POLLEN MORPHOLOGY AND SYSTEMATIC RELATIONSHIP OF SABIACEAE*

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ABSTRACT

In the present study 222 materials from 10 species of *Sabia* Colebr. and 21 species of *Meliosma* Bl. have been investigated. This study is an endeavour to interpret the systematic ambiguities on pollen morphological characters. Palynological data reinforce the placement of *Sabia* Colebr. and *Meliosma* Bl. in a single family Sabiaceae which is distributed over tropics and subtropics of the Old World. A phytogeographical note included facilitates the correlation of past climate and fossils with the present day distribution of the family. A lot of megafossil representatives have been described from the genus *Meliosma* Bl. and it is expected that there might be fossil pollen also, though not yet assigned. So, this study will also be helpful in identification of fossil pollen in future.

INTRODUCTION

The family Sabiaceae was first proposed and described by BLUME (1851). He described the only taxon *Sabia* Colebr. (*Meniscosta* Bl.) under his Sabiaceae. BENTHAM AND HOOKER, f. (1862), WARBURG (1896) and others expanded the family with four recognised genera : *Sabia*, *Meliosma*, *Phoxanthus* and *Ophiocaryon*. The latter two are monotypic genera from Brazil and Guiana. *Meliosma* Bl. with about one hundred thirty to one hundred forty described species and quite a few infraspecific taxa (*sensu* BEUSEKOM, 1971), is the largest genus.

In widely used systems, the botanists accepted Warburg's (l.c.) treatment for placing the genera. HOOKER f. (1876) in the Flora of British India followed the system of BENTHAM AND HOOKER f. (l.c.). Recently, AIRY SHAW (1973) has expressed doubt about the naturalness of the Sabiaceae in the sense of BENTHAM AND HOOKER f. (l.c.) and proposed a monotypic family Sabiaceae Bl. with about 55 species of *Sabia* and introducing a separate family Meliosmaceae Endl. which includes 2 genera, *Meliosma* (100 spp.) and *Ophiocaryon* (=*Phoxanthus*) (2 spp.). According to him Sabiaceae is an interesting group showing possible/or probable connections with Menispermaceae, Icacinaceae and Meliosmaceae. Minute obscure gland dots on leaves resemble Myrsinaceae. He stated that relationship between Sabiaceae and Meliosmaceae requires confirmation. Regarding the possible relationship of Sabiaceae (s.l.) with other families BEUSEKOM (l.c.), CHEN (1943) and others say that there is no concensus of opinion (Table-1). Most authors have related them (especially *Meliosma*) to the Sapindaceae, Hippocastanaceae or Anacardiaceae, others assume a relationship with families like Menispermaceae, Lardizabalaceae, Icacinaceae and Schizandraceae. So, this appears that taxonomic disagreement lies as regards its naturalness, affinities and relationships.

CUFODONTIS (1939) and How (1955) revised Chinese *Meliosma* only. There are two important revisions on the family (in part). One is of *Sabia* Colebr. by CHEN (l.c.). He divided the genus *Sabia* into two sections depending on the disc characters of the flower. Sect. I—Pachydiscus and Sect. II—Odontodiscus. Most of the Indian repre-

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Table 1—Treatment of Sabiaceae under different orders by different authors

	Terebinthales	Sapindales	Rutales	Placed next to or in Between
Wallich (1824) (Discussed about Sabia only)	+			Anacardiaceae
Planchon (1855)	+			Anacardiaceae
Bentham & Hooker (1862-1883)	+			Sapindaceae & Anacardiaceae
Warburg (1896)		+		Sapindaceae & Melianthaceae
Hutchinson (1926)		+		Sapindaceae & Aceraceae
Wettstein (1935)	+			Hippocastanaceae
Benson (1957)		+		Hippocastanaceae & Melianthaceae
Engler (1964)		+		Hippocastanaceae & Melianthaceae
Thorne (1968)			+	——
Takhtajan (1969)		+		Melianthaceae & Greyiaceae
Dahlgren (1975)		+		

sentatives of *Sabia* belong to Sect. Odontodiscus. Another revision is by BEUSEKOM (l.c.) of *Meliosma* Bl. He divided the genus into two subgenera, 4 sects, 2 subsects and 2 series. These are very much detail and comprehensive taxonomic study which are of immense importance to other workers at present.

Palynological information on the family Sabiaceae, so far available, is meagre. CHEN (l.c.) in his revision of the genus *Sabia* Colebr. described for the first time the pollen grains of 6 species. Further available information on pollen morphology of the family comes from ERDTMAN (1952), IKUSE (1956), GUINET (1962), HUANG (1967), PALACIOS (1968), etc. All these casual informations were based on very few samples. First detail information comes from MULLER (1971). He investigated about 25 species of *Meliosma* and could find only minute difference and suggested the necessity of detail work covering as much species as possible from the family. Considering all the above mentioned taxonomic discrepancies and inadequate palynological informations, the present investigation was carried out in order to find out affinities and relationship of the family and to interpret the systematic ambiguities on pollen morphological characters.

PHYTOGEOGRAPHICAL NOTES AND FOSSIL RECORDS

The family Sabiaceae is characteristic of certain tropical and subtropical regions of the Old World, having no representatives in Africa, Madagascar, Australia, Polynesia and the New World (Map-1). Phytogeographical history reveals that *Sabia* Coblebr. is mainly confined to the Indo-Malaysian and Indo-Chinese regions. CHEN (l.c.) mentioned that *Sabia* reached its highest development in China. He tabulated 36 species and 9 varieties from China with maximum in Southwest province Yunnan, where 21 species

Map. 1—World distribution of Sabiaceae [After Beusekom (1971) and Heywood (1978)].

are now known. More than half of the now known species of *Sabia* are confined to China. Present record for India is 10 species. Ten species occur in Burma, Japan, Formosa, Indochina, Thailand (Siam), the Malay peninsula, Sumatra, Java, Borneo, the Philippines and Moluccas. New Guinea and Solomon Islands are represented by one or two species. In Malay Archipelago including Philippines the genus is not strongly represented. Most of the Indian species of *Sabia* are reported from temperate and tropical Himalayan region. From Peninsular India only one species is reported. HOOKER f. (l.c.) in "The Flora of British India" included 10 species of *Sabia*, native of tropical and temperate India. HARA (1966, 1971) reported 4 species from Eastern Himalayas. SANTAPAU *et al.* (1973) mentioned the occurrence of 10 species in India of which *Sabia campanulata* from temperate Himalaya and *S. malabarica* from South Indian hills are common. Two most widely distributed species are *Sabia limoniacea* and *S. parviflora*. The former extends from north India to Burma, Siam, Malay peninsula, Sumatra, Yunnan and includes its var. *ardisioides* Chen to Kwangsi, Kwangtung, Hainan to Hongkong in China. The latter extends from northern India to Burma, Yunnan, Kweichow, Kwangsi, Indochina and Borneo and includes its var. *harmandiana* (Pierre) Lecomte to Yunnan, Indochina, Siam and Borneo. A point to be mentioned here that India is completely devoid of the representative of the sect. Pachydiscus (*sensu* CHEN, l.c.).

Meliosma, the largest genus of the family is represented by 100 species (*sensu* AIRY SHAW, l.c.) and number of infraspecific taxa, is distributed in tropics and subtropics of the world. Approximately 35 species occur in Mexico, Central America, the West Indies and S. America. The remaining three fourths of the proposed species are characteristic of the Indo-Malaysian and Indochinese region. The world generic range is from Northern India down to Ceylon in east and in southeast to Korea, Japan, Malaysia and New Guinea. BEUSEKOM (l.c.) in his revision of S. E. Asian *Meliosma* (American sect. Lorenzanea excluded) reduced 100 previously recongised species into his 15 species under 2 subgenera, 4 sections, 2 subsections and series and several subspecies with number of local races. BEUSEKOM (l.c.) came to a conclusion that both the subgenera have bicentric origin and originated with number of unrelated genera (homologous). Hence they must have originated in the same period and under the same physiological and climatological conditions. Subsect. Simplices (7 species) of subgenus

Meliosma is distributed over S. W. and Central China, only two species enter in W. Malesia, and subsect. Pinnatae (5 species) is distributed over W. Malesia (N. Borneo, N. & C. Sumatra) with only 1 species extending far into continental Asia and E. Malesia. Sect. Kingsboroughia of subgenus *Kingsboroughia* (3 species) is distributed over S. E. and Central China (2 spp.) and Sect. Hendersonia is represented in W. Malesia with 1 species. It is interesting to note that there is no representative of subgenus *Kingsboroughia* (*sensu* Beusekom, l.c.) in India. On the other hand sect. Simplices as well as sect. Pinnatae are well represented in S. India, Eastern India and a few in Western India. Van Steenis (1962) included *Meliosma* under his 'Amphitrans pacific genera'. He recorded about 50 species as West Pacific (Indo Malaysian) extending from Ceylon to Korea, Formosa and New Guinea and 12 species as East Pacific (tropical American) extending from Mexico to Brazil.

