µm thick, apparently thicker [i.e. darker] where parts of the constituent cells overly others; overall dimensions 51–56 µm. After re-examination of the holotype, we found that the two parts of the fungus are partly free; the three or four distalmost cells of the shaft of the left wing freely overlie the shaft of the right wing; the distalmost cell of the right shaft is broken away. More proximally, the shafts appear to be fused, as the septa and cell walls show evidence of merging and affecting each other's outline. A few of the (transverse) septa show septal folds, indicating that septal pores may be present (Kalgutkar & Jansonius 2000).

Location: Fremont County, Colorado, U.S.A.

Age: Late Cretaceous (Vermejo Formation coal beds).

Remarks: Kalgutkar and Jansonius (2000) formally named Fungal Spore sp. A (in Clarke 1965) after Martha Sherwood, in recognition of her important contributions to the knowledge of fossil fungal spores.

4. Genus: ***Dictyosporites*** Félix 1894

Index Fungorum Registration Identifier: 21075.

Type species: *Dictyosporites loculatus* Felix 1894 (type selected by Jansonius & Hills 1976).

Heterotypic synonyms: 1. *Arbusculites* Paradkar 1976, Index Fungorum Registration Identifier: 21013. 2. *Dactylosporites* Paradkar 1976, Index Fungorum Registration Identifier: 21070. 3. *Pleosporonites* R.T. Lange & P.H. Sm. 1971, Index Fungorum Registration Identifier: 21253. 4. *Ravenelites* Ramanujam & Ramachar 1980, Index Fungorum Registration Identifier: 28630.

Original diagnosis: The so-called wall-shaped conidia become multicellular by repeated transverse and longitudinal divisions. In addition to large conidia, whose growth can probably be regarded as complete, uni- and bicellular conidia representing the initial developmental stages also occur. They are all of brownish coloration. Their outlines are rather variable, depending on the position of the conidium to the plane of section. Viewed from the top or bottom, they often appear spherical with flatly indented outlines; longitudinal sections are of rather irregular shape; elliptical, pear-shaped or resembling short, corpulent snails (e.g. *Turbo*). The maximum length is 0.0204 mm [20.4 µm], the maximum diameter 0.0153 mm [15.3 µm]; the respective dimensions of an only bicellular conidium are 0.0102 and 0.0085 mm [10.2 and 8.5 µm] (Felix 1894).

Emended diagnosis: Inaperturate, multicellate (apparently by internal septation, of irregular pattern), muriform fungal spores, cells rounded to rounded polygonal. Overall shape rounded, oval/ovoid to elongate; indentations may occur where septa intersect the amb. A hilum cannot be discerned. *Staphlosporonites* differs in showing a distinct hilum, or proximal hilar cell. *Papulosporonites* consists of spore clusters or aggregates, in which there is no suggestion of linear or planar symmetry (Kalgutkar & Jansonius 2000).

Number of species known: Fifteen.

Remarks: According to Kalgutkar and Jansonius (2000), different species of *Dictyosporites* are comparable to the conidia of some modern genera like *Alternaria*, *Dictyosporium*, *Septosporium* and

Stemphylium, all belonging to dematiaceous hyphomycetes, and the ascospores of *Pleospora*.

4.1. Species: ***Dictyosporites dicotylophylli*** (Paradkar) Kalgutkar & Janson. 2000

Figure 10

Index Fungorum Registration Identifier: 483297.

Basionym: *Arbusculites dicotylophylli* Paradkar 1976, Index Fungorum Registration Identifier: 483814.

Original description: Saprophytic fungus; mycelium of septate hyphae; conidial head with paraphyses; conidia of dictyospore type, irregular in size and shape, 15–22 µm in size each, in simple or branched chains. Host: decaying dicotyledonous leaves. Conidial head 60–65 µm in size; conidia in chains (text-figures 1, 4; plate 1, figure 5), muriform, compound, dictyospore type, with transverse and vertical septa forming a checkered structure inside the compound spore (text-figures 3, 7).

Some conidial chains and many conidia are scattered on the leaf peel, as are some septate hyphae and some mycelial projections like paraphyses between the spore chains on the conidial head (text-figures 1; plate 1, figure 5). Haustoria are absent. The growth of these spores is not acropetal. Conidia are irregular in size and shape (text-figures 4, 7). They vary from 15–22 µm in size, and are oval, oblong, squarish or rounded in shape.

Location: Mohgaonkalan, Chhindwara District, Madhya Pradesh, India.

Figure 10. *Dictyosporites dicotylophylli* (Paradkar) Kalgutkar & Janson. 2000, Bar = 20 µm.

Age: Late Cretaceous (Maastrichtian).

Remarks: According to Paradkar (1976), this species can be compared with the *Arbuscula* Bat. & Peres (Batista & Peres 1965). *Arbuscula* is recorded on fallen *Eugenia* leaves. The specific name is after its occurrence on a dicotyledonous leaf.

4.2. Species: ***Dictyosporites dictyosus*** (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483298.

Figure: In Salard-Cheboldaeff & Locquin 1980: 190, plate 3, figure 17.

Basionym: *Pleosporonites dictyosus* Sal.-Cheb. & Locq. 1980, Index Fungorum Registration Identifier: 108376.

Original description: Spores muriform, monohilate, internal septa of average thickness, dividing the spore into 16 cells; 20 × 15 µm.

Location: Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa.

Age: Oligocene.

4.3. Species: ***Dictyosporites firbasii*** (Hammen) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483299.

Figure: In Van der Hammen 1954: 105, plate 21.

Basionym: *Polyadosporites firbasii* Hammen 1954, Index Fungorum Registration Identifier: 337454.

Original description: Spores 33–34 µm; cells discrete, with one or several pores; pores very small; wall distinctly two-layered, fairly dark.

Location: Magdalena Valley, Eastern Cordellera, Colombia, South America.

Age: Maastrichtian.

4.4. Species: ***Dictyosporites garciabarrigae*** (Hammen) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483300.

Figure: In Van der Hammen 1954: 105, plate 21.

Basionym: *Polyadosporites garciabarrigae* Hammen 1954, Index Fungorum Registration Identifier: 337455.

Original description: Spores 50 × 39 µm; psilate scabrate; consist of approximately 8 cells.

Location: Magdalena Valley, Eastern Cordellera, Colombia, South America.

Age: Maastrichtian.

4.5. Species: ***Dictyosporites globimuriformis*** Kalgutkar 1997

Index Fungorum Registration Identifier: 437903.

Figure: In Kalgutkar 1997: 211, plate 1, figure 17.

Original description: Spores multicellular, muriform, inaperturate, smooth, pale to dark brown, consisting of few to many cells to form an unevenly muriate spherical group. Spores globose, circular, multiseptate with regular longitudinal and transverse septa. Central group of cells more or less isodiametric, surrounded by a peripheral layer of elongated rectangular cells. Basal cell roughly triangular, protruding, light colored to hyaline (in figure 17 at 7 o'clock). Spore diameter 20–30 µm.

Location: Kanguk Peninsula, Axel Heiberg Island, Northwest Territories, Canada.

Age: Late Palaeocene-Early Eocene.

Remarks: The species epithet refers to the rounded and muriform nature of spores.

4.6. Species: ***Dictyosporites hyalinus*** (R.T. Lange & P.H. Sm. 1971) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483301.

Figure: In Lange & Smith 1971: 672, plate 6, figure B.

Basionym: *Pleosporonites hyalinus* R.T. Lange & P.H. Sm. 1971, Index Fungorum Registration Identifier: 320665.

Original description: Spores muriform, ellipsoid to ovoid in outline, of many hyaline thin-walled polyhedral cells irregularly arranged; the spore more than one cell thick. Observed lengths 24–28 µm, observed widths 10–17 µm.

Location: Maslin Bay, South Australia.

Age: Early-Middle Eocene.

Remarks: The transfer of this species, the type of *Pleosporonites*, makes *Pleosporonites* a later taxonomic synonym of *Dictyosporites*.

4.7. Species: ***Dictyosporites loculatus*** Félix 1894 Figure 11

Index Fungorum Registration Identifier: 189946.

Original description [combined description]: The so-called wall-shaped conidia become multicellular by repeated transverse and longitudinal divisions. In addition to large conidia, whose growth can probably be regarded as complete, uni- and bicellular conidia representing the initial developmental stages also occur. They are all of brownish coloration. Their outlines are rather variable, depending on the position of the conidium to the plane of section. Viewed from the top or bottom, they often appear spherical with flatly indented outlines; longitudinal sections are of rather irregular shape; elliptical, pear-shaped or resembling short, corpulent snails (e.g. *Turbo*). The maximum length is 0.0204 mm [20.4 µm], the maximum diameter 0.0153 mm [15.3 µm]; the respective dimensions of an only bicellular conidium are 0.0102 and 0.0085 mm [10.2 and 8.5 µm].

Location: Perekeschkul, near Baku, Azerbaijan.

Age: Eocene.

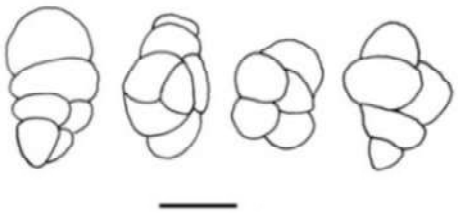

Figure 11. *Dictyosporites loculatus* Félix 1894, Bar = 5 µm.

Remarks: Félix (1894) stated that as compared with the conidia of recent forms, the fossils show the closest resemblance to those of the genera *Macrosporium* Bon., *Septosporium* Zopf., *Stemphylium* Wallr. and *Stigmella* Lév.

4.8. Species: ***Dictyosporites morularis*** (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000.

Index Fungorum Registration Identifier: 483302.

Figure: In Salard-Cheboldaeff & Locquin 1980: 190, plate 3, figure 22.

Basionym: *Pleosporonites morularis* Sal.-Cheb. & Locq. 1980, Index Fungorum Registration Identifier: 108377.

Original description: Monohilate murospore, subdivided by thin septa into 32 small cells; spore wall smooth; size 40 × 50 µm.

Location: Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa.

Age: Oligocene.

4.9. Species: ***Dictyosporites moruloides*** (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483303.

Figure: In Salard-Cheboldaeff & Locquin 1980: 190, plate 3, figure 13.

Basionym: *Pleosporonites moruloides* Sal.-Cheb. & Locq. 1980, Index Fungorum Registration Identifier: 108378.

Original description: Spore muriform, probably monohilate, septa of average thickness, spore wall thin, smooth; 16 cells visible, globular; 24 µm.

Location: Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa.

Age: Early Miocene.

4.10. Species: ***Dictyosporites ovalis*** (Sheffy & Dilcher) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483304.

Figure: In Sheffy & Dilcher 1971: 48, plate 16, figure 79.

Basionym: *Staphlosporonites ovalis* Sheffy & Dilcher 1971, Index Fungorum Registration Identifier: 111947.

Homotypic synonym: *Transeptaesporites ovalis* (Sheffy & Dilcher) V.S. Ediger 1981, Index Fungorum Registration Identifier: 108587.

Original description: Dictyospore 9.7 × 20.3 µm, oval, with twelve or more irregular cells visible in two rows. Psilate, light pigment, wall 1 µm thick.

