PALYNOTAXONOMY AND PHYLOGENY OF INDIAN SYMPLOCACEAE AND SAPOTACEAE

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ABSTRACT

The present paper embodies the results of pollen morphological investigations of the allied families Symplocaceae and Sapotaceae. The major apertural types in Symplocaceae are 3- porate, 3-4- porate, 3-colporate and 3-4- colporate. The characteristic feature of the colporate aperture is the relative size of colpi and ora. The colpi are small, thin, streaky and generally smooth whereas ora are prominent, circular to elliptical with thickened margins. The family Sapotaceae is characterized by 3-5-colporate apertures. Parasyncolpate and 3-porate apertures are also met with although very rarely. A pollen key, depicting all the characteristic features, has also been given. Interspecific discrimination could be possible in most of the cases. The phylogenetic and taxonomic interrelationship has been discussed in the light of pollen morphology. The pollen evolutionary levels have also been discussed in these families and their systematic status has been ascertained.

INTRODUCTION

Opinions have been diversified as regards the systematic position of families Symplocaceae and Sapotaceae since 1912 when ENGLER grouped both the families under Ebenales together with Styracaceae and Ebenaceae. On the basis of gross morphological characters, he has considered that Symplocaceae be treated as a separate taxon. However, HUTCHINSON (1967) regarded both the families differently and, therefore, he retained Sapotaceae under Ebenales together with Ebenaceae and Sarcospermataceae, whereas Symplocaceae was placed under the order Styracales along with Lissocarpaceae and Styracaceae because of the sympetalous nature of the flowers in common. HUTCHINSON (1967) further suggested that Symplocaceae merits the rank of an independent and monotypic family with the type genus *Symplocos* Jacq. He suggested this segregation on the basis of anther characters which are didynamous, short ovoid or subglobose, indumentum when present not stellate, stamens mostly numerous. WETTSTEIN (1935) has opined that Symplocaceae and Sapotaceae be rightly grouped together with Ebenaceae and Styracaceae under the order Diospyrales. This is chiefly based on the common character of tetra-pentamerous orientation of the flowers. While making chemotaxonomical analysis of these families, WETTSTEIN has warned further that the family Sapotaceae be dealt separately.

The palynological information of Symplocaceae and Sapotaceae is indeed very meagre. ERDTMAN (1952) has reviewed the palynological literature and suggested that Sapotaceae is a stenopalynous family whereas monogeneric family Symplocaceae is more or less eurypalynous and if considered appropriately, the pollen morphology may be instrumental in subdividing the genus *Symplocos*. MEIJDEN (1970) has made a pollen morphological survey of the genus *Symplocos* and attempted to utilize the results of his taxonomic work. GUERS *et al.* (1971) have described the pollen morphology of some African species of Sapotaceae. SOWUNMI (1973) while describing pollen grains of Nigerian plants has reported the occurrence of 4-colporate and minutely reticuloid pollen in four genera.

The monogeneric family Symplocaceae is represented by more than 300 species throughout tropics and subtropics, except for Africa. In India the genus *Symplocos* has more or less sixty-four species which are invariably woody plants. HOOKER (1882) has mentioned that the distribution of *Symplocos* in India ranges from plains to 5,000—7,500 ft in Nilgiris and 2,000—8,000 ft in Kashmir Himalaya and 3,000—5,000 ft in Khasi Hills. The Sapotaceae has a total strength of three hundred and twenty species mostly distributed in the tropics all over the world. In India, Sapotaceae is represented by over sixty species and twelve genera. These species are mostly tropical but some extend into subtropical zone upto an elevation of 4,000 ft.

Up till now, not many fossil-dispersed of Symplocaceae and Sapotaceae have come to light from Indian sediments but it is hoped that the detailed description, illustrations and pollen-key presented here will definitely be of a great help in confirming the fossil records for these two families. From the phytogeographical account it is apparent that the representatives of these families play a vital role in constituting the forest, and also they cover a wider range in distribution, i.e. from tropical to subtropical and temperate zones. It has been further observed that while reconstructing the palaeoflora of the Quaternary Period, none of the members of the Symplocaceae and Sapotaceae is represented not merely due to the reasons that they are mostly insect pollinated but also due to the paucity of recognizable features. The detailed pollen morphological features have enabled us to recognize subfossil pollen to their respective taxa and thus the occurrence of their members as forest constituents can now be well attested.

MATERIAL AND METHOD

The polliniferous material for present studies was chiefly procured from the sheets of Blatter Herbarium, St. Xavier's College, Bombay (BLAT) and the Herbarium, Forest Research Institute, Dehra Dun (DD). The method of acetolysis and terminology used here is in accordance with that of ERDTMAN (1943, 1952). The abbreviations used here for the above herbaria have been taken from the Index Herbariorum (1974).

The pollen morphological observations were carried out under light microscopy (Olympus microscope with a magnification of 100×15). The size measurements are based on random selection of 25—50 pollen grains per species.

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GENERAL DIAGNOSIS

The Symplocaceae is largely characterized by subtriangular, triangular and/or rectangular shapes of the pollen grains. The position of the apertures is generally angular and two major apertural types have been distinguished under this family. The majority of its members produce 3 (-4)-porate pollen grains. The pores are usually characterized by non-annulate condition but in a few cases, rims enveloping the pores have also been observed. The other important apertural type is 3-(-4)-colporate. The important feature of this aperture is that the colpi are much smaller and insignificant in contrast to ora which are mostly circular or lalongate. The occurrence of rectangular ora is quite uncommon. The sexine is largely comprised of psilate, obscure and granulate pattern

whereas reticulate pattern is uncommon. Sexine and nexine are generally equithick, or sometimes sexine is slightly thicker than nexine.

The commonest type of pollen grains produced by Sapotaceae are 3-5-colporate with ora lalongate. The other uncommon types of pollen grains are 3-parasyncolpate and 3-4-porate. In case of colporate pollen grains, the colpi are quite long and prominent in contrast to ora. The colpi membranes are generally psilate margined. The sexine pattern observed, so far, are psilate, obscure, granulate, and microreticulate. The sexine is usually equithick or slightly thicker than nexine.