Good (1964) designated the Sabiaceae as the discontinuous family of Angiosperms and described under his – "families of America and Eurasia and/or Australasia". Cain (1944) described the family as a disjuncted family between America and Asia. Out of 11 species of *Meliosma* in Indo-Malaya, 5 species predominate in Himalayas, 2 species in Western Peninsula and 4 species from Malay Peninsula.

Fyson (1932) in his Flora of South Indian hill stations reported 2 species of *Meliosma*, *M. wightii* Planch. from Western Ghats, Coorg, Mysore, northwards to Bombay and southwards to Ceylon and *M. arnottiana* Wight. from Nilgiri, Western Ghats, Coorg, etc. to Bombay, Manipur, Burma and Ceylon.

Hara (l.c.) and Ohashi (1975) reported 3 species of *Meliosma* from Eastern Himalaya. Santapau *et al.* (l.c.) reported 9 species of *Meliosma* in India of which *M. dilleniifolia* (Wall. ex Wt. & Arn.) Walp., distributed almost throughout Himalayas, *M. microcarpa* (Wt. & Arn.) Graib. from Khasi hills, Manipur and Peninsular India and *M. pungens* (Wall. ex Wt. & Arn.) Walp. from subtropical and temperate Himalayas are common.

Palaeobotanical literature so far at hand reveals rather abundant record of fossil Sabiaceae mostly from the genus *Meliosma*. These records, almost all, refer to fossils from the Tertiary Period, viz. from the Lower Eocene up to far into the Pliocene, only few being of Quaternary age. All the localities of fossil *Meliosma* are situated in the northern hemisphere, outside the tropics and often up to rather high latitudes. Study of fossil members might add a valuable palaeobotanical dimension to the taxonomic and distributional picture of this genus. Chaney and Sanborn (1933) reported fossil remnants of *Meliosma* for the first time from W. America. Most of the fossils are organ genera represented by fossilized endocarp and leaf imprints. No flowers or reliable pollen data are at hand up till now. One or two fossilized wood ascribed to *Meliosma* has been reported but these need confirmation. Sometimes these fossil members have been found to occur in assemblages which are more of a heterogenous floristic composition, for instance tropical genera as *Cinnamomum*, *Meliosma* and *Diospyros* and some temperate genera as *Ulmus*, *Prunus*, *Acer*, etc. In such cases it is hard to analyse the floristic composition and probable climatic conditions of the past under which these flora lived, because such genera cover several climatic zones. Up till now three tentatively placed endocarp and about 40 leaf impressions have been described, of which *Meliosma aesculifolia* Chaney & Sanborn, *M. californica* Berry and *M. cantiensis* Reid & Chandler are the endocarp organ genera, and *M. cuneata* (Newb.) Berry, *M. europea* C. & E. M. Reid, *M. myriantha* Sieb & Chandler and *M. goshenensis* Chaney & Sanborn are important leaf impressions. Cain (l.c.) reported 133 individuals of *Meliosma goshenensis* Chaney & Sanborn from

Goshen flora. BEUSEKOM (l.c.) mentioned that most of the fossil endocarps described so far doubtlessly belong to subg. *Kingsboroughia* sect. *Kingsboroughia* whereas none could relate to sect. *Hendersonia*. From subg. *Meliosma* not only endocarps but leaf imprints are also abundant. Out of all endocarps referable to sect. *Meliosma*, none of sect. *Lorenzanea* (*sensu* BEUSEKOM, l.c.) have yet been found. The fossil leaves on the other hand are referable to both sect. *Meliosma* and *Lorenzanea* but not to sect. *Meliosma* subsect. Pinnatae. On the basis of palaeobotanical as well as physiognomical evidences BEUSEKOM (l.c.) considered the Arcto Tertiary concept as advanced by WOLFE (1969) and concluded—"its distributional history would then resemble that of sect. *Kingsboroughia* which I also assume to have had its origin in Asia and expanded its range via Beringia to North America with two differences, viz. (i) that its migration took place at later period of the Tertiary and (ii) that it maintained a foothold in Mexico (*M. alba*) as relict of this migration."

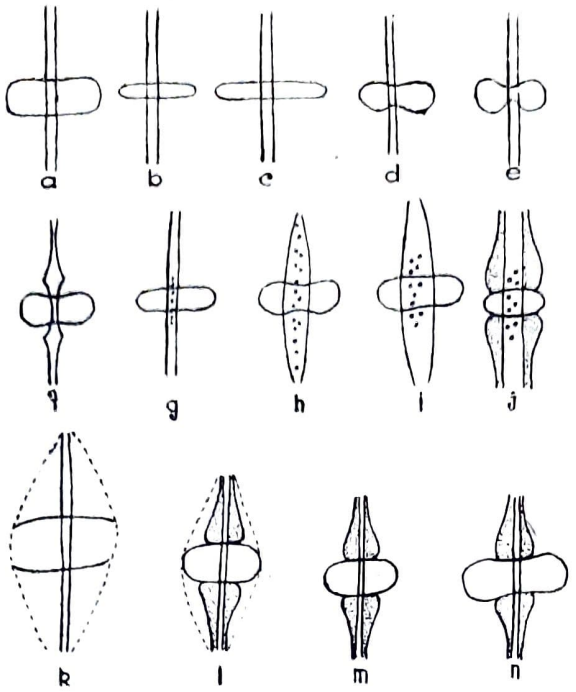
MATERIALS AND METHODS

Polliniferous materials were collected from the herbarium sheets of the Central National Herbarium (CAL). For identification of some disputed specimens photographs of type materials from Kew Herbarium and microfiches have been consulted. Nomenclature followed after CHEN (l.c.) and BEUSEKOM (l.c.). Pollen slides were prepared by acetolysis method (ERDTMAN, l.c.) and have been deposited in the Sporotheca of Palynology Laboratory, C. N. H. The reading corresponds to the mean of 25 measurements of pollen grains for each material and were taken from acetolysed nonchlorinated grains. Infra specific variations for Polar axis (P) and Equatorial axis (E) measurements were analysed statistically which are of very narrow range. Standard deviation (σ) for P and E (n=25) is insignificant and range from 1.2-2.5 μm. Photomicrographs were enlarged $\times$1600.

OBSERVATION AND DISCUSSION

Pollen isopolar, 3-zonocolporate, medium-sized, prolate or subprolate in equatorial view, either compressed oval or elliptic oval in meridional forms. Circular, subangular or lobate in polar view. Ectoapertures (Colpa) distinct either narrow slit-like or broad tapering and extended up to poles. Aperture membrane generally smooth, rarely granulated, when granulated, granules either in a definite orientation or randomly distributed. Endoapertures (OS) distinct except in few where equatorial outline not so clearly demarcated. Generally large, lalongate, rectangular type of circular or indistinct with rare exception. Different aperture types met in this family are shown in Text-fig. 1 Exine ornamentation coarsely or finely reticulate, rarely obscure. Reticulation homobrochate or heterobrochate. When heterobrochate, finer around apertures or coarser at apocolpium than mesocolpium. *Sabia* represents comparatively more fine exine ornamentation than *Meliosma* in general. One species of *Sabia* has negatively reticulate and another with obscure exine ornamentation.

