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A PALYNOFLORAL DIVERSITY IN THE KOPILI FORMATION (LATE EOCENE) FROM NORTH-EAST INDIA

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Abstract. Palynological diversity in the Kopili Formation of North Cachar Hills, Assamand Jaintia and East Khasi hills, Meghalaya has been discussed here. The Kopili Formation is the youngest lithostratigraphic unit of the Jaintia Group and is Late Eocene in age. Common palynological forms found to occur in the Kopili Formation from North Cachar Hills, Assamand from Jaintia and East Khasi hills, Meghalaya are *Cyathidites*, *Dictyophyllidites*, *Lygodiumsporites*, *Todisporites*, *Striatriletes*, *Monolites*, *Polypodiaceaesporites*, *Polypodiisporites*, *Pinuspollenites*, *Podocarpidites*, *Spinizonocolpites*, *Acanthotricolpites*, *Palmaepollenites*, *Densiverrupollenites*, *Margocolporites*, *Tricolpites*, *Lakiapollis*, *Pellicieroipollis*, *Retitricolporites*, *Tricolporopollis*, *Cleistosphaeridium*, *Cordosphaeridium*, *Phragmothyrites*, *Trichothyrites* etc. in addition to reworked Gondwana palynofossils.

■ Palynofloral, diversity, Kopili Formation, Late Eocene, North Cachar Hills, Assam, Jaintia Hills, East Khasi Hills, Meghalaya, north-east India.

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Introduction

Palynological diversity means variability and diversity among spore-pollen and other related microscopic organic forms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. Broadly speaking, the term palynodiversity includes genetic diversity(diversity within the species), species diversity (diversity between species) and ecosystem diversity(habitat diversity).

Species richness and relative abundance of different species is one of the criteria used to measure the degree of diversity. However, and as a general rule, the palynomorph diversity probably gives an idea of the generic diversity of a fossil flora, irrespective of age *(cf.* Germeraad *et al.* 1968). A rich and diversified palynological assemblage has been recorded from the Kopili Formation, in this regard the formation is represented by many different plant groups such as algae, fungi, bryophytes, pteridophytes, gymnosperms and angiosperms.

The north-eastern region of India comprises a number of states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. It has a vast geological record which are represented by different litho units spanning a long period of geological time. This region is one of the best areas to study the living as well as palaeopalynodiversity.

The palynoflora recovered from the different areas that are spread over the AssamArakan Basin and the palaeofloristic diversity in the Kopili Formation during the Late Eocene period, have been summarised and discussed here.

The north-eastern extension of the Indian peninsular shield is represented by the Shillong Plateau. The plateau reveals an extensive and well developed Palaeogene sedimentary rock succession in its southern and south-eastern parts. The Kopili Formation is best exposed in the southern and south-eastern parts of the Shilong Plateau i.e. Jaintia Hills, Meghalaya and North Cachar Hills, Assam. The type area, Khorungma and the type section of the Kopili Formation, Kopili River Section, are both located in the North Cachar Hills District, Assam where it attains a maximum thickness of about 500 metres (Evans, 1932). In Khasi Hills, Meghalaya, the formation is well exposed at Isamati, Kommorah and in the SheIla River Section. In Upper Assam, the Kopili Formation can be seen exposed in the Karbi Anglong District along the river Kailajan, south-east of Kailajan Colliery. It is not so well developed in the latter mentioned area in comparison with its occurrences in other places. The Kopili Formation occurs extensively in the subsurface of the Upper Assam and Dhansiri Valley. These rocks also occur in the subsurface of the West Bengal Basin.

The Rewak Formation, the equivalent of the Kopili Formation in Garo Hills, Meghalaya, has similar lithology and age i.e. Late Eocene. In geosynclinal facies the equivalent of the Kopili Formation is known as the Disang Group.

The Kopili Formation, the youngest lithostratigraphic unit of the Jaintia Group occurs as narrow linear outcrops in Assam (Mikir and North Cachar hills) and Meghalaya (East Khasi and Jaintia hills). Evans (1932) named this formation "Kopili Alternation Stage", after the river Kopili, due to its characteristic lithology, having alternating bands of shales

and sandstones, hence "Kopili Alternating Stage". Bhandari *et al.* (1973) and Chakraborty *et al.* (1974) gave it a lithostratigraphic status with formation rank. The formation is made up of alternations of shales and sandstones with thin bands of limestones, siltstones and marls. Mudstones and coal are also present. The shales are generally black to grey to khaki in colour, iron stained and are splintery in nature. Sandstones are ferruginous, some may be carbonaceous, fine grained and there are thin as well as thick bedded sections.