Location: Puryear clay pit, 800 m south of Puryear, Henry County, Tennessee, U.S.A.

Age: Middle Eocene (Claiborne Formation).

4.11. Species: ***Dictyosporites ovoideus*** Sal.-Cheb. & Locq. 1980

Index Fungorum Registration Identifier: 107916.

Figure: In Salard-Cheboldaeff & Locquin 1980: 190, plate 3, figures 14a, b.

Basionym: *Pleosporonites ovoideus* Sal.-Cheb. & Locq. 1980, Index Fungorum Registration Identifier: 108379.

Original description: Monohilate murospore; thick septa dividing the spore into eight cells, each with a small depression resembling a pore; size 32 × 17–37 µm.

Location: Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa.

Age: Oligocene.

4.12. Species: ***Dictyosporites paradkariae*** Kalgutkar & Janson. 2000

Figure 12

Index Fungorum Registration Identifier: 483305.

Basionym: *Dactylosporites dicotylophylli* Paradkar 1976, Index Fungorum Registration Identifier: 483815.

Original description: Fungus saprophytic,

mycelium septate; elongated or oval, smooth phragmospores (text-figure 5; plate 1, figure 2), 31–40 µm long and 12–18 µm broad, 4- to 9-celled, seen singly and not as groups. Mycelium (observed only in one case; text-figure 5), septate.

Location: Mohgaon Kalan, Chhindwara District, Madhya Pradesh, India.

Figure 12. *Dictyosporites paradkariae* Kalgutkar & Janson. 2000, Bar = 20 µm.

Age: Late Cretaceous (Maastrichtian).

Remarks: Paradkar (1976) stated that such spores are found in the genera *Alternaria* and *Dactylosporium* (Barnett 1965). More resemblance is seen, however, with *Dactylosporium* in the shape, size and number of cells in the compound spores, than with *Alternaria*. Kalgutkar and Jansonius (2000) transferred this species to *Dictyosporites* Felix 1894 with a new name (*Dictyosporites paradkariae* Kalgutkar & Janson. 2000, '*paradkarii*') because the name *Dictyosporites dicotylophylli* (Paradkar) Kalgutkar & Janson. 2000 was preoccupied, The species epithet is in honour of Professor B.S. Trivedi, Department of Botany, Lucknow University, Lucknow, India.

4.13. Species: ***Dictyosporites symmetricus*** (V.S. Ediger) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483306.

Figure: In Ediger 1981: 94, plate 3, figure 9.

Basionym: *Transeptaesporites symmetricus* V.S. Ediger 1981, Index Fungorum Registration Identifier: 108588.

Original description: Fungal spores of five or more inaperturate cells, four or more septa. Shape is irregular oval. There are three or more parallel rows of cells which are perpendicular to the long axis. One or three cells are present in each row. Cells are separated by septa. Septa are dark colored, thick, at least one of them is transverse to the others. A hyaline, rounded and weak zone is present at the middle of the cells. Exine is psilate, light colored. There is usually one cell at least at one end. Dimensions: 8–18 × 20–38 µm.

Location: Thrace Basin, Turkey.

Age: Late Eocene-Oligocene, Miocene-Pliocene.

Remarks: Ediger (1981) opined that this species has probable affinity with *Alternaria*.

4.14. Species: ***Dictyosporites tirumalacharii*** (Ramanujam & Ramachar) Kalgutkar & Janson. 2000

Figure 13

Index Fungorum Registration Identifier: 483307.

Figure: In Ramanujam & Ramachar 1980: 83, plate 1, figure 12.

Basionym: *Ravenelites tirumalacharii* Ramanujam & Ramachar 1980, Index Fungorum Registration Identifier: 483759.

Original description: Teliospore heads rounded, chestnut-brown, often darkly so, 35–55 µm in diameter, usually 4–8 spores across in each head; configuration and size of spores in each head variable, individual spores 8–11.5 µm, wall up to 2.5 µm thick, smooth or finely flecked; germ pores one in each cell (spore) of telial head, 1.5 µm across, occasionally faint.

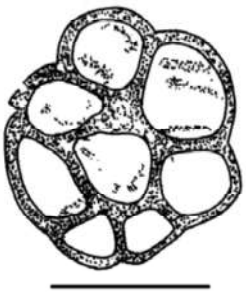

Figure 13. *Dictyosporites tirumalacharii* (Ramanujam & Ramachar) Kalgutkar & Janson. 2000, Bar = 20 µm.

Location: Neyveli Lignite Mine, Cuddalore District, Tamil Nadu, India.

Age: Miocene (Neyveli lignite).

4.15. Species: ***Dictyosporites tristratosus*** (Sheffy & Dilcher) Kalgutkar & Janson. 2000

Figure 14

Index Fungorum Registration Identifier: 483308.

Basionym: *Staphlosporonites tristratosus* Sheffy & Dilcher 1971, Index Fungorum Registration Identifier: 111948.

Homotypic synonym: *Transeptaesporites tristratosus* (Sheffy & Dilcher) V.S. Ediger 1981, Index Fungorum Registration Identifier: 108589.

Original description: Eight or more irregular cells arranged in an ovate structure 10.6 × 19.3 µm, two to three cells wide. Psilate, light pigment, septa opaque, varying in thickness, continuous with wall, 0.7 µm thick.

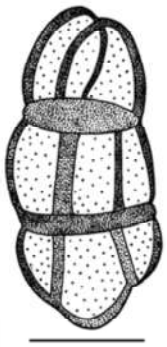

Figure 14. *Dictyosporites tristratosus* (Sheffy & Dilcher) Kalgutkar & Janson. 2000, Bar = 5 µm.

Location: Puryear clay pit, 800 m south of Puryear, Henry County, Tennessee, U.S.A.

Age: Middle Eocene (Claiborne Formation).

Remarks: The specific name refers to the arrangement of the cells into three layers.

5. Genus: ***Dictyosporiuminites*** Debi Mukh. 2012

Index Fungorum Registration Identifier: 588466.

Type species: ***Dictyosporiuminites intermedius*** Debi Mukh. 2012.

Original diagnosis: Conidiophore compact in sporodochium-like structure, clustered, dark in colour; size mediumly large, 400–450 × 125–150 µm; conidia produced singly, acrogenous; branches multiseptate, 5–8 septa observed; 4–5 branches present (Mukherjee 2012).

Number of species known: One.

Remarks: The genus is named after extant *Dictyosporium* (*Hyphomycetes*).

5.1. Species: ***Dictyosporiuminites intermedius*** Debi Mukh. 2012

Figure 15

Index Fungorum Registration Identifier: 588479.

Original description: Conidiophore compact encompassed as sporodochium-like structure; cluster, dark coloured, conidiophores branches multicellular and multiseptate; 5–8 septa in each conidiophore; size 400–450 × 125–150 µm, each cell measures 25 × 50–20 × 40 µm, basal attachment not discernible.

Figure 15. *Dictyosporiuminites intermedius* Debi Mukh. 2012, Bar = 20 µm.

Location: Neyveli Lignite Mine–I, Cuddalore District, Tamil Nadu, India.

Age: Miocene (Neyveli Lignite).

Remarks: *Dictyosporiuminites intermedium* can be compared with the extant *Dictyosporium* in having sporodochium-like structure with multiseptate conidiophores (united together).

6. Genus: ***Kutchiathyrites*** R.K. Kar 1979)

Index Fungorum Registration Identifier: 21145.

Type species: *Kutchiathyrites eccentricus* R.K. Kar 1979.

Heterotypic synonym: *Dictyostroma* R. Kar et al. 2010, Index Fungorum Registration Identifier: 622180.

Original diagnosis: Microthyriaceous ascostromata eccentric in development, no free hyphae present, dimidiate, nonostiolate, radially arranged hyphae thick, dark, diverging from one another, transverse hyphae comparatively thinner, ± translucent, interconnecting radial ones to form squarish, pseudoparenchymatous cells without any pore; Description: Microthyriaceous ascostromata of approximately semicircular shape in most specimens, in others they look like fish scales, size range 64–110 × 41–73 µm. Upper surface of ascostromata darker than inner one; radial hyphae also well pronounced in former. Radial hyphae look like dark strands; transverse hyphae ill-developed, sometimes hardly discernable at places (Kar 1979).

Emended diagnosis: Hilate conidia, fan-shaped, formed by numerous linear filaments radiating out from the hilum; conidia may be flattened (i.e. two–) or three dimensional; filaments may be joined to their neighbours, or partially free, and may branch towards the periphery; hilum may or may not show the stipe from which it developed (Kalgutkar & Jansonius 2000).

Number of species known: Five.

Remarks: Kalgutkar and Jansonius (2000) opined that *Kutchiathyrites* is not a microthyriaceous fructification, as stated by Kar (1979), but a multicellular spore/conidium showing a clear attachment area, scar or pore. *Kutchiathyrites eccentricus*, as described by Kar (1979), demonstrates a close similarity to the conidia of the hyphomycetous fungus *Mycoenterolobium platysporum* Goos 1970. This similarity was also pointed out by Jain & Kar (1979), who referred to Kendrick & Carmichael (1973), where such eccentric structures are shown as conidia of the hyphomycetous *Mycoenterolobium platysporum*. Kar et al. (2010) proposed *Dictyostroma* ("*Dictyostromata*"), which is identical to *Kutchiathyrites* R.K. Kar 1979 and therefore the former is considered here as later synonym of the latter.

6.1. Species: ***Kutchiathyrites canadensis*** Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483412.

Figure: In Kalgutkar 1993: 73, plate 4.3, figure 4.

Basionym: *Dictyosporites eccentricus* Kalgutkar 1993, Index Fungorum Registration Identifier: 483865.

Original description: Spore [clusters] eccentric, laterally flattened in one plane, variable in shape, brown, smooth; spores appear muriform with juxtaposed rows of cells radiating and diverging from the hilum to form a loose pseudoparenchymatous tissue or a fascicle of square to rectangular cells. The rows of cells are of unequal length and held close together in a somewhat semicircular shape; the middle ones being generally longer than those at the sides. Illustrated specimen 55 × 35 µm in size.

Location: Peel River, Yukon Territory, Canada.

Age: Late Palaeocene-Early Eocene.

Remarks: The species epithet refers to the place of its occurrence in Canada.

6.2. Species: ***Kutchiathyrites eccentricus*** R.K. Kar 1979

Figure 16

Index Fungorum Registration Identifier: 112385.

Original description: Microthyriaceous ascostromata eccentrically developed, 64–110 × 41–73 µm. Stromata dimidiate, non-ostiolate; radial hyphae diverging, dark, better-developed than the transverse

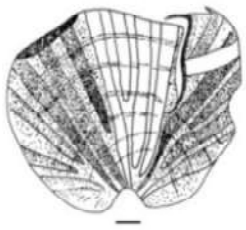

Figure 16. *Kutchiathyrites eccentricus* R.K. Kar 1979, Bar = 10 µm.

ones; hyphae interconnecting [with] each other to form squarish, non-porate, pseudoparenchymatous cells.

Location: Barkhana nala cutting, near Sarangwara village, Kutch District, Gujarat, India.

Age: Oligocene (Maniyara Fort Formation).

