Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-III. Pteridophytic spores

M. R. Rao & H. P. Singh

In all, 288 rock samples were collected from the Barail-Surma sediments of Sonapur-Badarpur Road Section, out of them 216 samples proved to be palynologically productive. The palynofossils recovered from these samples include dinoflagellate cysts, fungal remains, spore-pollen and micro remains of obscure origin. The present paper deals exclusively with the systematic description of 18 pteridophytic spore genera and 32 species, which constitutes only a part of the study. Six species belonging to different genera have been established as new. In addition, the diagnosis of Lygodiumsporites lakiensis has been emended. The systematic description of the dinoflagellate cysts...
THE PALAEOBOTANIST

(Saxena & Rao, 1984) and fungal remains (Singh et al., 1986) have already been published.

For the recovery of palynofossils, samples were treated with HCl, HF and HNO₃. The digestion period of samples varied from 7 to 10 days. The samples were then washed with distilled water and then treated with 5% KOH solution for about 5-10 minutes. The material was finally washed through 400 mesh sieve. The slides were prepared in polyvinyl alcohol and mounted in DPX Mountant. All slides and negatives were deposited in the repository of Birbal Sahni Institute of Palaeobotany, Lucknow.

The present palynological assemblage has been arranged following the classification proposed by Potonié and Kremp (1954, 1955, 1956) and subsequently modified by Potonié (1956, 1958, 1960, 1966, 1970) and Dettmann (1963).

**SYSTEMATIC DESCRIPTION**

**Genus—** *Cyathidites* Couper 1953

Type species—*Cyathidites australis* Couper 1953.

*Cyathidites australis* Couper 1953

*Pl. 1, fig. 1*

**Distribution**—*Cyathidites australis* Couper (1953) is widely distributed in the Upper Mesozoic and Tertiary strata of India.

**Occurrence**—Bhuban Formation, Surma Group.

**Affinity**—Cyatheaceae (Couper, 1953).

*Cyathidites minor* Couper 1953

*Pl. 1, fig. 2; Pl. 2, fig. 16*

**Remarks**—The miospores of *C. minor* reported from the Barail and Surma (Oligocene-Miocene) sediments of Sonapur-Badarpur Road Section, Meghalaya and Assam are slightly bigger in size (up to 52 μm) than those described by Couper (1953) from New Zealand.

**Distribution**—*C. minor* Couper (1953) is reported both from the Mesozoic and Tertiary sediments of India.

**Occurrence**—Laisong Formation, Barail Group; Lusha and Dona members, Bhuban Formation, Surma Group.

**Affinity**—Cyatheaceae (Couper, 1953, 1958).

**Genus—** *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié 1956

Type species—*Lygodiumsporites adriennis* (Potonié & Gelletich, 1938) Potonié, Thomson & Thiergart 1950.

*Lygodiumsporites lakiensis* Sah & Kar 1969 emend.

*Pl. 1, figs 3, 4*

**Emended diagnosis**—Miospores triangular to subtriangular in equatorial view, apices broadly rounded, interapical sides convex. Size range 50-56 μm. Trilete mark distinct, Y-rays reaching 2/3–4/5 of the spore radius, labra distinct, enclosing the suture, ray-apex and vertex raised, broader near the apex, gradually narrowing towards the ray-ends. Proximal face convex, distal face almost flat. Exine 1.5 μm thick, laevigate. *Exrema lineamenta* smooth.

**Remarks**—The restated diagnosis of *L. lakiensis* is based on the study of about 25 specimens which have been recovered from the present assemblage. The presence of thick labra in the illustration of the type specimen of *Lygodiumsporites lakiensis* is clearly discernible though it has not been mentioned by Sah and Kar (1969, pl. 1, figs 15-17).


**Occurrence**—Barail and Surma groups.

**Affinity**—Schizaeaceae.

*Lygodiumsporites eocenicus* Dutta & Sah 1970

*Pl. 1, figs 5, 10*

**Restated diagnosis**—Miospores subtriangular to triangular in equatorial view, apices broadly rounded, interapical sides usually convex. Size range 53–77 μm. Trilete mark distinct, Y-rays extending 2/3 of the spore radius, ray-apex conspicuously raised over a small area, ray-vertex almost flat and tapering towards the ray-ends. Exine 1.2 μm thick, laevigate often heavily folded. Proximal face of the exine almost flat, distal face deeply convex. *Exrema lineamenta* smooth.

**Remarks**—Most of the specimens of *Lygodiumsporites eocenicus* from the present assemblage possess very distinct trilete rays, extending usually 2/3 of the spore radius together with a flat proximal and deeply convex distal face in contrast to the observations of Dutta and Sah (1970). According to these authors the proximal face of *L. eocenicus* appears to be almost convex. This fact has not been confirmed by our observations on the specimens studied from the present assemblage as well as those illustrated by the original authors.

**Distribution**—Lower Eocene of South Shillong Plateau, Meghalaya (Dutta & Sah, 1970); Palaeocene–Eocene sediments of Tura Formation, Meghalaya (Singh, 1977); Palaeocene of Kachchh, Gujarat (Saxena, 1978).

