PART I

CONTRIBUTION OF THE POLLEN MORPHOLOGY TO SYSTEMATIC RELATIONSHIP OF SABIACEAE WITH REFERENCE TO PLANT GEOGRAPHY
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INTRODUCTION

Palynological information on the family Sabiaceae, so far available, is meagre up till now. The family has been treated differently from taxonomic and systematic points of view from time to time. In the present study an attempt has been made to investigate in detail the morphology of pollen grains of the family, in order to find out affinities and relationships on pollen characters. It is expected that there might be fossil pollens of this family, though not yet assigned, as lot of fossil representatives have been described from the genus Meliosma. So this study will also be helpful to identify the fossil pollens in future.

REVIEW OF LITERATURE

PALYNOLOGY:

Chen (1943) in his revision of the genus Sabia Colebrooke, describes the pollen grains of Sabia - the type genus of the family, for the first time as - "Globose to ellipsoid, when globose vary from 24 to 31 μm in diam; when ellipsoid 27-33 x 22-29 μm in size. The surface varies from almost smooth to finely medium or even massively pitted, the pores being rounded - oblong."

His observations were made on the pollen of six species - Sabia philippinensis C.B. Robinson, S. serriflora Wall., S. javanica (Bl.) Baker, S. campanulata Wall.,
S. kachinica Chen and S. lanceolata Colebr., none being closely allied to each other with the exception of the first two. Erdtman (1952) has given a diagnosis of the pollen types of Meliosma and Sabia which are based however on a few samples. It appears that these pollen types very much resemble each other, and similar types also occur in several other families. Ikuse (1956), described pollens of Sabia and Meliosma of Japan. Guinet (1962) described pollen grains of Meliosma from India and Huang (1968) one sp. each of Sabia and Meliosma of Japan. He described the pollen grains of Sabia swinhoei Hemsl. as prolate - subprolate, 26 - 30 \( \mu m \times 19 - 22 \mu m \), amb. circular, exine 1.5\( \mu m \) thick and Meliosma squamulata Hance as subprolate to prolate - spheroidal, 23 - 28\( \mu m \times 20 - 25 \mu m \), exine 2\( \mu m \) thick. Palacios (1968) described pollen grains of Meliosma. Muller (1971) investigated about 25 species of Meliosma and could find only minute differences. He suggested the necessity for detailed work covering as many species as possible from the family.

**TAXONOMY:**

The family Sabiaceae was first proposed and described by Blume (1851). He described the only taxon Sabia Colebrooke (Meniscosta Bl.) and stated:

"Genus typum parvi ordinis inter Menispermaces et Lardigabalaceas medii exhibens. Auctores alii Terebirthaceis, Sapindaceis alii illud annumeravere, etsitam habitus, quam maxime fructus fabrica affinitatem cum Menispermacis indicat." But Planchon (1849, 1855), Bentham & Hooker f. (1862), Warburg (1896) and others expanded the family with four recognised genera: Sabia, Meliosma, Phoxanthus and Phloxocarvon. Phoxanthus Benth. and Phloxocarvon Schomb. are monotypic genera from Brazil and Guiana. Meliosma Bl., with about one hundred and thirty to forty described species and quite few infraspecific taxa (sensu Beusekom 1971), is the largest genus.
Endlicher (1840) proposed the designation of a subgroup - Meliosmeae under Sapindaceae to include Meliosma Bl. He did not treat this taxon as having independent family status. Further he treated Sabia as genus anomalous under Anacardiaceae.

Planchon (1849) listed Llavea PlANCH. (= Meliosma Bl.), Ophiocaryon Schomb. and Sabia celebr. (Meniscosta Bl.) as constituting - "Un groupe naturel auquel nous conservons le nom de Meliosmeés, créé par Endlicher pour le seul genre Meliosma, et subordonne y par lui an titre plus général de Sapindacées," and stated that its affinities were not with the Sapindaceae. Later on Planchon (1855), when discussing the position of Ophiocaryon, stated - "On place, d'ordinare les Meliosmeés parvi les Sapindacées, on du moins sont à côté d'elles." After discussing its relationship with various families now placed in the Sapindales and certain genera of the Anacardiaceae, he concluded: "Par ces raisons et par l'analogie de facies, Je placerais volontiers les Meliosmeés à la suite des Terebinthacées".

Miers (1853) thought that the Sabiaceae was intermediate between the Menispernaceae and the Lardizabalaceae.

Bentham & Hooker (1862) accepted the family name Sabiaceae and included four genera Sabia, Meliosma, Phoxanthus and Ophiocaryon and placed the family in between the Sapindaceae and Anacardiaceae.

Warburg (1896) recognised the genera as Bentham & Hooker (l.c.) and placed the family in the Sapindaceae between the Sapindaceae and Melianthaceae.

Wettstein (1935) placed the family in the order Terebinthales following the Sapindaceae, Aceraceae and Hippocastanaceae. Hutchinson (1926) suggested no change in position, leaving it in the Sapindales following Sapindaceae and the
Aceraceae. In the 3rd edition of his book he placed the family just before
Anacardiaceae.

Wallich (1824) suggested that Sabia resembles the Terebinthaceae
(= Anacardiaceae) because of its general characters and the presence of small
coloured puncared glands.

de Candolle (1825) merely listed the genus Sabia in his treatment of
this family among the allied and insufficiently known genera.

Meissner (1836-1843) retained the genus Sabia as an anomalous one in
the Anacardiaceae. Hook.f. & Thomson (1855) suggested that it was intermediate
between the Schizandraceae and the Menispermaceae. Baillon (1874) limited his
subsidiary group II Sabieae to Sabia and Meliosma, retaining the Sabieae in
the Sapindaceae.

Planchon (l.c.) proposed that the genus Sabia should be placed in the
family "Meliosmeae" following the Anacardiaceae and he seemed to be the first
botanist to suggest what all future investigators have accepted as the proper
place of the genus i.e. - in alliance with Meliosma Bl.

Benson (1957) placed the family under Sapindales in between Hippocastan-
aceae and Melianthaceae. Engler (1964) treated the family Sabiaceae in between
Hippocastanaceae and Melianthaceae under the order Sapindales. Sabia under the
tribe Sabieae and Meliosma, Phoxanthus and Cophiocaryon under the tribe
Meliosmateae. Thorne (1968) placed the family under Futaes. Treatment of the
family under different order by different authors is given in Table I. Johnson
(1977) treated the family under Sapindales in between Sapindaceae & Melianthaceae.
He recognised 4 genera and 70 species. Takhtajan (1969) treated the family
Sabiaceae in Sapindales and placed next to Melianthaceae and Greyiaceae.
<table>
<thead>
<tr>
<th>Author</th>
<th>Terebinthales</th>
<th>Sapindales</th>
<th>Rutales</th>
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<tr>
<td>Wallich (1824)</td>
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<tr>
<td>(Discussed about Sabia only)</td>
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<td>Planchon (1855)</td>
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<tr>
<td>Bentham &amp; Hooker (1862 - 1883)</td>
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<td>Warburg (1895)</td>
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<tr>
<td>Wettstein (1935)</td>
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<td>Hutchinson (1926)</td>
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<td>Benson (1957)</td>
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<td>Engler (1964)</td>
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<td>Thorne (1968)</td>
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<td>Takhtajan (1969)</td>
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<td>Dahlgren (1975)</td>
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</table>
He mentioned that "systematic position of the Sabiaceae is uncertain."