Remarks: The species epithet refers to fan like shape of the conidia.

6.3. Species: ***Kutchiathyrites mehrotrae*** R.K. Saxena & S.K.M. Tripathi 2011

Figure 17

Index Fungorum Registration Identifier: 519945.

Synonym: *Kutchiathyrites* sp. in Singh et al. 1986.

Original description: Ascomata ± semicircular in shape, some specimens look like fish scales, eccentric in development. Size range 88–110 × 67–75 µm. Nonostiolate. No free hyphae present, dimidiate. Radially arranged hyphae thick, dark, diverging from one another; transverse hyphae comparatively thinner, interconnecting radial ones forming squarish, pseudoparenchymatous cells without having any pore. Some specimens exhibit development of spines from the marginal cells.

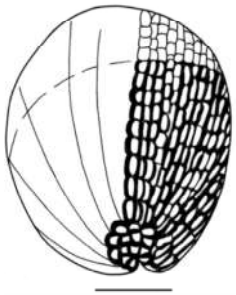

Figure 17. *Kutchiathyrites mehrotrae* R.K. Saxena & S.K.M. Tripathi 2011, Bar = 40 µm.

Location: Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam, India.

Age: Early Miocene (Bhuban Formation).

6.4. Species: ***Kutchiathyrites palmatus*** (P. Ke & Z.Y. Shi) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483414.

Figure: In Ke & Shi 1978: 52, plate 5, figure 14.

Basionym: *Microthyriacites palmatus* P. Ke & Z.Y. Shi 1978.

Original description: Ascomata hemispherical or elongated, with a distinct protuberance in the middle which may have been a point of attachment. Outline eccentrically flattened, elliptical in shape. Ascoma lacks centrally placed ostiole, and no small cavities are found in the cells. Ascomata composed of radiating, interconnected hyphae. Hyphae and the cells on them gradually increase in size from the center of the ascoma towards its periphery. Hyphae generally non-branching. Central cells of ascoma square, 2.5 × 2.5 to 1.2 × 1.2 µm in size. Cells become slightly elongated toward the periphery of the ascoma, measuring 5 × 3.7 to 5 × 5 µm. Ascoma margin sinuous, by no means smooth, ascoma surface conspicuously scabrate. Ascomata 50–70 µm in size.

Location: Kenlixian and Bingxian, Shandong Province, Coastal region of Bohai, China.

Age: Eocene-Oligocene.

6.5. Species: ***Kutchiathyrites perfectus*** (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi 2011

Figure 18

Index Fungorum Registration Identifier: 519897.

Basionym: *Dictyostromata perfecta* R. Kar et al. 2010, Index Fungorum Registration Identifier: 622214.

Original description: Stromata with two lateral sides divergent from each other, outer margin convex, slightly undulated due to pseudoreticulation, 35–42 × 23–37 µm; haustorium present or absent, 4–7 × 2–3 µm, hyaline, no septa observed, stromata generally conical at attachment zone; radial hyphae stronger than transverse hyphae, anastomose to develop pseudoreticulation, meshes square-rectangular; faint at basal region.

Figure 18. *Kutchiathyrites perfectus* (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi 2011, Bar = 10 µm.

Location: Tlangsam, Mizoram, India.

Age: Miocene (Bhuban Formation).

7. Genus: ***Lirasporis*** R. Potonié & S.C.D. Sah 1960

Index Fungorum Registration Identifier: 21154.

Type species: *Lirasporis intergranifer* R. Potonié & S.C.D. Sah 1960.

Original diagnosis: Size varies from 69 × 103 µm to 116 × 134 µm; outline oval, longitudinal ends of oval broadly rounded or somewhat tapering, sometimes showing irregular protuberances which form a jumbled mass; *extrema lineamenta* somewhat smooth except the longitudinal ends which are always nearly notched; following the longer axis exist perhaps 20–30 parallel but narrow ribs showing between them spaced grana (Potonié & Sah 1960).

Emended diagnosis: Fungal bodies oval-elliptical with equal or unequal, broad, generally notched ends. Mycelia, long, septate, ± parallel to one another, extending from one end to other; wall generally laevigate, sometimes granulose (Jain & Kar 1979).

Number of species known: Two.

Remarks: Jain & Kar (1979) opined that the parallel ribs seem to be septate fungal mycelia arranged in longitudinal direction and transferred from Polyplicates to Fungi. Kalgutkar and Jansonius (2000) had reservations about the fungal nature these forms.

7.1. Species: ***Lirasporis elongatus*** R.K. Kar in Saxena 2012

Figure 19

Index Fungorum Registration Identifier: 519798.

Original description: Fungal bodies oval with elongated ends, 135 × 60 µm, broader in the middle and tapering at lateral sides. Mycelia longitudinally and transversally septate, spore wall laevigate.

Figure 19. *Lirasporis elongatus* R.K. Kar 1990a, Bar = 10 µm.

Location: Rokhia borehole; Tripura, north-east India.

Age: Early-Middle Miocene.

Remarks: Kar (1990a) did not validly publish *Lirasporis elongatus* as he did not cite information on where its type is stored. Saxena (2012) validated the name of this species and ascribed it to Kar, because its description and illustrations published by Kar (1990a) are the validating ones. The holotype of this species name is that designated by Kar (1990a).

7.2. Species: ***Lirasporis intergranifer*** R. Potonié & S.C.D. Sah 1960

Figure 20

Index Fungorum Registration Identifier: 519797.

Original description: Additional to the generic description: Ribs much more narrow than the canals between them; in the canals sparse grana more or less regularly distributed in distances, perhaps a little greater than the breadth of the canals and always only a single granum between the two adjoining ribs; about 10–20

grana in each canal along the longer axis. Holotype: 82 × 109 µm; perhaps 20 ribs on the exposed surface; 16–20 grana in an entire canal; chiefly at one of the longitudinal ends the exine is jumbled to form irregular rounded protuberances (such as illustrated by Samoilovich 1953, plate 9, figure 4a, in *Vittatina subsaccata*; and Bolkhovitina 1953, plate 9, figure 18, in *Welwitschiapites magniolobatus*; and as has been observed in *Ephedra*).

Emended description (Jain & Kar 1979, p. 108): Oval-elliptical fungal bodies, 112–154 × 65–113 µm; ends equally or unequally broad, generally notched at one or both ends. Mycelia distinct, run from end to end, septate; wall mostly smooth.

Figure 20. *Lirasporis intergranifer* R. Potonié & S.C.D. Sah 1960, Bar = 12 µm.

Location: European Club, Kannur Beach, (Potonié & Sah 1960); Padappakkara, Edvai and Varkala, Kerala, India (Jain & Kar 1979).

Age: Late Miocene or Pliocene (Potonié & Sah 1960); Early Miocene-Early Pliocene (Jain & Kar 1979).

8. Genus: ***Octosporites*** Sal.-Cheb. & Locq. 1980

Index Fungorum Registration Identifier: 25608.

Type species: *Octosporites stauroides* Sal.-Cheb. & Locq. 1980.

Original diagnosis: Monohilate, octocellate murospores, globular, the middle partitions forming a cross; 15 µm (Salard-Cheboldaeff & Locquin 1980).

Number of species known: One.

8.1. Species: ***Octosporites stauroides*** Sal.-Cheb. & Locq. 1980

Figure 21

Index Fungorum Registration Identifier: 108279.

Original description: Monohilate, octocellate murospores, globular, the middle partitions forming a cross; 15 µm.

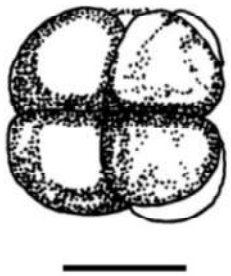

Figure 21. *Octosporites stauroides* Sal.-Cheb. & Locq. 1980, Bar = 12 µm.

Location: Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa.

Age: Early Miocene.

9. Genus: ***Papulosporonites*** Schmied. & A. J. Schwab 1964

Index Fungorum Registration Identifier: 21220.

Type species: *Papulosporonites sphaeromorphus* Schmied. & A. J. Schwab 1964.

Original diagnosis: Fungal remains of globular to elongate shape, consisting of numerous more or less polygonal cells that are firmly fused into mulberry-shaped aggregates. Cells without any regular order, or concentrically arranged. No differentiation of an outer wall layer; however, one to three of the innermost cells commonly much larger. Occasionally individual aggregates fused together (Schmiedeknecht & Schwab 1964).

Number of species known: Seven.

9.1. Species: ***Papulosporonites enormis*** (V.S. Ediger) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483501.

Figure: In Ediger 1981, p. 95, plate 3, figure 13.

Basionym: *Polyadosporites enormis* V.S. Ediger 1981, Index Fungorum Registration Identifier: 108395.

Original description: Polyad fungal spores, composed of many cells. Overall shape is rounded to oval. Cells are clustered irregularly, there are more than one series of cells on top of each other. Individual cells are irregularly rounded, monoporate. There is usually a thickening around the pore. Exine is thin, folded and much cracked, light to medium melanin color. There isn't any special structure at the contact of cells. Overall size 28 × 35 µm.

Location: Thrace Basin, Turkey.

Age: Late Eocene-Oligocene, Miocene-Pliocene.

9.2. Species: ***Papulosporonites hammenii*** (Haseld.) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483502.

Figure: In Haseldonckx 1973: 151, plate 1, figure 19.

Basionym: *Polyadosporites hammenii* Haseld. 1973, Index Fungorum Registration Identifier: 483817.

Original description: Inaperturate, psilate fungal spore, composed of several grains in a spherical pattern. The shape of the grains is variable. Wall thickness: 0.5 µm. Size: 24 × 24 µm.

Location: Arén, Ribagorzana Valley, Pyrenees, Spain.

Age: Early Palaeocene-Late Eocene.

9.3. Species: ***Papulosporonites multicellatus*** (R.K. Saxena & H.P. Singh) Kalgutkar & Janson. 2000

Figure 22

Index Fungorum Registration Identifier: 483504.

Basionym: *Staphlosporonites multicellatus* R.K. Saxena & H.P. Singh 1983, Index Fungorum Registration Identifier: 485255.

Original description: Fungal spores circular to subcircular, size range 58–80 × 40–80 µm. Multicellate, number of cells more than 25 in each spore, individual cell polygonal in shape and about 5–8 µm in size. Inaperturate. Septa very thin. Spore wall up to 2 µm thick, psilate, sometimes weakly granulose.

Figure 22. *Papulosporonites multicellatus* (R.K. Saxena & H.P. Singh) Kalgutkar & Janson. 2000, Bar = 20 µm.

Location: Hoshiarpur-Una Road section, near Bankhandi, Hoshiarpur District, Punjab, India.

Age: Miocene-Pliocene.

9.4. Species: ***Papulosporonites orbis*** (V.S. Ediger) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483505.

Figure: In Ediger 1981: 95, plate 3, figure 17.

Basionym: *Polyadosporites orbis* V.S. Ediger 1981, Index Fungorum Registration Identifier: 108396.

Original description: Polyad of more than 13–14 cells. Irregularly rounded shape, cells are clustered randomly. Individual cells rounded, nearly 7 µm in diameter. Exine is relatively thick, psilate to scabrate. Cells are probably monoporate?. Spore size 20–23 µm.

