PART II

POLLEN MORPHOLOGY OF CONNARACEAE IN RELATION TO TAXONOMY
AND PLANT GEOGRAPHY.
POLLEN MORPHOLOGY OF CONNARACEAE IN RELATION TO TAXONOMY AND PLANT GEOGRAPHY

REVIEW OF LITERATURE AND INTRODUCTION

PALYNOLOGY

Mohl (1834) in his "Beiträge Zur Anatomie und physiologie der Gewächse Erstes Heft Über den Bau und die Formen der Pollen Körner." described pollen grains of Connaraceae for the first time, as "Eiförmig, drei Falten, in Wasser dreistreifiges Oval". He studied only one species Gnetais glabra. Schnizlein (1843-70) also described few pollens of Connaraceae in his "Iconographia Familicarn Naturalium regni Vegetabilis". Bruck (1887) worked on stylar morphology of the family and mentioned the size difference of pollen grains in different whorls of stamens.

These ancient works, no doubt important and basic, are of little use due to lack of details. In recent years Erdtman (1952) worked out 6 species from 5 genera of which 3 genera occur in India. Chadeaud (1955) and Campos (1962) described only tropical Manotes and Connarbus from Cerrado respectively. Barth and Silva (1965) described pollen grains of Connarbus and Rourea from Brazil. Assemien (1966, 1971) described Connarbus and Agelaea from Afrique occidentale. Chlonova (1967) mentioned about the pollen grains of Jollydora and Sladkov (1967) worked on Manotes in relation to sporopollenin analysis. Huang (1967, 1972) described pollen grains of Rourea from Formosa and Taiwan. Labouriau (1973)
described *Connarus* and *Rourea* from Brazil. Forero (1976) and Fredoux (1977) provided some additional information on American species of *Rourea*. Dickison (1977) presented an overall discussion on pollen morphology of the family.

A perusal of the literature revealed that the palynological studies in this family was not sufficient and with this understanding this palynological work was selected for my Ph.D. thesis in the middle of 1978. Since this work was near completion, Dickison (1979) has published SEM as well as light microscopic data for the family. This is an excellent and significant contribution, no doubt. He studied 96 species from 16 genera.

In the present study an attempt has been made to investigate detailed morphology of the pollen grains of the Connaraceae in order to find out affinities and relationships on pollen characters from different approach which are lacking in the previous contribution. This work is mainly confined to the Indian Connaraceae and also Ceylon, Malaysia, Philippines and Bangladesh. A few African, American & Chinese materials have also been studied.

The impact of my work is somewhat diminished by the recent publication of Dickison (l.c.) but I have given stress in the present study on different critical aspects of pollen morphology, especially the endoaperture and other infrastructures with a suggestive trend in evolutionary line. The study of pollen grains from different related families viz. Anacardiaceae, Averrhoaceae, Burseraceae, Capparidaceae, Geraniaceae, Leguminosae, Malvaceae, Oxalidaceae, Resedaceae, Rosaceae, Sapindaceae and Zygophyllaceae etc. have been taken into account to find out the affinities, relationship and in solving many critical problems of this controversial (Vide Table - 1) as well as not-well-understood tropical family.


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So, this study is an endeavour to fill up the lacuna partially by studying most of the genera of Eastern and South-Eastern Asia to throw some light on the complexity of this family and its probable solution from palynological point of view.

**TAXONOMY**

The family Connaraceae was originally described by Robert Brown (1818). Most comprehensive taxonomic treatment was made by Schellenberg (1938). According to him this family contains twenty four genera, but this figure must be regarded with reserve, because the constituent taxa of the family have suffered a radical shuffling at the hands of taxonomists.

The well-known workers on the systematics of Connaraceae are Radlkofker (1886), Bruck (1887), Gilg (1897), Schumacher (1828), Bentham & Hooker (1862-1883), Engler (1893), Warming (1904), Hallier (1912), Melchior (1964), Rendle (1959), Hutchinson (1959, 1969), Cronquist (1968), Takhtajan (1966, 1969), Thorne (1968, 1976), Dahlgren (1975) and others.

Since this time members of the Connaraceae have been treated in different regional floras by Baker (1866), Hemsley (1956), Hutchinson et al (1958), Leenhouts (1958), Hara (1966, 1971), Huang (1967), Hooker (1876) and Trivengadum (1980). As stated earlier this family has been shifted one place to another from time to time by different taxonomists (Table - 1). Warming (l.c.) placed the family under his Terebinthinae together with Meliaceae, Rutaceae, Burseraceae, Zygophyllaceae, Ochnaceae, Anacardiaceae and Icacinaceae, just before his Aesculinae where the family Sapindaceae is included. He stated that
Connaraceae forms the connecting link between Terebinthinae and Rosiflorae (Spiraea) as well as Leguminosae.

Cronquist (l.c.) & Bentham & Hooker (l.c.) treated this family under the order Sapindales. Cronquist stated that the family provide a connecting link between Rosales and Sapindales. Embryologically the members of the family are much like the Cunoniaceae. He further mentioned that the wood structure of Connaraceae is fairly advanced being comparable to that of Sapindaceae rather than to the Rosalian families. However, his view can be cleared from his own statement - "their position in either order could be defended, but on balance I prefer to keep them with the Sapindales." Haywood (1978) stated that "In evolutionary terms it is considered to be rather more advanced than the Leguminosae, possibly on a line leading to the Oxalidaceae." He retained its traditional place among Sapindales. Thorne (l.c.), Engler (l.c.) & Bessey (1915) treated the family under the order Rosales. It is reported from the Dickison's works that Thorne at present is of opinion to align Connaraceae near Sapindaceae. Hallier (l.c.) treated the family under his Aesculinaceae together with Sapindaceae, Melianthaceae and Leguminosae and traced its origin from Capparidaceae via Oxalidaceae (Fig.1). Rendle (l.c.) stated the family allied to Leguminosae but differ by typical pentamerous pistil and absence of stipules. Dahlgren (l.c.) treated the family under Rosanae.

Hutchinson (l.c.) in the 1st edition of his book - "The families of flowering plants" - treated the family near Sapindaceae but in 3rd edition of this book placed the family in Dilleniales next to Dilleniaceae as free carpels and arillate seeds are common features of both families. Takhtajan (l.c.) gave the family an order status of its own.

Intrafamiliar classification of the family has been subject of disagreement (Table 2). Bentham & Hooker (l.c.) divided the family into two tribes. Tribe Connaraeae - characterized by imbricate calyx lobes and exalbuminous seeds,
Fig. 1. Scheme of line of evolution (in part) as proposed by Hallier (1912)
TABLE 2

COMPARISON OF INTRAFAMILIAL TAXONOMIC TREATMENTS OF COENARACIDAE BY VARIOUS TAXONOMISTS

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<td>2. Normandrea Flach.</td>
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<td>3. Aglasen Soland.</td>
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<td>4. Subtribe A</td>
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<td>5. Connerus Limm.</td>
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<td>Tribe II. Castanoleae</td>
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<td>7. Tribe VI.</td>
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<td>8. Tribe VII.</td>
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<td>10. Tribe IX.</td>
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<td>11. Tribe XI.</td>
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<td>12. Tribe XII.</td>
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**Subfam. I. Concastellidae**
   Subgen. Concastellus
   Tribe I. Concastellus
   Tribe II. Castellus
   Tribe III. Bryocorpus
   Tribe IV. Castellus
   Tribe V. Concastellus
   Tribe VI. Concastellus
   Tribe VII. Concastellus
   Tribe VIII. Concastellus
   Tribe IX. Concastellus
   Tribe X. Concastellus
   Tribe XI. Concastellus
   Tribe XII. Concastellus

**Subfam. II. Jollydoreae**
1. Jollydore Pierre
   Tribe I. Concastellus
   Tribe II. Castellus
   Tribe III. Bryocorpus
   Tribe IV. Castellus
   Tribe V. Concastellus
   Tribe VI. Concastellus
   Tribe VII. Concastellus
   Tribe VIII. Concastellus
   Tribe IX. Concastellus
   Tribe X. Concastellus
   Tribe XI. Concastellus
   Tribe XII. Concastellus

**Subfam. III. Castanoleae**
   Tribe I. Castanoleas
   Tribe II. Castanoleas
   Tribe III. Bryocorpus
   Tribe IV. Castanoleas
   Tribe V. Concastellus
   Tribe VI. Concastellus
   Tribe VII. Concastellus
   Tribe VIII. Concastellus
   Tribe IX. Concastellus
   Tribe X. Concastellus
   Tribe XI. Concastellus
   Tribe XII. Concastellus

**Subfam. IV. Pseudocorpus**
1. Pseudocorpus Juss.
   Tribe I. Pseudocorpus
   Tribe II. Pseudocorpus
   Tribe III. Pseudocorpus
   Tribe IV. Pseudocorpus
   Tribe V. Pseudocorpus
   Tribe VI. Pseudocorpus
   Tribe VII. Pseudocorpus
   Tribe VIII. Pseudocorpus
   Tribe IX. Pseudocorpus
   Tribe X. Pseudocorpus
   Tribe XI. Pseudocorpus
   Tribe XII. Pseudocorpus

**Subfam. V. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. VI. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
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   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. VII. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. VIII. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. IX. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. X. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. XI. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
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   Tribe XI. Connerus
   Tribe XII. Connerus