Palynological investigation of the Kopili Formation was carried out by Baksi (1962), Sah and Dutta(1968), Banerjee et al. (1973), Baksi (1974), Salujha et al. (1974), Sein and Sah (1974), Singh (1979), Dutta and Jain (1980), Tripathi and Singh (1984a, b, 1985), Trivedi (1985), Singh and Tripathi (1987), Trivedi (1987), Sah and Mehrotra (1988), Tripathi (1989), Trivedi (1991a, b), Kar et al. (1994), Trivedi (1999), Mehrotra et al. (2000), Trivedi and Saxena (2000), Mehrotra et al. (2002), Mehrotra et al. (2005) and Trivedi (2005).

Methods

The literature regarding botanical and ecological affinities of the fossil palynomorphs from the Indian records (Mathur and Chowdhary, 1977; Rawat et al. 1977; Venkatachala and Chowdhary, 1977; Tripathi, 1982; Rao, 1983; Thanikaimoni et al*.,* 1984) was studied and the affinities of the fossil palynomorphs described here in the text are coupled with their nearest living counterparts. The families of the modern / living taxon were known and therefore also of the fossil palynomorphs. The present day distribution of these families has been described after consultation with the above mentioned literature. In addition Kanjilal et al. (1934–1940), Duthie (1952), Rao (1968), Nayar and Kaur (1974) were also studied in connection with the botanical and ecological affinities and distribution.

Study of ecology and distribution of modern / living taxon led to a similar understanding of the fossil taxon, in keeping with the expression, "Present is the key to the Past". From this information ecological conclusions were made.

Ecological groups within the palynoflora

The palynoflora can be divided into various ecological groups, viz., montane, coastal, mangrove, lowland or inland, fresh water swamp, phytoplanktons, ferns, fungi and reworked Gondwana palynofossils. An analysis of the ecological groups reveals that ferns are dominant over the other plant groups of the assemblage which are listed below.

Montane – *Araucariacites australis, Podocarpidites khasiensis, P. clarus, P. classicus, P. cognatus, Pinuspollenites crestus, Abiespollenites cognatus.*

Coastal – *Acanthotricolpites bulbospinosus, A. brevispinosus, Palmaepollenites nadhamunii, Palmidites plicatus, P.obtusus,Neocouperipollis kutchensis, Proxapertites assamicus, P. microreticulatus, Pellicieroipollis langenheimii.*

Mangrove – *Spinizonocolpites echinatus.*

Lowland or Inland – *Rhoipites kutchensis, Tricolpites parvireticulatus, T. crassireticulatus, Retitrescolpites assamicus, Lakiapollis assamicus, Tricolporopollis rubra, T. matanomadhensis, Dermatobrevicolporites dermatus, Margocoloporites tsukadae, M. complexum, Triporopollenites vimalii, Palaeomalvaceaepollis paucispinosus.*

Fresh water swamp – *Striatriletes susannae, S. multicostatus, S. microverrucosus, S. paucicostatus, S. aidaensis, S. attenuatus.*

Ferns – *Pteridacidites africanus, Cyathidites australis, C. minor, Biretisporites potoniaei, Dictyophyllidites cymbatus, D. granulatus, Dandotiaspora telonata, D. plicata, D. dilata, Osmundacidites wellmanii, O. minutus, O. cephalus, O. kutchensis, Osmundacidites* spp. A., B.*, Todisporites major, T. minor, T. flavatus, T. plicatus, T. kutchensis, Polypodiisporonites ornatus, P. repandus, P. splendidus, P. turbinatus, P. impariter, P. mawkmaensis, Polypodiisporonites* spp. A., B., *Laevigatosporites chatterjii, L. major, L. levis, L. tertiarus, L. lakiensis, Monolites mawkmaensis, Pilamonoletes excellensus, P. moderatus, Verrucatosporites* sp., *Lygodiumsporites lakiensis, L. eocenicus, Malayaeaspora costata, lntrapunctisporis intrapunctis, Punctatisporites sarangwaraensis, Cicatricosisporites* sp.