**Occurrence**—Laisong and Jenam formations, Barail Group; Bhuban Formation, Surma Group.

**Affinity**—Schizaeaceae.

*Lygodiumsporites donaensis* sp. nov.

*Pl. 1, figs 7, 16*

**Holotype**—*Pl. 1, fig. 7, size 60 μm; BSIP slide no. 8408.*
Type locality—166.5 km-stone (from Shillong), Sonapour-Badarpur Road Section, Meghalaya.

Type Horizon—Dona Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis—Miospores triangular to subtriangular. Size range 65-85 μm. Trilete mark distinct, Y-rays reaching ± half of the radius accompanied by thickened exine all along the Y-mark. Ornamentation laevigate-scabrate.

Description—Miospores mostly subtriangular in equatorial view, interapical sides straight to convex. Trilete mark distinct, Y-rays straight, tapering, reaching ± half of the radius accompanied by thickened exine in the vicinity of the Y-mark, thickening usually diffused but almost of uniform width. Exine uniformly thick, 1.5 μm. Ornamentation laevigate to finely scabrate. Extrema lineamenta smooth.

Comparison—Lygodiumsporites donaensis sp. nov. resembles L. eocenicus Dutta & Sah (1976) by its shape and general characters but can be distinguished by the presence of thickened exine all along the trilete mark L. adriennis (Potonié & Gelletich) Potonié, Thomson & Thiergart (1950) possesses infrapunctate structure and hence it is not comparable. L. lakiensis Sah & Kar (1969) is distinguished by its smaller size (up to 60 μm). L. padapakkarensis Rao & Ramanujam (1978) can be distinguished by having infrapunctate exine. L. pachyexinus Saxena (1978) is different as it possesses thicker exine.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Affinity—Schizaceae.

Genus—Todisporites Couper 1958

Type species—Todisporites major Couper 1958

Todisporites major Couper 1958

Pl. 1, fig. 8

Remarks—The miospores assignable to Todisporites major Couper (1958) reported from this assemblage possess larger size (65-105 μm) than the forms of T. major (52-78 μm) described by Couper (1958).

Distribution—Todisporites major Couper, 1958 is a long ranging species which is distributed in the Mesozoic and Tertiary sediments of both the hemispheres.

Occurrence—Barail Group and Dona Member, Bhuban Formation, Surma Group.

Affinity—Osmundaceae.

Todisporites minor Couper 1958

Pl. 1, fig. 6

Distribution—It is widely distributed in the Mesozoic and Tertiary sediments of both the hemispheres.

Occurrence—Laisong Formation, Barail Group; Lubha and Dona members, Bhuban Formation, Surma Group.

Affinity—Osmundaceae.

Genus—Biretisporites (Delcourt & Sprumont) Delcourt, Dettmann & Hughes 1963

Type species—Biretisporites potoniaei Delcourt & Sprumont 1955.

Biretisporites oligocenicus sp. nov.

Pl. 1, figs 17, 15

Holotype—Pl. 1, fig. 15, size 88 μm; BSIP slide no. 8388.

Type locality—142 km-stone (from Shillong), Sonapour-Badarpur Road Section, Meghalaya.

Type Horizon—Laisong Formation, Lower Oligocene, Barail Group.

Diagnosis—Miospores subcircular to subtriangular. Size range 70-88 μm. Trilete mark distinct, Y-rays straight, tapering, reaching ± 2/3 of the radius surrounded by thick labra, broader at the centre of the Y-mark and narrower at the ray-ends, enclosed within the extension of the upturned exine. Exine 2.4 μm thick, scabrate. Few folds present.

Comparison—Biretisporites oligocenicus sp. nov. compares with B. meghalayaensis sp. nov. by its smaller size (65 μm) and uniform thickening along the Y-mark. However, the former can be distinguished in having thicker exine (4 μm thick) and broader labra at the centre which narrows down at the ray-ends and is usually straight. B. potoniaei Delcourt & Sprumont (1955) differs by having longer trilete rays, extending up to the periphery. B. convexus Sah & Kar (1969) is different in having smaller size (65 μm) and uniform thickening along the Y-mark. B. spectabilis Dettmann (1963) possesses conspicuous lips and extension of the trilete mark up to the equator, hence it is not comparable. B. bellus Sah & Kar (1970) and B. singularis Saluja, Kindra & Rehman (1974) are smaller in size. B. crassisexinus Venkatachala & Rawat (1973) possesses finely granulose ornamentation and hence it is not comparable.

Occurrence—Laisong Formation, Barail Group.

Affinity—Hymenophyllaceae.

Biretisporites meghalayaensis sp. nov.

Pl. 1, figs 9, 13

Holotype—Pl. 1, fig. 9, size 61 μm; BSIP slide no. 9030.

Type locality—169 km-stone (from Shillong), Sonapour-Badarpur Road Section, Meghalaya.
Type Horizon—Dona Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis—Miospores subtriangular. Size range 60-88.5 μm. Trilete mark distinct. Y-rays reaching 3/4 of the radius, enclosed within the extension of the upturned exine. Exine laevigate to finely scabrate.