**Subfam. XII. Conneraeae**
   Tribe I. Connerus
   Tribe II. Connerus
   Tribe III. Connerus
   Tribe IV. Connerus
   Tribe V. Connerus
   Tribe VI. Connerus
   Tribe VII. Connerus
   Tribe VIII. Connerus
   Tribe IX. Connerus
   Tribe X. Connerus
   Tribe XI. Connerus
   Tribe XII. Connerus

**Genera not treated by Leenhouts in YL, Mal, but implied:**
- Connerus Limm.
- Connerus Limm.
- Connerus Limm.
- Connerus Limm.
- Connerus Limm.
- Connerus Limm.
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- Connerus Limm.
and the tribe Cnestideae - characterized by valvate calyx lobes and albuminous or exalbuminous seeds. Both Bentham & Hooker (l.c.), and Hooker (l.c.) placed the genera like *Agelaea*, *Rourea*, *Roureopsis* (not included in Bentham & Hooker) and *Connarus* in the tribe Connareae and *Cnestis*, *Taeniochlaena* and *Ellipanthus* in the tribe Cnestideae. Gilg (1897) separated the family into two subfamilies, Jollydoroideae and Connarioideae - a treatment also followed by Schellenberg (1938) in his family monograph for Engler's Das Pflanzenreich. Mélchior (l.c.) in Engler's Syllabus der Pflanzenfamilien follows the system as Gilg (1897). Major difference between Schellenberg (1938) and Bentham & Hooker's (l.c.) system lies in the fact that Schellenberg subdivided the family into two subfamilies and 5 tribes, and placed the genera like *Agelaea* in the tribe Agelaeae, *Cnestis* in the tribe Cnestideae, *Rourea* and *Connarus* in Connareae.

Leenhouts (l.c.) in his recent revision of the family in Flora Malesiana, preferred not to divide the family into different tribes. He segregated the genera with the characters based on pistil, pits on leaflets, calyx, inflorescence and petals in his generic key. It is evident from the Table 2 that major disagreement exists between the generic concepts of Schellenberg and Leenhouts. Leenhouts merged *Castanola* of Schellenberg into *Agelaea* and subdivided the genus *Agelaea* into two subgenera on the character of inflorescence, trichomes and pits on the leaflets. Schellenberg (l.c.) recognised *Roureopsis* and *Taeniochlaena* as distinct genera but Leenhouts included *Taeniochlaena* under *Roureopsis* and subdivided the genus into two sections - Sect. *Roureopsis* with glabrous fruits and Sect. *Taeniochlaena* with pubescent fruits. Leenhouts also included, *Ellipanthus*, *Pseudellinanthus* and *Hemandradenia* - the distinct taxa of Schellenberg, into a single genus *Ellipanthus*. A notable point of disagreement exists in relation to Leenhouts' *Rourea* complex. Circumscription of the genus *Rourea* in Leenhouts system includes 5 distinct genera of Schellenberg viz.
Santaloide11a, Santaloides, Byrscarpus, Jaundea and Rourea and subdivided the genus Rourea into 3 subgenera.

PHYTOGEOGRAPHICAL NOTES AND FOSSIL RECORDS

PHYTOGEOGRAPHY:

The family Conna'raceae is restricted in tropics and subtropics of Old and New world. Map - 1 shows the world distribution after Van Steenis (1962) and Haywood (1978) and Map - 2 shows the Geographical area of species investigated in the present study. Van Steenis designated the family as truly megatherm family from thermoeological concepts of plant distribution. Leroy (1978) gave a special emphasis on the family for its phytogeographical interest. In a biogeographical survey of Madagascan flora he estimated 25 genera and 200 spp. of the family, which covers principally a palaeotropical area. According to him main centre of distribution of the family is African - Madagascan area where 16 genera occur, 11 of which are endemic. It is, however, poorly represented in Madagascar where only 5 genera occur, none being endemic. Some aspects, however, call for special mention: 1 African genus Byrscarpus, occurs there with 1 endemic species and 1 species common to Africa. There are 3 palaeotropical genera: Ellipanthus (1 sp.), Agelaea (3 spp.) Cnestis (4 spp.) and a pantropical one, Rourea = Santaloide11a (2 spp.). All of the Madagascan species are endemic.

Leenhouts (1958) revised the family for Flora Malesiana and estimated 16 genera with about 300-350 species. He mentioned that the family is circum-tropical, but predominantly developed in Africa, in Malaysia represented by 6 genera and about 40 species.
Map 2. Geographical area of species investigated (Connaraceae) in the present study.
FOSSIL RECORDS:

There is only one disputed fossil amber species assigned as the flower of the Connaraceae, viz. *Connarantha roureoides* Conw. Leenhouts was struck by its clawed petals - a feature unknown to him in the Connaraceae. In his opinion this fossil flower probably belongs to Caesalpinioideae of Leguminosae.

However, present study on pollen morphology of the family will be of much help in identification of the fossil pollen, if any, in future.

MATERIALS AND METHODS

The family Connaraceae comprises 24 genera and about 400 species as per Schellenberg (1938) but Leenhouts (1958) estimated 16 genera and 300-350 species. Assessment by Airy Shaw (1973) in Willis' "A Dictionary of flowering plants and Ferns" is same as proposed by Leenhouts (l.c.) for world distribution. Of which 7 genera are Indian (Treating *Roureopsis* and *Taeniochlaena* as different genera). In the present study 181 materials from 59 species (s.l.) distributed over 7 genera have been worked out palynologically. About 806 materials from 212 genera from the allied families have been studied.

Nomenclature is based mainly on Leenhouts (1958, 1972). In case of new combinations (Comb. nov.) or new status (stat. nov.), previous names are also maintained in the list of "Materials studied". In the Table 4 for "Summary of selected pollen morphological features", and in discussion, previous names have been used for better understanding in favour of new proposals.

Pollen slides were prepared and studied as per general schedule as given at the beginning. For convenience, arrangements of the taxa have been made according to Hooker's Flora of British India for the pollen description and presentation of data.
MORPHOLOGICAL CHARACTERS OF THE GENERA STUDIED

The family is exclusively woody, that range in habit from exceptionally large tree to small trees, shrubs and scandent lianas. Trees or shrubs in Rourea, Roureopsis, Connaraceae, Ellipanthus and Cnestis; erect or scandent shrub in Agelaeae; rambling shrub in Taeniochlaena. Leaves odd-pinnate, 3-5 leaflets in general, unifoliolate in Ellipanthus. Inflorescence axillary in Agelaeae, Roureia, Taeniochlaena and Ellipanthus; terminal in Connaraceae; panicle in Roureopsis and solitary or raceme in Cnestis. The family draw the attention of taxonomists from time to time for its heterostylous flowers. Several authors Gilg (l.c.), Hemsley (l.c.), Leenhouts (l.c.), Radlkofer (l.c.), Schellenberg (l.c.) and Baker (1962) have suggested that heterostyly in the Connaraceae might represent a trend towards dioecy. Hemsley suggested the functional unisexuality for the flowers of species from the tropics of East Africa. Leenhouts was more definite in describing Malaysian taxa and described the whole family as being "distinctly heterostylous"; Rourea is mentioned as "heterostristylous", Cnestis and Agelaeae are "heterotri- or -distylous" while Roureopsis and Connaraceae are "heterodistylous". Important characters like seed morphology, stamens, ovule, stomata and leaf epidermis have been depicted in the Table 3 and for convenience generic keys as proposed by Hooker (l.c.) and Leenhouts (l.c.) are given here.
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<td>Ex-alb.</td>
<td>Albuminous</td>
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<td>1. Conmaraus</td>
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<td>10; 5 shorter no anther</td>
<td>5; 4 ob-sol-ate</td>
<td>Anomoc-ytic</td>
<td>With mucilaginous cells</td>
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<td>2; lob-sol-ate</td>
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<td>Anisoc-ytic</td>
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<td>+</td>
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<td>10; Connate</td>
<td>5; non fert-ile</td>
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<td>6. Roureopsis</td>
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<td>10; Alternate longer</td>
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<td>7. Taeniochlaena</td>
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KEY TO GENERA BY J.D. HOOKER (1876) IN THE FLORA OF BRITISH INDIA


______ Calyx not clasping the base of the capsule, seeds exarillate ... Agelaea.

______ Calyx accrescent, clasping the base of the sessile capsule, seeds arillate ... Rourea.

______ Calyx slightly accrescent, not clasping the base of the sessile capsule, seeds exarillate ... Roureopsis.

______ Calyx not accrescent, clasping the pedicel of the stipitate capsule, seeds arillate ... Connarus.

Tribe II. Cnestideae. Calyx valvate, seeds albuminous or exalbuminous.

______ Calyx 5-partite, exceeding the petals, carpels 5, sessile, Capsule hispid within. Seeds albuminous ... Cnestis.

______ Calyx 5-partite, revolute, Petals narrow, carpels 5, seeds exalbuminous ... Taeniochlaena.

______ Calyx 5-partite, erect, petals oblong, stamens 5, perfect, carpel 1, seeds exalbuminous ... Ellipanthus.
KEY TO GENERA BY LEENHOOTS (1958) IN FLORA MALESIANA

1. Pistil 4-5, usually more than 1 fruit per fl. (if there is only one fruit, some undeveloped fruits are often still present at the base) calyx usually accrescent.