Exine layers differentiated into Tectum, Columella and Endexine. Foot layer not detectable. Tectum distinct, varying from 0.5 to 1.5 μm in thickness, often thicker than Columella layer and frequently equal, semitectate, with distinct or fused Columella heads. Columella layer distinct with distinct Columella heads and unbranched, which stands on thin and uniform layer of endexine, or Columella layer forms a compact, thick and firm tectum layer by fusion of the Columella heads. Endexine distinct, thin



Text-fig. 1

and uniform layer or very thick in the apertural area in both the genera to form costae colpate type of aperture. Detailed pollen morphological characters of individual species studied are given in table-2.

It is evident that polar axis range in most of the species of *Sabia* is from 25-32 μm but in *S. limoniacea* it is 21-26 μm. In equatorial axis the general range is from 18.5-25 μm whereas in *S. limoniacea* it is 15.5-18.5 μm. So, *S. limoniacea* represents the smallest range in the genus. Pollen grains are subprolate or prolate in shape, having compressed oval form mostly but sometimes both compressed oval and elliptic oval forms are available simultaneously. In *S. japonica* it is almost circular. In polar view all the species of *Sabia* have subangular shape with the exception in *S. lanceolata* and *S. purpurea* being circular in polar view. Exine thickness is uniform throughout. Exine generally is of 1.5-2 μm thickness but in *S. yunnanensis*, *S. limoniacea* and *S. lanceolata* is below 1.5 μm, or 1.5 μm thickness. Tectum thickness in general range from 0.75-1 μm with the exception in *S. limoniacea* and *S. lanceolata* being 0.5 μm thick. Tectum supported by short distant columella of about 0.5 μm high which stands on a thin and uniform layer of endexine. Columella height decreases from mesocolpal region towards the apertural area in *S. gracilis* and *S. lanceolata*. Sculptural pattern in the genus is finely reticulate in general but in *S. japonica*, *S. paniculata* and *S. parviflora* it is coarsely reticulate and in *S. gracilis* it is negatively reticulate and obscure in *S. lanceolata*. Lumina size range from 1-2 μm in general but in *S. limoniacea* it is 1 μm or less and in *S. gracilis* lumina heterobrochate being 1 μm towards aperture and 1-1.5 μm at mesocolpium. Ectoaperture in general is long slit extending upto poles and without costa but in *S. leptandra* and *S. limoniacea* it is costae colpate. Occasional long tapering colpae have been observed only in *S. yunnanensis* from different localities. Endoaperture distinct and lalongate type, generally rectangular with round ends. In some of the species endoaperture lalongate rectangular type with indistinct or faintly demarcated side wall. Endoaperture lalongate with tapered equatorial end is observed in some materials (not always) of *S. yunnanensis*.

Table 2—Summary of selected pollen morphological features of *Sabiaceae*

Genus and Species	Shape	Outline in pol. view	P(/μm) Mean	Eμm Mean	P/E ratio
1	2	3	4	5	6
Sabia					
campanulata	Pro.	Subang.	25-30 / 29.1	21-27 / 23.4	1.25-1.40
gracilis	Pro. sph.	Subang.	25-27.5 / 26.7	21-23 / 21.9	1.23-1.24
japonica	Sph.	Subang.	28-31 / 29.65	25-28.5 / 26.5	1.03-1.20
lanceolata	Pro.	Cir.	29-32 / 30	21-25 / 23	1.21-1.63
leptandra	Pro. sph.	Subang.	28-34 / 30.33	22-27 / 23.5	1.03-1.36
limoniacea	Pro. sph.	Subang.	21-26 / 22.25	15.5-18.5 / 16.5	1.31-1.73
paniculata	Pro.	Subang.	26-31 / 29	22-27 / 23.5	1.40-1.53
parviflora	Pro.	Subang.	29-32 / 29.95	19-22.5 / 21.15	1.45-1.52
purpurea	Pro.	±Cir.	27-32 / 29.05	20-23 / 21.35	1.21-1.60
yunnanensis	Pro. sph.	Subang.	25-30 / 28.85	19-25 / 22.4	1.20-1.35
Meliosma					
buchnanaefolia	Pro.	Lobate	25-27 / 25.7	19-21 / 19.53	1.25-1.34
colletiana	Pro.	Subang.	24.5-27.5 / 25.6	18-21 / 20.2	1.21-1.6
dentata	Pro. sph.	Lobate	29.5-32.5 / 31.2	22.5-25.5 / 23.2	1.23-1.5
dilleniifolia ssp. *dillenifolia*	Pro.	Semicir.	21-24 / 22.75	17-21 / 19	1.12-1.29
ssp. *cuneifolia*	Pro.	Lobate	26-29 / 27.2	17-20 / 17.8	1.13-1.5
ssp. *tenuis*	Pro.	Lobate	27-28.5 / 27.4	18-20 / 18.65	1.45-1.5
lanceolata var. *lanceolata*	Pro. sph.	Semilobate	25-29 / 28	19-22 / 20.5	1.22-1.51
lancifolia	Pro.	Lobate	19-23 / 22	17-20.5 / 18	1.13-1.5
lepidota ssp. *squamulata*	Pro. sph.	Lobate	30-36 / 33.25	22-25 / 23.2	1.41-1.56
multiflora	Pro.	Lobate	28-32 / 30.3	21.25 / 23.5	1.17-1.6
myriantha ssp. *myriantha*	Pro.	Lobate	29-34 / 31.35	22-25.5 / 23.25	1.13-1.54
nitida	Pro.	Lobate	27.5-30.5 / 29.5	22-25 / 23	1.13-1.54

EXINE (μm)					APERTURE			Remarks
Thickness			Sculpture		Ectoap.		Endoap.	
Tec.	Col.	Endex.	Pattern	Lumina size	Type	Width		
7	8	9	10	11	12	13	14	15
0.75	0.25	0.5	f. ret.	0.5-1	Slit	2	Lalong.	Colpa constricted at eq.
1	0.5	0.5	neg. ret	(0.5)-1-1.5	Slit	2.3	Lalong.	Ret. finer around aperture. Col. heads distinct.
0.75	0.25	0.5	ret.	1-2	Slit	2	Lalong.	Col. with distinct heads, particularly at poles.
0.5	0.25	0.25	± psilate	—	Slit	2.5	Lalong.	Col. indistinct.
0.75	0.25	0.5	f. ret.	0.5-1	Slit	2	Lalong.	Costae colpate.
0.75	0.25	0.5	f. ret.	0.5-1	Slit	2	Lalong.	Colpa constricted at eq.
0.75	0.25	0.5	ret.	(0.5)1-1.5	Slit	2.5	Lalong.	Heterobrochate, ret. finer towards aperture.
1	0.5	1	ret.	1-1.5(-2.5)	Slit	2.5	Lalong.	Heterobrochate, ret. coarser at poles (2-2.5 μm.)
0.5	0.25	0.5	f. ret.	0.5-1	Slit	2-3	±Cir.	Col. indistinct.
0.5	0.25	0.25	f. ret.	0.5-1	Tap.	2.5-3	Lalong.	In one mat. endoap. tap. at eq. margin.
0.75	0.25	0.5	f. ret.	0.5-1	Slit	1.8	Lalong.	Col. indistinct at mesocolpium.
0.75	0.25	0.5	obs./f. ret.	0.2 or less	Slit	2(1.5)	Lalong.	Colpa constricted at eq. endoap. margin indistinct.
1	0.5	0.75	ret.	1-1.2(±2)	Slit	2	Lalong.	Lumina linear at poles.
0.75	0.25	0.5	f. ret.	0.5-0.75	Slit	2	Lalong.	Endoap. margin indistinct. at eq.
0.5	0.25	0.5	f. ret.	0.5-1	Slit	2	Lalong.	——
0.75	0.5	0.5	f. ret.	0.5-1	Slit	2	±Cir.	Mat. from Japan show lalong. endoap.
1	0.5	0.5-1(1)	ret.	1-1.3	Tap.	3	Lalong.	Ex. thicker at poles (Nex. 1 μm). Col. heads distinct at poles.
0.5	0.25	0.5	f. ret.	0.5-1	Slit	1.8	Lalong.	——
1	0.5	0.5	ret.	(0.5)-1-2	Tap.	3	Lalong.	Col. heads distinct, ret. smaller around ap.
1	0.5	0.5	ret.	1-1.5	Slit	2	Lalong.	Col. heads distinct, at poles.
1	0.5	0.5	f. ret.	0.5-1	Slit	2	Lalong.	Col. heads distinct at poles.
1	0.5	0.5	ret.	1-1.5	Tap.	2.5-(1.5)	Lalong.	Colpa constricted at eq.