KEY TO THE POLLEN TYPES

SYMPLOCACEAE

I. 3-Porate

A.	Amb triangular	
B.	Pore circular	
C.	Annulate	
D.	Obscure	
E.	Papillate	*S. obtusa*
EE.	Spinate	*S. theaefolia*
DD.	Granulate	(i) *S. rosea*
		(ii) *S. crataegoides*
EEE.	Spinulate	*S. laurina*
AA.	Amb subtriangular	
B.	Pore circular	
CC.	Non-annulate	
D.	Obscure	*S. lancifolia*
AAA.	Amb circular	
BB.	Pore circular to elliptical	
CC.	Non-annulate	
D.	Obscure	*S. lucida*

II. 3-4-Porate

AAAA.	Amb triangular-rectangular	
B.	Pore circular	
C.	Annulate	
D.	Obscure	*S. beddomei*
DD.	Granulate	(i) *S. spectabilis*
		.. (ii) *S. latiflora*

III. 3-Colporate

b.	Brevicolpate	
c.	OS lalongate	
DD.	Granulate	(i) *S. paniculata*
		ii) *S. pendula*
		(iii) *S. sumuntia*
cc.	OS rectangular	
DD.	Granulate	*S. foliosa*
ccc.	OS circular	
DD.	Granulate	*S. dryophila*

IV. 3-4-Colporate

A.	Amb triangular	
b.	Brevicolpate	
c.	OS lalongate	
DD.	Granulate	(i) *S. leiostachya*
		(ii) *S. grandiflora*
D.	Obscure	*S. pyrifolia*
ccc.	OS circular	
DDD.	Microreticulate	*S. caudata*
AA.	Amb subtriangular	
b.	Brevicolpate	
c.	OS lalongate	
DD.	Granulate	*S. gardneriana*

SAPOTACEAE

I. 3-Colpate

A. Prolate
B. Parasyncolpate
C. Scorbiculate
D. Papillate .. .. *Chrysophyllum lanceolatum*

II. 3-Colporate

A. Prolate
BB. Colpi long and broad with acute apices
b. OS lalongate
CC. Microgranulate .. .. *Chrysophyllum cainito*

III. 3(-4-5)-Colporate

A. Prolate
BBB. Colpi long and thin with acute apices
b. OS lalongate
CCC. Psilate .. .. *Chrysophyllum* sp.
AA. Subprolate
BBB. Colpi long and thin with acute apices
b. OS lalongate
CCCC. Obscure .. .. *Madhuca longifolia*

IV. 4-(3)- Colporate

AA. Subprolate
BBB. Colpi long and thin with acute apices
b. OS lalongate
CCCC. Obscure .. .. *Mimusops elengi*

V. 3(-4)-5-Colporate

AA. Subprolate
BBB. Colpi long and thin with acute apices
b. OS lalongate
CCC, Psilate .. .. *Bassia latifolia*
CCCC. Obscure .. .. *Pouteria tomentosa*
bb. OS circular
CCCC. Obscure .. .. *Manilkara hexandra*

VI. (3-4)-5-Colporate

AA. Subprolate
BBB. Colpi long and thin with acute apices
b. OS lalongate
CCCC. Obscure .. .. *Madhuca indica*

VII. (3)-4-(5)-Colporate

AAA. Prolate-Spheroidal
BBB. Colpi long and thin with acute apices
b. OS lalongate
CCCC. Obscure .. .. *Achras sapota*

VIII. 3(-4)-Porate

AAAA. Spheroidal
BBBB. Pore circular and rimmed
CCCCC. Microreticulate .. .. *Palaquium ellipticum*

Description of Pollen Grains

SYMPLOCACEAE

A. *3-Porate*

1. **Symplocos obtusa** Wall. (Pl. 1, Figs. 12-15)
(Subramanian, K. N., Sheet no. 510/144181, DD)

Oblate (25 × 33.5 μm), range 24 –26 × 30—35 μm, aspidate. Amb triangular. Pore circular, about 2.5 μm in diameter with thickened margins. Pore membrane psilate.

Exine thickness about 3 μm (excluding papillae). Sexine thinner than nexine. Nexine much thicker towards the pores. Exine surface papillate, papillae about 1 μm in length with swollen heads. Papillae more prominent towards pore. Pattern ±obscure.

2. **Symplocos theaefolia** D. Don (Pl. 2, Fig. 18)

(McGale & Chitkoko, Sheet no. 5398/128940, DD)

Sub-oblate 40×50 μm (excluding spines), aspidate. Amb triangular. Pore circular about 5 μm in diameter, annulate (about 2 μm). Pore membrane psilate. Exine about 2 μm thick. Sexine as thick as nexine. Spines about 5 μm in length and 1 μm in width with acute apices, sparsely placed. Pattern ±obscure.

3. **Symplocos rosea** Bedd. (Pl. 3, Fig. 40)

(Bourdellon, Sheet no. 7064, DD)

Oblate (37.5×52.5 μm), aspidate. Amb triangular. Pore circular about 5 μm in diameter. Annular thickening about 4 μm. Pore membrane psilate. Exine thickness about 3 μm. Sexine and nexine equithick. Pattern granulate.

4. **Symplocos crataegoides** Buch.-Ham. ex D. Don (Pl. 3, Figs. 31-32)

(Parkinson, G. E., Sheet no. 64384, DD)

Sub-oblate (31.9×41.6 μm), range 31.2—33.8×39.0—44.2 μm, aspidate. Amb triangular. Pore circular with annular thickening. Pore diameter about 6 μm. Meso-aspidar diameter (mesoporium) about 29 μm. Exine about 1.5 μm thick, sexine as thick as nexine. Pattern granulate, grana (in LO analysis) amalgamating in such a manner that ±microreticulate pattern is formed.

5. **Symplocos laurina** (Retz.) Wall. ex G. Don (Pl. 3, Figs. 35-36)

Syn. *S. spicata* Roxb.

(Lambert, Sheet no. 22232, DD)

Sub-oblate (33×40 μm). Amb triangular. Pore circular, about 5 μm in diameter, mesoporium about 15 μm. Exine about 2 μm thick. Sexine slightly thicker than nexine. Spinules present, about 1.5 μm in length. Pattern granulate.

6. **Symplocos lancifolia** Sieb. & Zucc. (Pl. 3, Fig. 37)

(Kanjilal, U. N., Sheet no. 1870/102778, DD)

Sub-oblate (35×40 μm). Amb subtriangular. Pore circular about 4 μm in diameter. Pore membrane psilate. Exine thickness about 4 μm. Sexine thinner than nexine. Pattern obscure.

7. **Symplocos lucida** Wall. (Pl. 1, Fig. 4)

(Samaston, Sheet no. 21967, DD)

Spheroidal, about 25 μm in diameter (excluding spinules). Pore circular to elliptical in shape ; size of elliptical pore about 4×2.5 μm and 3 μm in circular pore. Pore membrane psilate. Exine about 2 μm in thickness. Sexine thicker than nexine. Spinulate, spinules about 1.5—2.5 μm in length with acute apices. Pattern obscure.

B. 3-4-*Porate*

8. **Symplocos spectabilis** Brand. (Pl. 1, Figs. 8-11)

(Maung Pokhaut, Sheet no. 75738, DD)

Sub-oblate (37 × 45 μm), range 35—40 × 45—50 μm, chiefly 3-porate and rarely 4-porate, aspidate. Amb triangular in 3-porate pollen grains. Pore circular to rectangular, about 5 μm in diameter and 5 × 4 μm. L/B respectively with irregular annular thickenings (about 6 μm thick). Exine about 2.5 μm thick. Sexine as thick as nexine or slightly thicker than nexine. Pattern obscure.

9. **Symplocos beddomei** Clarke (Pl. 3, Figs. 33-34)

(CLARKE, Sheet no. 4051/152, DD)

Sub-oblate (26.0×33.2 μm), range 20.8—38.6×28.6—39.0 μm, 3-4 porate (4-porate rarely), aspidate. Amb triangular in 3-porate pollen. Pore circular (5 μm diam.) with annulus (3.5 μm thick). Exine 2.5 μm thick. Sexine thinner than nexine. Pattern granulate. Tegillum uneven.