2. Upper surface of the dried leaflets with many minute pits.
   Lvs. 3 foliolate, fruits usually worthy to papillose
   ... 2. Agaeea

2. Upper surface of the dried leaflets not pitted, fruits smooth.

3. Calyx distinctly imbricate, also in flower, immediately often flowering conically contracted in a peculiar way, accrescent and hard in fruit and (in Mal. spp.) usually cupular in shape, enclosing the base of the fruit.
   Fruit 1 per flower (very rarely 2; no pistil remains at the base).
   Seed (in Mal. spp.) usually enveloped by a loose arilloid.
   ... 4. Rourea

5. Calyx only in the bud more or less imbricate, not conically contracted immediately after flowering, not appressed to the fruit. Usually more than 1 fruit/flower (and undeveloped pistils always still present). Seed provided with a sarcotesta.

4. Petals about as long as the sepals or shorter, not folded inwards in bud, calyx not accrescent. Fruits more or less fleshy, oblique to slightly acuminate; Pericarp inside densely pubescent. Seeds with endosperm. Leaflets not emerginate at the apex 1. Cnestis
4. Petals lorate, many times longer than the sepals in bud folded inwards, Calyx in fruit conspicuous. Fruit dry, uncinate - acuminate at the apex, pericarp inside glabrous. Seeds without endosperm, leaflets emarginate at the apex ... 3. Roureopsis

1. Pistil 1 per flower; Calyx not accrescent.

5. Inflo. axillary, small, often glomerulous. Tissue of floral parts without glands; epidermis without glandular - capitate hairs, seeds with endosperm. Lvs. unifoliolate ... 5. Ellipanthus.

5. Inflo. terminal, large, paniculate, sepals, petals & stamens with glands in their tissue; epidermis often with glandular - capitate hairs. Seeds without endosperm. Leaves rarely partly unifoliolate. ... 6. Connarus
OBSERVATION AND DISCUSSION

TRIBE: Connareae:

In the family Connaraceae the tribe Connareae (sensu Hooker) constitute an important group having the maximum number of species of the family including the type genus Connarus L. For distinguishing characters of the tribe and the genera therein vide key to genera (sensu Hooker, page No. 59) and Table - 3 for flower and seed morphological characters.

Four genera have been studied under the tribe. Palynologically this tribe represents two distinct types of palynomorphs. Pollen type I constituted by Rourea, Roureopsis and Agelaea and Pollen type II represented by the Connarus. Agelaea stands as the transitional form between the two pollen types. Every genus is very uniform and distinct palynologically with mere exceptions. Characteristic granules (operculoid) present in the endoapertural area in Pollen type I, and in Pollen type II these granules becomes coarser and coarsen to patch streak and ultimately to definite classical operculum.

Pollen morphological characters in detail of individual genus with interspecific notes are described below:

AGELAE: (Plate - VI, Figs. 1-17)

Shape: Oblate spheroidal - Prolate spheroidal in equatorial view, semicircular in polar view; small sized, range $P \times E = 26.3 \times 21.2 \mu m$, $P/E$ ratio = 0.88 - 1.22. Colpi: Slit like, extending up to poles. Endoapert.: indistinct, coarsely granulated (operculoid).

Exine: 1.5-3.5 $\mu m$ thick, semitectate, pattern: ruguloreticulate to reticulate. Sporang.: Sexine (1-1.5 $\mu m$) thicker than nexine (0.5 $\mu m$). Tectum
0.5 -0.75 μm thick, columellæ distinct, 0.5-0.75 μm height.

**MATERIALS STUDIED:**

*Agelaea bornensis* (Hk.f.) Merr.

- *A. vestita* Hook.f. Mal. Peninsula: Dr. King's Col. 10139, 5809; Mal. Archipelago: Dr. King's Col. 724; Perak: Wray, L (Jr.) - 2538, 2549; Rev. Father Scortechini 260, s.n. CAL - 100385.

*Agelaea everettii* Merr. Philippines: Ramos, M et Edano - 33783; Elmer, A.D.E. 15488, 12478; Ramos, M. - 13856.

*A. trinervis* (Llanos) Merr.

- *A. wallichii* Hk.f. Mal. Peninsula: Henderson - 24525; Dr. King's Col. 5729; Mal. Archipelago: Dr. King's Col. 3735; Perak: Rev. Father Scortechini s.n. CAL - 100404; Philippines: Elmer A.D.C. 14803.


*A. pinnata* King (= *Roureopsis pinnata* (King) Leenh. nov. Comb.

Mal. Peninsula: Dr. King's Col. 5425.

*Agelaea*, the 3rd largest genus (Schllenberger l.c.) and 1st described taxon under tribe Connareae (sensu Hooker l.c.) of the family.

Pollen grains of 19 materials distributed under 5 species from India, Malay peninsula, Philippines and Africa were studied. Pollen small-sized except *A. villosa* where it is medium-sized. Palynologically this genus is very uniform.

Exine 1.5-2 μm thick. Tectum 0.75-1 μm in general with the exception in *A. wallichii* (0.5 μm thick). Columella height 0.5-0.75 μm but 0.25 μm in *A. pinnata* and *A. obliqua*. Nexine thickness 0.5 μm in all except *A. obliqua*. 
where it is 0.75μm thick. Exine reticulate with the lumina size range from 0.5-2μ (mixed type) in general but A. vestita exceptionally differs from this normal reticulation type in being finely reticulate and lumina size range from 0.3-0.5μm. Colpi always slit-like, endoaperture indistinct, granulated. Leenhouts (1.c.) treated A. pinnata King as Roureopsis pinnata (King) Leenh. nov. Comb. Pollen morphologically A. pinnata will be better placed together with the species of Agelaea.

ROUREA: (Plate VII, Figs. 1-21).

Shape: Suboblate to oblate-spheroidal in equatorial view, subangular in polar view; small-sized; range P x E = 16.4 - 25.7μm. x 17.5 - 25.2μm.; P/E ratio = 0.66 - 1.5. Colpi: slit-like, extending up to poles; Endoap.: indistinct in most of the species or circular to lolongate, granules covering the whole area of the endoaperture area (operculoid).

Exine: 1.5 - 2μm thick, semitectate. Pattern: finely reticulate to ruguloreticulate. In few species reticulation is coarser due to thick muri and in others pattern may be fine or obscure towards aperture. Sporoderm: sexine thicker than nexine, tectum 0.5 - 1μm thick, columella very short, indistinct, sometimes distinct.

MATERIALS STUDIED:

Roureopsis cuspidata Spruce, Brazil: Spruce, R. - 2432, 2376; Spruce, R. s.n. (Nov. 1851), CAL. - 100678.
R. induta Planch. (Engl.) Brazil: Riedel s.n., F'X Herbario Horti Petropoli-tani, CAL - 100686.
R. ligulata Baker (Engl.) Brazil: Riedel s.n., CAL - 100687.
R. mimosoides (Vahl.) Planch. f. mimosoides

= R. parallela Planch. Malay peninsula: Dr. King's Col. - 8405, 10592; Wray, L (Jr.) - 1167; Singapore: Anderson, T. - 45; King, G. - s.n., CAL - 100597. Illegible - s.n., CAL - 100598.


R. minor (Gaertn.) Leenh.

= R. acuminata Hk. f. Malay peninsula: Dr. King's Col. 4241, 886, 10599; Pal, B. - 7781.

= R. caudata Planch. Assam: Kanjilal, U. - 6532; Mukherjee - 444; Meghalaya: Lister, J.L. s.n. CAL - 100528; Chittagong: Dr. King's Col. - 459; Siam: Kerr, A.F.G. - 2539.

= R. commutata Planch. Assam: Bal, S.N. - 396; Manipur: Meebold - 6232; Tripura: Debbarman, P.M. - 936; Andamans: Dr. King's Col. - 349; Dr. King's Col. s.n. (11.6.1892), CAL - 100469; Dr. King's Col. s.n. (15.7.1893) CAL - 100473; Prain's Col. - 23; Nagaland: Hock, M.A. - 10008; Burma: Without Col. Name & No. Herb. Sulp. Kurz., CAL - 100511; Khant, P. - 697.


= R. humilis Bl. Malay peninsula: Kunstler, H. - 4677; Fox, W. - 5121; Ridley, H.N. - 2645; Curtis, C. - 2285; Dr. King's Col. - 4677; Nicobar Islands: Kurz, S. s.n. CAL - 100629; Jelinek - 140.


R. revoluta Planch. America: Schoriburg s.n., CAL - 100688.

R. rugosa Planch. Malay peninsula: Dr. King's Col. 6376, 10434; Griffith 1261/1; Kunstler, H. - 1543; Malacca: Harvey - s.n., CAL - 100564; NIL - Herb. Sulp. Kurz. CAL - 100565; Derry, R. - 27.


Rourea constitutes the 2nd largest genus of the family. Palynology of 70 materials distributed under 19 species from India, Burma, China, Malay peninsula and South America were studied. It shows narrow range of variations in its pollen morphology.