Table 2

1	2	3	4	5	6
obtusifolia	Pro.	Lobate	26-29 27.85	21-24 22	1.16-1.28
pinnata ssp. *pinnata*	Pro. sph.	Subang.	27-30 28.15	18-21.5 19.55	1.37-1.52
pinnata ssp. *pinnata* var. *arnottiana*	Pro. sph.	Lobate	25-27.5 25.85	18-20.5 19.65	1.21-1.5
polyptera	Pro.	Lobate	28.5-31 30	18.5-23.5 21.5	1.10-1.5
simplicifolia ssp. *simplicifolia*	Pro. sph.	Subang.	26.5-30 27.25	18-24 22.5	1.10-1.58
ssp. *pungens*	Pro.	Lobate	30-32.5 31.45	22-24 23.3	1.28-1.40
ssp. *rigida*	Pro.	Lobate	29.5-32.5 31	21.5-24 23	1.3-1.5
wallichii	Pro. sph.	Lobate	25-27 25.6	18-20.5 19.8	1.23-1.5
wightii	Pro. sph.	Lobate	26-28.5 27.5	21-23.5 22.5	1.13-1.39

In the species of *Meliosma* the polar axis range is from 25-32 μm but in *M. dilleniifolia* it is 21-24 μm. Equatorial axis in general range from 18-25 μm with the exception in *M. dilleniifolia* and *M. myriantho* where it ranges from 17-21 μm. Subprolate or prolate pollen grains are common for the genus. Majority with elliptic oval outline and a few having compressed oval in meridional form. Polar view for majority of the species in this genus is lobate but subangular in *M. simplicifolia*, *M. myriantha*, *M. lanceolata* and *M. pinnata* and subangular or semicircular in *M. dilleniifolia*. Exine is of uniform thickness throughout in mesocolpium and poles except in *M. wightii* where it is thicker at poles. Exine in general is 1.5-2.5 μm thick except in *M. dilleniifolia* from Kumaon (U. P.) where it is ± 1 μm thick. *M. dilleniifolia* from Simla and Chakrata (Jaunpur div.) have 1.5 μm thick exine. However, exine thickness of pollen grains of *M. dilleniifolia* does not exceed 1.5 μm. Tectum is always thicker than the columella layer except *M wallichii* and *M. pungens* where tectum layer is equal to columella layer. Below the tectum layer there is a uniform layer of short, distinct columella layer. Columella heads are distinct in majority of the species studied but fuse to form flat and fine reticulation in mesocolpium and with distinct columella heads leading to coarse reticulation at poles in *M. lanceolata*. Sculptural pattern in the genus is either coarsely or finely reticulate. Exine obscure or ± microreticulate in *M. dilleniifolia* and *M. colletiana*. In reticulate pollen grains, reticulation is generally homobrochate, but heterobrochate having finer

(*Contd.*)

7	8	9	10	11	12	13	14	15
1	0.5	0.5	ret.	1-1.5	Slit	2	Lalong.	Endoap. tap. eq. margins.
1	0.5	0.5	f. ret.	0.5-1	Slit	2	Lalong.	Col. heads distinct at poles.
1	0.25	0.5	f. ret.	0.5-1	Slit	2.8	Lalong.	Endoap. tap. at eq. margin. mat. from Sri Lanka are larger (30 × 22.5 μm).
1	0.25	0.5	ret.	1-1.5	Tap.	3	Lalong.	Colpal membrane gr.
1	0.5	0.5	ret.	1	B. Slit	2.3	Lalong.	Colpal membrane provided with single row of granules.
1	0.5	0.5	ret.	1-2	B. Slit	2.5	Lalong.	Colpal membrane provided with single row of granules.
0.75	0.5	0.5	ret.	1-2	Slit	2	Lalong.	Col. distinct at poles.
1	0.5	0.5	ret.	1-1.25	B. Slit	2.5-3	Lalong.	Some gr. present in endoap. area.
1	0.25	0.75	ret.	1-2	Tap.	3	Lalong.	Endoap. very large, nearly fusing each other.

Abbreviations used: ap.—Aperture; B. slit—Broad slit; Cir.—Circular; Col.—Columella; E.—Equatorial diameter; Ex.—Exine; Endex.—Endexine; Endoap.—Endoaperture, Ectoap.—Ectoaperture, eq.—equator; f. ret.—finely reticulate ; gr.—granulose; Mat.—material, Neg. ret.—Negetively reticulate, Nex.—Nexine; obs.—obscure;P.—Polar axis length; Pol.—Pole;Pro.—Prolate; Pro. Sph.—Prolate-spheroidal; ret.-reticulate; ssp.—Subspecies; sph.—Spheroidal; Subang.—Subangular; Tap.—Tapering; Tec.—Tectum; var.—variety.

reticulation towards aperture in *M. squamulata* and reticulation coarser at poles than mesocolpium in *M. wightii* and *M. lanceolata*. Colpa long, narrow or broad slit-like in majority of the species but broad tapering in *M. polyptera*, *M. nitida* and *M. squamulata*. Colpa generally uniform but constricted at equator in *M. nitida* and *M. colletiana*. Granules on colpal membrane, though not a constant character for the genus, are observed in *M. simplicifolia*, *M. pungens*, *M. arnottiana*, *M. polyptera* and *M. squamulata*. Granules, when present, are either generally randomly distributed on colpal membrane or oriented in a single row in *M. simplicifolia* and *M. pungens*. *M. myriantha* differs from all other species of *Meliosma* having operculum-like thickened patch on either side of colpal breadth at equator.

From the above observation it is evident that Sabiaceae is a stenopalynous family. Homogeneity in palynological features reveals that circumscription of the family (*sensu* BENTHAM & HOOKER f.) together with those genera is quite a natural grouping. Though *Sabia* and *Meliosma* have many common palynological characters with overlapping data and finer details, exine in *Sabia* is thinner and with comparatively finer reticulation than *Meliosma* in general. It has also been observed that pollen grains in *Meliosma* is lobate in polar view in most of the cases whereas it is generally circular or subangular in *Sabia*. Out of 21 species studied from *Meliosma*, 16 species have lobate outline. Such lobate type of pollen grains with coarse exine ornamentation may be designated as the *Meliosma*

pollen type proper. But it would not be wise to treat these characters only in favour of creating a new and independent family.

Pollen morphology of some other families which are discussed elsewhere as the related family by the taxonomists have also been considered with the view to better understanding of the systematics of the family Pollen grains of the families like Hippocastanaceae, Menispermaceae, Sapindaceae, Melianthaceae, Aceraceae, Schizandraceae, Lardizabalaceae are different as referred from literature or from personal observation. Pollen grains of Hippocastanaceae are comparable to Sabiaceae in granulated colpal membrane only, which is rather not a common feature in Sabiaceae. Granulated colpal membrane is also observed in some taxa of Burseraceae (MITRA *et al.*, 1977), Leguminosae (MITRA *et al.*, 1979-80) and in Resedaceae (MITRA, 1976). But exine, aperture and general form are quite different. Lardizabalaceae comparable to Sabiaceae by granules on colpal membrane and shape only. Pollen grains of *Platea* and *Ottoschulzia* of this family are comparable to sabiaceous pollen grains in shape, aperture and exine characters but other genera are quite different. Some taxonomists placed the family next to or prior to Anacardiaceae. Pollen morphology is also suggestive to keep the family in approximation with Anacardiaceae. Pollen grains of *Gluta* and *Melanorrhoea* are similar with sabiaceous pollen grains in general shape, size, P/E ratio, exine and aperture characters. Rectangular type of endoaperture in *Gluta* is a common characteristic feature in Sabiaceae. Slit-like colpa in "Wrayi type" and "Laxiform type" (BAKSI, 1976) with median constriction is also evidenced in Sabiaceae. Lalongate rectangular type of endoaperture, exine and single row of granules on colpal membrane in species of *Buchnania* and *Schinus* reminds some pollen type in Sabiaceae. Other species studied from Anacardiaceae differ from Sabiaceae in striate or striatoreticulate exine.