10. **Symplocos latiflora** Clarke (Pl. 2, Figs.19-21)

(CLARKE, Sheet no. 35804, DD)

Pollen grains 3-4-porate, 3-porate pollen grain sub-oblate, 24×34 μm, aspidate. Amb ± triangular. 4-porate pollen are seen only in polar view which are either square or rectangular in shape and aspidate. Pore ± circular (4×3.5 μm), pore membrane granulate, annular thickening about 5-6 μm. Exine thickness about 2.5 μm. Sexine thinner than nexine. Papillate, papillae about 1 μm in length with swollen heads. Pattern granulate.

C. 3-*Colporate*

11. **Symplocos dryophila** Clarke (Pl. 3, Figs. 41-42)

(CLARKE, Sheet no. 705, BLAT)

Brevicolpate, anguloaperturate, oblate (30.6×41.3 μm), range 28.6—31.2×39.0—41.6 μm, aspidate. Amb triangular. Colpi thin, small with acute apices, colpi membrane psilate. Mesoaspidar diameter 30 μm. Ora circular about 6 μm in diameter, annular thickening present (4 μm thick). Exine thickness about 2 μm. Sexine as thick as nexine. Sexine margin uneven or wavy. Pattern granulate.

12. **Symplocos paniculata** Wall. ex D. Don

(AWASTHI, D. D., Sheet no. 577/111295, DD)

Brevicolpate, sub-oblate (30×35 μm). Amb triangular. Ora lalongate. Exine thickness about 2 μm. Sexine and nexine not very distinct. Pattern granulate.

13. **Symplocos pendula** Wight. (Pl. 1, Figs. 5-7)

(SILVA, J. M., Sheet no. 47733,DD)

Brevicolpate, oblate 23×31 μm excluding papillae, range 22—24×30—32 μm. Colpi very thin, small about 6 μm in length, colpi membrane psilate. Ora lalongate about 1.5×5 μm (rarely circular, about 7 μm in diameter) with psilate membrane. Annular thickening about 2.5 μm. Exine about 2.5 μm thick. Sexine thinner than nexine. Pattern granulate.

14. **Symplocos sumuntia** Buch.-Ham. ex D. Don (Pl. 2, Figs. 27-30)

(Sheet no. 46468, DD)

Brevicolpate, oblate 36×52 μm, range 34—36×50—52 μm, aspidate. Amb triangular. Colpi about 20 μm in length and 4 μm in width. Colpi membrane psilate. Ora transversely elongated (lalongate) about 5×15 μm with thickened margins, ora membrane ornamented. Exine about 2 μm thick. Sexine as thick as nexine. In some pollen grains sexine slightly wavy. Pattern granulate.

15. **Symplocos foliosa** Wight. (Pl. 3, Figs. 38-39)

(BOR, N. L., Sheet no. 83023, DD)

Brevicolpate, oblate 45×65 μm, aspidate. Amb triangular. Colpi very thin about 20 μm in length and 1.5 μm in width, membrane psilate. Ora rectangular 8×10 μm with thickened margins. Ora membrane psilate. Exine about 4 μm thick. Sexine thicker than nexine. Pattern granulate.

D. 3-4-*Colporate*

16. **Symplocos leiostachya** Kurz (Pl. 2, Figs. 22-25)
(Sukoe, Sheet no. 55384, DD)

3-colporate, rarely 4-colporate, brevicolpate. Sub-oblate (22×26 μm), range 21—23×24—28 μm, aspidate. Amb ± triangular. Colpi small about 10 μm in length and 4 μm in width with acute apices. Colpi membrane psilate. Ora transversely elongated (lalongate) 2×5 μm in length and breadth respectively. Ora membrane psilate but annulate. Exine about 2 μm thick. Sexine thicker than nexine. Sexine about 1.5 μm thick. Pattern granulate.

17. **Symplocos grandiflora** Wall. (Pl. 1, Figs. 1-3)
(Griffith, Sheet no. 3658/186364, DD)

3-Colporate, rarely 4-colporate, brevicolpate. Oblate (22.5×35 μm), range 20—25×32.5—37.5 μm. Colpi thin, small about 8 μm long and 5 μm wide. Colpi membrane psilate. Ora lalongate (2.5×4 μm), membrane psilate. Exine thickness 2 μm. Sexine as thick as nexine or slightly thinner than nexine. Pattern granulate.

18. **Symplocos pyrifolia** Wall. (Pl. 2, Fig. 26)
(R. D. N. C., Sheet no. 17988/102741, DD)

3-Colporate, rarely 4-colporate, brevicolpate. Sub-oblate (20×25 μm), range 17.5—22.5×22.5—27.5 μm, aspidate. Amb trianuglar. Colpi very thin, about 10 μm long, membrane psilate. Ora lalongate with thickened margins, membrane psilate (No perfect equatorial view could be seen). Exine about 2 μm thick. Sexine as thick as nexine. Sexine margins wavy. Pattern ± obscure.

19. **Symplocos caudata** Wall.
(Deb, G. K., Sheet no. 17539/10244, DD)

3-colporate, rarely 4-colporate, brevicolpate. Oblate, (22.5×32.5 μm), range 20—25×30—35 μm, aspidate. Amb triangular. Colpi small, ends pointed and membrane psilate. Ora ± circular with thickened margins. Ora membrane psilate. Exine thickness about 2 μm. Sexine as thick as nexine. Pattern finely reticulate. Tectate.

20. **Symplocos gardneriana** Wight. (Pl. 2, Figs. 16-17)
(Gamble, J. S., Sheet no. 20443, DD)

3-colporate, rarely 4-colporate, brevicolpate. Oblate (27×37 μm), range 24—32×32—40 μm, aspidate. Amb triangular. Colpi very thin, small about 10×2 μm in length and width, membrane psilate. Ora transversely elongated about 3×6 μm with thickened margins (about 5 μm thick). Ora membrane psilate. Exine about 3 μm thick, sexine thicker than nexine. Pattern granulate.

SAPOTACEAE

A. 3-*Colpate*

1. **Chrysophyllum lanceolatum** (Bl.) DC. Prodr. (Pl. 4, Figs. 43-44)
Syn. *Chrysophyllum roxburghii* G. Don
(Acklend, R. D., Sheet no. 662, BLAT)

Parasyncolpate, prolate (48×32 μm), colpi membrane ornamented. Exine about 2 μm thick. Sexine as thick as nexine. Sexine pattern finely granulate, grana densely placed. Punctate, puncta sparsely placed. OL scorbiculate. Tegillate. Papillate.

B. 3-*Colporate*

2. **Chrysophyllum cainito** Linn. (Pl. 4, Fig. 45)
(SHAH, G. L., Sheet no. 9163, BLAT)
Prolate (28×11 μm), range 26--30×9.5—12.5 μm. Colpi long (12 μm) and thin about 1.5 μm wide with broad centre and tapering apices. Colpi membrane prominent and thickened. Apocolpium diameter about 3 μm and mesocolpium diameter about 2.5 μm. Ora lalongate (1×2 μm) membrane conspicuous with thickened margins. Exine about 1.5 μm thick. Sexine thicker than nexine. Sexine pattern microgranulate. Tectate.