In most of the species the polar axis range is from 19-23.1 μm. R. induta and R. ligulata (25.5-25.7 μm) represent the largest and R. pulchella (16.4 μm) the shortest polar axis length for the genus. Pollen grains shape in R. ligulata, R. rugosa and R. stenopetala are prolate spheroidal to prolate with P/E ratio range from 0.96-1.5. This deviates from the general pollen shape (suboblate to oblate spheroidal) in the genus. Exine thickness is uniform throughout. Tectum thickness in general ranges from 0.5 - 0.75 μm. with the exception in R. cuspidata.
& R. humilis 1 µm thick. The tectum is supported by short indistinct columellae about 0.5 µm high which stand on a thin and uniform layer of nexine. Columella height decreases from mesocolpal region towards the apertural area in R. commutata, R. cuspidata, R. erecta and R. santaloides. The nexine thickness in R. commutata, R. erecta, R. microphylla, R. pulchella and R. volubilis is 0.25 µm and in R. induta 0.75 µm, which differ from the general thickness 0.5 µm.

Sculptural pattern in the genus is finely reticulate. But in R. commutata, R. humilis and R. parallela it is ruguloreticulate and coarsely reticulate in R. santaloides. Lumina size is in general from 0.5-1 µm with only exception in R. santaloides where lumina size ranges from 0.5 - 2 µm. Finer reticulation with decreased lumina size towards apertural area have been observed in R. acuminata, R. induta, R. santaloides and R. volubilis. Reticulation coarse due to thick muri and confined to poles is noted in R. commutata, R. glabra and R. microphylla. In R. commutata, R. erecta and R. semilis luminae fuse to form linear luminae especially at poles. It is interesting to note in R. rugosa where some free columellae is seen within the lumina. Colpi slit like in majority but tapering in R. multiflora, R. parallela and R. santaloides. Endoaperture is indistinct in general. In others it is circular to lalongate with only equatorial margin indistinct e.g. R. cuspidata, R. erecta, R. ligulata, R. pulchella, R. revoluta, R. rugosa and R. santaloides. Characteristic granules are always present in the endoaperture in all species. These granules are sexinous and nexinous in origin. The granules are either fine and cover the entire endoaperture area (irregular) or may be distinct, coarse and teeth like which are confined (ornate) to the endoaperture margin e.g: R. multiflora, R. semilis, R. revoluta and R. erecta. Apertural dimorphism is observed in R. santaloides having 3-colporate type of aperture as usual and number of bi-aperturate pollen grains.
ROUREOPSIS: (Plate - IV, Figs. 1-7).

Shape: Oblate spheroidal to prolate spheroidal in equatorial view, semicircular in polar view; small sized, range - $P \times E = 24.5 \times 21.2 \mu m$, $P/E$ ratio 0.95-1. Colpi: tapering, long, do not extend up to poles, Endopap.: indistinct, granulated (operculoid). Exine: 1.75 - 2 $\mu m$ thick, semitectate, Pattern: reticulate. Sporoderm: Sexine thicker than nexine. Tectum 0.75 - 1 $\mu m$ thick, columella distinct 0.5 $\mu m$ height, nexine as thick as columella height.

MATERIALS STUDIED:

Roureopsis emarginata (Jack.) Merr.
- = R. pubernervis Planch. Malay Peninsula: Dr. King’s Col. - 2032, 4537, 7862; Wray, L. (Jr.) 2876; Goodlough - 1506; Kunstler, H. - 5434;
- Malaya: Maingay, A.C. - 500.

Roureopsis, described under the tribe Commareae by Hooker (l.c.), is distributed in W. Africa, S.E. Asia (upper Burma to S. China and Indo China) and W. Malaysia as far east as W. Java and Borneo (Leenhouts l.c.). In India it is represented only by the species R. emarginata (Jack) Merr. (= R. pubernervis Planch.).

Palynologically this genus is very uniform as described in the general pollen description. About 80% of pollen grains become crippled and folded after acetolysis, which is observed in both the species studied. It may be due to nonviability of the considerable percentage of pollen grains (Muller & Caratimi...
1977). This fact reminds the suggestion of Gilg, Hemsley, Leenhouts and others for a trend toward dioecism in the family.

Pollen morphologically it is similar to that of Taeniochlaena. Leenhouts (l.c.) included Taeniochlaena within Roureopsis. It is justified from the palynological point of view. Roureopsis differs from Taeniochlaena in the absence of shrivelled pollen (sterile) in the later.

CONNARUS: (Plate - VIII, Figs. 1-14; Plate - IX, Figs. 1-16; Plate - X, Figs. 1-12; Plate - XI, Figs. 1-15; Plate - XII, Figs. 1-15; Plate - XIII, Figs. 1-16; Plate - XIV, Figs. 1-7.)

Shape: Prolate spheroidal to prolate in equatorial view, semiangular to circular or lobate in polar view; medium sized, range $P \times E = 27-36 \times 22.5-33 \mu m$, except two small-sized, range $P \times E = 19.5-21.4 \times 19-23.5 \mu m$; $P/E$ ratio = 0.85 - 1.27. Colpi: either slit-like or tapering, extending up to poles, 2-4.5 $\mu m$ width. Endoaperture: indistinct, circular to lalongate. Operculum: patch streak (two vertical thickening on either side of colpi at equator) or classical type. Exine: (1.5-) 2-2.5 $\mu m$ thick, semitectate, thickness of exine is more at poles and mesocolpal regions than that of colpal area. Pattern: reticulate, reticulation uniform throughout whether it is homobrochate or heterobrochate or variable - smaller around colpi and/or larger at poles and mesocolpium. Sporoderm: Sexine sometimes thicker than nexine, tectum 0.5-1 $\mu m$, tectum equal to columella height or columella height is more than tectum thickness, columella height uniform or decreases from pole/mesocolpium to colpal area. Nexine in some species thickened to form costae colpate aperture.
MATERIAI$ STUDIED:

Connarus championii Thw. Ceylon: without Col. Name & no., det. - D.D.

Trivendum, CAL - 100899.

G. craspifolius Spruce, America: Spruce, R. s.n. April, 1850, CAL - 101036.

G. cyunosus Planch, Brazil: Riedel s.n. Ex. Herb. Horti. Petropolitani,
CAL - 101029.

G. culicenensis Merr. = G. erianthus Elm.

America: Spruce, R. s.n. April-Aug. 1850, CAL - 101034.

G. fecundus Baker, Brazil: Riedel s.n. Ex. Herb. Horti. Petropolitani,
CAL - 101039.


G. grandis Jack. Mal. Peninsula: Goodlough, J.S. - 1390; Rev. Father Scortechini - 1386; Maingay, A.C. - 505; Griffith - 1266; Dr. King's Col. - 10721, 4932; Singapore: Ridley, H.N. - 5732, 4593.

= G. ellipticus King. Singapore: without Col. Name & No. - 14185,
CAL - 100951; Dr. King's Col. - 7480; Dr. King's Col. - 4090; Mal.
Peninsula: Dr. King's Col. - 4233.


G. monocarpus Linne' ssp. Malayensis Leenh. nov. sub sp.

= G. monocarpus Linne. Kerala: Calder C.C. & M.S. Ramaswami - 1856;
BamaRao, M. - 834; Madras: Shetty, B.V. - 10544; Tamil Nadu: Baker, C.A. - 5422; Peninsular India: Wight - 564; Philippines: Loher, A.
- 2096.
- : (71): -

= C. maingayi HK. f. Malay Peninsula: Dr. King's Col. - 10823; Wray, L. (Jr.) - 3106; Fox, W. - 5623;


C. paniculatus Roxb. Assam: Dr. King's Col. - 189; Col. - the reporter on Economic products to the Govt. of India - 11383; Clarke, C.B. - 452598; BGL. s.n. 20.6.1834; Nagaland: Col. The reporter on Economic Products to the Govt. of India - 11806; Chittagong: Dr. King's Col. - 674, 363; Siamese Peninsula: Kerr, A.F.G. - 2313.


C. semidecandrus Jack'. Malay Peninsula: Kunstler, H. - 1410; Wray, L. (Jr.) - 2779; Meebold: 18576; Derry, R. - 940; Cunts, C. - 2899; Philippines: Loher, A. - 2096; Burma: Russel, P.T. - 183; Shalik Mokim - 268, 421, 77, 676.

= C. gibbosus Wall. Andaman: Prain's Col. - 10; Dr. King's Col. - 317; Ali Ranger, H. - 107 H; Prain's Col. s.n. (6.2.1899); Nicobar Islands: Dr. King's Col. s.n. (27.9.80); Burma: Anderson, J. s.n. (6.3.1882).

= C. neurocalyx Planch. Philippines: Elmer, A.D.E. - 9087; Ramos, R. - 1512, 1816; Loher, A. - 2096, 2096; Ahern's Col. - 391.
*Connarus*, the type genus of the family is the largest taxon with about 100 total species (Schellenberg l.c.) or less (sensu Leenhouts l.c.), it is richly developed in S. America, S.E. Asia, and Malaysia. In Australia the genus is represented by one and in Melanesia by 2 species. This genus is described under the tribe Connareae (sensu Hooker l.c.).