Fungal elements – *Phragmothyrites eocaenicus, Parmathyrites robustus, Trichothyrites setifer, Kutchiathyites eccentricus, Fusiformisporites foedus, Dyadosporites* sp., *Diporicellaesporites stayci, D. pluricellus, Pluricellaesporites planus, Pluricellaesporites* sp*., Diporisporites* sp., *Lacrimasporonites* sp., *Paramicrothallites* sp., *Microthallites* sp., *Frasnacritetrus* sp.

Phytoplankton – *Deflandrea eocenica, Wetziella* sp., *Cordosphaeridium exilimurum, Amphorosphaeridium multispinosum, Cleistosphaeridium diversispinosum, C. heteracanthum, C. giganteum, Polysphaeridium subtile, P. ornamentum, Gonyaulacysta* sp., *Turbiosphaera filosa, T. proximata, Homotryblium plectilum, M. oceanicum, Operculodinium centrocarpum, O. major, Adantosphaeridium vittatum, Glaphyrocysta exuberans, G. divaricata, Hystrichokolpoma rigaudiae, H. unispinosum, Hystrichostrogylon membraniphorum.*

Reworked Gondwana fossils – *lndotriradites sparsus, Calamospora aplata, Lacinitriletes badamensis, Scheurengipollenites tentulus, Cannanoropollis medius, Corisaccites distinctus, Cuneatisporites rarus, Parasaccites distinctus, Lahrites raniganjensis, Rhizomaspora costa, Horriditriletes rampurensis, Lacinitriletes badamensis, Platysaccus ovatus, P. katriensis, Klukisporites variegatus, Densoisporites velatus, D. mesozoicus, Podosporites tripakshii, Callialasporites segmentatus, C. trilobatus, Vitreisporites densus, Klausipollenites sulcatus, Contiginisporites* sp., *Cingulatisporites* sp., *Polycingulatisporites* sp., *Callumispora* sp., *Lundbladispora* sp., *Striatopodocarpidites* sp., *Lunatisporites* sp.

Conclusions

The above mentioned Late Eocene palynoassemblage is both rich and diversified. It is quite evident that there was high palynofloral diversity in the floristic composition of the area among the different plant taxa including variation in morphological characteristics, adaptability and distribution during the Late Eocene in the Kopili Formation.

The above record also shows that Late Eocene palynoflora was more diverse than Palaeocene flora (Sah and

Tab. 1. Palynofloral composition in the kopili formation

	JAINTIA HILLS, MEGHALAYA (After Sein and Sah, 1974; Dutta and Jain, 1980; Tripathi and Singh, 1984 a, b, 1985; Trivedi, 1985; Singh and Tripathi, 1987; Trivedi, 1987; Trivedi, 1991a)	**EAST KHASI HILLS, MEGHALAYA** (After Trivedi, 1999; Trivedi, 2005)	**NORTH CACHAR HILLS, ASSAM** (After Trivedi, 1991b; Trivedi and Saxena 2000)
Dinoflagellate cysts (Algae)			
Deflandrea eocenica	+	-	-
Wetziella sp.	+	-	-
Cordosphaeridium exilimurum	+	+	+
Amphorosphaeridium multispinosum	+	-	-
Cleistophaeridium diversispinosum	+	-	-
C. *heteracanthum*	+	+	+
C. giganteum	+	-	-
Turbiosphaera filosa	+	-	-
T. proximata	+	-	-
Homotryblium plectilum	+	-	-
H. oceanicum	+	-	-
Glaphyrocysta exuberans	+	-	-
G. divaricata	+	-	-
Hystrichokolpoma rigaudiae	+	-	-
H. unispinosum	+	-	-
Hystrichostrogylon membraniphorum	+	-	-
Gonyaulacysta sp.	+	-	-
Polysphaeridium subtile	+	-	-
P. ornamentum	+	-	-
Operculodinium centrocarpum	+	-	-
O. major	+	-	-
Adantosphaeridium vittatum	+	-	-
Fungal remains:			
Phragmothyrites eocaenicus	+	+	+
Trichothyrites setifer	+	+	+
Kutchiathyrites eccentricus	+	-	-