C. 3 (-4-5)-*Colporate*

3. **Chrysophyllum** sp.
(FERNADEZ, R. R., Sheet no. 4269, BLAT)
3-colporate, rarely 4-5-colporate, prolate (33.7×22.1 μm), range 29.7--38.6×18.9—24.3 μm. Colpi thin with acute apices. Colpi quite broad in the centre and suddenly tapers afterwards. Colpi membrane psilate. Ora lalongate (2×4 μm), membrane psilate. Exine about 2 μm thick. Sexine thinner than nexine. Sexine pattern psilate.

D. 3-(4)-*Colporate*

4. **Madhuca longifolia** (Linn.) Macbride
Syn. *Bassia longifolia* Linn.
(Sheet no. 4117/154, BLAT)
Pollen grains, 3-colporate, rarely 4-colporate, subprolate (32.2×25.7 μm), range 31.2—33.8×23.4—26.0 μm. Colpi long, thin with acute apices. Colpi membrane psilate. Ora lalongate (3×4 μm), membrane psilate. Exine about 2 μm thick. Sexine as thick as nexine. Sexine pattern±obscure.

E. 4-5(-3)-*Colporate*

5. **Mimusops elengi** Linn. (Pl. 4, Figs. 49-50)
(IRANI, N. A., Sheet no. 4934, BLAT)
Pollen grains, 4-5-colporate, rarely 3-colporate, subprolate (46.4×38.8 μm), range 43.2—51.3×35.1—43.2 μm. Colpi, thin with acute apices, membrane psilate. Apocolpium diameter about 4 μm. Mesocolpium about 7 μm. Ora lalongate (4.4×7.7 μm), membrane psilate. Exine about 1.5 μm thick. Sexine slightly thicker than nexine. Sexine more thick at the equators. Sexine pattern obscure.

F. 3(-4)-5-*Colporate*

6. **Pouteria tomentosa** (Roxb.) Baehni (Pl. 4, Fig. 51)
Syn. *Sideroxylon tomentosum* Roxb.
(IRANI, N. A., Sheet no. 2746, BLAT)
Pollen grains, 3-5-colporate, rarely 4-colporate, sub-prolate (43.0×29.7 μm), range 35—40×27.5—35 μm. Colpi long, thin with acute apices, membrane psilate. Apocolpium diameter about 4 μm and mesocolpium about 5.5 μm. Ora lalongate (4×6 μm) and membrane psilate. Exine thickness about 2 μm. Sexine slightly thicker than nexine. Sexine pattern obscure.

7. **Bassia latifolia** Roxb. (Pl. 4, Fig. 52)

(WAGH, S. K., Sheet no. 5740, BLAT)

Pollen grains, 3-5-colporate, rarely 4-colporate, subprolate (38.3×34.0 μm), range 35.1—40.5×32.4—35.1 μm. Colpi thin, small and membrane psilate. Ora lalongate (3×5 μm) and membrane psilate. Exine about 1.5 μm thick. Sexine as thick as nexine. Sexine pattern psilate.

8. **Manilkara hexandra** (Roxb.) Dub.

Syn. *Mimusops hexandra* Roxb.

(TAVAKARI, S. C., Sheet no. 815, BLAT)

Pollen grains, 3-5-colporate, rarely 4-colporate, subprolate (33.8×27.3 μm), range 33.3—39×26.0—28.6 μm. Colpi thin with acute apices, membrane psilate. Apocolpium diameter about 4 μm and mesocolpium about 5 μm. Ora circular (5 μm), membrane psilate. Exine about 2 μm thick. Sexine slightly thicker than nexine. Sexine pattern±obscure.

G. (3-4)-5-*Colporate*

9. **Madhuca indica** Gmel.

(MERCHANT, Y. A., Sheet no. 955, BLAT)

Pollen grains, 5-colporate, rarely 3 and 4-colporate, subprolate (52.2×46.0 μm), range 46.8—57.2×41.6—52.2 μm. Colpi small, thin with acute apices. Apocolpium diameter about 13 μm and mesocolpium about 10 μm. Ora lalongate (5×10 μm), membrane smooth. Exine about 3 μm thick. Sexine thicker than nexine. Sexine pattern obscure.

H. (3)-4-(5)-*Colporate*

10. **Achras sapota** Linn. (Pl. 4, Figs. 53-54)

(TAVAKARI, S. C., Sheet no. 381, BLAT)

Pollen grains, 4-colporate, rarely 3 and 5-colporate, prolate-spheroidal (56.6×52.7 μm) range 51.0—59.8×51.0—54.6 μm. Colpi thin, small, membrane psilate. Apocolpium diameter about 12 μm and mesocolpium about 6 μm. Ora lalongate (5×11 μm), membrane psilate. Exine about 1.5 μm thick. Sexine and nexine equithick. Sexine pattern±obscure.

I. 3(-4)-*porate*

11. **Palaquium ellipticum** (Dale.) Baillon (Pl. 4, Figs. 46-48)

Syn. *Bassia elliptica* Dale.

(SANTAPAU, H., Sheet no. 5852, BLAT)

Pollen grains, 3-4-porate, 3-porate condition more prominent, spheroidal (31.2 μm), range 28.6—33.8 μm. Pore circular, diameter about 6.6 μm, pori surrounded by a prominent annular layer. Exine about 1.5 μm thick. Sexine as thick as nexine. Sexine pattern finely reticulate. Tegillate.

DISCUSSION

SYMPLOCACEAE

The monogeneric family Symplocaceae is represented by the genus *Symplocos* which was formerly often included in Styracaceae or Styracineae, but now is accepted to repre-

sent a separate family Symplocaceae. The Styracaceae possess stellate hairs or scales, non-fasciculate stamens, linear anthers, half or wholly superior ovary, and imperfectly celled fruit ; thus it distinctly differs anatomically from the Symplocaceae (STEENIS, 1948-54). HOOKER (1882) was the first to segregate the main genus *Symplocos* under two subgenera : *Hopea* and *Ciponima*. Later, BRAND (1901), in his monograph on the family Symplocaceae, has divided the genus *Symplocos* into four subgenera, viz., *Epigenia*, *Hopea*, *Microsymplocos* and *Eusymplocos*. This segregation is based on stamen character alone. Hence it would be worthwhile to investigate that to what extent the above two concepts based so far on the gross morphological features of *Symplocos* could be corroborated palynologically. As a result of present studies, palynological affinities and variations amongst different species of *Symplocos* have been discussed in the light of taxonomy and phylogeny.