Palynology of 87 materials distributed under 24 species from India, Burma, Bangladesh, Singapore, Malay Peninsula, Siamese Peninsula, Ceylon & America were studied. Pollen medium sized in general except *C. fecundus*, *C. maineavi* and *C. sprucei* where it is small-sized. In *C. maineavi* and *C. gibbosus* P/E ratio range from 0.85 – 0.96, in others it is from 1-1.4. Tectum thickness in general range from 0.75-1 μm. with the exception in *C. odoratus*, *C. fecundus*, *C. maineavi* 0.5 μm thick. Columella height range from 0.5-0.75 μm in general but 1 μm in *C. odoratus*, *C. Championii*, *C. mindanensis* & *C. trifoliatus*. Columella height generally uniform throughout but decreases from mesocolpium to colpal area in *C. championii*.
C. craspifolius, C. cvmosus, C. gibbosus, C. maingayi, C. monocarpus and C. paniculatus. Nexine thickness is very constant for the genus (0.5 μm) but 0.75 μm in C. Championii and C. paniculatus and 1 μm in C. ferrugeneus. Sculptural pattern in the genus is reticulate except in C. maingayi where it is psilate/obscure. Most interesting and important aspect to discuss the characters of aperture and operculum. In addition to the apertural characters discussed in general, apertural dimorphism is evidenced in some species. Typical apertural characters, its peculiarities with operculum has been shown in Fig. 2. On the basis of colpi, endoaperture and operculum nature, the following pollen types in Connarus can be described.

**TYPE:**

I. Colpi long slit like, continuous, costae colpate, endoaperture without any processes ... C. maingayi.

II. Colpi long slit like, continuous, no costa, endoaperture with coarse granules in definite arrangement or with thickened patch streak-like on either side of the colpi ... ... C. ritchiei, C. craspifolius, C. monocarpus, C. trifoliatus, C. sprucei.

III. Colpi long slit like, continuous, costae colpate, endoaperture with thickened patch streak like on either side of the colpi ... ... C. ellipticus, C. odoratus, C. stictophyllus, C. ferrugeneus, C. (Znocenni, C. paniculatus, C. championii.

IV. Colpi long, tapering, either constricted at equator or sometimes from the margin of the colpi at equator, one or two streaks of sexinous material protrudes into the endoaperture region ... C. cvmosus, ... C. oligophyllus, C. fecundus.
Fig. 2.
V. Aperture Complex:

A. Colpi long, slit like, with two vertical slits on either side of the equator, corresponding to the diameter of endoaperture. Sexinous bridge covers the endoaperture ... C. wightii, ... C. gibbosus

B. Apertural area is demarcated by a lens-shaped halo zone (psilate) with long slit like colpi with two vertical streaks at equatorial region. Gradual reduction of this so called colpi & its subsequent breaking is noted, confined within a circular zone within the halo ... ... ... ... C. nicobaricus, ...

... C. neurocalyx, C. semidecandrus

These interesting vertical slits in the aperture type V, are formed due to cracks in the endexine and is comparable to the term Endocrack of Oldfield (1959).

TRIBE: Cnestideae

The tribe Cnestideae (sensu Hooker l.c.) of the family Connaraceae is comparatively small but palynologically heterogenous. The detail morphological characters of the tribe and genera can be seen in the key to the genera (sensu Hooker or sensu Leenhouts) and in the Table 3, for important morphological characters.

Three genera represented in India have been studied palynologically of which Ellipanthus is distinctly different from the rest two - Cnestis and Taeniochlaena.
Pollen morphologically Ellipanthus constitutes the fairly advanced pollen type near to Connarus. Cnestis and Taeniochlaena constitute the pollen type having low level of advancement.

Pollen morphological characters in details for the individual genus is described below with critical notes, if any, for individual species.

Cnestis: (Plate - XIV, Figs. 8-19)

Shape: Pollen Spheroidal to oblate-spheroidal in equatorial view, circular in polar view. Small sized, range $P \times E = 18.3 \times 23.6\mu m$, $P/E$ ratio = 0.70 - 1.27; Colpi: slit like, extending up to poles, Endoap.: indistinct, lateral, granules cover the whole area of endoaperture (operculoid). Exine: 2\mu m thick, semitectate. Pattern: reticulate, finer towards aperture. Sporoderm: Sexine (1.5\mu m) thicker than nexine (0.5\mu m). Tectum 1\mu m thick, columella indistinct 0.5\mu m height.

Materials Studied:

Cnestis palata (Lour.) Merr.

- C. ramiflora Griff. Andamans: Dr. King's Col. - s.n. (8.12.1894), CAL - 101066; Dr. King's Col. - s.n. (17.2.1894), CAL - 101067; Dr. King's Col. s.n. (16.11.1892), CAL - 101073; Dr. King's Col. s.n. (26.11.1892), Herb. Hort. Calcuttensis. Malay Peninsula: Dr. King's Col. - 8394, 1330; Wray, L. (Jr.) - 176.

C. ferruginea DC. Africa: Zenker et Haudt - 204; Lester - 3876.


Cnestis, the type genus of tribe Cnestideae (sensu Hooker l.c.) has about 40 species, mainly distributed in Tropical Africa and Madagascar, 2 spp. in S.E. Asia and W. Malaysia (Leenhouts l.c.).

Pollens of 13 materials distributed under 4 species from India, Philippines, Malay peninsula and Africa have been studied. Pollen spheroidal to oblate spheroidal in C. ramiflora and C. diffusa but spheroidal to prolate spheroidal in C. ferruginea and C. platantha. Exine uniform throughout in all the materials studied but in C. platantha exine thick (2/μm) at poles than the mesocolpium (1.5/μm). Exine pattern reticulate and reticulation finer towards the apertural area a constant character for the genus. Tectum 1 μm thick in C. ramiflora and C. platantha but 0.5-0.75/μm thick in C. diffusa and C. ferruginea. Columellae indistinct and constant for all the taxa studied being 0.5/μm high and height decreases from mesocolpium to apertural area. Nexine 0.5/μm thick always except C. ferruginea, an African species where it is 0.75/μm thick. From apertural aspect, C. platantha differs from general slit like, long, 3-colporate type in being tapering; short, 3-colpate type aperture and devoid of granules. Endosporperture in other species are indistinct and always coarsely granulated.

TAENIOCHLAENA: (Plate - XIV, Figs. 1-7).

Shape: Pollen oblate spheroidal in equatorial view, semicircular in polar view, small sized, range P x E = 20 x 20.6/μm, P/E ratio =0.81 - 1.18; Colpi: slit like or tapering, long, do not extend up to poles.
Endocaperture: indistinct, granulated (operculoid); Exine: 1.5 - 2 \( \mu \)m thick, semitectate; pattern: reticulate; Sporoderm: Sexine (1-1.5 \( \mu \)m) thicker than nexine (0.5 \( \mu \)m), Tectum 1 \( \mu \)m thick, columella distinct, 0.25 - 0.5 \( \mu \)m height.

MATERIALS STUDIED:

Taeniochlaena griffithii Hook. f.

= Roureopsis acutipetala (Miq.) Leenh. nov. Comb. ssp. acutipetala.

Mal. peninsula: Dery, R. - 1193; Singapore: Myhur, s.n.(20.3.1918), CAL - 10117.

The genus Taeniochlaena, described under the tribe Cnastideae by Hooker (l.c.), is represented by the only species T. griffithii in India.

Leenhouts included the taxon with Roureopsis. Palynologically this inclusion is justified.

ELLIPANTHUS: (Plate XV, Figs. 8-16).

Shape: oblate spheroidal in equatorial view. Circular in polar view; medium sized, range P x E = 33.9 x 35.7 \( \mu \)m, P/E ratio - 0.77-1.6;

Colpi: Tapering, extends up to poles, 3.5-6.5 \( \mu \)m width, sometimes with two vertical slits corresponding endocapertural diameter on either side of equatorial line. Endocarp: large, circular to isodiametric or indistinct.

Operculum: Circular classic type or modified somewhat. Exine: 2.5-3 \( \mu \)m thick, semitectate; pattern: reticulate, heterobrochate, smaller around colpi.

Sporoderm: Sexine thicker than nexine, tectum 1 \( \mu \)m thick, columella 0.75 \( \mu \)m high, distinct, nexine thickness and columella height equal.
MATERIALS STUDIED:

**Ellipanthus calophyllus** Kurz.
Andaman: Dr. King's Col. 83, 106, 295; Dr. King's Col. s.n. (1884)
CAL - 101134; Dr. King's Col. s.n. CAL - 101137.

Calcuttensis; Burma: Collagit - s.n. Herb. Hookeriansis, CAL - 101138;
Meiold, A. - 17268; Illegible No. - 189; Ex. Herb. R.E.P. - 29269;
Falconer s.n. CAL - 101143; Falconer - 563.

**E. tomentosus** Kurz. ssp. tomentosus var. tomentosus
= **E. griffithii** Hook, f. Perak: Dr. King's Col. 1977.

**E. tomentosus** Kurz. ssp. tomentosus var. luzoniensis Vidahl
Leenh. nov. stat.
= **E. luzoniensis** Vidahl. Philippines: Meyer, R. - 2239; Elmer, A.D.E.
- 10889, 6869; Ramos, M. - 1590; Alvaraz, R.J. - 22140, 12975.