Other biosystematical data of the palynologically related families

Anatomically *Sabia* differs from *Meliosma* in number of characters like mesophyll cells in leaves, pericycle in axis, xylem fibre and xylem rays, etc. Other important anatomical features are similar. So, anatomical feature also does not strengthen to place them in two different families. For interfamiliar relationship, HEIMSCH (1942) and others suggested the Anacardiaceae as the closest family anatomically. Embryological features of Sabiaceae are common as in several dicotyledonous families. JOHNSON (1977) placed the family in Sapindales together with Anacardiaceae on embryological characters.

Cytological reports so far at hand [DARLINGTON & WYLIE (1955), GAJAPATHY (1962), BORGMANN (1964), FUNABIKI (1958), RAJU (1952), SUGIURA (1936) and FEDEROV (1969)] are insignificant and mostly from different species of *Meliosma*. Chromosome number so far known is n=16 and 2n=32 for *Meliosma* and 2n=24 for *Sabia*. But MEHRA *et al.* (1969) reported n=8 in *M. wallichi* and in other four species they reported n=16. The constancy in chromosome number reveal that the taxa are stable ones and speciation caused by structural changes in chromosome. Members of the Anacardiaceae like *Rhus, Sorindeia, Spondias*, etc. reported to have 2n=32 chromosomes [MANGENOT & MANGENOT (1962), BANERJEE (1936) and SIMMONDS (1954)]. Other members of Sapindaceae have 2n=28 or 32 mostly. For making a critical relationship between the families a detail karyotype analysis is necessary. It is impossible to make any further conclusion for the family from cytological point of view.

CONCLUSION

From the foregoing discussion it is apparent that retention of the family Sabiaceae in Terebinthales/Sapindales complex and near to Anacardiaceae is justified. However, the circumscription of the order Terebinthales and Sapindales is different from author to author; whatever may be the placement of the family, either in Terebinthales or in Sapindales, it is quite frequent that the taxonomists treat Anacardiaceae and Sapindaceae together in the same order irrespective of arrangement of the families.

Palynological observation and comparative analysis of morphological and taxonomical characters are suggestive to draw the following conclusions:

—Pollen morphological data provide no support for introducing two separate families Sabiaceae and Meliosmaceae.

—Specific and even generic seggregation is not possible for the two genera palynologically (at least with the light microscopic study).

—Pollen morphological features remind the phylogenetic relationship as proposed by BENTHAM & HOOKER f. (l.c.), WALLICH (l.c.) & PLANCHON (l.c.).

—Treatment of the family adjacent to Anacardiaceae is justified.

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MATERIAL STUDIED :

Sabia campanulata Wall. India : Sikkim, Herb. Sulp. Kurz, CAL—97401;Tongloo, Dr. King's col. s.n. CAL—97402; N.W. Himalaya, Mackinnon, P.W.—s.n. CAL—97386 (20. 5. 1897); Darjeeling, Osmastan, B.B.—s.n. (31. 5. 1903); Bashahr, N. W. Himalaya, Lace, J.H.—893; Garhwal, Nathani, B.D.—47967; Chamba, N. W. Himal., Lace, J.H.—1733; NEFA, Kameng F.D., Panigrahi, G.—6849; Arunachal, Rao, R.S.—10381; Nepal : Banerjee, M. L.—570253. *S. gracilis* Hemsl. China : Tungtge, Fl. of Kweichow, Tsiang, Y.—5072. *S. japonica* Maxim. C. China : Dr. Aug. Henry's col.—5421; 5421C; Dr. Aug. Henry's col.—6022. *S. lanceolata* Coleb. India: Tripura, D. B. Deb—1693; Assam, Panigrahi, G.—11263; 22370; Kanjilal—s.n. CAL—97479; Abor expedition, J.H. Burkill—37021; 37469; Dr. Prain's col.—346; Illegible no.—457, CAL—97459; Shillong, Joseph, J. —48306; 48852; 48339; Sikkim, Dr. King's col. s.n. CAL—97486; Bangladesh :

Sylhet, C. B. Clarks—42172; Burma: Shalik Mokim—8; 26; Capt. SM. & Toppin, R. H.—4478. *S. leptandra* Hook. f. & Th. India : Kalimpong, Gamble, J.S.—2694; Clarke, C.B.—26433C (B); Sikkim, King, G.—s.n.—1881; King, G.—s.n. CAL—97422; Gamble, J.S.—7603; Smith, W. W.—502; Darjeeling, Lace, J. H.—2457. *S. limoniacea* Wall. India : Tripura, D.B. Deb—27298; Mizoram, D.B. Deb—31208; Meghalaya, Khasi hills, JDH & Th. s.n. CAL—97502; Nagaland, Dr. Prain's col.—626; W. Bengal, Haines, H. H,—506; Bangladesh : Clarke, C. B.—18005; Chittagong, Khan, M.S.—827. *S. paniculata* Edgew. India : Sikkim, Rubu & Rhomoo—3610; Haines, H.H. 502; Illegible No.—358 (9. 1. 1876); King, G. s.n. (1869); Manipur, Meebold, A.—6474; Meebold, A.—s.n.—CAL—97520; Kurseong, Modder, E.H.C.—s.n. CAL—97518; Kumaon, Strachey, R.—2; Dehra Dun, Gamble, J.S.—24075; Mackinnon, P.W.—s.n.—CAL—97523; 97524; Siwalik, N.W. Himalaya, Das Parameshwar—122; Nepal: Burkil, I.H.—29516 (1907). *S. parviflora* Wall. India: Sikkim, Lister, J.L. s.n. April—1878, CAL—97446; Majumdar, N.C. et Dutta—382; King, G.—2344; King, G.—s.n. (8. 4. 1876); Assam, Debi valley—F. King, Downward—7990; Khasi hills, Collet, H.—s.n.—CAL—97439; E. Himalaya, Cave, G. H.—s.n.—CAL—561784 (19. 4. 1920); s.n.—CAL—561785 (1. 5. 1918); Bhutan : Sengupta, G.—1146; Borneo : Havilland, G.D.—1218. *S. purpurea* Hook. f. & Th. India : Sikkim, S. Kurz, s.n. Herb. Sulp. Kurz. CAL—97429; Cave, G.H. s.n.—(12. 3. 1916); Khasi hills, Colett, H. s.n. CAL—97436; Kalimpong, Illegible s.n. CAL—97428; Assam, Ganunie, G. A.—338; Clarke, C.B.—43378A; China : Dr. Aug. Henry's Col.—5265. *S. yunnanensis* Franch. C. China; Dr. Aug. Henry—5421; 6290; Yunnan, Plantae Formes tianae—15711, CAL—97578; Flora of E. Tibet & S. W. China, George Forest—4721 4707.