To avoid any discrepancy we have taken into account the aperture as primary, exine surface pattern as secondary and shape/size of pollen as well as aperture as tertiary characters. Based on apertural characters, all the species are categorized into two main groups—one producing colporate and other producing porate pollen grains. The number of apertures is generally three and very rarely four or five in both the types. The sexine pattern is chiefly granulate or obscure and crassimarginate. The shape of the pollen grains is invariably triangular to subtriangular and the shape of both pores and ora is either circular or elliptical. Taking into consideration the overwhelming palynological data *vis-a-vis* the justification in segregating of genus *Symplocos* into *Hopea* and *Ciponima* we failed to find any distinguishing pollen character between the two. Except for *S. paniculata* under subgenus *Ciponima*, all other species of *Symplocos* presently investigated are grouped under the subgenus *Hopea* by HOOKER (1882) and their pollen exhibit both types of apertures, i.e. colporate as well as porate. It is, therefore, quite evident that the palynology at least does not support the segregation of *Symplocos* into *Hopea* and *Ciponima*, and hence the genus *Symplocos* must be restored to its original status or circumscription.

A thorough perusal of pertinent palynodata as to the aperture types met in the genus *Symplocos* elucidates that the nature of colpi in colporate apertures, being so streaky, insignificant and short, makes one to infer that the porate condition must have been evolved as a result of further reduction of the colpi. The brevicolporate condition, which is observed in some of the species, may vanish in the course of further reduction, and ultimately give pace to porate condition. Taking into consideration the geological aspect, the porate condition is either derived from colpate and/or colporate condition (KUPRIANOVA, 1969) or is an independent unit (NAIR, 1965, 1970). Undoubtedly the evolutionary levels are closely related with the problems of parallelism and convergence of characters. The possibility that the evolution is both in upward and downward directions cannot be ruled out, and it does not necessarily involve all features of the pollen at the same time ; one character or set of characters may advance while others are static or retrograding. All the palynological features so far obtained have been considered most advanced (NAIR, 1965). If this is taken as an evidence, then the status of Symplocaceae is tipped towards advancement supporting the classification of angiosperms by HUTCHINSON (1967).

Symplocaceae is more related to Cornaceae and Theaceae, having in common primitive wood anatomy and serrated leaves. Its affinities with Cornaceae are more pronounced on account of similarity in bud scales, inferior ovary and copious endosperm. But pollen morphologically, Symplocaceae deviates distinctly both from Cornaceae as well as Theaceae, and the pollen grains ± similar to *Symplocos*, are met with in certain members of Styracaceae and Lissocarpaceae too, though differing from Ebenaceae. This further supports HUTCHINSON's view.

SAPOTACEAE

The palynological investigations of the family Sapotaceae have revealed that it is an eurypalynous family. The main types of apertures met with in the family are colporate, though porate and parasyncolpate apertures are of rare occurrence. Based on aperture, as many as ten different types of pollen grains have been recognized. As far as ornamentation is concerned, it is chiefly obscure to microgranulate in colporate pollen, scorbiculate in 3-parasyncolpate and microreticulate in 3-4-porate pollen grains. The 3-5-colporate condition of aperture seems to be more pronounced throughout the family. As regards to the phylogeny of pollen grains in this family, it is 3-colpate condition which must have given rise to parasyncolpate and colporate apertures. The porate aperture may have been of independent origin. Thus, all the pollen characters observed in this family, too, are advanced in the evolutionary level, and, therefore, Sapotaceae as such has been considered as an advanced family.

Pollen morphologically, however, Sapotaceae has closest affinities with Ebenaceae and Sarcospermataceae but differs from Symplocaceae. Thus pollen morphology strongly supports the retention of Sapotaceae, Ebenaceae and Sarcospermataceae under the order Ebenales as suggested by HUTCHINSON (1967).

CONCLUSIONS

The conclusions derived from palynotaxonomical investigations of the families Symplocaceae and Sapotaceae are as follows :

1. The pollen morphological evidences do not support HOOKER's (1882) segregation of the genus *Symplocos* into two subgenera, i.e. *Hopea* and *Ciponima*.
2. The subgenus *Hopea* comprises a large number of pollen subtypes and, therefore, its taxonomical status is not yet clear. Based on apertural types, four groups (i.e. 3-porate, 3-4-porate, 3-colporate and 3-4-colporate) could be recognised within the subgenus *Hopea*. Similarly, based on exine configuration two major types—such as obscure and granulate pattern, have been recognised. This study could be quite useful in providing additional characters for the interspecific delineations in a complex subgenus like *Hopea*.
3. The subgenus *Ciponima* comprises a few species and only one species has been pollen-morphologically investigated which produces 3-brevicolporate pollen with lalongate ora. In view of the above limitations, nothing could be discussed regarding interspecific relationships.
4. The family Sapotaceae is eurypalynous in nature, and pollen morphologically it shares affinities with Ebenaceae and Sarcospermataceae supporting their taxonomic grouping together.
5. The palynological features studied in both Symplocaceae and Sapotaceae in the light of evolutionary levels suggest that both the families be considered as advanced.
6. Pollen evolutionary levels if considered properly makes it apparant that colporate aperture must have been evolved from colpate and the colpi of colporate aperture on reduction may have given rise to porate and subsequently to pororate aperture. Now the commonest apertures in Symplocaceae and Sapotaceae are brevicolporate, porate and longicolporate, porate respectively. Taking into consideration the overwhelming palynological features involved in evolutionary levels, one is ought to realize that the longicolporate aperture of Sapotaceae might have given rise to brevicolporate of Symplocaceae and consequently to porate aperture. Relating the palynological affinities, it is suggested here that the Symplocaceae and

Sapotaceae be rightly grouped together confirming WETTSTEIN's (1935) classification.

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EXPLANATION OF PLATES

All figures are × 1,000

PLATE 1

1-3. *Symplocos grandiflora*, 1—optical view with brevicolpus, 2&3--polar view with granulate pattern.

4. *S. lucida*-equatorial view with spinules.

5-7. S. *pendula*, 5—optical view showing papillae; 6, equatorial view showing grana ; 7, polar view showing brevicolpae and also papillae.

8-11. *S. spectabilis*, 8—equatorial view showing rectangular os with irregular annular thickenings; 9—equatorial view showing sexine/nexine ratio ; 10—polar view showing obscure pattern; 11, Polar view showing aspids.

12-15. *S. obtusa*, 12—polar view showing papillae ; 13—polar view with obscure pattern and aspids ; 14 & 15, equatorial views showing circular pores and papillae.

PLATE 2

16-17. *S. gardneriana*, 16—optical view showing sexine/nexine ratio ; 17—equatorial view showing brevicolpate and annulate os.

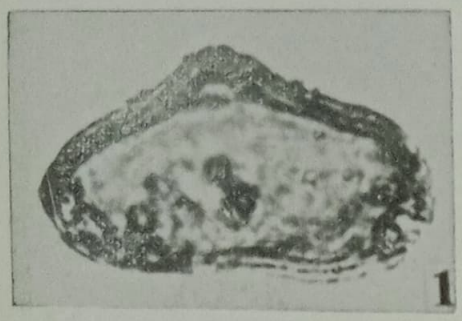
18. *S. theaefolia*—polar view showing spines.

19-21. *S. latiflora*, 19—polar view showing four pores; 20—equatorial view showing granulate pattern and papillae; 21—equatorial view showing aspidate pores and sexine and nexine ratio.

22-25. *S. leiostachya*, 22&23—polar view showing aspids and S/N ratio; 24—equatorial view showing annular thickenings around the os; 25—equatorial view showing brevicolpate and granulate pattern.