Location: Thrace Basin, Turkey.

Age: Late Eocene-Oligocene, Miocene-Pliocene.

9.5. Species: ***Papulosporonites siwalikus*** (R.K. Saxena & A.P. Bhattach.) Kalgutkar & Janson. 2000

Figure 23

Index Fungorum Registration Identifier: 483506.

Basionym: *Staphlosporonites siwalikus* R.K. Saxena & A.P. Bhattach. 1987, Index Fungorum Registration Identifier: 483890.

Original description: Fungal spores subcircular in shape, size range 61–77 × 52–70 µm. Multicellate, septa very thick, thicker than spore wall, individual cells circular-polygonal, small in size. Spore wall psilate.

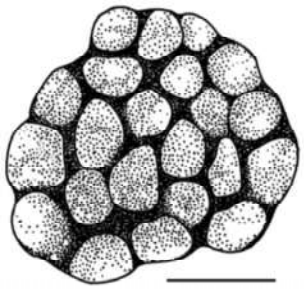

Figure 23. *Papulosporonites siwalikus* (R.K. Saxena & A.P. Bhattach.) Kalgutkar & Janson. 2000, Bar = 20 µm.

Location: Kala Amb-Nahan area, Sirmaur District, Himachal Pradesh, India.

Age: Miocene.

9.6. Species: ***Papulosporonites sphaeromorphus*** Schmied. & A.J. Schwab 1964

Figure 24

Index Fungorum Registration Identifier: 637505.

Original description: 40–70 µm (mostly 50–55 µm); number of cells variable; cells 8–17 µm, walls thin, smooth, more or less intensely brown, single layered, usually showing some concentric arrangement. [Jansonius & Hills (1977), card no. 3379.]

Location: Zwischenflöz, Tagebau des Braunkohlenwerkes Nachterstedt, Germany.

Figure 24. *Papulosporonites sphaeromorphus* Schmied. & A. J. Schwab 1964, Bar = 10 µm.

Age: Middle Eocene.

9.7. Species: ***Papulosporonites subcircularis*** (Anil Chandra et al.) Kalgutkar & Janson. 2000

Figure 25

Index Fungorum Registration Identifier: 483507.

Basionym: *Staphlosporonites subcircularis* Anil Chandra et al. 1984, Index Fungorum Registration Identifier: 107316.

Original description: Subcircular to oval fungal spores having eight or more, polygonal, irregularly arranged cells; size range 15–42 × 13–30 µm; inaperturate; septa thicker than spore wall; spore wall 1 µm thick; psilate, pigment medium to dark.

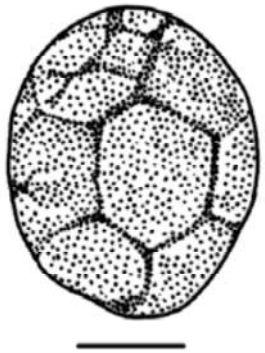

Figure 25. *Papulosporonites subcircularis* (Anil Chandra et al.) Kalgutkar & Janson. 2000, Bar = 10 µm.

Location: Sediment core no. 2 (Lat. 18°35.22 N: Long. 69°17.22 E), Arabian Sea.

Age: Late Quaternary.

10. Genus: ***Polyadosporites*** Hammen 1954

Index Fungorum Registration Identifier: 21256.

Type species: *Polyadosporites suescae* Hammen 1954.

Original diagnosis: Fungal spores composed of several grains or cells that are united along several axes or in a more or less irregular manner (Van der Hammen 1954).

Emended diagnosis: Spores (sub) spherical, loosely aggregated in clusters, with individual cells not

connected to others by shared walls; clusters (colonies) more or less regularly spherical to subspherical (Kalgutkar & Jansonius 2000).

Number of species known: Three.

10.1. Species: ***Polyadosporites nadahensis*** M.R. Rao & R. Patnaik 2001

Figure 26

Index Fungorum Registration Identifier: 519784.

Original description: Fungal spore colonies composed of number of cells, 16–20 in number. Overall size range 90–130 × 65–90 µm. Inaperturate. Individual cells more or less subspherical in shape, variation in overall shape and size, size range 35–42 × 28–33 µm. Wall 1 µm thick, perforated, surface showing finely pitted reticulate ornamentation.

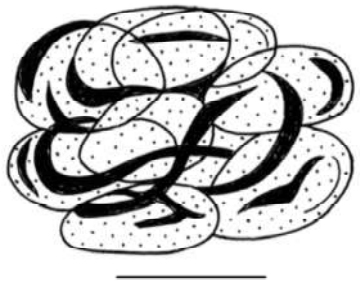

Figure 26. *Polyadosporites nadahensis* M.R. Rao & R. Patnaik 2001, Bar = 40 µm.

Location: Nadah, Panchkula, Haryana, India.

Age: Late Pliocene (Pinjor Formation).

10.2. Species: ***Polyadosporites siwalikus*** M.R. Rao & R. Patnaik 2001

Figure 27

Index Fungorum Registration Identifier: 519785.

Original description: Fungal spores composed of number of individual subspherical cells, cells inaperturate. Size range 127–145 × 112–120 µm. Cell wall thin, septa connecting to 2 or 3 cells, 1–2 µm thick, smooth.

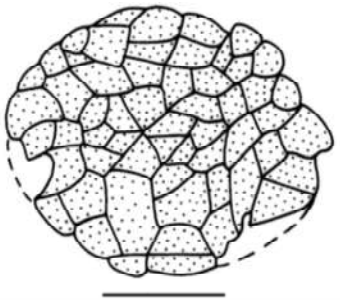

Figure 27. *Polyadosporites siwalikus* M.R. Rao & R. Patnaik 2001, Bar = 10 µm.

Location: Nadah, Panchkula, Haryana, India.

Age: Late Pliocene (Pinjor Formation).

10.3. Species: ***Polyadosporites suescae*** Hammen 1954

Figure 28

Index Fungorum Registration Identifier: 337456.

Original description: Spores 40–55 µm; psilate.

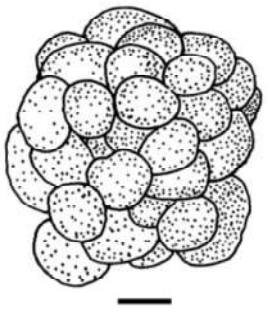

Figure 28. *Polyadosporites suescae* Hammen 1954, Bar = 10 µm.

Location: Magdalena Valley, Eastern Cordillera, Colombia, South America.

Age: Maastrichtian.

11. Genus: ***Staphlosporonites*** Sheffy & Dilcher 1971

Index Fungorum Registration Identifier: 21316

Type species: ***Staphlosporonites conoideus*** Sheffy & Dilcher 1971.

Heterotypic synonym: *Transeptaesporites* V.S. Ediger 1981, Index Fungorum Registration Identifier: 25599.

Original diagnosis: Inaperturate, psilate to punctuate fungal or algal bodies of four or more irregular cells. Cells in clusters, shape variable along more than one axis (Sheffy & Dilcher 1971).

Emended diagnosis: Inaperturate multicellate fungal spores, with muriform architecture (cells internally dividing without a regular pattern), lacking a plane or axis of symmetry. Cells rounded or rounded polygonal, septa may be depressed where they intersect the amb. Overall shape generally more or less elongate; sometimes oval to ellipsoidal, rarely subspherical. Always with a distinct proximal hold-fast cell and/or a hilar scar (Kalgutkar & Jansonius 2000).

Number of species known: Sixteen.

Remarks: Presence of a hilate scar differentiates this genus from *Dictyosporites*. According to Ediger (1981), these fossil fungal spores resemble the conidia of the modern *Alternaria*, however, the new genus is proposed because of inadequate knowledge about the relationship between the fossil and modern genera. Kalgutkar and Jansonius (2000) opined that the illustrated specimens assigned to *Transeptaesporites irregularis* by Ediger (1981) appear so variable that they may not all be conspecific. Ediger (1981) cited *Staphlosporonites* as a synonym of the new *Transeptaesporites*, but transferred its type species *S. conoideus* to *Polyadosporites.* Jansonius & Hills (1982) argued that Ediger (1981) did not provide bibliographic reference of basionyms in sufficient detail to validly publish the new combinations. Three other species of *Staphlosporonites*, named by Sheffy & Dilcher (1971), were also invalidly transferred to *Transeptaesporites* by Ediger (1981).

11.1. Species: ***Staphlosporonites allomorphus*** Sheffy & Dilcher 1971

Index Fungorum Registration Identifier: 111945.

Figure: In Sheffy & Dilcher 1971: 49, plate 16, figure 80.

Homotypic synonym: *Transeptaesporites allomorphus* (Sheffy & Dilcher) V.S. Ediger 1981, Index Fungorum Registration Identifier: 107699.

Original description: Eight or more irregular cells arranged in an oblong structure 10.2 × 30.9 μm, two cells in width tapering to a single cell. Psilate, light pigment, septa variable in width, continuous with wall, wall 1 μm thick.

Location: Puryear clay pit, 800 m south of Puryear, Henry County, Tennessee, U.S.A.

Age: Middle Eocene (Claiborne Formation).

Remarks: The specific name refers to the strange shape of the spore. According to Kalgutkar and Jansonius (2000), the narrow end appears to be hilate, possibly with a hyphal fragment attached.

11.2. Species: ***Staphlosporonites billelsikii*** Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483554.

Figure: In Kalgutkar 1993: 72, plate 4.1, figure 22.

Basionym: *Dictyosporites elsikii* Kalgutkar 1993, Index Fungorum Registration Identifier: 483864.

Original description: Spores muriform, aporate, light brown, solitary, simple, usually broadly ellipsoidal with a protruding hilum and rounded apex. Some three dimensional spores were noted (plate 4.1, figure 22). Spore wall smooth, thin; spores divided by longitudinal and cross walls to form an irregular, multicellular, reticulate pattern of thin-walled, squarish to rectangular cells. Spore size 55–73 × 30–38 μm. Not common but distinctive.

Location: Peel River, Yukon Territory, Canada.

Age: Late Palaeocene-Early Eocene.

Remarks: The species epithet honours Dr. William C. Elsik.

11.3. Species: ***Staphlosporonites chandrae*** A. Gupta 2002

Figure 29

Index Fungorum Registration Identifier: 540809.

Original description: Spores multicelled, cells arranged along more than one axis, inaperturate,

elongate, 17.5–67 µm long, 8–29 µm broad, cells irregularly arranged, number of cells across width ranges from two to four and across thickness by more than one, septa thin to as thick as wall, psilate-faintly granulate, wall 1 µm thick.

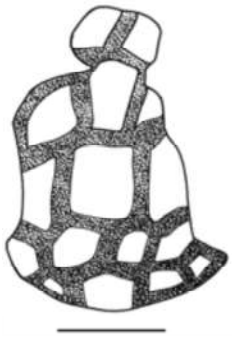

Figure 29. *Staphlosporonites chandrae* A. Gupta 2002, Bar = 20 µm.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Eocene (Subathu Formation).

Remarks: The species epithet is in honours of Dr. Anil Chandra, Birbal Sahni Institute of Palaeosciences, Lucknow, India.