Parmathyrites robustus	+	-	-
Diporicellaesporites sp.	-	-	+
Diporicellaesporites pluricellus	-	+	-
D. stayci	+	-	-
Pluricellaesporites sp.	+	-	-
Pluricellaesporites planus	-	+	+
Fusiformisporites foedus	-	+	-
Frasnacritetrus sp.	+	-	-
Lacrimasporonites sp.	+	-	-
Microthallites sp.	+	-	-
Paramicrothallites sp.	+	-	-
Diporisporites sp.	+	-	-
Dicellaesporites sp.	-	-	+
Dyadosporites sp.	+	-	+
Bryophytic spores:			
Operculosculptites globatus	+	-	+
Stereisporites grandis	+	-	-
Pteridophytic spores:			
Cyalhidites australis	+	+	+
C. *minor*	+	+	+
Intrapunctisporis intrapunctis	+	+	+
Dictyophyllidites sp.	+	-	+
Dictyophyllidites cymbatus	+	-	-
D. granulatus	+	+	+
Dandotiaspora dilata	+	-	-
D. plicata	+	+	+
D.telonata	+	-	-
Biretisporites potoniaei	+	-	-
Todisporites major	+	-	+
T. minor	+	-	+
T. flavatus	+	-	-
T. plicatus	+	-	-
T. kutchensis	+	-	-
Deltoidospora sp.	+	-	-
Lygodiumsporites pachyexinus	-	+	-
L. lakiensis	+	-	+
L. eocenicus	+	-	-

L. eocenicus	+	-	-
Osmundacidites wellmanii	+	-	-
O. minutus	+	-	-
O . kutchensis	+	+	+
O. cephalus	+	-	-
Osmundacidites sp. A	+	-	-
Osmundacidites sp. B	+	-	-
Corrugatisporites turpitus	+	-	-
Foveotriletes microreticulatus	+	-	-
Foveosporites sp.	-	-	+
Surmaspora sp.	+	-	-
Lycopodiacidites sp.	+	-	-
Verrutriletes sp.	+	-	+
Pteridacidites africanus	+	-	-
Lycopodiumsporites palaeocenicus	+	-	-
Verrucosisporites longiletus	+	-	-
Verrucosisporites sp. A	+	-	-
Verrucosisporites sp. B	+	-	-
Scantigranulites sparsus	+	-	-
Punctatisporites sarangwaraensis	+	-	+
Striatriletes sussanae	+	+	+
S. multicostatus	+	+	+
S.microverrucosus	+	-	-
S. attenuatus	+	-	-
S. paucicostatus	+	+	+
S. aidaensis	+	-	-
Malayaeaspora costata	+	+	+
Cicatricosisporites sp.	+	-	-
Verrucatosporites sp.	+	-	-
Polypodiisporonites repandus	+	-	-
P. ornatus	+	+	+
P. turbinatus	+	-	-
P.splendidus	+	+	+
P. impariter	+	-	-
P. mawkmaensis	+	-	+
Polypodiisporonites sp. A	+	-	-
Polypodiisporonites sp. B	+	-	-

Pilamonoletes excellensus	+	+	+
P. moderatus	+	-	-
Laevigatosporites levis	+	-	-
L. chatterjii	+	-	-
L. major	+	-	-
L. tertiarus	+	-	+
L. lakiensis	+	-	-
Monolites mawkmaensis	+	-	+
Gymnospermous pollen:			
Araucariacites australis	+	-	+
Podocarpidites khasiensis	+	-	-
P. clarus	+	-	-
P. classicus	+	-	-
P. cognatus	+	-	-
Pinuspolleniles crestus	+	-	+
Abiespollenites cognatus	+	-	-
Angiospermous pollen:			
Neocouperipollis kutchensis	+	-	+
Spinizonocolpites echinatus	+	+	+
Palmaepollenites nadhamunii	+	-	+
Palmidites plicatus	+	-	-
P. obtusus	+	-	-
Pinjoriapollis magnus	+	-	-
Proxapertites sp.	-	-	+
Proxapertites assamicus	+	-	-
P. microreticulatus	+	+	+
Tricolpites parvireticulatus	+	-	-
T. crassireticulatus	+	-	-
T. microreticulatus	+	+	-
Tricolporopollis rubra	+	-	-
Retitrescolpites assamicus	+	+	-
Verrutricolpites sp.	+	-	-
Sciadopityspollenites sp.	+	-	-
Acanthotricolpites brevispinosus	+	-	-
A. bulbospinosus	-	+	+
Ratariacolporites plicatus	+	-	-
Retitricolporites sp.	+	-	-