Description—Miospores subtriangular in equatorial view, apices broadly rounded, interapical sides straight to convex. Trilete mark distinct, Y-rays reaching 3/4 of the radius, enclosed within the upturned extension of the exine, extension mostly spathulate in form with wavy margin. Exine 1 μm thick, sometimes finely scabrate otherwise laevigate.

Comparison—The present species closely compares with Biretisporites convexus Sah & Kar (1969) in shape and general characters but can be distinguished from the latter by having continuous extension of the upturned exine with wavy margin around the trilete. B. poioniaei Delcourt & Sprumont (1955) possesses a thicker exine (up to 5 μm thick) and trilete rays extending up to the periphery and hence, it is not comparable. B. spectabilis Dettmann (1963) is different by its conspicuous lips and the extension of trilete mark up to the equator. B. bellus Sah & Kar (1970) and B. singularis Saluja, Kindra & Rehman (1974) are smaller in size. B. crassisexinus Venkatachala & Rawat (1973) can be distinguished from the present species by its finely granulose ornamentation.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Affinity—?Hymenophyllaceae.

Genus—Surmaspora Singh & Rao 1984

Type species—Surmaspora sinuosa Singh & Rao 1984.

Surmaspora sinuosa Singh & Rao 1984

Pl. 2, fig. 6

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Affinity—Unknown.

Genus—Gleicheniidites (Ross) Skarby 1964

Type species—Gleicheniidites senonicus Ross 1949.

Gleicheniidites senonicus Ross 1949

Pl. 2, fig. 17


Genus—Dictyophyllidites Couper 1958

Type species—Dictyophyllidites harrisii Couper 1958

Remarks—The genus Dictyophyllidites, as diagnosed by Couper (1958), was emended by Dettmann (1963). She described even the ornate forms under the same genus. This has enlarged the original circumscription of the genus more than necessary a treatment to which we do not agree. In the present treatise Dictyophyllidites is understood sensu stricto Couper (1958).

Dictyophyllidites indicus sp. nov.

Pl. 1, figs 18-20

Holotype—Pl. 1, fig. 18, size 75 μm; BSIP slide no. 8392.

Type locality—146.25 km-stone (from Shillong), Sonapur-Badarpur Road Section, Meghalaya.

PLATE 1

(All photomicrographs are enlarged ca. ×500. Coordinates of the specimen refer to the stage of the Censico Microscope no. 13167).

1. Cyalhidites australis Couper, slide no. BSIP 8739, coordinates 67.2 × 106.5.
2. Cyalhidites minor Couper, slide no. BSIP 9024, coordinates 73.5 × 105.7.
3, 4. Lygodiumsporites lakiensis Sah & Kar emend. slide nos. BSIP 8390, coordinates 49.10 × 101.3; BSIP 9025, coordinates 70.5 × 106.9.
5 & 10. Lygodiumsporites ecenicus Dutta & Sah, slide nos. BSIP 8736, coordinates 99.2 × 105.7; BSIP 8393, coordinates 48.8 × 109.10.
6. Todusporites minor Couper, slide no. BSIP 9029, coordinates 70.3 × 102.5.
7 & 16. Lygodiumsporites donaensis sp. nov. slide nos. BSIP 8408, coordinates 62.0 × 103.3 (Holotype); BSIP 8408, coordinates 70.3 × 112.5.
8. Todisporites major Couper, slide no. BSIP 8389, coordinates 48.10 × 98.7.
9 & 13. Biretisporites meghalayensis sp. nov., slide nos. BSIP 9030, coordinates 52.2 × 114.5 (Holotype); BSIP 8414, coordinates 54.9 × 108.9.
11 & 15. Biretisporites oligocenicus sp. nov., slide nos. BSIP 9031, coordinates 52.0 × 105.6; BSIP 8388, coordinates 62.4 × 99.6 (Holotype).
12. Corrugatissporites sp., slide no. BSIP 9034, coordinates 54.0 × 110.3.
14. Garaotriletes sp., slide no. BSIP 9033, coordinates 54.0 × 110.3.
17. Polytrichaceasporites chaterjii Kar, slide no. BSIP 9041, coordinates 74.7 × 102.5.
18-20. Dictyophyllidites indicus sp. nov., slide nos. BSIP 8392, coordinates 69.2 × 108.6 (Holotype); BSIP 9032, coordinates 59.5 × 100.8; BSIP 9032, coordinates 65.2 × 115.2. Foveosporites sp., slide no. BSIP 9039, coordinates 43.5 × 95.10.
Type Horizon—Renji Formation, Upper Oligocene, Barail Group.

Diagnosis—Miospores subtriangular to subcircular, size range 75.95 μm. Trilete mark distinct, Y-rays reaching more than half of the radius, commissures raised, flanked by distinct thick arcuate margo. Exine laevigate.

Description—Miospores mostly subcircular to subtriarngular in equatorial view, apices bluntly rounded, interapical sides straight to convex. Trilete mark distinct, usually laesurae straight, accompanied by a distinct and thick, arcuate margo lying in close proximity to the Y-rays following an interradial pathway leaving a longer part of the exine as unthickened. Exine up to 1.5 μm thick, laevigate. Distal face of the exine distinctly convex, proximal face being plane to slightly convex. Extrema lineamenta smooth.