Dahlgren (1975) placed the family Sabiaceae in Sapindales under his Rutinae.

Cufodontis (1959) and How (1955) revised Chinese Meliosma only. There are two important revisions on the family (in part). One is of Sabia by Chen (1943). 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 representatives of Sabia belong to Sect. Odontodiscus.

Another revision by Van Beusekom (1971) of Meliosma. Beusekom (l.c.) divided the genus Meliosma into 2 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. For convenience a synopsis of the infrafamilial classification as well as recognition of genera by different authors is given in the Table - 2.

However in widely used systems, the Botanists accepted Warburg's (1896) treatment for placing the genus Sabia in Sabiaceae - Sabieae and Meliosma, Phozanthus and Ophiocaryon in the Sabiaceae - Meliosmeae. He placed the family in between Sapindaceae and Melianthaceae under the order Sapindales.

Hooker f. (1876) in The Flora of British India followed the system of Bentham & 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 returned to the earlier concept of a monotypic family Sabiaceae Bl. with about 55 species of Sabia and introducing a separate family Meliosmaceae which includes 2 genera, Meliosma (100 spp.) and Ophiocaryon ( = Phozanthus ) (2 Spp.). According to
<table>
<thead>
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<th>Table - 2</th>
<th>Synopsis of the Intr familial classification with recognition of genera by different authors</th>
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<tr>
<td>Sabia: Staminia 4-5.</td>
<td>Sabia: Staminia 4-5, all perfect and equal.</td>
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<tr>
<td>Chan (1943) (Treated Sabia only) Sabiacae: Meliosma :</td>
<td>Sabia: Staminia 4-5, all perfect and equal.</td>
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<td>Meliosma:</td>
<td>Sabia: Staminia 4-5, all perfect and equal.</td>
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<td>Ovarium 2-3-loculare,样式 recte.</td>
<td>Ovarium 2-3-loculare,样式 recte.</td>
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<tr>
<td>Hunsham (1959) Sabiacae: Meliosma</td>
<td>Sabia: Staminia 4-5, all perfect and equal.</td>
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<tr>
<td>Beusekom (1971) (Treated Meliosma only) Sabiacae: Meliosma</td>
<td>Sabia: Staminia 4-5, all perfect and equal.</td>
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<td>Meliosma:</td>
<td>Meliosma:</td>
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<td>Subg. Meliosma</td>
<td>Subg. Meliosma</td>
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<td>Sect. Melianae</td>
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<td>Subsect. Similares</td>
<td>Subsect. Similares</td>
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<td>Ser. Rectinervia</td>
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<td>Ser. Curvlinervia</td>
<td>Ser. Curvlinervia</td>
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<tr>
<td>Subsect. Xiphtetae</td>
<td>Subsect. Xiphtetae</td>
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<td>Subg. Kingboroughia</td>
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<td>Sect. Henderonia</td>
<td>Sect. Henderonia</td>
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<td>For details of the character for the arrangements, the reader is referred to Beusekom (1971).</td>
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<td>Phoranthus:</td>
<td>Phoranthus:</td>
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<td>Petala elliptica to orbicularia, not tailed, stigmas contiguous.</td>
<td>Petala elliptica to orbicularia, not tailed, stigmas contiguous.</td>
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<td>Opheioceryon</td>
<td>Opheioceryon</td>
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<tr>
<td>BB. Inner petals different from outer much smaller, style will developed</td>
<td>BB. Inner petals different from outer much smaller, style will developed</td>
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<tr>
<td>Meliosma</td>
<td>Meliosma</td>
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</table>

For details of the family and generic characters and comments the reader is referred to Airy Shaw (1973).
him Sabiaceae is an interesting group showing possible or probable connections with Menispermaceae, Icacinaceae, Meliosmaceae etc. Minute obscure gland dots resemble Myrsinaceae. He stated that the relationship between Sabiaceae and Meliosmaceae requires confirmation.

Regarding the possible relationship of the Sabiaceae with other families, Van Beusekom (l.c.), Chen (l.c.) and other say that there is no consensus of opinion. Most authors have related them (especially Meliosma) to the Sapindaceae, Hippocastanaceae or Anacardiaceae, other assume a relationship with families like Menispermaceae, Lardizabalaceae, Icacinaceae and Schisandraceae.

PHYTOGEOGRAPHICAL NOTES AND FOSSIL RECORDS

PHYTOGEOGRAPHY:

The family Sabiaceae is characteristic of certain tropical and sub-tropical regions of the Old world, having no representative within Africa and Madagascar, Australia, Polynesia and the New world. Map 1 showing world distribution of Sabiaceae, after Beusekom (1971) & Haywood (1978) and Map 2 showing geographical area of species investigated in the present study.

The type genus Sabia contributes about 55 species and Meliosma, the largest genus of the family, is represented by total species of about 100 (Airy Shaw 1973). Hutchinson (1969) estimated 150 species for Meliosma.

Phytogeographical history reveal that Sabia Coblerooke is mainly confined to the Indo Malaysian and Indo Chinese regions. Chen (1943) mentioned that Sabia reached its highest development in China. He tabulated 36 species.
Map - I. World distribution of Sabiaceae [After Beusekom (1971) and Heywood (1978)]
Map 2. Geographical area of species investigated (Sabinaeae) in the present study.
and 9 varieties from China with maximum in Southwest province Yunnan, where 21 species are now known. Stapf, O. in early 1920 possibly (unpublished) had indicated 24 Chinese species deposited in the Kew Herbarium (Chen 1943).

More than half of the now known species of Sabia are confined to China. Present record for India, is 10 species. 10 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. Chen (l.c.) stated that 'It may be confidently expected that additional species will be found in China as exploration progress, but it may be doubted if many additional new forms will be found in the periphery of the generic range, especially in the east and South, such as Japan and Formosa, the Philippines, Malaysia and Pauasia'.

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. (1876) 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 from 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 extending from North India to Burma, Siam, Malay peninsula, Sumatra, Yunnan and including its var. ardisioides Chen to Kwangsi, Kwangtung, Hainan to Hongkong in China. The later extending from Northern India to Burma, Yunnan, Kweichow, Kwangsi, Indochina and Borneo and including 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. Map 3 shows the world distribution of Meliosma (After Beusekom 1971). The world generic range is from Northern India down to Ceylon in east and southeast to Korea, Japan, Malaysia and New Guinea.