Retitricolporites sp. 1	-	-	+
Retitricolporites sp. 2	-	-	+
Polycolpites sp.	+	-	-
Lakiapollis assamicus	+	-	+
Margocolporites tsukadae	+	-	-
M. complexum	+	-	+
Densiverrupollenites eocenicus	+	-	+
Pellicieroipollis langenheimii	+	+	+
Rhoipites kutchensis	+	-	-
Retipilonapites cenozoicus	+	-	-
Psiloschizosporis psilata	+	-	-
Granulostephanocolpites cooksoniae	-	+	-
Echitricolpites communis	-	+	-
Palaeomalvaceaepollis paucispinosus	-	+	-
Polyadopollenites oligocenicus	-	+	-
Triporopollenites vimalii	-	-	+
Echistephanocolpites sp.	-	-	+
Dermatobrevicolporites dermatus	-	-	+
Reworked Gondwana palynofossils:			
Palaeozoic:			
Indotriradites sparsus	+	-	-
Calamospora aplata	+	-	-
Lacinitriletes badamensis	+	-	-
Scheurengipollenites tentulus	+	-	-
Callumispora sp.	+	-	-
Cannanoropollis medius	+	-	-
Corisaccites distinctus	+	-	-
Lundbladispora sp.	+	+	-
Cuneatisporites rarus	+	-	-
Strotersporites sp.	-	+	-
Parasaccites distinctus	+	-	-
Striatopodocarpidites sp.	+	-	-
Lahrites raniganjensis	+	-	-
Rhizomapora costa	+	-	-
Horriditriletes rampurensis	+	-	-
Platysaccus ovatus	+	-	-
P. katriensis	+	-	-

Mesozoic:			
Klukisporites variegatus	+	-	-
Densoisporites velatus	+	-	-
D. mesozoicus	+	-	-
Podosporites tripakshii	+	-	-
Callialasporites segmentatus	+	-	-
C. trilobatus	+	+	-
Vitreisporites densus	+	-	-
Klausipollenites sulcatus	+	+	+
Lunatisporites sp.	+	-	-
Contiginisporites sp.	+	-	-
Cingulatisporites sp.	+	-	-
Polycingulatisporites sp.	+	-	-

INDEX:

+	= Present
-	= Absent

Tab. 2. Summary of the known botanical affinities of palynotaxa and present day distribution of their families.

Botanical group / family	Palynotaxa	Present day distribution of the family	Remarks
DIVISION / THALLOPHYTA **Algae**			
Deflandreaceae	*Deflandrea eocenica' (Baltes) Lentin and Williams 1973, Wetziella* sp.		
Cordosphaeridiaceae	*Cordosphaeridium exilimurum* Davey and Williams 1966, *Amphorosphaeridium multispinosum* (Davey and Williams) Sarjeant 1981		
Cleistophaeridiaceae	*Cleistosphaeridium diversispinosum* Davey, Downie, Sarjeant and Williams 1966, *C.heteracanthum* (Deflandre and Cookson) Davey, Downie, Sarjeant and Williams 1969, *C. giganteum* (Caro) Davey, Downie, Sarjeant and Williams 1966, *Polysphaeridium subtile* Davey and Williams 1966, *P. ornamentum* Jain and Tandon 1981	Marine	
Gonyaulacaceae	*Hystrichostrogylon membraniphorum* Agelopoulos 1964		
Gonyaulacystaceae	*Gonyaulacysta* sp.		
Spiniferitaceae	*Turbiosphaera filosa* (Wilson) Archangelsky 1969, *T. proximata* Tripathi 1989		
Areoligeraceae	*Glaphyrocysta exuberans* (Deflandre and Cookson) Stover and Evitt 1978, *G. divaricata* (Williams and Downie) Stover and Evitt 1978	Marine	
Hystrichosphaeridiaceae	*Hystrichokolpoma rigaudiae* Deflandre and Cookson 1955, *H.unispinosum* Williams and Downie1966		