Meliosma buchnanaefolia Kurz. India : Khasi hills, Illegible—s.n.; CAL—97886. *M. colletiana* King. Burma : Badal Khan s.n. CAL—97906. *M. dentata* Urban, Mexico : Pringle, C. G.—6381, State of Morelos, CAL—97958. *M. dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *dilleniifolia*. [*M. dilleniifolia* (Wall. ex. W. & A.) Walp.] India : Kumaon, Colett, H.—s.n. CAL—97592; Chakrata, NIL, CAL—97588; Simla, NIL, CAL—97595; Bangladesh : Griffith—1027; Nepal : Puri, V.—646; Rao, R. S.—14132. *M. dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *cuneifolia* (Franch.) Beus. Stat. nov. [*M. cuneifolia* Franch.] China : George Forest—23037, 21346. *M. dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *tenuis* (Maxim.) Beus. stat. nov. [*M. tenuis* Maxim.] Japan : Prov. Senanc. Tschonoski—1864; China : Hunan, Dr. Aug. Henry's Col.—7540, 6000. *M. lanceolata* Bl. var. *lanceolata* f. *lanceolata* [*M. lanceolata* Bl.] Mal. Peninsula : Griffith—s.n. CAL—97851; NIL, CAL—97854; Maingay, A.C.—361; Malacca : Ridley, H.M.—6341; Java : Forbes, H.O.—596, 1185, 1218; Singapore : Kelantan Kuala Rek, Md. Hanif et al.—10190; Ridley, H. N.—1892, 347, 3876. *M. lancifolia* Hook. f. Malaya : Maingay, A. C.—463/2. *M. lepidota* Bl. ssp. *squamulata* (Hance) Beus. Stat. nov. [*M. squamulata* Hance] China : Herb. of Lingnan Univ. Lung. T, au et shan s.n. CAL—97937 (det.—E. D. Merrill). *M. multiflora* Merrill, Philippines :Luzon, Alcasid *et al.* 1623, 1834 (det.—E. D. Merrill); Sulit, M.D.—7470; Santos, J. K.—31783; Merrill, E.D.—1751; Curran *et al.*—18118, Elmer, A.D.E.—8819. *M. myriantha* Sieb. & Zucc. ssp. *myriantha* Sieb. & Zucc. [*M. myriantha* Sieb & Zucc.] China : Hainan, Tsang Wai Tak—902; Dr. Aug. Henry's col.—5863, 5929, 5849A, 7550; Tsusima island, St. of Korea, Wilford, C.—1859, s. n. CAL—97899; Tsiang tan—365. *M. nitida* Blume, Mal. Peninsula : Rev. Father Scortechini—s.n. CAL—97823, CAL—97824; Dr. King's Col.—2707, 1051, 4153, 5661, 5657, Perak, Wray L. (Jr.)—3399, 4048; Maingay, A.C.—461; Penang, Curtis, C.—2836; Kunstler, H.—5301, 6944, 3260; Singapore : Ridley, H.N.—6342, s.n.—CAL—97872, s.n. CAL—97873. *M. obtusifolia* Kurg & Urban, America : Sintenis, P.—4039, 5326 (det.—I. Urban). *M. pinnata* (Roxb.) Walp. ssp. *pinnata* [=*M. pinnata* Roxb.] India : Assam, Herb. of E. India Company, NIL, CAL—97746; Panigrahi, G.—9592, 9619; Mann, G.—s.n.—CAL—97750; NIL, CAL—97757; Manipur, George Watt.—6916; Arunachal, Deb. D. B.—25782; Meghalaya, Rao, A.S.—38728; Sikkim, Biswas, K.—9235, King, G.—865, 187; Haines—531; Nagaland, Hook, M. A.—772; Bhutan : King, G.—187; Bangladesh : Chittagong, Dr. King's col.—443. *M. pinnata* (Roxb.) Walp. ssp. *arnottiana* var. *arnottiana* [*M. arnottiana* Wight] India : Nilgiri, Sebastine, K.M.—3173; Annamalai, Barber, C.A.—5861; Tamilnadu, Illegible—s.n. CAL—97798; Burma : Smales, C. B. 180; Lace, H. J.—3205; Sri Lanka : R.W.—293, CAL—97799. *M. polyptera* Miq. Sumatra : Diepenborst—2872 HB. *M. simplicifolia* (Roxb.) Walp. ssp. *simplicifolia* [=*M. simplicifolia* (Roxb.) Walp] India : Assam, Biswas, K.P.—1461; Prazer, J. C. s.n. (1880); s.n. CAL—97674; Seal, S.—80, 320, 361; Illegible No.—58, CAL—97664; Colett, H.—81; Watt, G.—10419; Burkill, I.H.—36626, 37416, 35976; Kingdonward, F.—11238; Meghalaya, Panigrahi, G.—19293; W. Bengal. Cowan, J. M. *et* Forest, A. C.—3; Sikkim, Smith, N. W.—607; Manipur, Meebold, A.—5579; Visakhapatnam, Balakrishnan, N. P.-723 ; Orissa, Nigirda, Panigrahi, G.-12565 Nagaland, NIL, No.-1303, CAL-97661 ; Burma : Biswas, K. P.—1023; Sri Lanka : NIL, CAL—97641, Devidse Gerrit—8450; China : Wang, C. W.—77878. *M. simplicifolia* (Roxb.) Walp. ssp. *pungens* (Wall. ex W. & A.) Beus. stat. nov. [—*M. pungens* Wall.] India : Garhwal, King, G.—s.n. CAL—97613; NEFA, Kameng, Rao, R. S.—8045; NIL, No.—15809; NIL, No.—6918; B.S.I. E. C.—15809; Panigrahi, G.—15809, 6918; Sikkim, King, G.—187; Rao, R. S.—380; N.

Sylhet, C. B. Clarks—42172; Burma: Shalik Mokim—8; 26; Capt. SM. & Toppin, R. H.—4478. *S. leptandra* Hook. f. & Th. India : Kalimpong, Gamble, J.S.—2694; Clarke, C.B.—26433C (B); Sikkim, King, G.—s.n.—1881; King, G.—s.n. CAL—97422; Gamble, J.S.—7603; Smith, W. W.—502; Darjeeling, Lace, J. H.—2457. *S. limoniacea* Wall. India : Tripura, D.B. Deb—27298; Mizoram, D.B. Deb—31208; Meghalaya, Khasi hills, JDH & Th. s.n. CAL—97502; Nagaland, Dr. Prain's col.—626; W. Bengal, Haines, H. H,—506; Bangladesh : Clarke, C. B.—18005; Chittagong, Khan, M.S.—827. *S. paniculata* Edgew. India : Sikkim, Rubu & Rhomoo—3610; Haines, H.H. 502; Illegible No.—358 (9. 1. 1876); King, G. s.n. (1869); Manipur, Meebold, A.—6474; Meebold, A.—s.n.—CAL—97520; Kurseong, Modder, E.H.C.—s.n. CAL—97518; Kumaon, Strachey, R.—2; Dehra Dun, Gamble, J.S. —24075; Mackinnon, P.W.—s.n.—CAL—97523; 97524; Siwalik, N.W. Himalaya, Das Parameshwar—122; Nepal: Burkil, I.H.—29516 (1907). *S. parviflora* Wall. India: Sikkim, Lister, J.L. s.n. April—1878, CAL—97446; Majumdar, N.C. et Dutta—382; King, G.—2344; King, G.—s.n. (8. 4. 1876); Assam, Debi valley—F. King, Downward—7990; Khasi hills, Collet, H.—s.n. —CAL—97439; E. Himalaya, Cave, G. H.—s.n.—CAL—561784 (19. 4. 1920); s.n.—CAL 561785 (1. 5. 1918); Bhutan : Sengupta, G.—1146; Borneo : Havilland, G.D.—1218. *S. purpurea* Hook. f. & Th. India : Sikkim, S. Kurz, s.n. Herb. Sulp. Kurz. CAL—97429; Cave, G.H. s.n.—(12. 3. 1916); Khasi hills, Colett, H. s.n. CAL—97436; Kalimpong, Illegible s.n. CAL—97428; Assam, Gammie, G. A.—338; Clarke, C.B.—43378A; China : Dr. Aug. Henry's Col.—5265. *S. yunnanensis* Franch. C. China; Dr. Aug. Henry—5421; 6290; Yunnan, Plantae Formes tianae—15711, CAL—97578; Flora of E. Tibet & S. W. China, George Forest—4721 4707.