Ellipanthus with 10 species distributed in Africa (3), Madagascar (2)
and others in Ceylon, continental S.E. Asia (Decan to Hainan), the Andamans
and the western half of Malaysia (Leenhouts l.c.). It is fourth genus described
under the tribe Cnestideae (sensu Hooker l.c.). Pollen morphology of 19 mater­
ials distributed under 4 species (s.l.) from Burma, India (Andamans), Philipp­
ines have been studied. Palynologically this taxon is very distinct and
uniform. Exine 2.5 μm in **E. calophyllus** and **E. luzoniensis** and 3 μm in
**E. tomentosus**. Columella height and nexine thickness is same always. In
**E. calophyllus** and **E. luzoniensis** it is 0.75 μm but in **E. tomentosus** it is 1 μm.
Lumina size ranges from 1.5-3μm, heterobrochate and smaller around colpi.
Colpi always broad tapering. In **E. calophyllus** only, colpi with two vertical
slits corresponding endospaturnal diameter on either side of equatorial line.
Endoaperture large, circular but indistinct in \textit{E. tomentosus}. Operculum circular, classic type in \textit{E. calophyllus} and \textit{E. tomentosus} but in \textit{E. luzoniensis} sexinuous materials extends at endoapertural area forming a bridge like structure.

From the above discussion it is evident that the genus \textit{Ellipanthus} is near to \textit{Connarus} pollen morphologically, both having medium sized pollen grains, coarsely reticulate exine pattern, with same lumina size range, comparatively finer reticulation with decreased lumina size towards aperture; Colpi tapering and circular classical operculum. \textit{E. luzoniensis} with its extended sexinuous material at endoaperture area (equatorial bridge) reminds the case of \textit{Connarus wightii} and \textit{C. gibbosus}. Two vertical slits, corresponding as diameter, on either side of equatorial line in \textit{E. calophyllus} is similar in this respect with \textit{C. wightii} & \textit{C. gibbosus}.

\textbf{GENERAL POLLEN MORPHOLOGICAL CHARACTERS OF THE FAMILY CONNARACEAE}

\textbf{Shape}: The pollen grains are isopolar, (Spheroidal or suboblate to oblate spheroidal or prolate spheroidal to prolate in equatorial view), subangular or semicircular or circular in polar view.

The apertures are composite type (colporate) and 3 in number, simple aperture type (colpate) noted rarely. These are equatorially distributed and are equidistant. Detailed pollen morphological characters are given below:

\textbf{I. Ektexine}: The ektexine is differentiated into tectum and columella in light microscopic observation. layers. The foot layer is not detectable. Columella layer is indistinct and short in most cases but tectum is quite distinct.
Tectum: Tectum forms a distinct layer and varies from 0.5 μm to 1 μm in thickness. Sometimes the thickness of the tectum is equal to that of the columella layer, sometimes it is thicker than the columella layer and in very rare cases the columella height is greater than the tectum thickness. It is semi-tectate type, and is more or less a continuous layer with indistinct columella heads in most of the cases and sometimes with distinct columella heads and with comparatively thick muri as in Connarus, Ellipenthus and some species of Agelaea.

Ornamentation: The sculptural pattern of the sporoderm in the family varies from ruguloreticulate (Rourea, Agelaea, Cnestis, Taeiniochlaena and Roureopsis) to finely reticulate (Rourea) to coarsely reticulate with distinct and comparatively larger lumina size with thick muri and distinct columella heads in Connarus and Ellipenthus. Reticulation is variable for the family, may be uniform throughout, whether it is homobrochate or heterobrochate, may be variable - smaller around colpi and / or larger at poles and mesocolpium or may be larger at poles than the mesocolpium.

Columella layer: The columellae are distinct or indistinct with distinct or indistinct heads, unbranched, which stands on thin and uniform layer of nexine. Sometimes columella height decreases from mesocolpium region to apertural area. Generally the columella layer forms a compact layer with the columella heads forming and supporting thick tectum, sometimes a few free columellae are seen within the lumina, especially in the species of Rourea.

2. Endexine: The endexine forms a distinct, thin and uniform layer more or less of equal thickness as the tectum, the variations can be seen from the
Table 4 (Summary of light microscopic measurements & data). Sometimes, endexine is very thick in the apertural area specially in some species of Connerus to form costae colpate type of aperture. Sometimes this type of thickening is restricted to the endocapertural area forming and/or acting variable types of granulated (operculoid) and operculum like structures.

3. Aperture: Apertures are composite type present in both, exotexine and endexine except in very rare cases like Cnestis platantha where only ectoaperture (colpus) is seen.

- **Ectoaperture:** The ectoaperture - Colpus is distinct and variable in its structural details. It is either slit-like or tapering and always extends up to poles. The aperture membrane may be smooth or granulated, sometimes this type of granulation are restricted in the endocapertural area only. Ectoapertures are uniform more or less in all the genera studied, except in the genus Connerus where it is of various types with point of interest for the evolutionary trends of the ectoaperture in the family. For details apertural type vide Fig. 2 (Chapter - 5).

- **Endoaperture:** Endoapertures are mostly indistinct, circular to elliptic in outline. The definite forms of endoaperture are available in the Connerus & Ellipanthus.

- **Operculum:** The endoaperture is finely or coarsely granulated (operculoid). This structure is comparable to "pseudo-opercule" of Roland (1966). The definite or classical type of operculum with various forms & shapes are evidenced in the genus Connerus. This is a point of interest for evaluation of the evolutionary trend in the family. The endexine is sometimes thickened in the apertural area especially in Connerus and distinguished as a distinct costae.
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<th>F. (mm)</th>
<th>E. (mm)</th>
<th>F/S</th>
<th>RAXINE (µm)</th>
<th>APERTURE</th>
<th>OECUMULUM</th>
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**Note:** The table continues with similar entries for other genera and species, detailing various attributes and measurements related to the study of aperture characteristics.
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*Note:* The table includes various measurements and descriptions of different species of cephalopods. The measurements provided are for comparison purposes and are not necessarily exhaustive. The descriptions highlight the unique features of each species, such as the shape and size of the cephalopod's body, the presence of teeth, and other anatomical characteristics.
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<td>0.5</td>
<td>ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>2</td>
<td>Indist.</td>
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<td>induta</td>
<td>21-23</td>
<td>26.2</td>
<td>0.85-1.04</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>2</td>
<td>Indist.</td>
<td>-</td>
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<td>ligata</td>
<td>21-23</td>
<td>26.2</td>
<td>0.85-1.04</td>
<td>0.5</td>
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<td>0.5</td>
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<td>0.5</td>
<td>0.5</td>
<td>m. ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>2.5</td>
<td>Indist.</td>
<td>-</td>
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<td>24</td>
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<td>0.5-1</td>
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<td>2</td>
<td>Indist.</td>
<td>-</td>
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<td>natalis</td>
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<td>20</td>
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<td>0.5</td>
<td>0.5</td>
<td>m. ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>2.5</td>
<td>Indist.</td>
<td>-</td>
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<tr>
<td>polibella</td>
<td>14-18</td>
<td>10.5</td>
<td>0.85-0.94</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>m. ret.</td>
<td>0.5-0.8</td>
<td>slit</td>
<td>2.5</td>
<td>circular</td>
<td>-</td>
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<td>ararata</td>
<td>19.5-23.5</td>
<td>18.8</td>
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<td>0.5</td>
<td>m. ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>2.5</td>
<td>Indist.</td>
<td>-</td>
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<td>xerica</td>
<td>19-21</td>
<td>17.5</td>
<td>1.12-1.14</td>
<td>0.75</td>
<td>0.5</td>
<td>0.5</td>
<td>ret.</td>
<td>0.5-2</td>
<td>slit</td>
<td>3.5</td>
<td>Circular</td>
<td>-</td>
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<tr>
<td>sanitoides</td>
<td>19-23.5</td>
<td>19.5</td>
<td>19-23.5</td>
<td>19.5</td>
<td>0.92-1.35</td>
<td>0.75</td>
<td>0.5</td>
<td>0.5</td>
<td>ret.</td>
<td>0.5-2</td>
<td>slit</td>
<td>3.5</td>
<td>Circular</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

- Pet. thinner at apical area.
- Pet. scar at siphuncle.
- Setae present in lamina.
- Some laminae fused to form linear lamina.
- Pet. scar at apices.
- Calps with median constriction.
- Pet. scar at mesoclupus and apocolupus.
- Fine round aperture.
- Gland thicker at apices.
- Calps scar at poles, calps narrow at equator.
- Gt. teeth like conicalizing the endocuticle.
- Pet. sorne at mesoclupus and apocolupus.
- Pet. columnellae present in the lamina.
- Pet. finer towards aperture.
<table>
<thead>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>11</th>
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<th>13</th>
<th>14</th>
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<th>16</th>
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<tbody>
<tr>
<td><em>amilla</em></td>
<td>12.25</td>
<td>12.25</td>
<td>0.92-1.76</td>
<td>0.75</td>
<td>0.5</td>
<td>ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>8</td>
<td>Indist.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td><em>cucumis</em></td>
<td>12.25</td>
<td>12.25</td>
<td>1.79-1.5</td>
<td>0.5</td>
<td>0.5</td>
<td>m.ret.</td>
<td>0.5-1</td>
<td>slit</td>
<td>2</td>
<td>Indist.</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td><em>volubilis</em></td>
<td>12.23</td>
<td>12.23</td>
<td>0.95-1.1</td>
<td>0.75</td>
<td>0.25</td>
<td>0.25</td>
<td>ret.</td>
<td>1-1.5</td>
<td>slit</td>
<td>2.5</td>
<td>Lacon.</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>CAU POSI</strong></td>
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<tr>
<td><em>pappacea</em></td>
<td>25-29</td>
<td>25-29</td>
<td>0.26-1.1</td>
<td>0.5</td>
<td>0.5</td>
<td>ret.</td>
<td>1-1.5</td>
<td>Tap.</td>
<td>3</td>
<td>Indist.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td><em>scopuloides</em></td>
<td>25</td>
<td>25</td>
<td>0.95-1</td>
<td>0.75</td>
<td>0.1</td>
<td>ret.</td>
<td>1-1.5</td>
<td>Tap.</td>
<td>5</td>
<td>Indist.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td><em>TANTOCHLAMIS</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>griffithi</em></td>
<td>15-18</td>
<td>15-18</td>
<td>0.94-1.18</td>
<td>0.5</td>
<td>0.5</td>
<td>ret.</td>
<td>0.5-1</td>
<td>Tap.</td>
<td>3</td>
<td>cir./ Indist.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>petaloidei</em></td>
<td>15-18</td>
<td>15-18</td>
<td>0.94-1.18</td>
<td>0.5</td>
<td>0.5</td>
<td>ret.</td>
<td>0.5-1</td>
<td>Tap.</td>
<td>3</td>
<td>Indist.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Some lines fuse to form linear. Luminous at poles.*