Beusekom (1971) in his revision of S.E. Asian Meliosma (American sect. Lorenzanea excluded) reduced 100 previously recognised species into his 15 species, 2 subgenera, 4 sections, 2 subsections and 2 series and several subspecies with number of local races. Beusekom (l.c.) came to a conclusion that both the subgenera have biceentric origin and originated with number of unrelated genera (homologous). Hence 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 entering 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 and Eastern India and a few in Western India. (Map 3 shows the world distribution of subg. Meliosma
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 family 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. 11 species of Meliosma of which 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 Ghashi (l.c.) reported 5 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.

**FOSSIL RECORDS:**

Paleobotanical literature so far at hand reveal 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 collection localities of fossil Meliosma are situated on 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 fossil 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 heterogeneous floristic composition, for instance tropical genera as Cinnamomum, Meliosma & Diospyros and some temperate, genera as Ulmus, Prunus and Acer etc. In such cases it is hard to analyze the floristic composition and probable climatic conditions of the past under which these floras lived, because such genera cover several climatic zones.

Up till now 3 tentatively placed endocarp and about 40 leaf impressions have been described, of which Meliosma aesculifolia Chaney & Sanborn, M. californica Berry and M. cantilensis Reid and Chandler are the endocarp organ genera and M. cuneata (Newb.) Berry M. europea C. & E.M. Reid M. myriantha Sieb & Chandler M. goschenensis Chaney & Sanborn are important leaf impressions. Cain (1944) reported 133 individuals of Meliosma goschenensis Chaney & Sanborn from Goshen flora.

Beusekom (1971) mentioned that most of the fossil endocarps described so far are doubtlessly belong to subg. Kingsboroughia sect. Kingsboroughia where
as none could relate to sect. *Hendersonia*. From subg. *Meliosma* not only endocarps but leaf imprints are also abundant. All endocarps referable to sect. *Meliosma* none of sect. *Lorenzana* (sensu Beusekom 1971) have yet been found. The fossil leaves on the other hand are referable to both sect. *Meliosma* and *Lorenzana* but not to sect. *Meliosma* subsect. *pinnatae*.

On the basis of palaeobotanical as well as physiognomical evidences Beusekom (1971) 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**

Present work deals with 222 materials from 31 of the species' genera *Sabia* and *Meliosma* palynologically. All the Indian species as mentioned in the Hooker's Flora of British India except a few which are not available in the Indian Herbaria and some American and Chinese materials have been studied. Map 2 shows the localities of plant species studied for the present work. Allied families, which are discussed as related to this family, have been studied either in this part or in the part II, where these families have better implication for understanding and resolving the relationship.

Pollen slides were prepared and studied as per general schedule as given at the beginning.
MORPHOLOGICAL CHARACTERS OF THE GENERA STUDIED

Deciduous or evergreen scandent shrub in Sabia, very rarely erect.

Evergreen trees or shrubs in Meliosma. Leaves always exstipulate, alternate, simple, entire, membranaceous to coriaceous in Sabia and alternate imparipinnate or sometimes simple in Meliosma. Leaflets in Meliosma opposite, entire or serrated.

Flowers regular, bisexual, small or very small usually in axil, few to many flowered cymes, more rarely in a small panicle or simple raceme in Sabia and small, bisexual or polygamodioecious (sensu Airy Shaw) in compound panicle in Meliosma. Calyx 5, imbricate, small in Sabia and calyx 4-5, imbricate, persistent in Meliosma. Corolla (4-)5(-6), imbricate, large or sometimes thickish, opposite to the sepal in Sabia and corolla 4-5, opposite the sepals, imbricate, unequal, rounded, the 2 inner small and sometimes bifid in Meliosma. Stamens (4-)5(-6), opposite the petals and attached to their base, with ovoid or oblong, extrorse or introrse anther in Sabia and stamens 5, opposite the petals, unequal, free or adnate at the base to petals, 2 larger perfect, 3 smaller (opposite the larger petals.) without anther, filament flattened, anther large globose in Meliosma. Ovary superior 2 celled, ovoid to conical, with 2 terminal erect + coherent styles and simple stigma and 2 collateral or superposed horizontal semianatropous ovule per locule in Sabia and ovary superior, 2-3 celled, with straight simple or 2-3 fid stigma and 2 axil superposed horizontal or pendulous ovule per locule in Meliosma. Fruit in Sabia of 2 flattened dorsally gibbous drupaceous carp., exocarp fleshy, endocarp crustaceous and conspicuous, sculptured or pitted, whereas in Meliosma an obliquely subglobose 1 seeded drupaceous with long endocarp. Seeds in Sabia reniform, testa coriaceous, dotted, embryo curved, cotyledons straight or incurved flat
rugose or undulate, radicle cylindric in contrast to globose, membranaceous testa, embryo sometimes spirally contorted, cotyledons conduplicate and incurved radicle of *Meliosma*.

**Generic circumscription of the family differs from author to author.** A scheme of infrafamilial subdivisions with generic key (where available) by different author is depicted in the table 2 in previous chapter (next to page 17).

**OBSERVATION AND DISCUSSION.**

Two genera studied for the present problem are categorised into two different subdivision (*sensu* Bentham & Hooker f. 1862), Sabiaceae- Sabiae with the type genus *Sabia* only and Sabiaceae - Meliosmae with *Meliosma* - the largest genus in the family. *Ophiocaryon = Phoxanthus* (*sensu* Airy Shaw l.c.) with two species only (Brazil and Guiana) is placed in the latter subdivision and is not studied at present for want of material. For detail distinguishing characters of the genera see Table 2.

Palynologically these two genera are very uniform. Most of the characters are overlapping each other which keep in a trouble for characterising the *Sabia* and *Meliosma* pollen type. It leads to a conclusion that these two genera are very homogeneous from palynological point of view and suggestive for a natural grouping in keeping them in a single family. From numerical data analysis it is evident that exine ornamentation in *Sabia* is finer in comparison to *Meliosma* (though not always) having comparatively finely reticulate or sometimes obscure exine ornamentation.
Aperture types are variable and interesting for both the genera. Different aperture types met in this study is given in the Fig. 2.

Detailed pollen morphological characters of individual genera with notes on interspecific palynological variations are described below.

An artificial key is given at the end of the description and discussion of each genus. This key is absolutely tentative and artificial as most of the characters are almost overlapping and is subject to modifications as and when more material become available to work out.

GENERAL POLLEN CHARACTERS

SABIA: (Plate - I, Figs. 1-16; Plate - II, Figs. 1-16; Plate - III, Figs. 1-4 ).