Comparison—Dictyophyllidites barrisi Couper (1958) is distinguished from the present species by its smaller size (up to 56 μm) and longer Y-rays, ± extending up to the equator. D. pectinataeformis (Bolkhovitina) Dettmann (1963) is different by its granulose exine and may perhaps have to be excluded from the limits of the genus Dictyophyllidites. D. crenatus (1963) is distinct from D. indicus sp. nov. in having sinuous laesurae and thicker exine (3.5 μm thick). D. cymbatus Venkatachala & Goczan (1964) possesses kryptomic folds hence it is not comparable. D. granulatus Saxena (1978) is different by having thicker exine (5 μm) and granulose ornamentation, thus it is not comparable.


Genus—Garotriletes Singh & Singh 1978

Type species—Garotriletes assamicus Singh & Singh 1978.

Garotriletes sp.

Pl. 1, fig. 14

Description—Miospore triangular in equatorial view, apices broadly rounded, interapical sides ± straight. Size ± 77 μm. Trilete mark distinct, reaching more than 3/4 of the radius, ray-ends bifurcated, labra around the trilete mark thick, ± globular at one of the ray-ends. Exine up to 3.5 μm thick, foveolate, foveolae compactly placed appearing foveo-reticulate in surface view.

Comparison—The present specimen is closely comparable to Garotriletes assamicus Singh & Singh (1978) in its shape and foveo-reticulate ornamentation of the exine. But the former is bigger in size (77 μm) and can also be distinguished by having distinct labra which is thick and almost encloses the Y-mark.


PLATE 2

(All photomicrographs are enlarged ca × 500. Coordinates of the specimen refer to the stage of the Censico Microscope no. 13167).

1 & 13. Striatrilites susannae van der Hammen emend. Kar, slide nos. BSIP 8385, coordinates 40.5 × 105.6; BSIP 8387, coordinates 54.4 × 104.2.

2-3. Striatrilites sinuatus sp. nov., slide nos. BSIP, 8397, coordinates 44.4 × 104.2; BSIP 8407, coordinates 66.10 × 95.10 (Holotype).

4-5. Malayaspora costata Trivedi et al., slide nos. BSIP 8228, coordinates 43.10 × 100.7; BSIP 8229, coordinates 60.9 × 104.6.

6. Surmaspora sinuosa Singh & Rao, slide no. BSIP 8825, coordinates 69.5 × 118.8.

7 & 10. Striatrilites pachyergus sp. nov. slide nos. BSIP 9040, coordinates 54.5 × 99.7; BSIP 8391, coordinates 56.0 × 101.5 (Holotype).

8 & 12. Pouosporites triangulus Sah & Dutta, slide no. BSIP 8132, coordinates 53.2 × 105.5; BSIP 9037, coordinates 52.5 × 100.5.

9. Pouosporites sp. B., slide no. BSIP 9036, coordinates 57.0 × 100.5.

11. Pouosporites sp. A., slide no. BSIP 9035, coordinates 60.5 × 115.3.

14. Cingulatrilites sp., slide no. BSIP 8112, coordinates 42.4 × 104.3.

15. Lycopodiumsporites abundans Salujha et al., slide no. BSIP 8103, coordinates 47.6 × 105.3.

16. Cyathidites minor Couper, slide no. BSIP 9023, coordinates 65.8 × 104.8.

17. Gleicheniidites senonicus Ross, slide no. BSIP 8383, coordinates 40.4 × 96.10.

18. Pouosporites miocenicus Ramanujam, slide no. BSIP 8746, coordinates 64.7 × 106.8.

19. Polypodiaceae sp. nov. Sah, slide no. BSIP 8122, coordinates 40.0 × 118.12.

20. Polypodiaceae sp. nov. Sah, slide no. BSIP 8404, coordinates 74.5 × 102.2.

21, 27. Polypodiaceae sp. nov. Sah & Dutta, slide no. BSIP 8388, coordinates 70.7 × 105.2; BSIP 8411, coordinates 49.5 × 98.8.

22. Polypodiaceae sp. nov. Sah & Dutta, slide no. BSIP 9045, coordinates 42.5 × 106.8.

23. Polypodiaceae sp. nov. Sah & Dutta, slide no. BSIP 9045, coordinates 42.5 × 106.8.

24. Monolites major (Cookson) Potonie, slide no. BSIP 8123, coordinates 40.3 × 98.8; BSIP 9042, coordinates 60.0 × 115.4.

25. Polypodiaceae sp. nov. Sah & Dutta, slide no. BSIP 9045, coordinates 49.2 × 111.3.
Genus—**Corrugatisporites** (Thomson, Pflug & Ibrahim) Weyland & Griefeld 1953

Type species—*Corrugatisporites solidus* (Potonié) Thomson & Pflug 1953.