*Ret. occurs at poles.*

*Ret. fuses toward spaltare.*

*Vest of the pollen grains becomes shrivelled after mesotylisation.*
GENERAL CONCLUSION

PALYNOCLOGICAL FINDINGS:

Present investigation in the family Connaraceae has been carried out to establish its relationship, affinities and position on the pollen characters and to constitute palynological information along with the evidences available from other branches viz. leaf anatomy, wood anatomy, carpel anatomy, carpology and embryology etc. towards a more natural and modern taxonomy of the family.

Moreover, pollen-morphological studies on such a controversial family was very meagre till the publication of Dickison (1979), when this work was near completion. The importance of my work though somewhat diminished by this publication, study of pollen grains of related families, in which the family placed or relationship made by different taxonomists in different times, will be of much help in resolving the relationship, affinities and taxonomic position of the family.

The present contribution covers the considerable aspects in pollen morphological diversity in Connaraceae. Special attention is paid to the aperture characters and endoapertural granules (operculoid). Indistinct endoapertural area with granules culminates in its line of evolution into distinct endoaperture with perfect classical operculum.

Although the ontogenetical development and functioning of these granules in the endoapertural area still remain to be investigated, it appears probable that these are the result of evolution and cost of natural selection in course of forming definite operculum or vice versa in the family.

Other features of importance is columella height, lumina size range etc. which have been discussed in respective places. Detailed study of these characters
will be of immense importance to establish an evolutionary trend within and amongst the families. In addition to that, this investigation will help in fossil pollen analysis, in particular for the study of palaeogeographical flora.

From the present palynological investigations it may be concluded as follows:

1. The family Conneraceae is stenopalynous (Erdtman l.c.) and the different taxa available in India under this family have been differentiated quite early probably from a common ancestor. Inspite of their overall resemblances in pollen characters they form two distinct group though not fit for the tribe classed by Bentham & Hooker (l.c.) or Schellenberg (l.c.) or Hooker (l.c.). Group - I comprises *Agelaea*, *Rourea*, *Roureopsis*, *Cnestis* and *Taeniochlaena* (sensu Hooker) with ruguloreticulate, finely reticulate or coarsely reticulate exine, with smaller lumina size, thin muri and indistinct endoaperture and the Group - II includes *Connarus* and *Ellipanthus* with coarse reticulate exine and comparatively much larger lumina size with thick muri and distinct endoaperture. The genus *Agelaea* stands the transitional form (Fig. 3).

   Group - I be further classed as (a) Endoaperture with fine granules covering endoapertural area only ... *Rourea*, *Roureopsis*, *Taeniochlaena* & *Cnestis*.

   (b) Endoaperture with comparatively coarser granules and covering area beyond endoaperture sometimes ... *Cnestis*, *Agelaea*.

2. Pollen in general are primitive type in being small to medium sized, oblate to oblate spheroidal to prolate spheroidal to prolate in shape, 3-colporate with weakly defined granulated endoaperture (operculoid) in most
Fig. 3. Pollen dimensional diagram of Connaraceae.

1. Connarus ○
2. Ellipanthus ●
3. Agelsa +
4. Rourea □
5. Ruraopsis ▲
6. Taeniochlaena △
7. Cnestis ■
of the species, ruguloreticulate or microreticulate to coarsely reticulate of exine sculpture. Pollens/Connarus and Ellipanthus seem to be advanced type in the family with prolate spheroidal/oblate spheroidal to prolate in shape, distinct and coarsely reticulate exine ornamentation with fairly large lumina size and definite endoaperture with classical operculum. To these are further added some considerable complexity in ectoapertures. (Walker & Doyle 1975, Walker, 1974, 1976 a & 1976 b)

3. After a close comparison of the pollen types, it is possible to suggest a number of "evolutionary trends" in the family (Fig. 4). By the term "evolutionary trends", I here mean only the tendency from one form to the diverse form, as evidenced in the taxa studied. However, evolutionary trend for the family be considered as theory only and fossil evidence in favour of this theory, shall confirm the true evolution, which is yet to be investigated.

Evolutionary trends as evidenced in the present study are as follows:

1. **Shape:**
   (a) **Equatorial view:**
   - Suboblate → oblate spheroidal → Prolate spheroidal → Prolate.
   (b) **Polar view:**
   - Circular → Semicircular → Subangular.

2. **Size:**
   - Small → Moderately medium → Medium.

3. **Ectoaperture (Colpus):**
   (a) Tapering → slit like with halozone
      - with halozone & with two vertical slits. (as endocrack of Old field 1959.)
   (b) Without costae → with costae.
Fig. 4. Pollen morphological trends in Connaraceae.

- Increase in lumina size, different wall thickness for different columella height.
- Muri incomplete to form linear lumina particularly at poles.
- Increase in ectoapertural complexity & lumina size.
- With patch streak, classical operculum or equatorial Sinuous bridge.
- With classical operculum or equatorial Sinuous bridge.

Species:
- Cnestis
- Bourea
- Taenochlaena
- Roureopsis
- Agelaea
- Connarus
- Ellipanthus

Granules Coarse (Operculoid) vs. Fine (Indoaperturate)
4. **Endoaperture:**

   (a) Absent (In one sp.) $\rightarrow$ Indistinct (weakly differentiated)
   $\rightarrow$ Circular to elliptic $\rightarrow$ Longate $\rightarrow$ Structurally complex.

   (b) Normal type $\rightarrow$ with sexinous emergence from both sides
   (equatorial bridge).

5. **Operculum:** Operculoid with randomly distributed fine granules $\rightarrow$ Operculoid
   with coarse randomly distributed granules $\rightarrow$ Operculoid with teeth
   like granules in definite arrangement $\rightarrow$ Operculum in the form of
   patch streak on either side of the ectoaperture $\rightarrow$ definite operculum
   (classical.)

6. **Exine Ornamentation:**

   (a) Ruguloreticulate $\rightarrow$ Microreticulate $\rightarrow$ Finely reticulate $\rightarrow$
   Coarsely reticulate.

   (b) Homobrochate $\rightarrow$ Heterobrochate.

   (i) Lumina size uniform throughout $\rightarrow$ Lumina size decreases towards
   apertural area. (A condition also noted by Punt (1976) in
   Dichapetalaceae).

   (ii) Lumina size uniform in mesocolpium $\rightarrow$ Lumina size increases in
   apocolpium $\rightarrow$ Luminae fuse side by side to form linear lumina.

   (iii) Muri thin (up to 1 $\mu$m) $\rightarrow$ Muri thick (1 $\mu$m or more)

   (iv) Muri not interrupted $\rightarrow$ Muri interrupted to form large and
   linear lumina.

7. **Sporoderm:**

   **Sexine:** Sexine thicker than Nexine $\rightarrow$ Sexine = Nexine $\rightarrow$ Sexine
   thinner than Nexine.

   **Tectum:** 0.5 $\mu$m thick $\rightarrow$ 0.75 $\mu$m thick $\rightarrow$ 1 $\mu$m thick.

   **Columella:** (a) Indistinct $\rightarrow$ Distinct $\rightarrow$ More distinct with distinct heads.

   (b) Height uniform throughout $\rightarrow$ Height decreases towards
   apertural area.
DIFFERENT DISCIPLINES OF BOTANY IN BETTER UNDERSTANDING OF THE CLASSIFICATION & RELATIONSHIP OF THE FAMILY

ANATOMICAL EVIDENCES:

Leaf anatomy: Sperlich (1911) and Funke (1929) reported some anatomical details on the leaf joints only. A comprehensive study of the nodal as well as foliar anatomy have been done by Dickison (1973). This outstanding work provides additional evidence for evaluation in relation to the systems of this tropical family. The fundamental nodal pattern in both compound and simple leaved genera is trilacunar, 3-trace is derived. The characters which are important for specific delimitation within the family include: mature stomatal type, trichome form, occurrence of epidermal papillae, presence of hypodermis, degree of cuticularization and the nature of high order venation. According to him foliar anatomy is very consistent with the placement of the family near Rosaceae and Leguminosae.