Meliosma buchnanaefolia Kurz. India : Khasi hills, Illegible—s.n.; CAL—97886. *M. colletiana* King. Burma : Badal Khan s.n. CAL—97906. *M. dentata* Urban, Mexico : Pringle, C. G.—6381, State of Morelos, CAL—97958. *M. dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *dilleniifolia*. [*M. dilleniifolia* (Wall. ex. W. & A.) Walp.] India : Kumaon, Colett, H.—s.n. CAL—97592; Chakrata, NIL, CAL—97588; Simla, NIL, CAL—97595; Bangladesh : Griffith—1027; Nepal : Puri, V.—646; Rao, R. S.—14132. *M. dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *cuneifolia* (Franch.) Beus. Stat. nov. [*M. cuneifolia* Franch.] China : George Forest—23037, 21346. *M. dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *tenuis* (Maxim.) Beus. stat. nov. [*M. tenuis* Maxim.] Japan : Prov. Senanc, Tschonoski—1864; China : Hunan, Dr. Aug. Henry's Col.—7540, 6000. *M. lanceolata* Bl. var. *lanceolata* f. *lanceolata* [*M. lanceolata* Bl.] Mal. Peninsula : Griffith—s.n. CAL—97851; NIL, CAL—97854; Maingay, A.C.—361; Malacca : Ridley, H.M.—6341; Java : Forbes, H.O.—596, 1185, 1218; Singapore : Kelantan Kuala Rek, Md. Hanif et al.—10190; Ridley, H. N.—1892, 347, 3876. *M. lancifolia* Hook. f. Malaya : Maingay, A. C. —463/2. *M. lepidota* Bl. ssp. *squamulata* (Hance) Beus. Stat. nov. [*M. squamulata* Hance] China : Herb. of Lingnan Univ. Lung. T, au et shan s.n. CAL—97937 (det.—E. D. Merrill). *M. multiflora* Merrill, Philippines :Luzon, Alcasid *et al.* 1623, 1834 (det.—E. D. Merrill); Sulit, M.D.—7470; Santos, J. K.—31783; Merrill, E.D.—1751; Curran *et al.*—18118, Elmer, A.D.E.—8819. *M. myriantha* Sieb. & Zucc. ssp. *myriantha* Sieb. & Zucc. [*M. myriantha* Sieb & Zucc.] China : Hainan, Tsang Wai Tak—902; Dr. Aug. Henry's col.—5863, 5929, 5849A, 7550; Tsusima island, St. of Korea, Wilford, C.—1859, s. n. CAL—97899; Tsiang tan—365. *M. nitida* Blume, Mal. Peninsula : Rev. Father Scortechini—s.n. CAL—97823, CAL—97824; Dr. King's Col.—2707, 1051, 4153, 5661, 5657, Perak, Wray L. (Jr.)—3399, 4048; Maingay, A.C.—461; Penang, Curtis, C.—2836; Kunstler, H.—5301, 6944, 3260; Singapore : Ridley, H.N.—6342, s.n.—CAL—97872, s.n. CAL—97873. *M. obtusifolia* Kurg & Urban, America : Sintenis, P.—4039, 5326 (det.—I. Urban). *M. pinnata* (Roxb.) Walp. ssp. *pinnata* [=*M. pinnata* Roxb.] India : Assam, Herb. of E. India Company, NIL, CAL—97746; Panigrahi, G.—9592, 9619; Mann, G.—s.n.—CAL—97750; NIL, CAL—97757; Manipur, George Watt.—6916; Arunachal, Deb. D. B.—25782; Meghalaya, Rao, A.S.—38728; Sikkim, Biswas, K.—9235, King, G.—865, 187; Haines—531; Nagaland, Hook, M. A.—772; Bhutan : King, G.—187; Bangladesh : Chittagong, Dr. King's col.—443. *M. pinnata* (Roxb.) Walp. ssp. *arnottiana* var. *arnottiana* [*M. arnottiana* Wight] India : Nilgiri, Sebastine, K.M.—3173; Annamalai, Barber, C.A.—5861; Tamilnadu, Illegible—s.n. CAL—97798; Burma : Smales, C. B. 180; Lace, H. J.—3205; Sri Lanka : R.W.—293, CAL—97799. *M. polyptera* Miq. Sumatra : Diepenborst—2872 HB. *M. simplicifolia* (Roxb.) Walp. ssp. *simplicifolia* [=*M. simplicifolia* (Roxb.) Walp] India : Assam, Biswas, K.P.—1461; Prazer, J. C. s.n. (1880); s.n. CAL—97674; Seal, S.—80, 320, 361; Illegible No.—58, CAL—97664; Colett, H.—81; Watt, G.—10419; Burkill, I.H.—36626, 37416, 35976; Kingdonward, F.—11238; Meghalaya, Panigrahi, G.—19293; W. Bengal. Cowan, J. M. *et* Forest, A. C.—3; Sikkim, Smith, N. W.—607; Manipur, Meebold, A.—5579; Visakhapatnam, Balakrishnan, N. P.-723 ; Orissa, Nigirda, Panigrahi, G.-12565 Nagaland, NIL, No.-1303, CAL-97661 ; Burma : Biswas, K. P.—1023; Sri Lanka : NIL, CAL—97641, Devidse Gerrit—8450; China : Wang, C. W. —77878. *M. simplicifolia* (Roxb.) Walp. ssp. *pungens* (Wall. ex W. & A.) Beus. stat. nov. [=*M. pungens* Wall.] India : Garhwal, King, G.—s.n. CAL—97613; NEFA, Kameng, Rao, R. S.—8045; NIL, No.— 15809; NIL, No.—6918; B.S.I. E. C.—15809; Panigrahi, G.—15809, 6918; Sikkim, King, G.—187; Rao, R. S.—380; N.

W. Himalaya, NIL, Herb. Sulp. Kurz.; Mackinnon—s.n., CAL—97610; Kumaun, Gill, N.—575; Jaunsar div., Forester, T. W.—21; Laiq Ram—s.n.; CAL—97612 (Ref. Kanjilal flora—123). Mussorie, Robson, S.—7; Mackinnon, P. W.—s.n. May 1895. CAL—97609. *M. simplicifolia* (Roxb.) Walp. ssp. *rigida* (Sieb. & Zucc.) Beus. stat. nov. [=*M. rigida* Sieb. & Zucc.] China : Herb. Fan. Memorial Inst. of Biol. Peiping China—53349; Wang, C. W.—67495. *M. wallichii* Planch. India : Assam, Herb. Sulp. Kurz.—233; Panigrahi, G.—16126; Meghalaya, Clarke, C.B.— 44673B, 44673 J; Herb. Sulp. Kurz. s.n. CAL—97784; Sikkim, King, G.—187; Illegible—803B, CAL—97787; Darjeeling, Gamble, J.S. s.n. CAL—97789; Tamil Nadu, Shetty, B.V.—10305; Sebastine, K.M.—3173. *M. wightii* Planch. India : Tamil Nadu, Sebastine, K. M.—3227, 2589, 4024; Herb. Wight. Peninsular India orientalis, NIL, CAL—97827; Maharashtra, Hock.—s.n. CAL—97628; Sri Lanka : Illegible s.n. CAL—97623; Cramer, L.H.—4464.

EXPLANATION OF PLATE—1. (×1600)

1-3. *Sabia japonica* Maxim. Fig. 1. Aperture and details of exine. Fig. 2. Optical section meridicnal and aperture profile. Fig. 3. Optical section equatorial.
4-6. *S. leptandra* Hook. f. & Th. Fig. 4. Aperture and details of exine. Fig. 5. Details of exine. Fig. 6. Optical section meridional and aperture profile.
7-8. *S. gracilis* Hemsl. Fig. 7. Aperture and details of exine. Fig. 8. Same in the 2nd focus.
9-12. *Meliosma lepidota* Bl. ssp. *squamulata* (Hance) Beus. Fig. 9. Optical section equatorial. Fig. 10 & 11. Details of exine. Fig. 12. Optical section meridional and aperture in profile.

EXPLANATION OF PLATE 2. (× 1600)

1-3. *Sabia limoniacea* Wall. Figs. 1 & 2 Aperture and details of exine. Fig. 3. Optical section meridional.
4-5. *Meliosma dilleniifolia* (Wall. ex W. & A.) Walp. ssp. *tennuis* (Maxim) Beus. Fig. 4. Optical section meridional and aperture profile. Fig. 5. Optical Section equatorial.
6-8. *M. simplicifolia* (Roxb.) Walp. ssp. *pungens* (Wall. ex W. & A.) Beus. Fig. 6. Aperture and details of exine. Fig. 7. Optical section meridional and aperture profile. Fig. 8. Optical section equatorial.

TEXT-FIG.—1

Aperture types in Sabiaceae (diagrammatic).