11.4. Species: ***Staphlosporonites conoideus*** Sheffy & Dilcher 1971

Figure 30

Index Fungorum Registration Identifier: 111946.

Homotypic synonym: *Polyadosporites conoideus* (Sheffy & Dilcher) V.S. Ediger 1981, Index Fungorum Registration Identifier: 108394.

Figure 30. *Staphlosporonites conoideus* Sheffy & Dilcher 1971, Bar = 8 µm.

Original description: Seven or more irregular cells arranged in conical shaped body 13.5 × 24.2 µm. Psilate, wall and septa opaque, varying in thickness.

Location: Puryear clay pit, 800 m south of Puryear, Henry County, Tennessee, U.S.A.

Age: Middle Eocene (Claiborne Formation).

11.5. Species: ***Staphlosporonites delumbus*** Norris 1986

Index Fungorum Registration Identifier: 126577.

Figure: In Norris 1986: 26, plate 3, figure 18.

Original description: Multicellular, linear, uni-, bi- and tri-serial, inaperturate, fungal spores. Spore wall thin and laevigate. Cells rounded proximally, becoming polygonal and thinner-walled distally. Basal cell 5–10 µm in diameter giving rise to biserial cells within 2 cells of basal cell, and to triserial cells within 4 or 5 cells of basal cell. Triserial cells partly overlapping. Spore wall approximately 0.25 µm thick in basal cell, becoming progressively thinner distally. Septa about 0.25 µm thick, porate, and dentate in some specimens. Loci of septal insertion constricted, 1–2 µm in the uniserial part of the spore, becoming less constricted distally. Cells increase in diameter up to 15 µm distally. Spores comprise 6–11 rows of cells and may occur in pairs with overlapping distal ends and opposing basal cells. Total length 60–150 µm (holotype 105 µm).

Location: Imperial Nuktak C–22 Well. Mackenzie Delta Region, District of Mackenzie, Northwest Territories, Canada.

Age: Eocene to Oligocene.

11.6. Species: ***Staphlosporonites dichotomus*** A. Gupta 2002

Figure 31

Index Fungorum Registration Identifier: 540810.

Original description: Spores multicelled, many cells wide, dichotomously branched or lobed bodies, inaperturate, 52–93 µm long, 17.5–29 µm (rarely up to 49 µm) broad, cells irregularly placed, more than

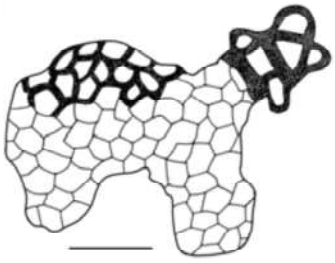

Figure 31. *Staphlosporonites dichotomus* A. Gupta 2002, Bar = 20 µm.

one cell thick, septa thickness variable, from thin to as thick as wall, psilate-granulate.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Eocene (Subathu Formation).

11.7. Species: ***Staphlosporonites discitypicus*** P. Ke & Z.Y. Shi 1978

Index Fungorum Registration Identifier: 115634.

Figure: In Ke & Shi 1978: 51, plate 5, figure 20.

Original description: Spores about 30 µm in size. Outline slightly discoidal. Inaperturate. Composed of 14 cells, septa dark-colored, 1.5 µm wide, terminal cells subcircular in shape. Spore wall 1.5 µm thick, might be two layered, surface scabrate.

Location: Panshan, Liaoning Province, Coastal region of Bohai, China.

Age: Eocene-Oligocene.

11.8. Species: ***Staphlosporonites elongatus*** A. Gupta 2002

Figure 32

Index Fungorum Registration Identifier: 540811.

Original description: Spores multicelled, cells arranged along more than one axis, inaperturate, elongate, 17.5–35 µm long, 7.5–13 µm broad, number of cells along width varies by up to two, largely granulate-subverrucose, surface folded.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Eocene (Subathu Formation).

Figure 32. *Staphlosporonites elongatus* A. Gupta 2002, Bar = 8 µm.

11.9. Species: ***Staphlosporonites elsikii*** Ramanujam & Srisailam 1980

Figure 33

Index Fungorum Registration Identifier: 109551.

Original description: Spores dark brown, irregularly cylindrical to elongate ovoid in shape, inaperturate, 50–57.8 × 12–15.3 µm, more or less rounded at apex, truncate at base, muriform with 6–12 transverse and 4–8 longitudinal or oblique septa, septa fairly thick (3.4 µm), spore wall up to 2 µm thick psilate.

Figure 33. *Staphlosporonites elsikii* Ramanujam & Srisailam 1980, Bar = 10 µm.

Location: Kannur Beach area, Palayangadi and Cheruvattur (southern side of Karingottu River), Kerala, India.

Age: Miocene.

Remarks: Kumar (1990) transferred this species to *Multicellaesporites*, as *Multicellaesporites elsikii* (Ramanujam & Srisailam) Kumar 1990. However, Kalgutkar and Jansonius (2000) did not accept this transfer.

11.10. Species: ***Staphlosporonites felixii*** (R.T. Lange & P.H. Sm.) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 282643.

Figure: In Lange & Smith 1971: 672, plate 6, figure A.

Basionym: *Dictyosporites felixii* R.T. Lange & P.H. Sm. 1971, Index Fungorum Registration Identifier: 312993.

Original description: Spores muriform, of up to 12 cells with bulging outer walls, budded into an irregular but elongate spore about twice as long (30–70 μm) as broad (up to 25 μm), with dark separating walls.

Location: Maslin Bay, South Australia.

Age: Early-Middle Eocene.

11.11. Species: ***Staphlosporonites irregularis*** (V.S. Ediger) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 483556.

Figure: In Ediger 1981: 94, plate 3, figure 7.

Basionym: *Transeptaesporites irregularis* V.S. Ediger 1981, Index Fungorum Registration Identifier: 108586.

Original description: Fungal spores of seven or more irregular cells. Shape is irregularly elongate. There are six or more septa, at least two of them are transverse to the others. Septa are thick and dark colored. A light colored, rounded weak zone at the middle of [each of] the cells is obvious. A hyaline and more rectangular cell is at one end. Cells are inaperturate, or there may be a pore-like aperture at the middle of the cells. Dimensions: 10–15 × 26–45 μm.

Location: Thrace Basin, Turkey.

Age: Upper Eocene-Oligocene, Miocene-Pliocene.

Remarks: Ediger (1981) suggested possible affinity of this species to *Alternaria sp.*

11.12. Species: ***Staphlosporonites neyveliensis*** Ambw. 1983

Figure 34

Index Fungorum Registration Identifier: 107315.

Original description: The fungal body consisting of about 17 fungal cells arranged in an oblong structure; brown in color measuring about 105 × 60 μm in size. The fungal body is 2–3 cells wide and the whole mass tapering to a single cell thickness. Each cell is psilate, measuring up to 20 μm in size. Wall of the spore is thin and smooth.

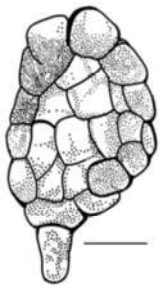

Figure 34. *Staphlosporonites neyveliensis* Ambwani 1983, Bar = 20 μm.

Location: Neyveli Lignite Mine, Cuddalore District, Tamil Nadu, India.

Age: Late Miocene or Pliocene.

Remarks: According to Ambwani (1983), this species appears similar to the spore type illustrated by Graham (1962) as *Alternaria* but differs in having larger number of cells and considerably bigger size.

11.13. Species: ***Staphlosporonites pachycellularis*** (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000

Index Fungorum Registration Identifier: 637508.

Figure: In Salard-Cheboldaeff & Locquin 1980: 190, plate 3, figure 21.

Basionym: *Dictyosporites pachycellularis* Sal.-Cheb. & Locq. 1980, Index Fungorum Registration Identifier: 107917.

Original description: Spore muriform, monohilate [monoporate], septa thick, irregularly dividing the spore into 12 cells; 45 × 50 μm.

Location: Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa.

Age: Oligocene.

11.14. Species: ***Staphlosporonites raoi*** A. Gupta 2002

Figure 35

Index Fungorum Registration Identifier: 540812.

Original description: Spores multicelled, showing a many cells wide multistratose main body and thin branch(es), inaperturate, main body 32–40 µm long, 8–15 µm (rarely up to 29 µm) broad, cells irregularly placed, in main body but along single axis in side branch, psilate.

Figure 35. *Staphlosporonites raoi* A. Gupta 2002, Bar = 10 µm.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Eocene (Dagshai Formation).

11.15. Species: ***Staphlosporonites settyi*** A. Gupta 2002

Figure 36

Index Fungorum Registration Identifier: 540813.

Original description: Spores multicelled, comprising a globular mass, inaperturate, subcircular, 20 × 17–32 × 23 µm, cells variable in shape (i.e. ± hemispherical to polyangular), irregularly placed, number more than one across thickness; septa variable in thickness, thin or thick as wall; nearly psilate, surface slightly folded.

Figure 36. *Staphlosporonites settyi* A. Gupta 2002, Bar = 10 µm.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Eocene (Subathu Formation).

11.16. Species: ***Staphlosporonites tetracellatus*** A. Gupta 2002

Figure 37

Index Fungorum Registration Identifier: 540814.

Original description: Spores tetrad/four celled mass, cells arranged along more than one axis in a manner forming a one cell thick plate, inaperturate, 12 × 8–17 × 15 µm, psilate, surface often folded, wall up to 1.5 µm thick, often two layered.

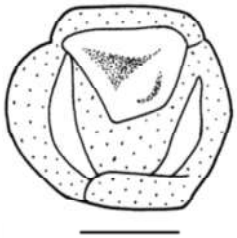

Figure 37. *Staphlosporonites tetracellatus* A. Gupta 2002, Bar = 10 µm.

Location: Jamtah Road Section, Sirmaur District, Himachal Pradesh, India.

Age: Eocene (Subathu Formation).