Remarks—Thomson and Pflug (1953) described three species under the genus *Corrugatisporites*, viz., *C. solidus*, *C. multiwalleratus* and *C. paucivallatus*. They presumed that the genus was instituted by Ibrahim (1933). Later, Weyland and Griefeld (1953) assigned a new species to the same genus, viz., *Corrugatisporites toratus*. Then it was observed that Ibrahim did not publish any genus with the name *Corrugatisporites*. Therefore Potonié (1956) proposed *C. toratus* as the type species for the genus *Corrugatisporites* and restated its diagnosis. But Jansonius and Hills (1976) in “Genera file of fossil spores” cited *C. solidus* as the type species for the genus *Corrugatisporites* because this species was placed first in order of its publication as described by the original authors (Thomson & Pflug, 1953). In the present treatise, systematic treatment as given by Jansonius and Hills (1976) of *Corrugatisporites* has been followed.

*Corrugatisporites* sp.

Pl. 1, fig. 12

Description—Miospores subtrangular, apices broadly rounded, interapical sides ± convex. Size up to 72 μm. Trilete mark not distinct due to heavy ornamentation. Exine 1.5 μm thick, verrucose, verrucae laterally fused both on the proximal and distal sides forming variously shaped small, irregular channels. Outline undulate.

Comparison—*Corrugatisporites* sp. compares closely to *C. terminalis* Sah & Dutta (1968) by its verrucose exine but the latter can be distinguished in having distinct trilete mark and different exine ornamentation on the proximal and distal surfaces.

Occurrence—Laisong Formation, Barail Group; Bhuban Formation, Surma Group.

Affinity—Not known.

Genus—**Foveotriletes** van der Hammen ex Potonié 1956

Type species—*Foveotriletes scrobiculatus* (Ross) Potonié 1956.

*Foveotriletes* sp. A

Pl. 2, fig. 11

Description—Miospore triangular in equatorial view, apices broadly rounded, interapical sides ± convex. Size 92 μm. Trilete mark distinct, Y-rays reaching almost up to the equator, ends bifurcated. Exine 4 μm thick, foveolate, foveolae compactly placed, bigger at the apices and smaller towards the Y-mark. Surface view foveoreticulate.

Comparison—*Foveotriletes* sp. closely compares with *F. scrobiculatus* (Ross) Potonié (1956) in having foveolate exine but the former can be distinguished by its bigger size (92 μm). *F. miocenicus* Ramanujam (1966, 1967) possesses an ill-developed trilete mark and smaller size (48.5 μm) thus it is not comparable. *F. pachyexinus* Dutta & Sah (1970), *F. bifurcatus* Rao & Ramanujam (1978) are distinguished by their smaller size. *F. microreticulatus* Couper (1958) differs by its raised commissures.

Occurrence—Laisong Formation, Barail Group.

Affinity—Not known.

*Foveotriletes* sp. B

Pl. 2, fig. 9

Description—Miospore triangular in equatorial view, apices broadly rounded, interapical sides ± convex. Size ± 77 μm. Trilete mark distinct, Y-rays reaching 3/4 of the spore radius. Exine 1.5 μm thick, foveolate, foveolae small, compactly placed. Surface view finely foveo-reticulate.

Comparison—*Foveotriletes* sp. A can be distinguished from *Foveotriletes* sp. B in possessing differential foveolate ornamentation at the apices and near the Y-mark.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Affinity—Not known.

Genus—**Foveosporites** Balme 1957

Type species—*Foveosporites canalis* Balme 1957.

*Foveosporites* triangularis Dutta & Sah 1970

Pl. 2, figs 8, 12

Remarks—The specimens of *Foveosporites triangularis* Dutta & Sah (1970) reported from the Sonapur-Badarpur Road Section (Middle Bhuban Formation, Surma Group) in the present study are bigger in size (up to 75 μm) than those (35-48 μm) described by Dutta & Sah (1970) from the Cherra Formation, Meghalaya.

Distribution—Lower Eocene of South Shilong Plateau, Meghalaya (Dutta & Sah, 1970).

Occurrence—Umkiang and Dona members, Bhuban Formation, Surma Group.

Affinity—Lycopodium phegmaria (Lycopodiaceae).

*Foveosporites* miocenicus Ramanujam 1972

Pl. 2, fig. 18

Remarks—*Foveosporites miocenicus* Ramanujam (1972) is reported from the Upper Bhuban Formation, Surma Group. Its size ranges up to 62 μm.

Distribution—Miocene sediments around Warkalli Lignite, South India (Ramanujam, 1972).
**Occurrence**—Dona Member, Bhuban Formation, Surma Group. 

**Affinity**—Unknown.

*Foveosporites* sp.  
Pl. 1, fig. 21

**Description**—Miospore circular, size ± 99 μm. Trilete mark distinct, strongly built with bifurcated ends. Exine 2.5 μm thick, foveolate, foveolae small rounded, compactly placed. Surface view foveoreticulate.

**Comparison**—*F. canalis* Balme (1957) differs from the present species by its smaller size and also in possessing coalescent foveolae.

**Occurrence**—Laisong Formation, Barail Group. 

**Affinity**—Not known.

**Genus**—*Lycopodiumsporites* (Thiérgart) Delcourt & Sprumont 1955

**Type species**—*Lycopodiumsporites agothoecus* (Potonié) Delcourt & Sprumont 1955.

*Lycopodiumsporites abundans* Salujha, Kindra & Rehman 1972  
Pl. 2, fig. 15

**Remarks**—The present specimens of *Lycopodiumsporites abundans* are bigger in size (up to 60 μm) than those reported by Salujha et al. (1972) from the Palaeogene of Garo Hills (52 μm).