Shape: Subprolate to prolate in equatorial view, subangular or circular in polar view, medium sized, range P x E z 21 - 34 x 15.5 - 29\,\mu \text{m}, P/E ratio = 1.03 - 1.75. Aperture: 3 colporate, Colpi: long, slit like, sometimes tapering; extending up to poles, occasionally with costae. Endocaperture: Generally lalongate, rectangular with rounded ends, rarely indistinct or circular. Exine: (1) 1.5-2\,\mu \text{m} thick, semitectate. Pattern: Mostly fine, sometimes coarsely and rarely negative reticulate. Coarse reticulation due to distinct columella heads (thick muri). Reticulation homobrochate, with a few exception heterobrochate - having fine pattern towards aperture. Sporoderm: Sexine thicker than nexine, tectum (0.5\,\mu \text{m}) - 0.75 - 1\,\mu \text{m} thick, columella short, 0.5\,\mu \text{m}, distinct with rare exception, nexine 0.5 - 0.75\,\mu \text{m} thick. Detailed palynological data have been depicted in the Table 3.
MATERIALS STUDIED:

Sabia campanulata Wall. India: Sikkim, Herb. Sulp. Kurz, CAL - 97401; Tonglou, Dr. King's col. s.n. CAL - 97402; N.W. Himalaya, Mackinnon, F.W. - s.n. CAL - 97386 (20.5.97); Darjeeling, Osmastan, B.B. - s.n. (31.5.1903); Basahar, N.W. Himalaya, Lace, J.H. - 832; Garhwal, Nathani, B.D. - 47767; Chamba, N.W. Himal., Lace, J.H. - 1733; NEFA, Kameng F.D., Panigrahi, G. - 6849; Arunachal, Rao, R.S. - 10581; Nepal: Banerjee, M.L. - 570253.

S. gracilis Hemsl. China: Tungtge, Fl. of Kweichow, Tsiang, Y. - 5072.


S. lanceolata Coleb. India: Tripura, D.B. Deb - 1693; Assam; Panigrahi, G. - 11263; 22570; Kanjilal - s.n. CAL - 97479; Abor expedition, J.H. Burkhill - 37021; 37469; Dr. Prain's col. - 346; Illegible no. - 457, CAL - 97459; Shillong: Joseph, J. - 46306; 48832; 48839; Sikkim, Dr. King's col. s.n. CAL - 97486; Bangladesh: Sylhet, C.B. Clarke - 42172; Burma: Shalik Mokim - 8; 26; Capt. SM. & Toppin, R.H. - 4478.

S. leptandra Hook.f. & Th. India: Kalimpong, Gamble, J.S. - 269A; 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; Misoram, 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. panicalata Edgew. India: Sikkim, Rubu & Rhomoo - 3610; Haines, H.H. - 502; Illegible No. - 358 (9.1.76); 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; Macinnon, P.W. - s.n. CAL - 97523; 97524; Siwalik, N.W. Himalaya, Das Parmeshwar - 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, donward - 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. - (12.3.16); Khasi hills, Colett, H. s.n. CAL - 97456; Kalimpong, Illegible s.n. CAL - 97428; Assam, Gammie, G.A. - 358; Clarke, C.B. - 43378A; China: Dr. Aug. Henry's Col. - 5265.

S. yunnanensis Franch. C. China: Dr. Aug. Henry - 5421; 6290; Yunnan, Plantae Formae tianae - 15711, CAL - 97578; Flora of E. Tibet & S.W. China, George Forest - 4721, 4707.

Sabia is the type and 2nd largest genus of the family. Palynology of 79 materials distributed over 10 species from India, Bangladesh, Nepal, Bhutan and China were studied. It shows constant palynological features and naturally very narrow range of variations in pollen morphology.

In most of the species the polar axis range is 25 - 32 \( \mu m \) but in S. limoniacea it is 21 - 26 \( \mu m \). 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 to 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 thick but in S. vunnanensis, 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 or nexine. Columella height decreases from mesocolpium 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 exine 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 up to poles and without costa but in S. lentandra and S. limoniacea it is costae colpate. Occasional long tapering colpi have been observed only in S. vunnanensis 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 tappered equatorial end is observed in some materials (not always) of S. vunnanensis.
A TENTATIVE PALYNOLOGICAL KEY FOR THE SPECIES OF SABIA

A. Exine pattern obscure ...
   B. Exine negatively reticulate (OL) ...
   C. Reticulation coarse (Lumina size more than 1μm)
      D. Homobrochate ...
      E. Lumina finer towards aperture ...
      F. Exine thickness 1.5μm or below ...

   AA. Exine pattern reticulate
      B. Exine not negatively reticulate (LO)
      C. Reticulation fine (Lumina size up to 1μm)
         D. Equatorial axis range from 15.5 - 18μm ...
         E. Circular in polar view ...
         F. Exine thickness above 1.5μm
   
   S. gracilis
   S. japonica
   S. paniculata
   S. perviflora
   S. limoniacea
   S. purpurea
   S. yunnanensis
   S. leptandra
   S. campanulata

MELIOSMA: (Plate - III, Figs. 5-15; Plate-IV, Figs. 1-16; Plate - V, Figs.1-12).

Shape: Subprolate to prolate in equatorial view. Lobate or subangular in polar view, medium sized, range P x E = 21 - 32 x 17 - 25μm; P/E ratio = 1.1 - 1.58. Aperture: 3 colporate, Colpi: long, extending up to poles,
narrow slit to broad slit like, exceptionally broad and tapering. Colpi generally devoid of any processes or granules, sometimes with granules on colpal membrane. Colpi uniform, rarely with equatorial constriction. Endoaperture: Distinct, large, lalongate, rectangular with rounded ends, rarely indistinct lalongate or indistinct circular. Exine: 1.5 - 2.5 μm thick, semitectate. Pattern: finely or coarsely reticulate, rarely obscure. Ornamentation generally homobrochate, rarely heterobrochate, being finer towards aperture or coarser at apocolpium than the mesocolpium. Sporoderm: Sexine thicker than nexine, tectum 0.75 - 1.5 μm thick, columella short and distinct 0.5 - 0.75 μm high, indistinct with rare exception, nexine 0.5 - 0.75 μm thick. Detailed palynological data have been tabulated in the Table 3.

MATERIALS STUDIED:

Meliosma buchhanaracfolia Kurz. India: Khasi hills, illegible - s.n.; CAL - 97886.
M. colletiana King. Burma: Padal Khan s.n. CAL - 97906.
M. dentata Urban, Mexico: Pringle, C.G. - 6581, 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. tenuis Maxim. Japan: Prov. Senanc, Tschonoski - 1864; China:
  Hunan, Dr. Aug. Henry's Col. - 7540, 6000.
M. lanceolata Bl. var. lanceolata f. lanceolata


M. lepidota Bl. ssp. squamulata (Hance) Beus. Stat. nov.

M. multiflora Merrill, Philippines: Luzon, Alcasid et al. 1622, 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. China: Hainan, Tsang Wai Tak - 902; Dr. Aug. Henry's Col. - 5865, 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.) - 3599, 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. pinnata (Roxb.) Walp. ssp. pinnata
= M. pinnata Roxb. India: Assam, Herb. of E. India Company, NIL, CAL - 97746; Panigrahi, G. - 9592, 9519; Mann, G. - s.n. - CAL - 97750; NIL, CAL - 97757; Manipur, George Watt. - 6916; Arunachal, Deb. D.B. - 25782;
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: Smale; 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; Frazer, J.C. s.n. (1880); s.n. CAL - 97674; Seal, S. - 80, 320, 361; Illegible No. - 58, CAL - 97664; Colett, H. - 61; 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, Mebold, A. - 5579; Visakhapatnam, Balakrishnan, N.P. - 723; Orissa, Nigirda, Panigrahi, G. - 12565; Meghalaya, 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.