Homotrybliaceae	*Homotryblium plectilum* Drugg and Loeblich 1967, *H. oceanicum* Eaton 1976		
Lingulodiniaceae Adnatosphaeridiaceae	*Operculodinium centrocarpum* (Deflandre and Cookson) Wall 1967, *O. major* Jain and Dutta in Dutta and Jain, 1980 *Adantosphaeridium vittatum* Williams and Downie 1966	Marine	
Fungi Fungal spores and mycelia/Fungal bodies (Ascomycetes, Basidiomycetes and Deuteromycetes) / Microthyriaceae	*Phragmothyrites eocaenicus* (Edwards) Kar and Saxena 1976, *Parmathyrites robustus* Jain and Kar 1979, *Trichothyrites setifer* (Cookson) Saxena and Misra 1990, *Kutchiathyrites eccentricus* Kar 1979a, *Fusiformisporites foedus* Salujha, Kindra and Rehman 1974, *Di*	Warm, humid and tropical	
Bryophyta Sphagnaceae Calobryaceae	*Stereisporites grandis* Dutta and Sah 1970 *Operculosculptites globatus* Kar 1991	Temperate Temperate	
DIVISION/PTERIDOPHYTA Adiantaceae	*Pteridacidites africanus* Sah 1967	Cosmopolitan	Mostly in the damp and shady places.

Cyatheaceae	*Cyathidites australis* Couper 1953, *C. minor* Couper 1953	Tropical to subtropical	
Hymenophyllaceae	*Biretisporites potoniaei* Delcourt and Sprumont 1955	Tropical to subtropical	
Matoniaceae	*Dictyophyllidites cymbatus* Venkatachala and Goc'zan 1964, *D. granulatus* Saxena 1978, *Dandotiaspora telonata* Sah, Kar and Singh 1971, *D. plicata* (Sah and Kar), Sah, Kar and Singh 1971, *D. dilata* (Mathur) Sah, Kar and Singh 1971	Tropical to subtropical	
Osmundaceae	*Osmundacidites wellmani* Couper 1953, *O. minutus* Sah and Jain 1965, *O. cephalus* Saxena 1978, *O. kutchensis* Sah and Kar 1969, *Osmundacidites spp.* A., B., *Todisporites major* Couper 1958, *T. minor* Couper 1958, *T. flavatus* Sah and Kar 1969, *T. plicatus* Sah and Kar 1969, *T. kutchensis* Sah and Kar 1969	Cosmopolitan	Swamp and shady places
Parkeriaceae	*Striatriletes susannae* (v.d. Hammen) Kar 1979a, *S. multicostatus* Kar and Saxena 1981, *S. microverrucosus* Kar and Saxena 1981, *S. paucicostatus* Kar 1985, *S. aidaensis* Kar 1985, *S. attenuatus* Singh and Tripathi 1983	Warm and humid, tropical to subtropical	Aquatic
Polypodiaceae	*Polypodiisporonites ornatus* Sah 1967, *P. repandus* Takahashi 1974, *P. splendidus* Salujha, Kindra and Rehman 1972, *P. turbinatus* Sah 1967, *P. impariter* (Potonie' and Sah) Dutta and Sah 1970, *P. mawkmaensis* (Dutta and Sah) Mathur and Chopra 1982, *Polypodiisporonites* spp. A., B., *Monolites mawkmaensis* Sah and Dutta 1966, *Pilamonoletes excellensus* Kar 1991, *P. moderatus* Kar 1991, *Verrucatosporites* sp.	Cosmopolitan	

Schizaeaceae	*Lygodiumsporites lakiensis* Sah and Kar 1969, *L. eocenicus* Dutta and Sah 1970, *L. pachyexinus* Saxena 1978, *Malayaeaspora costata* Trivedi, Ambwani and Kar 1981, *Intrapunctisporis intrapunctis* Krutzsch 1959, *Punctatisporites sarangwaraensis Kar 1979a, Cicatricosisporites* sp.	Tropical to subtropical	
Lycopodiaceae	*Lycopodiumsporites palaeocenicus* Dutta and Sah 1970, *Lycopodiacidites* sp., *Foveotriletes microreticulatus* Couper 1958	Tropical to temperate	Favours moist, shady areas and tropical climate.
Incertae sedis	*Corrugatisportes turpitus* Dutta and Sah, 1970, *Scantigranulites sparsus* Kar 1978, *Verrucosisporites longiletus* Mathur and Mathur 1969, *Verrucosisporites* spp., *Surmaspora* sp., *Deltoidospora* sp., A.,B., *Verrutriletes* sp.		
DIVISION/ **SPERMATOPHYTA** SUB-DIVISION/ **GYMNOSPERMAE**			
Araucariaceae	*Araucariacites australis* Cookson 1947	In tropics	Mainly restricted to higher altitudes.
Pinaceae	*Pinuspollenites crestus* Kar 1985, *Abiespollenites cognatus* Kar 1985	Temperate	Members of the family mainly inhabit higher altitudes.
Podocarpaceae	*Podocarpidites khasiensis* Dutta and Sah 1970, *P. clarus* Sah 1967, *P. classicus* Salujha, Kindra and Rehman 1972, *P. cognatus* Kar 1979a	Tropical to temperate	