**Distribution**—Palaeogene of Garo Hills, Meghalaya (Salujha, Kindra & Rehman, 1972).

**Occurrence**—Dona Member, Bhuban Formation, Surma Group. 

**Affinity**—Lycopodiaceae.

**Genus**—*Striatriletes* van der Hammen 1956 emend. Kar 1979


*Striatriletes susannae* van der Hammen 1956 emend. Kar 1979  
Pl. 2, figs 1, 13

**Remarks**—In the diagnosis of *Striatriletes susannae* van der Hammen emend. Kar (1979) has mentioned that the exine of the miospores is ± laevigate. But in the present investigation some forms referable to *S. susannae* have imperceptibly punctate-microverrucose exine. Even such spores have also been included in the same species.

**Distribution**—Palaeogene of Garo and Khiasi-Jaintia Hills (Salujha et al., 1972, 1974); Oligocene of Kachchh (Kar, 1979).

**Occurrence**—Barail and Surma groups. 

**Affinity**—Ceratopteris thalictroides (L) Brongniart.

*Striatriletes sinuosus* sp. nov.  
Pl. 2, figs 2, 3

**Holotype**—Pl. 2, fig. 3, size 55 μm; BSIP slide no. 8407.

**Type locality**—150.1 km-stone (from Shillong), Sonapur-Badarpur Road Section, Meghalaya.

**Type Horizon**—Lubha Member, Bhuban Formation, Surma Group, Lower Miocene.

**Diagnosis**—Miospores triangular to subtriangular. Size 50-70 μm. Trilete mark distinct, sinuous, strongly built, Y-rays reaching 3/4 of the radius. Exine 1.2-5 μm, costate, costate, arising at ray-ends, 4-6 in each concentric ring, very closely placed, laevigate.

**Description**—Miospores triangular, apices more or less pointed, interapical sides straight to more or less convex. Trilete mark distinct, sinuous, strongly built, Y-rays tapering, reaching 3/4 of the radius. Length of the ray ranges from 18 to 25 μm. Exine 1.5 μm thick, costate, costae mostly 4 in number at each ray-end and 4 in each concentric ring on the distal side opposite to each inter-ray area, sometimes branching of costae on the distal face evident, resulting in increase in number, 6 costae in each concentric ring, 2.5-3.5 μm wide and 2-3 μm high, closely placed, flat to well-developed, parallelly arranged. Costae and intervening spaces between them laevigate.

**Comparison**—*Striatriletes sinuosus* sp. nov. is distinguished from all known species of *Striatriletes* (van der Hammen, 1956) Kar (1979) by its strongly built and tapering trilete mark. Also the Y-rays are longer reaching up to 3/4 of the spore radius together with a smaller size range (50-70 μm).

**Oligocene**—Lubha Member, Bhuban Formation, Surma Group. 

**Affinity**—Parkeriaceae.

*Striatriletes pachyexinus* sp. nov.

**Holotype**—Pl. 2, fig. 10, size 70 μm; BSIP slide no. 8391.

**Type locality**—145.4 km-stone (from Shillong), Sonapur-Badarpur Road Section, Meghalaya.

**Type Horizon**—Jenam Formation, Upper Oligocene, Barail Group.

**Diagnosis**—Miospores subtriangular. Size range 60-70 μm. Trilete mark distinct, Y-rays strongly built, reaching 3/4 of the spore radius. Exine 2.5-3.5 μm thick, costate, costae ill-developed, ± laevigate.

**Description**—Miospores subtriangular in equatorial view, apices broadly rounded, interapical sides ± convex. Trilete mark distinct, commissures strongly built, Y-rays reaching 3/4 of the spore radius. Exine 3.5 μm thick, costate, costae ill-developed, nature of the costae on the distal side not clearly discernible. Costae and intervening spaces between them ± laevigate, outline undulate.

**Comparison**—*Striatriletes susannae* (van der Hammen, 1956) Kar 1979 is distinguished from *S.
**Genus** *Malayaespora* Trivedi, Ambwani & Kar 1981

Type species—*Malayaespora costata* Trivedi, Ambwani & Kar 1981.

Malayaespora costata, Trivedi, Ambwani & Kar 1981

Distribution—Tertiary coal of Malaya (Trivedi et al., 1981).

**Occurrence**—Dona Member, Bhuban Formation, Surma Group.

**Affinity**—Schizaceae.

**Genus** *Cingutriletes* (Pierce) Dettman 1963

Type species—*Cingutriletes congruens* Pierce 1961.

Cingutriletes sp.

Pl. 2, fig. 14

Description—Miospores subtriangular, apices rounded, interapical sides ± convex. Size ± 55 μm. Trilete mark distinct, slightly raised. Y-rays extending up to the equator. Cingulate, cingulum up to 8.5 μm thick. Exine 1.5 μm thick, laevigate.