Meliosma is the largest genus of the family. Pollen morphology of 143 materials distributed under 21 species from India, Sri Lanka, Burma, Singapore, Malay Peninsula, Philippines, Nepal, China, Mexico, America, Korea and Japan have been observed for the present study. Palynologically the genus Meliosma shows quite reserve and uniform characters with very narrow range of variations in infrastructure of pollen morphology.

In most of the species the polar axis, 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. myriantha where it ranges from 17 - 21 μm. Subprolate to prolate pollen grains are common for the genus. Majority with elliptic oval outline and a few having compressed oval outline. Polar view for majority of the species in this genus is lobate but subangular in M. simplificifolia, 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 \( \mu \)m thick except in *M. dilleniifolia* from Kumaon (U.P.) where it is \( \pm 1 \mu \)m thick. *M. dilleniifolia* from Simla and Chakrata (Jaunpur div.) have 1.5 \( \mu \)m thick exine. However exine thickness of pollen grains of *M. dilleniifolia* does not exceed 1.5 \( \mu \)m. Tectum 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 an uniform layer of short, distinct columella. Columella heads quite 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 \( \pm \) microreticulate in *M. dilleniifolia* and *M. collatiana*. In reticulate pollen grains, reticulation is generally homobrochate, but heterobrochate having finer reticulation towards aperture in *M. squamulata* and reticulation coarser at poles than mesocolpium in *M. wightii* and *M. lanceolata*. Colpi long, narrow or broad slit like in majority of the species but broad tapering in *M. polyptera*, *M. nitida* and *M. squamulata*. Colpi generally uniform but constricted at equator in *M. nitida* and *M. collatiana*. 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 are 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.
A TENTATIVE PALYNOLGICAL KEY FOR THE SPECIES OF MELIOSMA

A. Exine pattern coarse reticulate

B. Reticulation homobrochate -

C. Pollens compressed oval in outline -
   D. Colpi broad, tapering
      ... M. polyptera
   D. Colpi narrow slit like
      E. Muri width greater than lumina
      ... M. dentata
      E. Muri width equal to lumina
      ... M. rigida

C. Pollens elliptic oval in outline -
   D. Colpi broad tapering -
      E. Colpi constricted at equator
      ... M. nitida
      E. Colpi not constricted at equator
      ... M. obtusifolia
   D. Colpi slit like -
      E. Colpal membrane granulated
      ... M. pungens
      E. Colpal membrane devoid of granules -
      F. Tectum thickness equal to columella height
      ... M. wallichii
      F. Tectum thicker than columella height ... M. multiflora (*)

B. Reticulation heterobrochate -

C. Lumina at mesocolpium and apocolpium region equal, fine towards aperture; Colpal membrane with randomly distributed granules
   ... M. squamulata

C. Lumina coarser at apocolpium than mesocolpium; Colpal membrane devoid of granules
   ... M. wightii
   ... M. lanceolata

A. Exine pattern fine reticulate

B. Pollen compressed oval in equatorial (meridional) outline
C. Pollen lobate in polar view
   D. Colpal membrane devoid of granules ... M. tenmuiss
   D. Colpal membrane granulated ... M. arnottiana
C. Pollen subangular in polar view
   D. Colpi constricted at equator ... M. colletiana
   D. Colpi not constricted at equator ... M. pinnata
B. Pollen elliptic oval in equatorial view
   C. Pollen lobate in polar view ... M. buchnianaefolia
   C. Pollen subangular in polar view ... M. cuneafolia
   D. Colpal membrane devoid of granules ... M. dilleniifolia
   D. Colpal membrane granulated
   E. Granules in single row ... M. simplisticifolia
   E. Granules in the form of thickened patch on either side of Colpal breadth ... M. myriantha

(*) Both Compressed oval as well as elliptic oval pollen grains occur in these species.
### TABLE 3