DISTRIBUTION

It has been observed that *Dictyosporae* have been recorded from widespread areas, e.g. Australia, Azerbaijan, Cameroon, Canada, China, Colombia, Germany, India, Spain, Turkey and U.S.A. (Table 1). In Australia, dictyospores were recorded from the Early-Middle Eocene sediments of Maslin Bay, South Australia (Lange & Smith 1971). Félix (1894) recorded *Dictyosporites loculatus* from the Eocene sediments of Perekeschkul, near Baku, Azerbaijan. Salard-Cheboldaeff and Locquin (1980) described *Dictyosporites dictyosus*, *D. morularis, D. moruloides, D. ovoideus, Octosporites stauroides*

Table 1. Showing global distribution of various species of fossil *Dictyosporae.*

Country	Species	Reference	Age
Australia	*Dictyosporites hyalinus* (R.T. Lange & P.H. Sm. 1971) Kalgutkar & Janson. 2000	Lange & Smith 1971	Early-Middle Eocene
	Staphlosporonites felixii (R.T. Lange & P.H. Sm.) Kalgutkar & Janson. 2000	Lange & Smith 1971	Early-Middle Eocene
Azerbaijan	*Dictyosporites loculatus* Félix 1894	Félix 1894	Eocene.
Cameroon	*Dictyosporites dictyosus* (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000.	Salard-Cheboldaeff & Locquin 1980	Oligocene.
	Dictyosporites morularis (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000.	Salard-Cheboldaeff & Locquin 1980	Oligocene.
	Dictyosporites moruloides (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000	Salard-Cheboldaeff & Locquin 1980	Early Miocene.
	Dictyosporites ovoideus Sal.-Cheb. & Locq. 1980	Salard-Cheboldaeff & Locquin 1980	Oligocene.
	Octosporites stauroides Sal.-Cheb. & Locq. 1980	Salard-Cheboldaeff & Locquin 1980	Early Miocene.
	Staphlosporonites pachycellularis (Sal.-Cheb. & Locq.) Kalgutkar & Janson. 2000	Salard-Cheboldaeff & Locquin 1980	Oligocene
Canada	*Alternaria alternariata* (Kalgutkar & Sigler) R.K. Saxena et al. 2022	Kalgutkar & Sigler 1995	Palaeocene or Early Eocene
	Dictyosporites globimuriformis Kalgutkar 1997	Kalgutkar 1997	Late Palaeocene-Early Eocene.
	Kutchiathyrites canadensis Kalgutkar & Janson. 2000	Kalgutkar 1993	Late Palaeocene-Early Eocene.
	Staphlosporonites billelsikii Kalgutkar & Janson. 2000	Kalgutkar 1993	Late Palaeocene-Early Eocene
	Staphlosporonites delumbus Norris 1986	Norris 1986	Eocene to Oligocene
China	*Alternaria clavellata* (Z.-C. Song & G.-X. Li in Song et al.) R.K. Saxena et al. 2022	Song et al. 1989	Middle-Late Oligocene
	Kutchiathyrites palmatus (P. Ke & Z.Y. Shi) Kalgutkar & Janson. 2000	Ke & Shi 1978	Eocene-Oligocene.
	Staphlosporonites discitypicus P. Ke & Z.Y. Shi 1978	Ke & Shi 1978	Eocene-Oligocene
Colombia	*Dictyosporites firbasii* (Hammen) Kalgutkar & Janson. 2000	van der Hammen 1954	Maastrichtian.
	Dictyosporites garciabarrigae (Hammen) Kalgutkar & Janson. 2000	van der Hammen 1954	Maastrichtian.
	Polyadosporites suescae Hammen 1954	van der Hammen 1954	Maastrichtian
Germany.	*Papulosporonites sphaeromorphus* Schmied. & A.J. Schwab 1964	Schmiedeknecht & Schwab 1964	Middle Eocene
India	*Alternaria bella* (Anil Chandra et al.) R.K. Saxena et al. 2022	Chandra et al. 1984	Late Quaternary.
	Alternaria psilata (A. Gupta) R.K. Saxena et al. 2022	Gupta 2002	Late Palaeocene to Early Oligocene
	Alternaria saxenae (A. Gupta) R.K. Saxena et al. 2022	Gupta 2002	Late Palaeocene to Early Oligocene
	Alternaria sirmaurensis (A. Gupta) R.K. Saxena et al. 2022	Gupta 2002	Late Palaeocene to Late Eocene
	Dictyosporites dicotylophylli (Paradkar) Kalgutkar & Janson. 2000	Paradkar 1976	Late Cretaceous (Maastrichtian).
	Dictyosporites paradkariae Kalgutkar & Janson. 2000	Paradkar 1976	Late Cretaceous (Maastrichtian).
	Dictyosporites tirumalacharii (Ramanujam & Ramachar) Kalgutkar & Janson. 2000	Ramanujam & Ramachar 1980	Miocene
	Dictyosporiuminites intermedius Debi Mukh. 2012	Mukherjee 2012	Miocene
	Kutchiathyrites eccentricus R.K. Kar 1979	Kar 1979	Oligocene
	Kutchiathyrites mehrotrae R.K. Saxena & S.K.M. Tripathi 2011	Saxena & Tripathi 2011	Early Miocene
	Kutchiathyrites perfectus (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi 2011	Kar et al. 2010	Miocene

Table 1. Contd...

Country	Species	Reference	Age
	Lirasporis elongatus R.K. Kar in Saxena 2012	Kar 1990a	Early-Middle Miocene.
	Lirasporis intergranifer R. Potonié & S.C.D. Sah 1960	Potonié & Sah 1960	Late Miocene or Pliocene
	Papulosporonites multicellatus (R.K. Saxena & H.P. Singh) Kalgutkar & Janson. 2000	Saxena & Singh 1983	Miocene-Pliocene
	Papulosporonites siwalikus (R.K. Saxena & A.P. Bhattach.) Kalgutkar & Janson. 2000	Saxena & Bhattacharyya 1987	Miocene.
	Papulosporonites subcircularis (Anil Chandra et al.) Kalgutkar & Janson. 2000	Chandra et al. 1984	Late Quaternary
	Polyadosporites nadahensis M.R. Rao & R. Patnaik 2001	Rao & Patnaik 2001	Late Pliocene
	Polyadosporites siwalikus M.R. Rao & R. Patnaik 2001	Rao & Patnaik 2001	Late Pliocene
	Staphlosporonites chandrae A. Gupta 2002	Gupta 2002	Eocene
	Staphlosporonites dichotomus A. Gupta 2002	Gupta 2002	Eocene
	Staphlosporonites elongatus A. Gupta 2002	Gupta 2002	Eocene
	Staphlosporonites elsikii Ramanujam & Srisailam 1980	Ramanujam & Srisailam 1980	Miocene
	Staphlosporonites neyveliensis Ambw. 1983	Ambwani 1983	Late Miocene or Pliocene
	Staphlosporonites raoi A. Gupta 2002	Gupta 2002	?Eocene
	Staphlosporonites settyi A. Gupta 2002	Gupta 2002	Eocene
	Staphlosporonites tetracellatus A. Gupta 2002	Gupta 2002	Eocene
Spain	*Papulosporonites hammenii* (Haseld.) Kalgutkar & Janson. 2000	Haseldonckx 1973	Early Palaeocene-Late Eocene.
Turkey	*Dictyosporites symmetricus* (V.S. Ediger) Kalgutkar & Janson. 2000	Ediger 1981	Late Eocene-Oligocene, Miocene-Pliocene.
	Papulosporonites enormis (V.S. Ediger) Kalgutkar & Janson. 2000	Ediger 1981	Late Eocene-Oligocene, Miocene-Pliocene.
	Papulosporonites orbis (V.S. Ediger) Kalgutkar & Janson. 2000	Ediger 1981	Late Eocene-Oligocene, Miocene-Pliocene
	Staphlosporonites irregularis (V.S. Ediger) Kalgutkar & Janson. 2000	Ediger 1981	Late Eocene-Oligocene, Miocene-Pliocene
U.S.A.	*Alternaria acuminata* (Rouse & Mustard) R.K. Saxena et al. 2022	Rouse & Mustard 1997	Late Palaeocene.
	Centonites symmetricus Peppers 1964	Peppers 1964	Late Pennsylvanian.
	Ctenosporites sherwoodiae Kalgutkar & Janson. 2000	Kalgutkar & Jansonius 2000	Late Cretaceous
	Dictyosporites ovalis (Sheffy & Dilcher) Kalgutkar & Janson. 2000	Sheffy & Dilcher 1971	Middle Eocene
	Dictyosporites tristratosus (Sheffy & Dilcher) Kalgutkar & Janson. 2000	Sheffy & Dilcher 1971	Middle Eocene
	Staphlosporonites allomorphus Sheffy & Dilcher 1971	Sheffy & Dilcher 1971	Middle Eocene
	Staphlosporonites conoideus Sheffy & Dilcher 1971	Sheffy & Dilcher 1971	Middle Eocene

and *Staphlosporonites pachycellularis* from the Oligocene-Early Miocene sediments of Coast of Equatorial Africa, Gulf of Guinea, Cameroon, Africa. Norris (1986) recorded *Alternaria acuminata* from the Late Palaeocene sediments of Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, Canada and the Northwestern Washington State, U.S.A. and *Staphlosporonites delumbus* from the Eocene to Oligocene sediments of Imperial Nuktak C–22 Well. Mackenzie Delta Region, Northwest Territories, Canada. Kalgutkar and Sigler (1995) described *Alternaria alternariata* from the Iceberg Bay Formation (Late Palaeocene or Early Eocene) of Kanguk Peninsula, Axel Heiberg Island, Northwest Territories, Canada. Kalgutkar (1993) recorded *Kutchiathyrites canadensis* and *Staphlosporonites billelsikii* from the Late Palaeocene-Early Eocene sediments of Peel River, Yukon Territory, Canada. Kalgutkar (1997) described *Dictyosporites globimuriformis* from the Late Palaeocene-Early Eocene sediments of Kanguk Peninsula, Axel Heiberg Island, Northwest Territories, Canada. In China, *Alternaria clavellata* was recorded by Song & Li in Song et al. (1989) from the Shahejie and Dongying formations (Middle-Late Oligocene) of Heze County and Shenxian County of Shandong Province, China. Ke and Shi (1978) recorded *Kutchiathyrites palmatus* from the Eocene-Oligocene sediments of Kenlixian and Bingxian, Shandong Province, Coastal region of Bohai, China and *Staphlosporonites discitypicus* from the Eocene-Oligocene sediments of Panshan, Liaoning Province, Coastal region of Bohai, China. Van der Hammen (1954) recorded *Dictyosporites firbasii*, *D. garciabarrigae* and *Polyadosporites suescae* from the Maastrichtian sediments of Magdalena Valley, Eastern Cordellera, Colombia, South America. Schmiedeknecht & Schwab (1964) recorded *Papulosporonites sphaeromorphus* from the Middle Eocene sediments of Zwischenflöz, Tagebau des Braunkohlenwerkes Nachterstedt, Germany. Haseldonckx (1973) described *Papulosporonites hammenii* from the Early Palaeocene-Late Eocene sediments of Arén, Ribagorzana Valley, Pyrenees, Spain. Ediger (1981) studied fossil fungi from Late Eocene-Oligocene and Miocene-Pliocene sediments of Thrace Basin, Turkey and recorded *Dictyosporites symmetricus*, *Papulosporonites enormis*, *Papulosporonites orbis* and *Staphlosporonites irregularis*. Peppers (1964) recorded *Centonites symmetricus* from the Late Pennsylvanian sediments of Illinois, U.S.A. Sheffy & Dilcher (1971) described *Dictyosporites ovalis*, *D. tristratosus*, *Staphlosporonites allomorphus* and *S. conoideus* from the Claiborne Formation (Middle Eocene) of Puryear clay pit, 800 m south of Puryear, Henry County, Tennessee, U.S.A. Rouse & Mustard (1997) recoded *Alternaria acuminata* from the Late Palaeocene sediments of Strait of Georgia, eastern Vancouver Island, the Fraser River lowlands of southwest British Columbia, Canada and the Northwestern Washington State, U.S.A. Vermejo Formation coal beds **(**Late Cretaceous) of Fremont County, Colorado, U.S.A. *Ctenosporites sherwoodiae* (based on Fungal Spore sp. A of Clarke 1965) was described by Kalgutkar & Jansonius (2000) (Table 1).