Comparison—Cingutriletes sp. closely compares with *C. congruens* Pierce (1961) which can be distinguished by its smaller size (26 μm) and proximally smooth and distally punctate exine.

**Occurrence**—Umkiang and Dona members, Bhuban Formation, Surma Group.

**Affinity**—Unknown.

**Genus** *Polypodiisporites* (Potonie) Potonié 1956

Type species—*Polypodiisporites javus* Potonié 1931 ex Potonié, 1956.

Polypodiisporites javus Potonié 1931 ex Potonié 1956

Pl. 2, figs 21, 27

Remarks—The exine seems to be thinner at the polar region as compared to the peripheral area, a character which is seen in the illustration of the type species as given by the original authors though not mentioned in the systematic description.

**Distribution**—Eocene (Buresi Valley (Burundi) by Sah (1967); Tertiary Succession of Assam (Sah & Dutta, 1968); Paleogene of Garo and Khasi-Jaintia Hills, Meghalaya (Salujha et al., 1972, 1974).

**Occurrence**—Laisong Formation, Barail Group; Bhuban Formation, Surma Group.

**Affinity**—Polypodiaceae.

Polypodiisporites speciosus Sah 1967

Pl. 2, fig. 20

Distribution—Oligocene of Kachchh, Gujarat (Kar, 1979).

**Occurrence**—Lubha and Dona members, Bhuban Formation, Surma Group.

**Affinity**—Polypodiaceae.

**Genus** *Monolites* (Cookson) Potonié 1956

Type species—*Monolites major* (Cookson) Potonié 1956.

Monolites major (Cookson) Potonié 1956

Pl. 2, figs 24, 25

Remarks—The specimens of *Monolites major* (Cookson) Potonié (1956) recorded from the present material have thicker exine (2.5 μm thick) as compared to those described by Cookson (1947).

**Distribution**—Lower Tertiary of Kerguelen (Cookson, 1947).

**Occurrence**—Umkiang and Dona members, Bhuban Formation, Surma Group.

**Affinity**—Polypodiaceae.

**Genus** *Polypodiaceaesporites* (Thiergart) ex. Potonié 1956

Type species—*Polypodiaceaesporites baardti* (Potonié & Venitez) Thiergart 1938.

Polypodiaceaesporites tertiarius Sah & Dutta 1968

Pl. 2, figs 21, 27

Distribution—Upper Neogene profile from Rusizi Valley (Burundi) by Sah (1967); Tertiary Succession of Assam (Sah & Dutta, 1968); Paleogene of Garo and Khasi-Jaintia Hills, Meghalaya (Salujha et al., 1972, 1974).

**Occurrence**—Laisong Formation, Barail Group; Bhuban Formation, Surma Group.

**Affinity**—Polypodiaceae.
**Polypodiisporites formosus** Salujha, Kindra & Rehman 1972

*Pl. 2, fig. 26*

**Distribution**—Palaeogene of Garo Hills, Meghalaya (Salujha et al., 1972).

**Occurrence**—Umkiang Member, Bhuban Formation, Surma Group.

**Affinity**—Polypodiaceae.

**Polypodiisporites tuberculensis** Baksi (1962) comb. nov.

*Pl. 2, fig. 22*


**Description**—Miospores oval, bean-shaped, extremities broadly rounded. Size range 45-60 μ. Monolete mark distinct, extending 2/3 along the longer axis. Exine up to 1.5 μ thick, verrucose, verrucae sparsely placed, 2-3 μ in diameter.

**Remarks**—Baksi (1962) published a new genus *Polypodiaceaesporites* from the Simsang River Tertiaries, South Shillong Front, Assam with a single species *P. tuberculensis*. *Polypodiaceaesporites Baksi* (1962) is a junior homonym of *Polypodiaceaesporites Thiergart ex Potonie* (1956). The characters of *Polypodiaceaesporites Baksi* (1962) do not conform with those of *Polypodiaceaesporites Thiergart ex Potonie* (1956). However, *Polypodiaceaesporites tuberculensis* Baksi (1962) falls within the generic circumscription of *Polypodiisporites* (Patonie) Potonie, 1956 and hence has been transferred to the latter as a new combination.

**Occurrence**—Jenam Formation, Barail Group.

**Affinity**—Polypodiaceae.

**DISCUSSION**

The pteridophytic spores described in this paper from the Barail and Surma groups (Oligocene-Lower Miocene) are represented by 18 genera and 32 species. Of these, *Biretisporites oligocenicus, B. meghalayaensis, Striatriletes pachyexinus, S. sinuosus, Dictyophyllidites indicus* and *Lygodiumsporites donaensis* have been established as new species. The distribution of different species is as follows:

<table>
<thead>
<tr>
<th>PALYNOTAXA</th>
<th>Barail Group</th>
<th>Surma Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laisong Form.</td>
<td>Jenam Form.</td>
</tr>
<tr>
<td><strong>Gleicheniidites senonicus</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Biretisporites oligocenicus</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Foveosporites sp.</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Foveotriletes sp.</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Garotriletes sp.</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Striatriletes pachyexinus</strong></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><strong>Polypodiisporites tuberculensis</strong></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><strong>Dictyophyllidites indicus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Striatriletes sinuosus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Polypodiisporites formosus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Foveotriletes sp. B</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Malayaeaspora costata</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Surnaspora simiosa</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Lygodiumsporites donaensis</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Biretisporites meghalayaensis</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Lycopodiumsporites abundans</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Foveosporites miocenicus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Monolites major</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Foveosporites triangulus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cingutriletes sp.</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Polypodiaceaesporites chatterji</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Polypodiisporites faus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cyatbidites australis</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Corrugatisporites sp.</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Todisporites major</strong></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Cyatbidites minor</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Todisporites minor</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Polypodiisporites speciosus</strong></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Lygodiumsporites eocenicus</strong></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>L. lakiensis</strong></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Striatriletes susannae</strong></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Polypodiaceaesporites tertiarus</strong></td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
The diagnosis of *Lygodiumsporites lakiensis* has been emended. *Lygodiumsporites lakiensis* Sah & Kar, 1969, from the present assemblage possesses very distinct trilete mark, reaching 2/3-4/5 of the spore radius, labra distinct, enclosing the suture, ray-apex and vertex raised, broader near the apex, gradually narrowing towards the ray-ends. The presence of thick labra in the illustration of the type specimen is clearly discernible though it has not been mentioned by Sah and Kar (1969). *Lygodiumsporites eocenicus* (Dutta & Sah, 1970) as studied possess trilete mark distinct, rays extending 2/3 of the spore radius, ray-apex conspicuously raised over a small area, ray-vertex almost flat and tapering towards the ray-ends. Proximal face of the exine almost flat, distal face deeply convex. Besides, the genus *Dictyophyllidites* as diagnosed by Couper (1958) was emended by Dettmann (1963). She described even the ornate forms under the genus. This has enlarged the original circumscription of the genus more than necessary. The miospores of *Striatriletes susannaes* described by van der Hammen emend. Kar (1979) possess laevigate exine, but in the present study, some forms belonging to this species have imperceptibly punctate-microverrucose exine. So such spores have also been included in the same species. In *Polypodiaceaesporites tertiarus* Sah & Dutta (1968), the exine seems to be thinner at the polar region as compared to the peripheral area, a character which is seen in the illustration of the type species as given by the original authors though not mentioned in the systematic description.

On the basis of the possible affinities of the dispersed pteridophytic spores studied the presence of the following families is inferred. Taxa of uncertain botanical affinity are also listed below:

**Taxon**

- Cyathidites australis
- C. minor
- *Lygodiumsporites lakiensis*
- *L. eocenicus*
- *L. donaensis*
- Todisporites major
- T. minor
- Biretisporites megalayaensis
- *B. oligocenicus*
- Surmaspora sinuosa
- Gleichenidites senonicus
- Dictyophyllidites indicus
- Garotriletes sp.
- Corrugatisporites sp.
- Foveotriletes sp. A
- Foveotriletes sp. B
- Foveospores triangulus

**Family**

- Cyatheaceae
- Schizaceae
- Osmundaceae
- *?Hymenophyllaceae*
- Unknown
- Gleicheniaceae
- *?Matoniaceae*
- Unknown
- Unknown
- Unknown
- Lycopodiaceae
- F. miocene
- Foveosporites sp.
- Lycopodiunsporites abundans
- Striatriletes susannaes
- S. pachyexinus
- S. sinuosus
- Malayaeaspors costata
- Cingutriletes sp.
- Polypodiaceaesporites tertiarus
- P. chatterji
- Monolites major
- Polypodiisporites javus
- P. speciosus
- P. formosus
- P. tuberculensis

These families possibly indicate tropical-subtropical humid climate during the sedimentation of the present sequence.

An analysis of the assemblage reveals that the pteridophytic spores dominate the Surma Group as compared to the Barail Group. The presence of *Biretisporites oligocenicus*, *Dictyophyllidites indicus*, *Striatriletes pachyexinus*, *Gleichenidites senonicus*, *Foveosporites sp. A*, *Foveotriletes sp. A*, *Garotriletes sp.* and *Polypodiisporites tuberculensis* is restricted to the Barail Group, whereas *Striatriletes sinuosus*, *Malayaeaspors costata*, *Surmaspora sinuosa*, *Lygodiumsporites donaensis*, *Biretisporites megalayaensis*, *Cyathidites australis*, *Foveosporites triangulus*, *F. miocene*, *Lycopodiunsporites abundans*, *Monolites major*, *Foveotriletes sp. B*, *Cingutriletes sp.*, *Polypodiaceaesporites chatterji* and *Polypodiisporites javus* are restricted to the Surma Group. The forms in common between the Barail and Surma groups are *Todisporites major*, *T. minor*, *Lygodiumsporites lakiensis*, *L. eocenicus*, *Striatriletes susannaes*, *Cyathidites minor*, *Corrugatisporites sp.*, *Polypodiaceaesporites tertiarus* and *Polypodiisporites speciosus*.

**ACKNOWLEDGEMENT**

The authors are thankful to Dr R. K. Saxena for collecting the rock samples in the field.

**REFERENCES**