1. a. *M. rigida, S. japonica ;* b. *M. pungens, M. tenuis ;* c. *M. wightii, M. dilleniifolia, M. buchnanaefolia, S. paniculata ;* d. *M. squamulata, S. gracilis* e. *M. lancifolia, M. wallichii ;* f. *M. nitida, M. colletiana ;* g. *M. arnottiana, M. pungens, M. obtusifolia ;* h. *M. simplicifolia, M. squamulata, M. polyptera ;* i. *M. arnottiana, M. dilleniifolia, S. yunnanensis ;* j. *M. myriantha, S. limoniacea ;* k. *S. campanulata ;* l. *S. parviflora ;* m. *M. wightii, S. leptandra ;* n. *S. lanceolata.*


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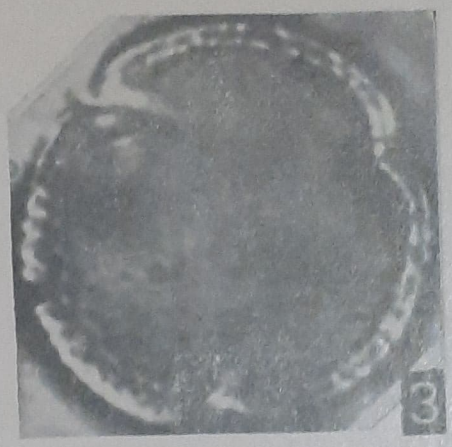
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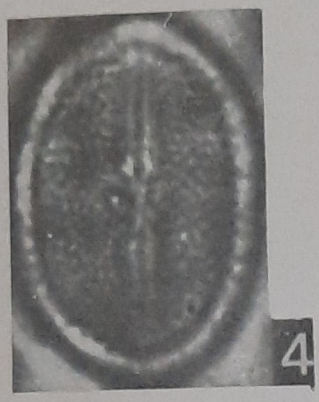
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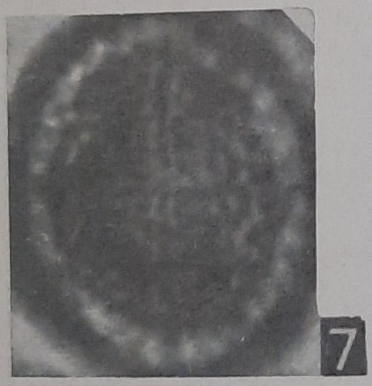
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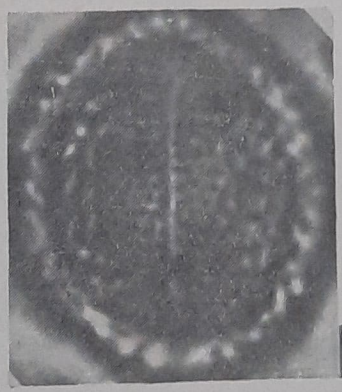
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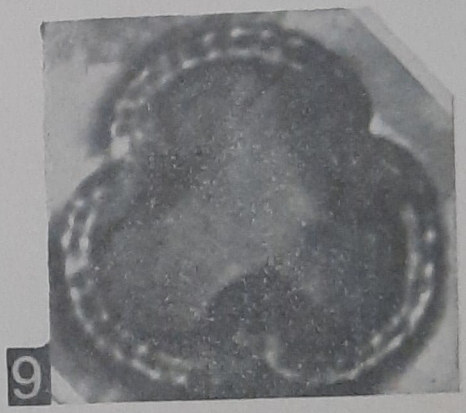
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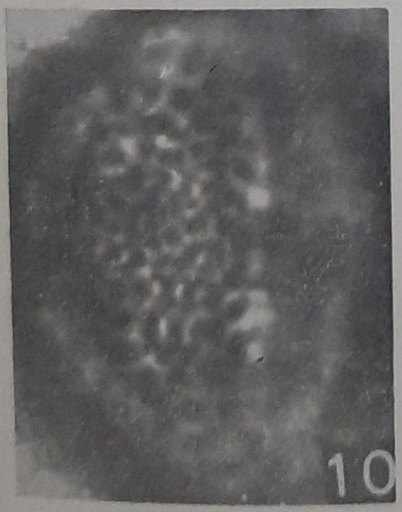
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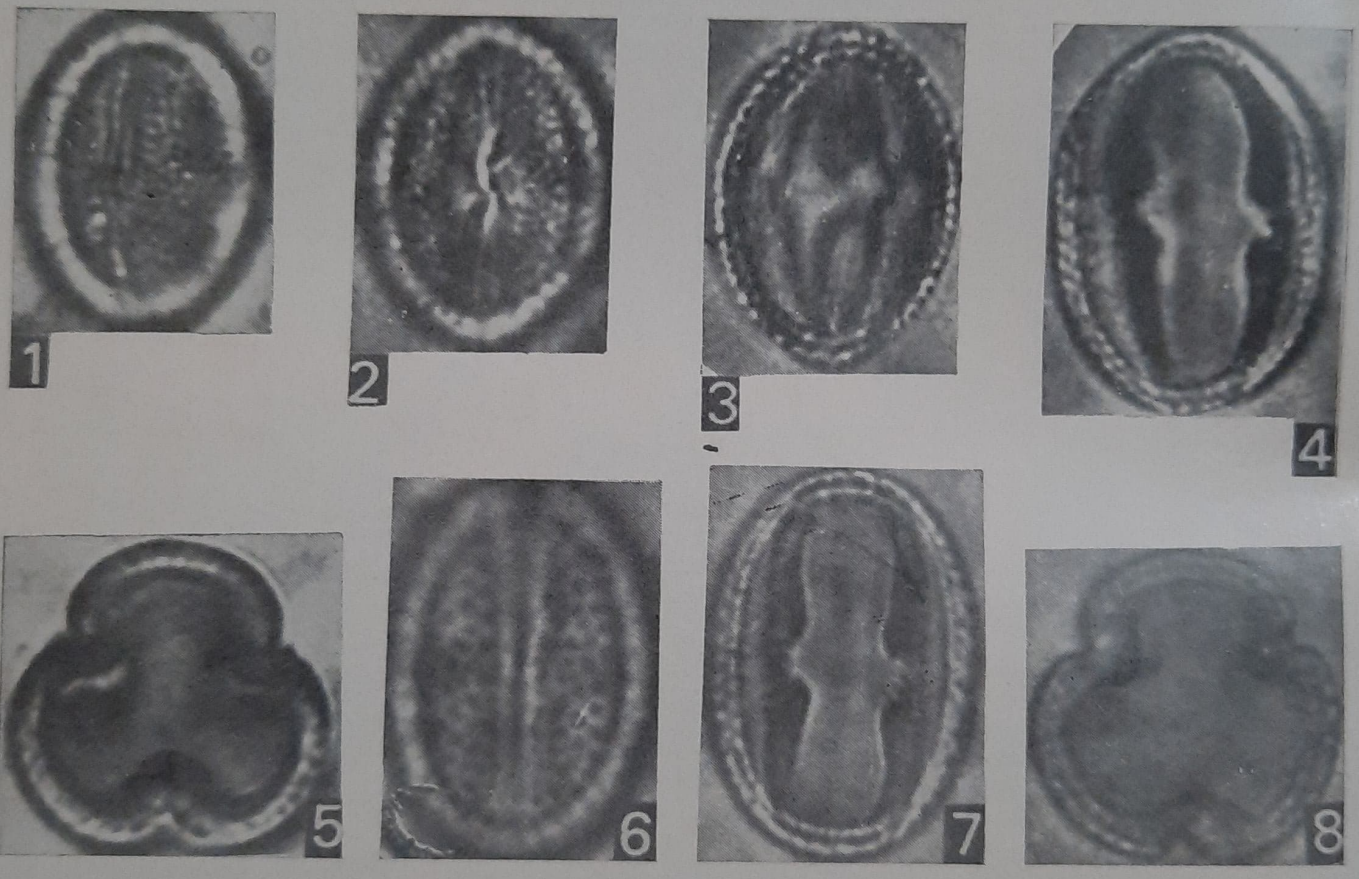
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