Distribution in India: In India, *Dictyosporae* have been recorded from many areas, e.g. Late Quaternary sediment cores, Arabian Sea; Kutch and Cambay basins, Gujarat; Haryana; Sirmaur, Kangra and Solan districts, Himachal Pradesh; Kollam, Alleppey, Thiruvananthapuram and Kannur districts, Kerala; Chhindwara District, Madhya Pradesh; Sindhudurg District, Maharashtra; Meghalaya-Assam, Mizoram, Cuddalore District, Tamil Nadu, Tripura; and Darjeeling District, West Bengal. Distribution of 8 genera and 30 species of fossil *Dictyosporae* in India and their stratigraphic unit (geologic age) and areas of occurrence, along with citation of relevant References is shown in Tables 2 and 3.

Table 2. Representation of species of fossil *Dictyosporae* in various states of India.

Geographical area	Species recorded (References)
Arabian Sea (sediment cores)	***Alternaria bella*** (Anil Chandra et al.) R.K. Saxena et al.: Late Quaternary sediment core no. 1, Arabian Sea (Chandra et al. 1984). ***Papulosporonites subcircularis*** (Anil Chandra et al.) Kalgutkar & Janson. Late Quaternary sediment core no. 2, Arabian Sea. (Chandra et al. 1984).
Gujarat (Kutch and Cambay basins)	***Alternaria bella*** (Anil Chandra et al.) R.K. Saxena et al.: Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, Kutch District, Gujarat (Saxena & Ranhotra 2009). ***Dictyosporites tirumalacharii*** (Ramanujam & Ramachar) Kalgutkar & Janson.: Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, Kutch District, Gujarat (Saxena & Ranhotra 2009). ***Kutchiathyrites eccentricus*** R.K. Kar: Maniyara Fort Formation (Oligocene), Barkhana Nala Cutting near Sarangwara, Kutch District, Gujarat (Kar 1979); Middle-Late Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat (Kar & Saxena 1981, Kar 1985); Early Eocene, (Rajpardi Lignitr), Broach District, Gujarat (Bhattacharya 1987, Kar & Bhattacharya 1992). ***Papulosporonites multicellatus*** (R.K. Saxena & H.P. Singh) Kalgutkar & Janson. Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, Kutch District, Gujarat (Saxena & Ranhotra 2009).
Haryana	***Alternaria bella*** (Anil Chandra et al.) R.K. Saxena et al.: Pinjor Formation (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana (Saxena et al. 1988). ***Polyadosporites nadahensis*** M.R. Rao & R. Patnaik: Pinjor Formation (Late Pliocene), Nadah, Panchkula, Haryana (Rao & Patnaik 2001). ***Polyadosporites siwalikus*** M.R. Rao & R. Patnaik: Pinjor Formation (Late Pliocene), Nadah, Panchkula, Haryana (Rao & Patnaik 2001).
Himachal Pradesh	***Alternaria bella*** (Anil Chandra et al.) R.K. Saxena et al.: Lower Siwalik-Nahan and Upper Siwalik (Middle Miocene-Pliocene), Kala Amb-Nahan Section, Sirmaur District, Himachal Pradesh (Saxena & Bhattacharyya 1987); Dharmsala Group (Oligocene-Early Miocene), Churan Khad Section near Dharmsala, Kangra District, Himachal Pradesh (Saxena & Bhattacharyya 1990). ***Alternaria psilata*** (A. Gupta) R.K. Saxena et al.: Subathu Formation (Eocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Alternaria saxenae*** (A. Gupta) R.K. Saxena et al.: Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Alternaria sirmaurensis*** (A. Gupta) R.K. Saxena et al.: Subathu Formation (Eocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Kutchiathyrites eccentricus*** R.K. Kar: Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh (Singh & Sarkar 1994). ***Papulosporonites siwalikus*** (R.K. Saxena & A.P. Bhattach.) Kalgutkar & Janson.: Lower Siwalik-Nahan and Upper Siwalik (Middle Miocene-Pliocene), Kala Amb-Nahan Section, Sirmaur District, Himachal Pradesh (Saxena & Bhattacharyya 1987). ***Staphlosporonites chandrae*** A. Gupta: Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Staphlosporonites dichotomus*** A. Gupta: Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Staphlosporonites elongatus*** A. Gupta: Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Staphlosporonites raoi*** A. Gupta: Dagshai Formation (?Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Staphlosporonites settyi*** A. Gupta: Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002). ***Staphlosporonites tetracellatus*** A. Gupta: Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002).
Kerala	***Kutchiathyrites eccentricus*** R.K. Kar: Neogene, around Kollam and Varkala, Kerala (Jain & Kar 1979); Miocene, Tonakkal, Thiruvananthapuram District, Kerala (Patil & Ramanujam 1988); Miocene, Tonakkal, Padappakkara, Edavai, Kerala (Rajendran et al. 1989); Tertiary, Alleppey and Kannur districts, Kerala (Rao 1995); Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala (Rao & Nair 1998). ***Lirasporis intergranifer*** R. Potonié & S.C.D. Sah: Cannanore lignite (Late Miocene), Kannur District, Kerala (Potonié & Sah 1960). Neogene, around Kollam and Varkala, Kerala (Jain & Kar 1979); Miocene, Palayangadi, Kerala (Rajendran et al. 1989); Eocene-Early Miocene, Arthungal Borehole, Alleppey District, Kerala (Rao 1990); Tertiary, Alleppey and Kannur districts, Kerala (Rao 1995); Early Miocene, Turavur Borehole near Panchayat L.P. School, west of N.H. 47 between 380 and 381 km, Alleppey District, Kerala (Rao 1996); Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala (Rao & Nair 1998).

Table 2. Contd...

Geographical area	Species recorded (References)
	Staphlosporonites elsikii Ramanujam & Srisailam: Warkalli Beds (Miocene), Kannur District, Kerala (Ramanujam & Srisailam 1980); Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala (Varma & Patil 1985).
Madhya Pradesh	***Dictyosporites dicotylophylli*** (Paradkar) Kalgutkar & Janson.: Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh (Paradkar 1976).
	Dictyosporites paradkariae Kalgutkar & Janson.: Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh (Paradkar 1976).
	Papulosporonites multicellatus (R.K. Saxena & H.P. Singh) Kalgutkar & Janson.: Late Cretaceous, Maastrichtian, Mohgaon Kalan, Chhindwara District, Madhya Pradesh (Chitaley & Yawale 1978).
Maharashtra	***Kutchiathyrites eccentricus*** R.K. Kar: Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra (Saxena 2000); Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra (Rao 2004).
	Lirasporis intergranifer Potonié & Sah: Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra (Saxena & Misra 1990); Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra (Saxena 2000); Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra (Rao 2004).
Meghalaya-Assam	***Kutchiathyrites eccentricus*** R.K. Kar: Renji Formation (Late Oligocene), Silchar-Haflong Road Section, Assam (Kar 1990b); Tertiary, subsurface sediments in Upper Assam (Kar et al. 1994); Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya (Saxena & Rao 1996); Kherapara Formation (Oligocene), Tura-Dalu Road Section near Kherapara, West Garo Hills District, Meghalaya (Rao 2000); Bhuban Formation (Miocene), Tlangsam, Mizoram (Kar et al. 2010).
	Kutchiathyrites mehrotrae R.K. Saxena & S.K.M. Tripathi: Bhuban Formation (Early Miocene), Sonapur–Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam (Singh et al. 1986).
	Lirasporis intergranifer R. Potonié & S.C.D. Sah: Lubha Member, Bhuban Formation (Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam (Singh et al. 1986); Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya (Saxena & Rao 1996).
Mizoram	***Kutchiathyrites eccentricus*** R.K. Kar: Bhuban Formation (Miocene), Tlangsam, Mizoram (Kar et al. 2010).
	Kutchiathyrites perfectus (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi: Bhuban Formation (Miocene), Tlangsam, Mizoram (Kar et al. 2010).
Tamil Nadu	***Dictyosporites tirumalacharii*** (Ramanujam & Ramachar) Kalgutkar & Janson.: Neyveli lignite (Miocene), Neyveli, Cuddalore District, Tamil Nadu (Ramanujam & Ramachar 1980).
	Dictyosporiuminites intermedius Debi Mukh.: Neyveli Lignite (Miocene); Neyveli Lignite Mine–I, Cuddalore District, Tamil Nadu (Mukherjee 2012).
	Kutchiathyrites eccentricus R.K. Kar: Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu (Saxena & Khare 1992).
	Staphlosporonites neyveliensis Ambw.: Neyveli lignite (Miocene), Neyveli, Cuddalore District, Tamil Nadu (Ambwani 1983).
Tripura	***Kutchiathyrites eccentricus*** R.K. Kar: Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura (Kar 1990a).
	Lirasporis elongatus R.K. Kar in Saxena: Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura (Kar 1990a).
West Bengal	***Kutchiathyrites eccentricus*** R.K. Kar: Geabdat Sandstone (Neogene), Darjeeling District, West Bengal (Pathak & Banerjee 1984).
	Lirasporis intergranifer R. Potonié & S.C.D. Sah: Geabdat Sandstone (Neogene), Darjeeling District, West Bengal (Pathak & Banerjee 1984).

Table 3. Distribution of species of fossil *Dictyosporae* in India with stratigraphic unit (age) and area of their occurrence.

Genus	Species	Stratigraphic unit, age and area (References)
Alternaria Nees 1816	***Alternaria alternariata*** (Kalgutkar & Sigler) R.K. Saxena et al. 2022	Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat (Saxena & Ranhotra 2009, p. 692, figure 3.30).
	Alternaria bella (Anil Chandra et al.) R.K. Saxena et al. 2022	Late Quaternary, Sediment core no. 1 (Lat. 17°57.9'N: Long. 70°46.0'E), Arabian Sea (Chandra et al. 1984, p. 49, plate 2, figures 20–21, text-figure 2); Pinjor Formation (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana (Saxena et al. 1988, p. 277, plate 2, figure 30); Lower Siwalik-Nahan and Upper Siwalik (Middle Miocene-Pliocene), Kala Amb-Nahan Section, Sirmaur District, Himachal Pradesh (Saxena & Bhattacharyya 1987, p. 189); Dharmsala Group (Oligocene-Early Miocene), Churan Khad Section near Dharmsala, Kangra District, Himachal Pradesh (Saxena & Bhattacharyya 1990, p. 113); Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat (Saxena & Ranhotra 2009, p. 692, figure 3.31–32).
	Alternaria psilata (A. Gupta) R.K. Saxena et al. 2022	Subathu Formation (Eocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 146, plate 4, figure 7).
	Alternaria saxenae **(**A. Gupta) R.K. Saxena et al. 2022	Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 145, plate 4, figure 4).
	Alternaria sirmaurensis **(**A. Gupta) R.K. Saxena et al. 2022	Subathu Formation (Eocene), Dadahu Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 145, plate 4, figure 3).
Dictyosporites Félix 1894	***Dictyosporites dicotylophylli*** (Paradkar) Kalgutkar & Janson. 2000	Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh (Paradkar 1976, p. 119–120, plate 1, figure 5, text-figures 1, 3–4, 7–8).
	Dictyosporites paradkariae Kalgutkar & Janson. 2000	Deccan Intertrappean Series (Late Cretaceous), Mohgaon Kalan, Chhindwara District, Madhya Pradesh (Paradkar 1976, p. 120, 123, plate 1, figure 2, text-figure 5).
	Dictyosporites tirumalacharii (Ramanujam & Ramachar) Kalgutkar & Janson. 2000	Neyveli lignite (Miocene), Neyveli, Cuddalore District, Tamil Nadu (Ramanujam & Ramachar 1980, p. 83, plate 1, figures 11–12); Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat (Saxena & Ranhotra 2009, p. 692, figures 3.27, 35).
	Dictyosporites tristratosus (Sheffy & Dilcher) Kalgutkar & Janson. 2000	Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu (Ambwani 1983, p. 150, plate 1, figure 8); Siju Formation (Middle Eocene), Simsang River Section near Siju, South Garo Hills District, Meghalaya (Saxena & Sarkar 2000, p. 257).
Dictyosporiuminites Debi Mukh. 2012	***Dictyosporiuminites intermedius*** Debi Mukh. 2012	Neyveli Lignite (Miocene), Neyveli Lignite Mine–I, Cuddalore District, Tamil Nadu, India (Mukherjee 2012, p. 5, figure 13G).