**SUMMARY OF SELECTED POLLEN MORPHOLOGICAL FEATURES OF SABIACEAE**

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</thead>
<tbody>
<tr>
<td><strong>SABIA</strong></td>
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<tr>
<td>samanulate</td>
<td>Pro.</td>
<td>Subang.</td>
<td>25-30</td>
<td>21-27</td>
<td>1.25-1.40 0.75 0.25 0.5</td>
<td>f.ret. 0.5</td>
<td>Slit 2</td>
<td>Lalang.</td>
<td>Colpi constricted at eq.</td>
</tr>
<tr>
<td>gracilis</td>
<td>Pro.sph.</td>
<td>Subang.</td>
<td>25-22.5</td>
<td>21-23</td>
<td>1.23-1.24 1 0.5 0.5</td>
<td>mag.ret (0.5)-1-1.5</td>
<td>Slit 2-3</td>
<td>Lalang.</td>
<td>Ret. finer around aperture, Col. heads distinct.</td>
</tr>
<tr>
<td>japonica</td>
<td>Sph.</td>
<td>Sugang.</td>
<td>28-31</td>
<td>25-28.7</td>
<td>1.03-1.20 0.75 0.25 0.5</td>
<td>ret. 1-2</td>
<td>Slit 2</td>
<td>Lalang.</td>
<td>Col. with distinct heads, particularly at poles.</td>
</tr>
<tr>
<td>lancolata</td>
<td>Pro.</td>
<td>Cir.</td>
<td>29-32</td>
<td>21-25</td>
<td>1.21-1.63 0.5 0.25 0.25</td>
<td>± Psilate</td>
<td>Slit 2.5</td>
<td>Lalang.</td>
<td>Col. indistinct.</td>
</tr>
<tr>
<td>leptigera</td>
<td>Pro.sph.</td>
<td>Subang.</td>
<td>28-34</td>
<td>22-27</td>
<td>1.03-1.36 0.75 0.25 0.5</td>
<td>f.ret. 0.5-1</td>
<td>Slit 2</td>
<td>Lalang.</td>
<td>Colpi constricted at eq.</td>
</tr>
<tr>
<td>lirionacea</td>
<td>Pro.sph.</td>
<td>Subang.</td>
<td>21-26</td>
<td>18.5-18.5</td>
<td>1.31-1.73 0.75 0.25 0.5</td>
<td>f.ret. 0.5-1</td>
<td>Slit 2</td>
<td>Lalang.</td>
<td>Heterobrochate, ret. finer towards aperture.</td>
</tr>
<tr>
<td>paniculata</td>
<td>Pro.</td>
<td>Subang.</td>
<td>26-31</td>
<td>22-27</td>
<td>1.40-1.53 0.75 0.25 0.5</td>
<td>ret. (0.5)-1-1.5</td>
<td>Slit 2.5</td>
<td>Lalang.</td>
<td>Heterobrochate, ret. coarser at poles (2-3.5 um)</td>
</tr>
<tr>
<td>verriflora</td>
<td>Pro.</td>
<td>Sugang.</td>
<td>29-33</td>
<td>29.75</td>
<td>1.45-1.52 1 0.5 1</td>
<td>ret. 1-1.5(-2.5)</td>
<td>Slit 2.5</td>
<td>Lalang.</td>
<td>Col. indistinct.</td>
</tr>
<tr>
<td>purpurea</td>
<td>Pro.</td>
<td>± Cir.</td>
<td>22-32</td>
<td>20-23</td>
<td>1.21-1.60 0.5 0.25 0.5</td>
<td>f.ret. 0.5-1</td>
<td>Slit 2-3 ± Cir</td>
<td>Lalang.</td>
<td>Col. indistinct.</td>
</tr>
<tr>
<td>purpuranaensis</td>
<td>Pro.sph.</td>
<td>Subang.</td>
<td>25-30</td>
<td>22-25</td>
<td>1.20-1.35 0.5 0.25 0.25</td>
<td>f.ret. 0.5-1</td>
<td>Tap. 2.5-3</td>
<td>Lalang.</td>
<td>In one est. endoap. tap. at eq. margin.</td>
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<tr>
<td><strong>VELIOSA</strong></td>
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<tr>
<td>hypophanesfolia</td>
<td>Pro.</td>
<td>Lobate</td>
<td>35-27</td>
<td>20.21</td>
<td>1.25-1.34 0.75 0.25 0.5</td>
<td>f.ret. 0.5-1</td>
<td>Slit 1.8</td>
<td>Lalang.</td>
<td>Col. indistinct at mesocolplasm.</td>
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<td><em>Melhorna</em></td>
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<tr>
<td>collnesiana</td>
<td>Pro.</td>
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<td>1.31-1.6</td>
<td>0.25</td>
<td>0.5</td>
<td>0.2 or less.</td>
</tr>
<tr>
<td>Sentata</td>
<td>Pro.sph. Lobate</td>
<td>29.5-32.5</td>
<td>22-25.5</td>
<td>23.2</td>
<td>1.23-1.5</td>
<td>1</td>
<td>0.5</td>
<td>1-1.2(2) Slit. 2 La.long.</td>
<td></td>
</tr>
<tr>
<td>dillemifolia</td>
<td>Pro. Lobate</td>
<td>23-28.1</td>
<td>21-21.5</td>
<td>19</td>
<td>1.12-1.29</td>
<td>0.75</td>
<td>0.5</td>
<td>0.5-0.75 Slit. 2 La.long.</td>
<td></td>
</tr>
<tr>
<td>asp. dillemifolia</td>
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<tr>
<td>asp. superforlia</td>
<td>Pro. Lobate</td>
<td>26-29</td>
<td>27-27</td>
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GENERAL POLLEN MORPHOLOGICAL CHARACTERS OF THE FAMILY SABIACEAE

Shape: The pollen grains are isopolar, subprolate to prolate in equatorial view and either compressed oval or elliptic oval in forms (for clarification of forms vide Fig. 1). Subangular or lobate in polar view.

Aperture: Composite type (Colporate) and 3 in number. These are equatorially distributed (Zonal) and are equidistant. Detailed pollen morphological characters are given below.

1. Ektesine: The ektesine is differentiated into tectum and columella layer. Foot layer is not detectable. Columella layer is distinct with distinct columella heads mostly.

Tectum: Tectum forms a distinct layer and varying from 0.5 μm to 1.5 μm in thickness. Tectum thicker than columella layer mostly but sometimes it is equal to columella height. It is semi-tectate type and conforms a distinct layer with distinct or fused columella heads.

Ornamentation: The sculptural pattern of the sporoderm in the family is either coarsely reticulate or finely reticulate or obscure. The genus Sabia represents comparatively more fine exine ornamentation than Meliosma. The genus Meliosma on the other hand possesses coarse or fine exine ornamentation in equal proportion. One species of Sabia has interestingly negatively reticulate exine and another species has obscure exine. Reticulation is either homobrochate or heterobrochate. When heterobrochate it is sometimes finer around aperture or coarser at apocolpium than mesocolpium.

Columella layer: The columella layer is distinct with distinct heads and unbranched, which stands on thin and uniform layer of nexine. Columella layer
forms a compact, thick and firm tectum layer by the fusion of the columella heads.

2. **Endexine**: The endexine forms a distinct, thin and uniform layer. Sometimes endexine is very thick in the apertural area in both the genera to form costae colpate type of aperture.

3. **Aperture**: The apertures are composite type, present in both ektexine and endexine layers, 3 in number. Apertures are variable in forms, with or without costae. Different apertural diversities evidenced in the family have shown in the Fig. 2.

   **Ectoaperture**: The ectoaperture - colpus is distinct. It is either narrow slit like or broad tapering and extending up to poles. Aperture membrane either smooth or granulated. When granulated, granules are either in a definite orientation or randomly distributed.

   **Endoaperture**: The endoapertures are distinct except in few where equatorial outline is not so clearly demarcated. Generally large lalongate, rectangular type, circular or indistinct with rare exception.

Another genus of the family Ophiocarvon = Phoxanthus (not studied personally) reported to have subprolate (36 x 20 μ) pollen grains, sexine thicker than nexine, pattern indistinct (Erdtman - 1952).

**GENERAL CONCLUSION**

**Palynological findings:**

Present study in the family Sabiaceae has been carried out to establish its relationship, affinities and position on the pollen characters and correlating the palynological characters with the information available from other branches of Botany.
Fig. 2. Aperture types in the family Sabiaceae.
Moreover, palynological information of this tropical family was very meagre. Pollen grains of some other families have been considered (described in detail for part II, chapter 9) for better understanding of the relationship, affinities and taxonomic position of the family.

Present contribution covers all the considerable aspects of pollen morphological details in genera studied. From the present investigations, following conclusions can be made for the family.

1. Sabiaceae is a stenopalynous family. Homogeneity in palynological features reveal that circumscription of the family (sensu Bentham & Hooker f.) together with those genera is quite a natural grouping (Fig. 3).

2. Though Sabia and Meliosma have many common palynological characters with overlapping measurements and finer details, exine in Sabia is thinner and with comparatively finer reticulation than Meliosma in general. Distinct columella with distinct heads are common for Meliosma than Sabia.

3. Pollen in general are medium sized, subprolate to prolate in shape, isopolar, tricolporate, coarsely or finely reticulate. So, Sabiaceae represent a common type of pollens as evidenced in other families of dicotyledons also.

4. From the close comparison of the pollen types, it is possible to suggest some intrafamilial evolutionary trend or better called it a tendency from one form to the other.

**Evolutionary trends in the pollen morphology of Sabiaceae**

- **Shape**: Eq. view: A. Subprolate → Prospheoidal → Prolate.
  