26. *S. pyrifolia*

27-30. *S. Sumuntia*, 27—equatorial view showing relative size of colpus and os ; 28—polar view showing brevicolpus; 29—polar view showing granulate pattern; 30—polar view showing S/N ratio.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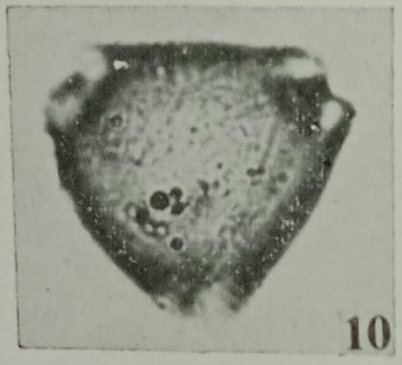
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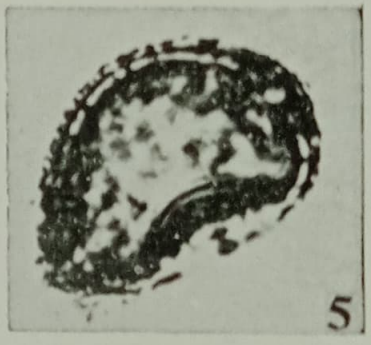
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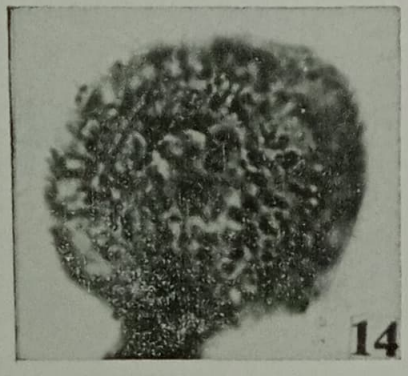
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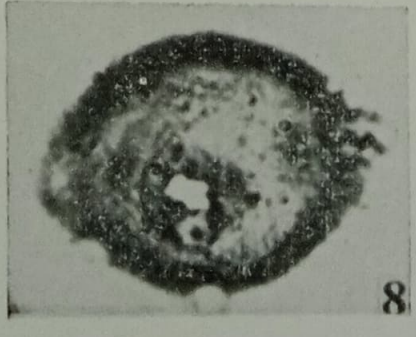
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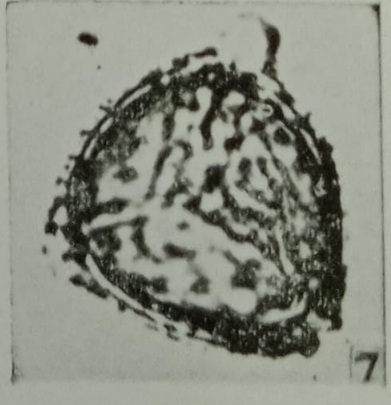
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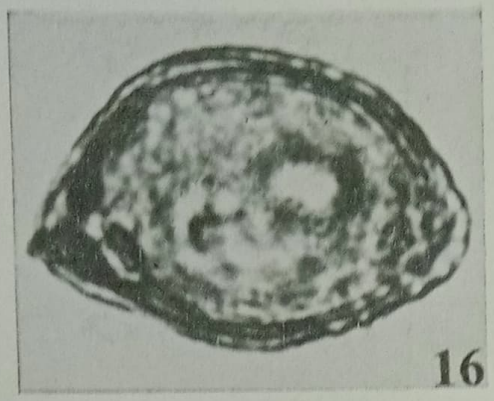
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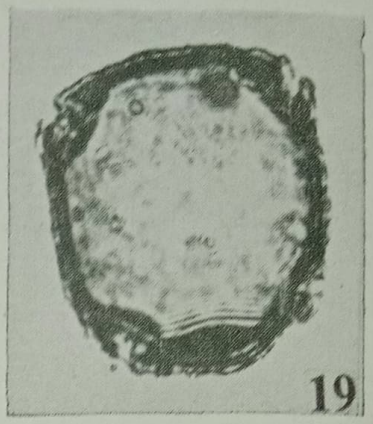
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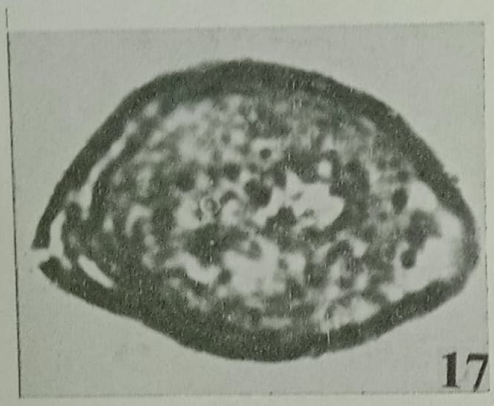
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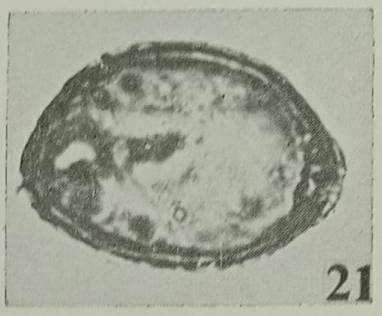
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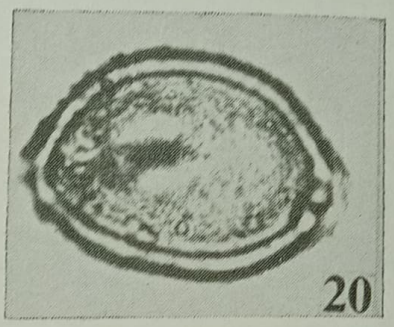
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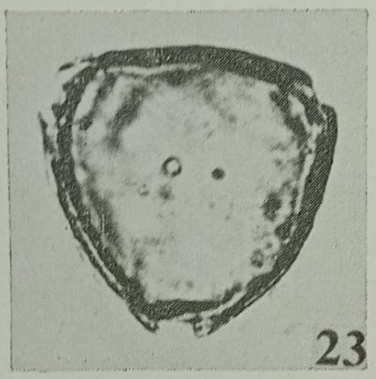
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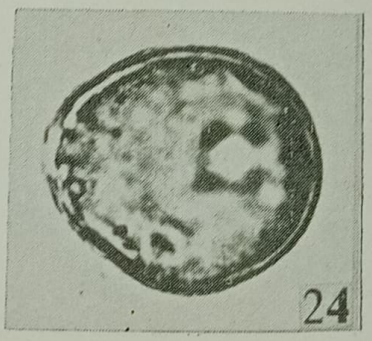
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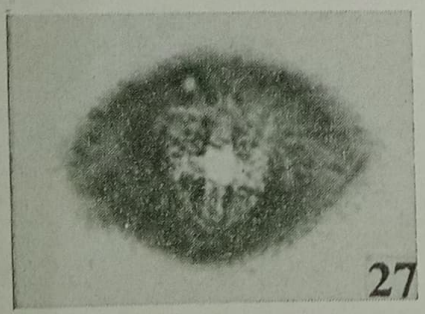
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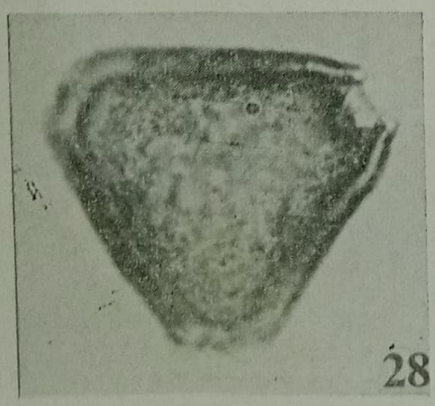
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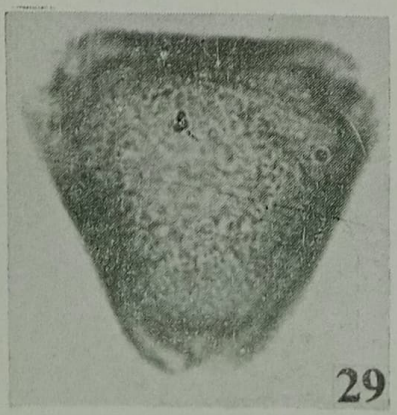