SUB DIVISION / **ANGIOSPERMAE** CLASS – **MONOCOTYLEDONAE**			
Arecaceae	*Acanthotricolpites bulbospinosus* Kar 1985, *A. brevispinosus* Saxena and Khare 2004, *Palmaepollenites nadhamunii* Venkatachala and Kar 1969a, *Palmidites plicatus* Singh in Sah and Singh 1974, *P. obtusus* Tripathi and Singh 1985, *Spinizonocolpites echinatus* Muller 1968, *Neocouperipollis kutchensis* (Venkatachala and Kar) Kar and Kumar 1987	Tropical to subtropical	
Araceae	*Proxapertites assamicus* (Sah and Dutta) Singh 1975, *P. microreticulatus* Jain, Kar and Sah 1973	Tropical to subtropical	
Potamogetonaceae	*Retipilonapites cenozoicus* Sah 1967	Tropical to subtropical	
CLASS- **DICOTYLEDONAE**			
Alangiaceae	*Verrutricolpites* sp.		
Anacardiaceae	*Rhoipites kutchensis* Venkatachala and Kar 1969a	Tropical to subtropical	
Aristolochiaceae	*Sciadopityspollenites* sp.	Tropical	
Bombaceae	*Lakiapollis assamicus* Tripathi and Singh 1985, *Tricolporopollis rubra* Dutta and Sah 1970, *T. matanomadhensis* (Venkatachala and Kar) Tripathi and Singh 1985, *Dermatobrevicolporites dermatus Kar 1985*	Tropical to subtropical	

Brassicaceae	*Tricolpites parvireticulatus* Sah 1967	Mostly temperate	
Caesalpiniaceae	*Tricolpites crassireticulatus* Dutta and Sah 1970, *Tricolpites microreticulatus* Belesky, Boltenhagen and Potonie' 1965, *Margocolporites tsukadae* Ramanujam 1966[a], *M. complexum* Ramanujam 1966a, *Retitrescolpites assamicus* Dutta and Sah 1970	Cosmopolitan	
Lentibulariaceae	*Granulostephanocolpites cooksoniae* (Sah and Dutta) Saxena 1982	Cosmopolitan	
Magnoliaceae	*Pinjoriarpollis magnus* Saxena and Singh 1981	Temperate	
Malvaceae	*Palaeomalvaceaepollis paucispinosus* Kar 1985	Tropical to subtropical	
Mimosaceae	*Polyadopollenites* sp.	Cosmopolitan	
Myricaceae	*Triporopollenites vimalii* Sah and Dutta 1966	Tropical	
Oleaceae	*Retitrescolpites* sp.	Subtropical	
Pelliceriaceae	*Pellicieroipollis langenheimii* Sah and Kar 1970	Tropical to subtropical	
Incertae sedis	*Densiverrupollenites eocenicus* Tripathi and Singh 1984a, *Echitricolpites communis* Da Silva Pares Regali, Uesugul and Da Silva Santos 1974, *Ratariacolporites plicatus* Kar 1985, *Psiloschizosporis psilata* Kar and Saxena 1978, *Retitricolporites* spp. 1, 2, *Ech*		

Dutta, 1974; Sah and Singh, 1974; Mehrotra and Sah, 1982) while there was a gradual decrease in the previously luxuriantly thriving Early Eocene – Middle Eocene pollen taxa during Late Eocene times. Angiosperms, especially dicots, were well represented in the Late Eocene but were not so prominent during Oligocene times (Rao, 1983).

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