  B. Form → Elliptic oval → Compressed oval.

- **Polar view**: Subangular → lobate.
Fig. 3. Pollen dimensional diagram of Sabiaceae
b. **Ectoaperture:**  
(i) long narrow slit → Broad tapering.  
(ii) without costa → costae Colpate.

c. **Endoaperture:**  
(i) Indistinct → Distinct.  
(ii) Lalongate → Circular.

d. **Exine:**

- **ornamentation:**
  
  (i) Microreticulate (finely reticulate) → coarsely reticulate.  
  (ii) Homobrochate → Heterobrochate.

- **lumina size**
  
  (a) Lumina size uniform throughout →  
  (b) lumina size decreases towards aperture.  
  (c) Lumina size increases in apocolpium → lumina fuse side by side to form linear lumina.

- **Muri thin** (upto 1μm) → **Muri thick** (more than 1μm.)

**Sporoderm:**

(i) Tectum thin → Tectum thick.  
(ii) Tectum equal to columella height → Tectum thicker than columella height.

There has been no effort here to establish which characters are evolutionarily advanced or what are primitive. It might be rather dangerous to call these trends evolutionary. They can be simply regarded as morphological traits.
OTHER BRANCHES OF BOTANY IN BETTER UNDERSTANDING OF THE RELATIONSHIP OF THE FAMILY.

ANATOMICAL EVIDENCES: Anatomical informations so far at hand are mainly contributed by Heimsch (1942), Metcalfe & Chalk (1950) and Baily (1957). Anatomically *Sabia* differs from *Meliosma* in number of characters. Mesophyll cells of *Meliosma* is composed of arm palisade cells together with somewhat variable spongy tissue, in contrast to *Sabia* where arm palisade cells absent except *S. campanulata*. Pericycle in axis of *Sabia* is with a composite and continuous ring of sclerenchyma but in *Meliosma* it is isolated strands of sclerenchyma. Xylem rays fairly broad (upto 20 cells) in *Sabia* but rather narrow (4-15 cells) in *Meliosma*. Fibre in *Sabia* provided with distinctly bordered pits, which are very numerous on both radial and tangential walls but in *Meliosma* with simple or very small bordered pits which are more numerous on the radial than on the tangential wall.

However, for interfamilial relationship most of the authors suggested the Anacardiaceae as the closest family. Heimsch (l.c.) states that in their wood structure Sabiaceae resemble certain of the Anacardiaceae and that if the family really belongs to the Terebinthales Complex, it would seem to be closest to that family.

EMBRYOLOGICAL EVIDENCES: A comparative embryological data available from the literature of different families of dicotyledonous plants have been shown in the Table 6 in the part II (Chapter -8, next to page 88). It is not possible to assign a definite close affinity for Sabiaceae from embryological characters because these characters are common for the several families in dicotyledonous plants. Johnson (1977) placed the family in Sapindales together with Anacardiaceae on embryological characters (Table 7 in Part II. Chapter-8, before page - 89).
CYTOLOGICAL EVIDENCES: Chromosome number and karyotype so far reported are very meagre and for different species of Meliosma mostly. Cytological reports so far at hand are by Darlington & Wylie (1955), Gajapathy (1962) Borgmann (1964), Funabiki (1958), Raju (1952), Sugiura (1956 a,b) and Federov (1969). In majority of the species chromosome number so far confirmed by different authors is n = 16. Darlington & Wylie (l.c.) reported only one species viz. 2n = 32 for *M. wightii* (= *M. simplicifolia* ssp. *pungens*) the basic number being X = 16. Borgmann (l.c.) reported an unknown species of *Meliosma* where 2n = 32 - 36. Sugiura (l.c.) reported 2n = 24 for *Sasia japonica*. Mehra et al. (1969) reported n = 8 in *M. wallichii* but in other 4 species they reported a constant number n = 16. Federov (l.c.) enumerates counts for *M. myriantha*, *M. simplicifolia* (= *M. simplicifolia* ssp. *simplicifolia*) and *M. tenuis* (= *M. dilleniifolia* ssp. *tenuis*) and in all the cases 2n = 32. The constancy in chromosome number reveal that the taxa are stable ones and speciation is caused by structural changes in chromosomes.

Members of the Anacardiaceae like *Rhus*, *Sorindeia*, *Spondias* as reported by Mangenot & Mangenot (1962) Banerjee (1956) and Simmonds (1954) possess 2n = 32 chromosomes. Some other members of Anacardiaceae have higher number. Some members of Sapindaceae like *Alectryon*, *Blichia*, *Dodonea* etc. have 2n = 32 chromosomes as reported by Guervin (1964), Mangenot & Mangenot (l.c.) and others. 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.

PALYNLOGICAL EVIDENCES: Before Muller (1971a), palynological informations were very insufficient. Muller (l.c.) studied 25 species of *Meliosma* and found very
minute difference and suggested for detail work including SEM study.

Present palynological investigations support the retention of the family in Terebinthales/Sapindales and near to Anacardiaceae. Most of the taxonomists are in full agreement for placing the family under Terebinthales complex. However, the circumscription of the orders Terebinthales and Sapindales is different from author to author. Those who place the family in Terebinthales, it is quite frequent that they treated Anacardiaceae and Sapindaceae also in the same order. Same is true for other authors also, who placed the family in Sapindales, they often treated the family Anacardiaceae, in Sapindales. So, it is clear that the authors placed these families together whatever may be the designation of the order. Now discrepancy remains in the placement of Sabiaceous amongst the families. Placement of the family in the order differs from author to author. Sometimes it has been placed in between Hippocastanaceae and Menispermaceae, sometimes in between Sapindaceae and Melianthaceae, sometimes in between Hippocastanaceae and Aceraceae, or in between Schizandraceae and Menispermaceae or in between Menispermaceae & Lardizabalaceae. The pollen grains of these families are different to some extent as referred from literature or from personal observation. (details in Part II, Chapter-9 ). Pollen grains of Hippocastanaceae are comparable to Sabiaceous in granulated colpal membrane only, which is rather not a common feature in Sabiaceous. Granulated colpal membrane is also observed in Burseraceae (Mitra et al. 1977), in Leguminosae (Mitra et al 1979 - 80) and in some taxa of Resedaceae (Mitra 1976). But exine, aperture and general form are quite different. Pollen grains of Menispermaceae and Schisandraceae are quite different from Sabiaceous pollen grains. Lardizabalaceae comparable to Sabiaceous by granules on colpal membrane and shape only. Pollen grains of Plateae and Ottoschulzia of this family are comparable to Sabiaceous pollen grains in shape, aperture characters and exine, but other genera are quite
different from the general pollen characters of Sabiaceae. Bentham & Hooker f. (l.c.) Wallich (l.c.), Planchon (l.c.) and other placed the family next to or prior to Anacardiaceae. Pollen morphology also suggestive to keep the family in approximation with Anacardiaceae.