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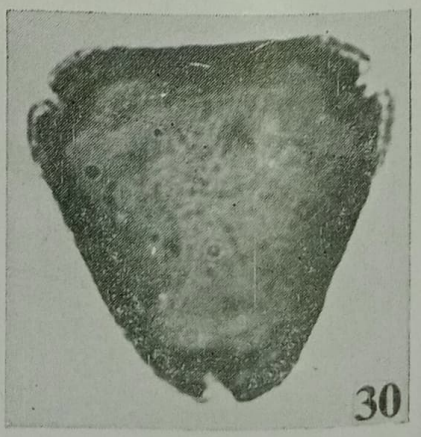
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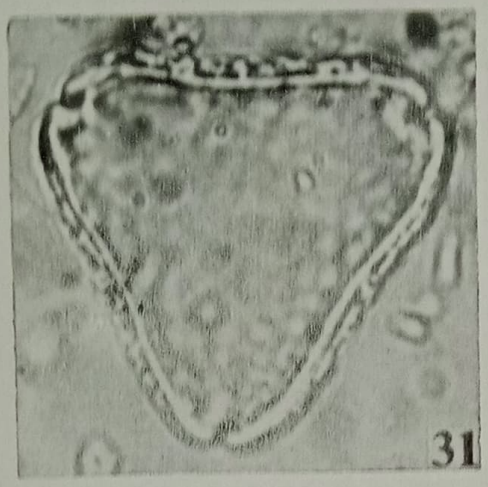
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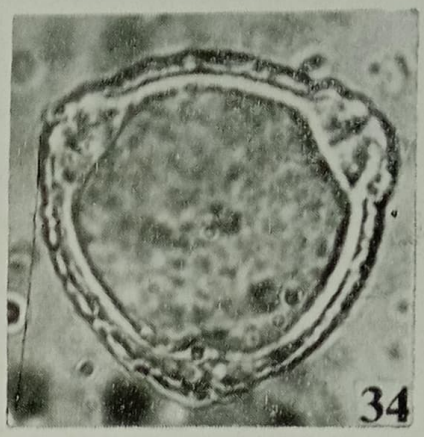
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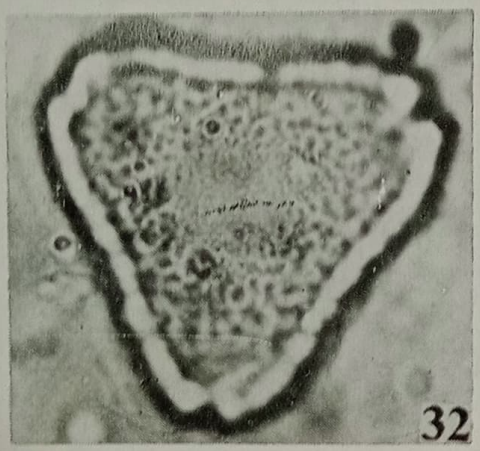
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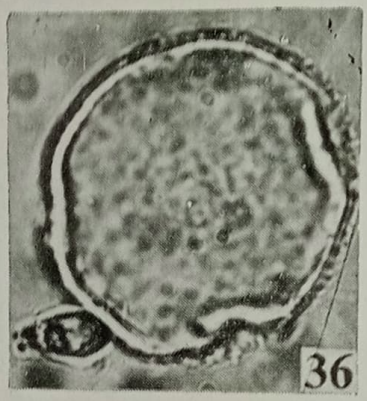
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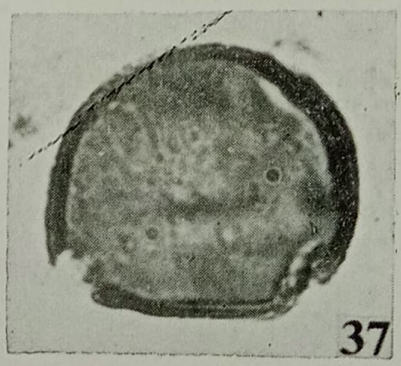
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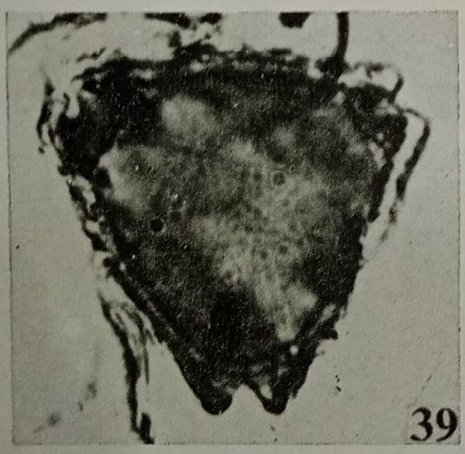
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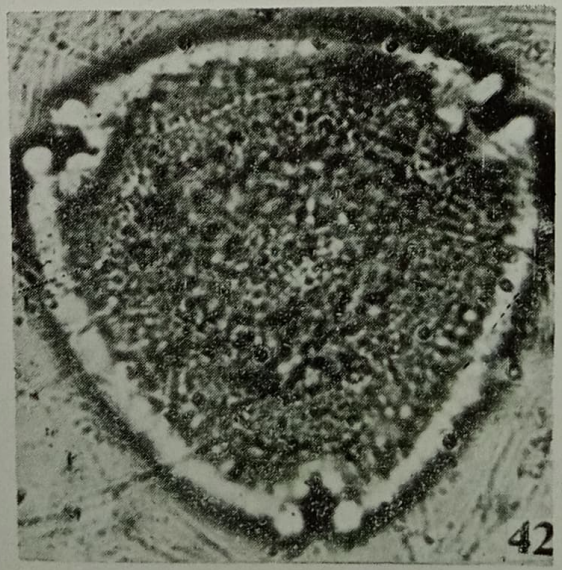
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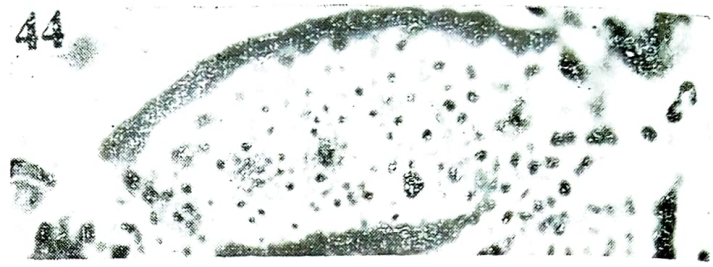
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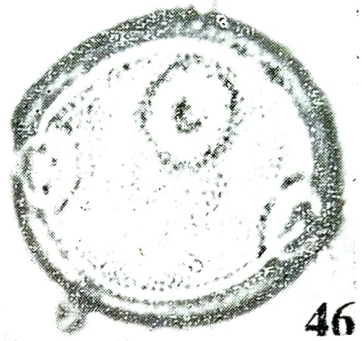
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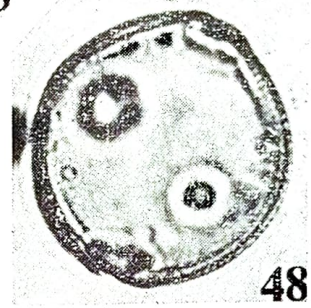
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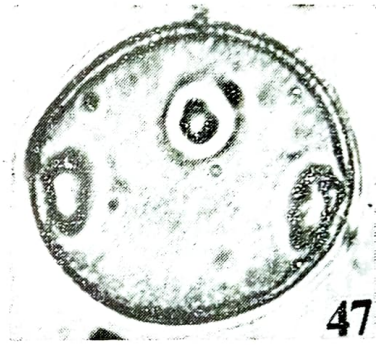
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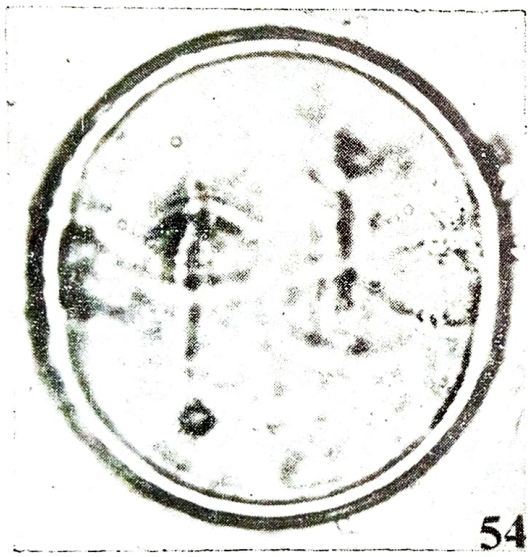
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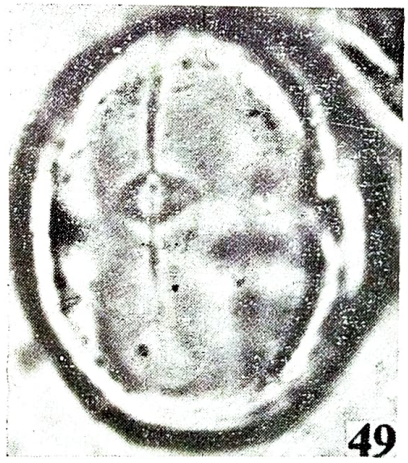
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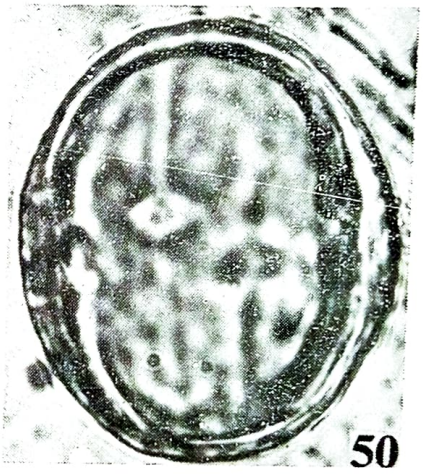
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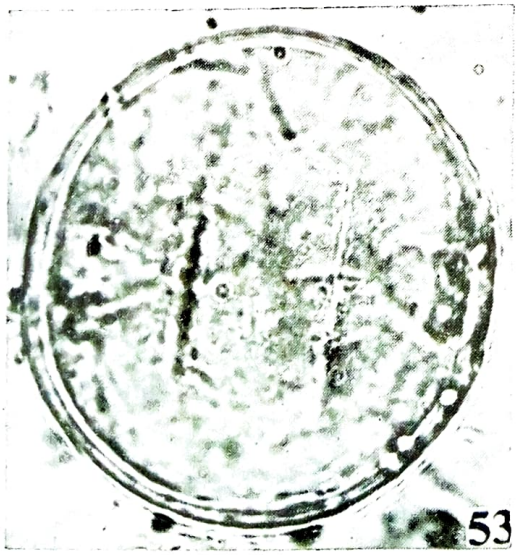
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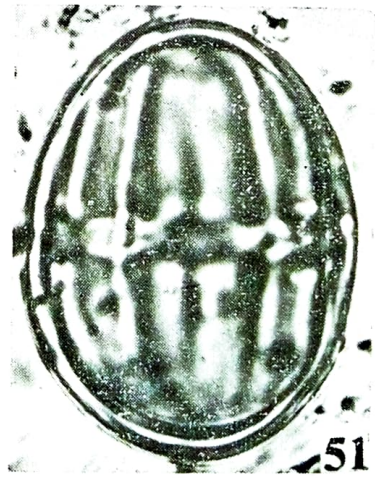
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PLATE 3