Table 3. Contd...

Genus	Species	Stratigraphic unit, age and area (References)
Kutchiathyrites R.K. Kar 1979	***Kutchiathyrites eccentricus*** Kar 1979	Maniyara Fort Formation (Oligocene), Barkhana Nala Cutting near Sarangwara, Kutch District, Gujarat (Kar 1979, p. 32, plate 3, figures 49–52); Neogene, around Kollam and Varkala, Kerala (Jain & Kar 1979, p. 107, plate 1, figure 15, plate 2, figure 23); Middle-Late Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat (Kar & Saxena 1981, p. 115); Geabdat Sandstone (Neogene), Darjeeling District, West Bengal (Pathak & Banerjee 1984, p. 250, 254, plate 2, figure 25); Eocene, bore core no. 27 near Rataria, Kutch District, Gujarat (Kar 1985, p. 130); Early Eocene, Rajpardi, Broach District, Gujarat (Bhattacharya 1987, p. 120); Miocene, Tonakkal, Thiruvananthapuram District, Kerala (Patil & Ramanujam 1988, p. 266, plate 2, figure 11); Miocene, Tonakkal, Padappakkara, Edavai, Kerala (Rajendran et al. 1989, p. 41, 42, 43, plate 1, figure 17); Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura (Kar 1990a, p. 179, plate 8, figure 121); Renji Formation (Late Oligocene), Silchar-Haflong Road Section, Assam (Kar 1990b, p. 238); Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra (Saxena & Misra 1990, p. 265); Rajpardi lignite (Early Eocene), Bharuch District, Gujarat (Kar & Bhattacharya 1992, p. 251, plate 2, figure 37); Late Palaeocene-Middle Eocene, Jayamkondacholapuram Well 12, Tiruchirapalli District, Tamil Nadu (Saxena & Khare 1992, p. 37); Tertiary, subsurface sediments in Upper Assam (Kar et al. 1994, p. 187); Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh (Singh & Sarkar 1994, p. 52); Tertiary, Alleppey and Kannur districts, Kerala (Rao 1995, p. 233); Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya (Saxena & Rao 1996, p. 46); Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala (Rao & Nair 1998, p. 52); Kherapara Formation (Oligocene), Tura-Dalu Road Section near Kherapara, West Garo Hills District, Meghalaya (Rao 2000, p. 295); Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra (Saxena 2000, p. 163); Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District, Maharashtra (Rao 2004, p. 124, plate 3, figure 15); Bhuban Formation (Miocene), Tlangsam, Mizoram, India (Kar et al. 2010, p. 242).
	Kutchiathyrites mehrotrae R.K. Saxena & S.K.M. Tripathi 2011	Bhuban Formation (Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam (Singh et al. 1986, p. 97, plate 1, figures 11–12).
	Kutchiathyrites perfectus (R. Kar et al.) R.K. Saxena & S.K.M. Tripathi 2011	Bhuban Formation (Miocene), Tlangsam, Mizoram, India (Kar et al. 2010, p. 247, plate 2, figure 6).
Lirasporis R. Potonié & S.C.D. Sah 1960	***Lirasporis elongatus*** R.K. Kar in Saxena 2012	Surma and Tipam groups (Miocene), Rokhia Borehole No. 1, Gojalia Borehole No. 1 and Baramura Borehole No. 2, Tripura (Kar 1990a, p. 196, plate 8, figures 116–117); Late Tertiary, Site 218, Deep Sea Drilling Project Leg 22, Bengal Fan, Indian Ocean (Chandra & Kumar 1998, p. 58, 60, plate 1, figures 11, 15).

Table 3. Contd...

Genus	Species	Stratigraphic unit, age and area (References)
	Lirasporis intergranifer R. Potonié & S.C.D. Sah 1960	Cannanore lignite (Late Miocene), Kannur District, Kerala (Potonié & Sah 1960, p. 131–132, plate 4, figures 32–33); Neogene, around Kollam and Varkala, Kerala (Jain & Kar 1979, p. 108, plate 2, figure 25, plate 3, figure 50); Geabdat Sandstone (Neogene), Darjeeling District, West Bengal (Pathak & Banerjee 1984, p. 250, plate 2, figure 23); Lubha Member, Bhuban Formation (Early Miocene), Sonapur-Badarpur Road Section, Jaintia Hills, Meghalaya and Cachar District, Assam (Singh et al. 1986, p. 97, plate 1, figure 13); Miocene, Palayangadi, Kerala (Rajendran et al. 1989, p. 44, plate 1, figures 5, 12); Eocene-Early Miocene, Arthungal Borehole, Alleppey District, Kerala (Rao 1990, p. 248, plate 3, figure 14; Ratnagiri Beds (Neogene), Amberiwadi Section, Sindhudurg District, Maharashtra (Saxena & Misra 1990, p. 265); Tertiary, Alleppey and Kannur districts, Kerala (Rao 1995, p. 233); Early Miocene, Turavur Borehole near Panchayat L.P. School, west of N.H. 47 between 380 and 381 km, Alleppey District, Kerala (Rao 1996, p. 156); Boldamgiri Formation (Early Miocene), Adugiri-Purakhasia Road near Boldamgiri, West Garo Hills District, Meghalaya (Saxena & Rao 1996, p. 46); Miocene, Kannanellur-Kundra Road area, Kollam District, Kerala (Rao & Nair 1998, p. 52); Sindhudurg Formation (Miocene), Mavli Mine at Redi, Sindhudurg District, Maharashtra (Saxena 2000, p. 163); Sindhudurg Formation (Miocene), Kalviwadi, Sindhudurg District (Rao 2004, p. 124, plate 3, figure 12).
Papulosporonites Schmied. & A. J. Schwab 1964	***Papulosporonites mohgaoensis*** (Chitaley & Yawale) Kalgutkar & Janson. 2000	Late Cretaceous, Maastrichtian, Mohgaon Kalan, Chhindwara District, Madhya Pradesh (Chitaley & Yawale 1978, p. 190, plate 1, figure 1); Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat (Saxena & Ranhotra 2009, p. 692, figure 3.33).
	Papulosporonites multicellatus (R.K. Saxena & H.P Singh) Kalgutkar & Janson. 2000	Upper Siwalik (Pliocene), Hoshiarpur-Una Road Section, Hoshiarpur District, Punjab and Una District, Himachal Pradesh (Saxena & Singh 1982, p. 295, plate 2, figures 28–29); Pinjor Formation (Pliocene), Masol-Kiratpur Section, Ambala District, Haryana (Saxena et al. 1988, p. 277, plate 2, figures 23, 27); Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh (Singh & Sarkar 1994, p. 52); Siju Formation (Middle Eocene), Simsang River Section near Siju, South Garo Hills District, Meghalaya (Saxena & Sarkar 2000, p. 257); Intertrappean Beds (Early Palaeocene), 5 km west of Naredi, on Naliya-Narayan Sarovar Road, Kutch District, Gujarat (Saxena & Ranhotra 2009, p. 691).
	Papulosporonites siwalikus (R.K. Saxena & A.P. Bhattach.) Kalgutkar & Janson. 2000	Lower Siwalik-Nahan and Upper Siwalik (Middle Miocene-Pliocene), Kala Amb-Nahan Section, Sirmaur District, Himachal Pradesh (Saxena & Bhattacharyya 1987, p. 193, plate 1, figures 12, 14).
	Papulosporonites subcircularis (Anil Chandra et al.) Kalgutkar & Janson. 2000	Late Quaternary, Sediment core no. 2 (Lat. 18°35.2'N: Long. 69°17.2'E), Arabian Sea (Chandra et al. 1984, p. 48, plate 2, figure 17–18).
Polyadosporites van der Hammen 1954	***Polyadosporites nadahensis*** M.R. Rao & Patnaik 2001	Pinjor Formation (Late Pliocene), Nadah, Panchkula, Haryana (Rao & Patnaik 2001, p. 270, 272, plate 1, figures 14–16).

Table 3. Contd...

Genus	Species	Stratigraphic unit, age and area (References)
	Polyadosporites siwalikus M.R. Rao & Patnaik 2001	Pinjor Formation (Late Pliocene), Nadah, Panchkula, Haryana (Rao & Patnaik 2001, p. 272, plate 3, figures 6, 9).
Staphlosporonites Sheffy & Dilcher 1971	***Staphlosporonites chandrae*** A. Gupta 2002	Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 143, plate 3, figure 12).
	Staphlosporonites conoideus Sheffy & Dilcher 1971	Kasauli Formation (Early Miocene), Banethi, Sirmaur District, Himachal Pradesh (Singh & Sarkar 1984, p. 48, plate 2, figure 27); Kundlu and Nalagarh formations (Miocene), Kundlu and Ramshahr, Solan District, Himachal Pradesh (Sarkar & Singh 1994, p. 100); Kasauli Formation (Early Miocene), Kasauli, Solan District, Himachal Pradesh (Singh & Sarkar 1994, p. 52, plate 1, figure 28).
	Staphlosporonites dichotomus A. Gupta 2002	Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 142, plate 3, figure 9).
	Staphlosporonites elongatus A. Gupta 2002	Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 142, plate 3, figure 9).
	Staphlosporonites elsikii Ramanujam & Srisailam 1980	Warkalli Beds (Miocene), Kannur District, Kerala (Ramanujam & Srisailam 1980, p. 122, plate 1, figures 6–7); Miocene, Tonakkal clay mine, Thiruvananthapuram District, Kerala (Varma & Patil 1985, p. 156).
	Staphlosporonites neyveliensis Ambw. 1983	Neyveli lignite (Miocene), Neyveli, South Arcot District, Tamil Nadu (Ambwani 1983, p. 149–150, plate 1, figure 7).
	Staphlosporonites raoi A. Gupta 2002	Dagshai Formation (?Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002 p. 142, plate 3, figure 10).
	Staphlosporonites settyi A. Gupta 2002	Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 143, plate 3, figure 13).
	Staphlosporonites tetracellatus A. Gupta 2002	Subathu Formation (Eocene), Jamtah Road Section, Sirmaur District, Himachal Pradesh (Gupta 2002, p. 142, plate 3, figure 8).

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