Pollen grains of Anacardiaceae are similar to some extent with that of Sabiaceae. Baks^i (1976) worked on two genera of the family. Pollen grains of Gluta and Melanorrhoea is similar with that of Sabiaceous pollen grains in general shape, size, P/E ratio, exine thickness, reticulate to microreticulate exine and aperture characters. Rectangular type of endoaperture in Gluta is a common characteristic features in Sabiaceae. Slit like colpi in "Drayl type" and "Laxiflorum type " (sensu Baks^i l.c.) with median constriction is also evidenced in Sabiaceae. Lalongate rectangular type of endoaperture, exine and single row of granules in colpal membrane in species of Buchanania and Schinus reminds some pollen types in Sabiaceae. Other species studied from Anacardiaceae differ from Sabiaceae in striate to striato-reticulate exine.

MATERIALS STUDIED: (ANACARDIACEAE)

Anacardium occidentale Linn. IBG., Howrah, fresh, 9.8.68; Digha, W.B. Banerjee, R.N. - 25.


Dracontomalum mangiferum Bl. India, Cult. IBG. fresh, 14.2.68.

Mangifera andamanica King, Andaman, NIL sn. CAL - 98876.

M. Caesia Jack., Java: NIL s.n. CAL - 98907; Malay: Illegible CAL - 98863.


M. foetida Lour. Malay: NIL, CAL - 98841.

M. griffithii Hk. f. Malacca: NIL, CAL - 98784.
M. indica Linn. India: IBG, Cult. fresh 24.8.66; S. India, s.n. CAL - 98722.
M. Keranga Bl. Sumatra: NIL - CAL - 98872.
M. lagenifera Griff. Malay: Mukherjee, S.K. s.n. CAL - 98834.
M. longipes Griff. Malay: NIL, CAL - 98808.
M. longipetiolata King Malay: NIL, CAL - 98879.
M. microphylla Gri.. Malaypeninsula: NIL, CAL - 98828.
M. sclerophylla Hk.f. Malaya: NIL, CAL - 98787.
M. superba Hk. f. Malaya: NIL, CAL - 98869.
M. sylvatica Roxb. India: Khasia hills, Mukherjee, S.K. - 5021.
Schinus teraninthefolius Reddi. India: Cult. IBG, Howrah, fresh
Semecarpus anacardium Linn. f. Fresh, IBG, 10.11.65; Purulia, Mallick, C.P.- 1828.

CORRELATION OF POLLEN CHARACTERS WITH TAXONOMIC
AND OTHER EVIDENCES AND DISCUSSION

From the foregoing discussion it is quite apparent that the family Sabiaceae is very closely related to Anacardiaceae. Palynological observation and comparative analysis of morphological and taxonomical characters helped in drawing certain conclusion about the family.

--- Division of the family Sabiaceae into subsidiary group Sabiae and - Meliosmae is not firmly established palynologically.
Pollen morphological data provide no support for introducing two separate family Sabiaceae and Meliosmaceae as proposed by Endlicher in early days and Airy Shaw at present.

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

Pollen morphological features reminds 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.

In summing up this chapter, I like to mention that palynological data provide the preference for the retention of the family in between or adjacent to Anacardiaceae and Sapindaceae.

**SUMMARY**

Sabiaceae is strictly a tropical and subtropical family. It comprises of 4 genera - Sabia, Meliosma, Phoxanthus and Ophiocarvon (3 genera sensu Airy Shaw (l.c.) Ophiocarvon = Phoxanthus) and about 162 total species (sensu Airy Shaw l.c.). Type genus Sabia reached its highest development in China. More than half of the now known species of Sabia are confined to China, 11 species are known from British India. In India excluding Burma 9 species are recorded at present. One or two species is known from Japan, Formosa, Indochina, Thailand (Siam), the Malay peninsula, Sumatra, Java, Borneo, the Philippines and Maluccas, New Guinea and Solomon Islands. In Malay Archipelago including Philippines the genus is not strongly represented. In India most of the species of Sabia are reported from temperate & tropical Himalayan regions and only one
Other genus *Meliosma* is the largest genus in the family having 100 total species (sensu Airy Shaw *l.c.*) with number of infraspecific taxa (sensu Beusekom *l.c.*) distributed in tropics & subtropics of the world. Well flourished in Indo-Malaysian, Indo-Chinese and Mexico, Central America, West Indies and S. America. Old world generic range from Northern India to Ceylon eastward to Korea and Japan and Southward through Malaysia to New Guinea. Details distributional history, origin and dispersal have been discussed in Chapter III.

Two genera, *Sabia* and *Meliosma*, occur in India have been investigated palynologically in the present study. 222 materials from 31 species mainly from India and a few foreign taxa have been studied.

Taxonomically it is a natural family (sensu Bentham & Hooker *l.c.*) but disagreement lies as regards its naturalness, affinities and relationship within the general system of classification as well as its infraspecific recognition of taxa also (details has been shown in Table - 1 & Table - 2 in previous chapter.)

Present study is an endeavour to interpret these ambiguities on pollen morphological characters. Purpose of the present study is to make a critical evaluation of palynological characters in Indian Sabiaceae and correlate those findings with other relevant informations, mainly contributed by other authors for better understanding the relationship and taxonomic disputes of the family.

Palynology has succeeded to some extent in discarding or strengthening some disputed and controversial aspects associated with the systematic assessment of the family. Pollen grains of *Sabia* and *Meliosma* are very homogeneous palynologically with least infrastructural differences. In most of the cases the data are overlapping each other. The generic differences in between the two genera on
pollen morphological characters is practically beyond the limit of light microscopic observation. This work is exclusively based on light microscopy, as SEM and TEM facilities were not available. However, present work on light microscopic observation reveal that the family composition of Sabiaceae with Sabia and Meliosma (other genus Ophiocarvon = Phoxanthus (2 sp.) not studied) constitute a stenopalynous family and therefore a natural family. Pollen is medium sized, radially symmetrical, isopolar, microreticulate to coarsely reticulate (rarely obscure), lumina generally homobrochate, sometimes heterobrochate in being either gradual decrease towards aperture area from mesocolpium or by increase in lumina size from mesocolpium to apocolpium. 5-colporate, ectoaperture slit-like or tapering, extending up to poles, with or without costa, endoaperture distinct, mainly laalongate, rectangular type, rarely circular or indistinct. Generally devoid of granules on colpal membrane, sometimes with granules. When granulate, granules are either in a single row or randomly distributed.

Pollen morphology supports the familial circumscription as proposed by Bentham & Hooker (l.c.) with the genera Sabia and Meliosma together with other two monotypic genera (sensu Bentham & Hooker l.c.) not studied but not support author's subdivisions of the family into tribe Sabiae & Meliosmæae. Palynology also does not strengthen the circumscription of two different family Sabiaceae (monotypic) and Meliosmaceae (Meliosma, Ophiocarvon = Phoxanthus) of Airy Shaw (l.c.). These conclusions should be treated as proposed and tentative one. It needs details SEM study subject to modifications as more abundant materials covering all the species from different corner of the world becomes available in future.