31-32. *S. crataegoides*, 31—polar view showing S/N ratio; 32—polar view showing granulate pattern in the centre and microreticulation at the periphery.

33-34. *S. beddomei*, 33—porate; 34—polar view showing granulate pattern, aspids and S/N ratio with uneven tegillum.

35-36. *S. laurina*, 35—showing granulate pattern; 36-showing spinules and S/N ratio.

37. *S. lancifolia*

38-39. *S. foliosa*, 38—equatorial view showing rectangular os; 39—polar view showing aspids and S/N ratio.

40. *S. rosea*.

41-42. *S. dryophila* showing brevicolpate, granulate pattern and S/N ratio.

PLATE 4

43-44. *Chrysophyllum lanceolatum*, 43—polar view showing scorbiculate structure and papillate sculpture. S/N ratio is also shown here; 44—showing puncta.

45. *Chrysophyllum cainito*.

46-48. *Palaquium ellipticum*, 46—equatorial view showing granulate pattern; 47—showing pore with prominent annulus; 48—showing 4 pores and S/N ratio.

49-50. *Mimusops elengi*, 49—showing obscure pattern and lalongate os with longicolpus; 50—4-colporate showing thickened exine at the equators.

51. *Pouteria tomentosa* showing 5-colporate aperture with lalongate ora.

52. *Bassia latifolia* 5-colporate showing prominent lalongate ora in contrast to colpi.

53-54. *Achras sapota*, 53—showing S/N ratio; 54—showing 4-colporate aperture with prominent lalongate ora and small streaky colpae.