Wood anatomy: Schellenberg (1910), Moll & Janssonius (1914), Schellenberg (1938), Heimsch (1942), Metcalf & Chalk (1950) and Dickison (1972) described woods of the family. Salient anatomical features indicative of a moderately high level of phylogenetic advancement include: vessel elements of medium length with exclusively simple perforation plates, alternative intervacular pitting, short libriform fibres that are often septate and crystalliferous and rays predominantly uniseriate. Axial parenchyma is typically absent, scanty or diffuse. Growth ring are absent or ill-defined, whereas mucilage canals and pith flecks are characteristic features. Liana members of the family show modifications of wood structure such as shorter, broader vessels, solitary pore distribution, tracheids surrounding vessels and anomalous development of the concentric type.
Woods of Connaraceae is structurally of an advanced type and similar to most other families of the Sapindales. Heimsch (1942) suggested that the Connaraceae may belong to Hutchinson's 'pinnatae' standing near the Sapindaceae rather than the Rosaceae or Leguminosae. Table 5 show the intergeneric characteristics regarding the foliar and wood anatomy of the family.

Carpel anatomy: Dickison (1971) described in detail the carpel anatomy with special reference to bundles in the carpel. According to him carpel morphology confirms the relationship between Connaraceae & Rosaceae.

Van Der Pijl (1957) studied the floral anatomy and carpology with special reference to seed anatomy and developmental features of the arilloid (arils in Connaraceae s.l.) and according to him the situation in Connaraceae as a whole seems comparable with that in the Sapindaceae. Corner (1976) interpreted the similarity in carpellary vasculature between Connaraceae, Rosaceae and Leguminosae as an "example of convergence through neotonic simplification".

Carpological evidences: Corner (1976) after extensive studies on seed morphology, suggested an alliance between Connaraceae and Celastraceae, Flacourtiaceae, Violaceae, Sapindaceae and Meliaceae. He gave special emphasis on Sapindaceae and Meliaceae. Fibrous exotegmen of Connaraceae is the characteristic feature for Sapindales. Hutchinson placed the family in Dilleniaceae but this possibility can be ruled out because the endotestal seeds of Dilleniaceae has no affinity with exotegmic pre-raphe seed of Connaraceae. Similarly a connection with exo-mesotestal Rosaceae and exotestal Leguminosae or Saxifragales can be ruled out. With exstipulate pinnate leaves, apocarpous flowers and arillate follicles, Connaraceae fit well a side branch of Meliaceous - Sapindaceous ancestry.
<table>
<thead>
<tr>
<th>Genus</th>
<th>TRICHOMES</th>
<th>EPIDERMIS</th>
<th>STOMATA</th>
<th>MECOPHYLL</th>
<th>NODAL ANATOMY</th>
<th>VASCULAR BUNDLES</th>
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</thead>
<tbody>
<tr>
<td>Coelia</td>
<td>Glandular hairs mostly confined to the floral organs.</td>
<td>Papillose on lower surface; mucilage cells present frequently large and penetrate the mesophyll.</td>
<td>Paracytic</td>
<td></td>
<td>Trilacunar</td>
<td>Surrounded by Schlerenchyma; small cells containing solitary crystals. No spiral thickening.</td>
</tr>
<tr>
<td>Agelas</td>
<td>Stellate hairs in clusters of 4 or occasionally more members.</td>
<td>Mucilage cells absent.</td>
<td>Anisocytic</td>
<td></td>
<td>Trilacunar</td>
<td>Surrounded by schlerenchyma; small cells containing solitary crystal present above and below the vascular bundle. No spiral thickening.</td>
</tr>
<tr>
<td>Roussea</td>
<td>Glandular hairs mostly confined to the floral organs.</td>
<td>Mucilage cell present, frequently large and penetrate the mesophyll.</td>
<td>Paracytic</td>
<td>Sclereide element recorded in E. ligulata Baker</td>
<td>Trilacunar</td>
<td>Surrounded by Schlerenchyma; small crystals occur in the mucilaginous lining, no spiral thickening.</td>
</tr>
<tr>
<td>touraecea</td>
<td>Short pin like trichomes present amongst longer ones.</td>
<td>Mucilage cells in adaxial surface only</td>
<td>Paracytic</td>
<td></td>
<td>Trilacunar</td>
<td>Surrounded by ordinary mesophyll cells. No spiral thickening.</td>
</tr>
<tr>
<td>Taeniochlaena</td>
<td>-</td>
<td>Mucilage cells present</td>
<td>Paracytic</td>
<td></td>
<td>Trilacunar</td>
<td>Surrounded by ordinary mesophyll cells. No spiral thickening.</td>
</tr>
<tr>
<td>Concarus</td>
<td>Unicellular, 2 armed, glandular hairs mostly confined to floral organs.</td>
<td>Mucilage cells absent.</td>
<td>Anomocytic</td>
<td>Secretary Cavities filled with brown resinous materials</td>
<td>Multilacunar &amp; Trilacunar</td>
<td>Spiral thickening.</td>
</tr>
<tr>
<td>Allipernthus</td>
<td>-</td>
<td>Mucilage cells absent.</td>
<td>Anomocytic</td>
<td></td>
<td>Trilacunar</td>
<td>Spiral thickening.</td>
</tr>
</tbody>
</table>
Embryological evidences: Mauritian (1936, 1939), Sougas (1939), Thathachar (1942), Raju (1962), Pijl (1957) and others describe the embryology of different families from time to time, which has been summarised in the Table 6. From this it is evident that Connaraceae resembles Sapindaceae, Anacardiaceae, Sabiaceae and Burseraceae in having Hemianatropous type of ovule, Bitegmic integument, Crassinucellar type of Nucellus, Polygonum type embryosac and Nuclear or cellular type of endosperm development. Averrhoaceae differs from Connaraceae by its anatropous type of ovules, other embryogenic characters are same. Capparaceae differ from Connaraceae by its Campyloptropous type of ovule only, other characters are same. Cronquist (l.c.) mentioned that embryologically this family have much similarity with Cunoniaceae.

It is hard to postulate closest affinity of the family from embryological characters only, because of similarity in some embryogenic features but dissimilarity in others.

From a syllabic chart of the grouping of order proposed by Johnson (1977) as shown in the Table 7, it is evident that Connaraceae shows affinity towards Sapindales in parallel with the Geraniales and Rhoeadales. Johnson placed Connaraceae under his Rosales - the order which bears both inferior and superior ovary as well. Connaraceae is a family strictly with superior ovary.

Cytological evidences: Chromosome counts and karyotype reports as far at hand is very meagre. Report on chromosome number available at hand is by Mangenot & Mangenot (1957, 1958, 1962) and Baker (1962). They reported chromosome number of different species of Agalaea, Byrsocarpus, Castanola, Cnestis, Hemandrdenia, Manotes and Santaloides and 2n number in all the cases are 28 except in Manotes longifolia where 2n = 26. So, it seems to be uniform in its chromosome number and structural changes in chromosome lead to speciation. It is not possible to make any further conclusion for the family from such scanty
<table>
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<tr>
<th>FAMILY</th>
<th>DEVELOPMENT</th>
<th>POLLEN GRAIN</th>
<th>OVULE</th>
<th>NUCELLUS</th>
<th>EMBRYOSAC</th>
<th>ENDOSPERM</th>
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<td>BISPHERIDACEAE</td>
<td>Tetrasporangiate</td>
<td>2-Celled</td>
<td>Anatropousto</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
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<tr>
<td>ROSACEAE</td>
<td>Tetrasporangiate</td>
<td>--</td>
<td>Anatropousto</td>
<td>Unitegmic or Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>OXALIDACEAE</td>
<td>Tetrasporangiate</td>
<td>3-celled/2-celled</td>
<td>Anatropousto</td>
<td>Bitegmic</td>
<td>Tenuinuclellar</td>
<td>+</td>
</tr>
<tr>
<td>AVENNACEAE</td>
<td>Not reported</td>
<td>2-celled</td>
<td>Anatropousto</td>
<td>Bitegmic</td>
<td>Crassinuclellar</td>
<td>+</td>
</tr>
<tr>
<td>CARYACEAE</td>
<td>Not reported</td>
<td>2-Celled</td>
<td>Anatropousto</td>
<td>Unitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>PAPILIONACEAE</td>
<td>Tetrasporangiate</td>
<td>2-celled/3-celled</td>
<td>Anatropousto</td>
<td>Bitegmic</td>
<td>Crassinuclellar</td>
<td>+</td>
</tr>
<tr>
<td>CAESALPINACEAE</td>
<td>Tetrasporangiate</td>
<td>2-celled</td>
<td>Anatropousto to Campylotrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Mimosaceae</td>
<td>+</td>
<td>+</td>
<td>Anatropousto to Anatrop</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>MELIAACEAE</td>
<td>+</td>
<td>2-celled/3-celled</td>
<td>Campylotrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>CAPARIDACEAE</td>
<td>+</td>
<td>2-celled/3-celled</td>
<td>Campylotrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>ANACARDIACEAE</td>
<td>+</td>
<td>2-celled</td>
<td>Anatrop.</td>
<td>Unitegmic or Bitegmic</td>
<td>+</td>
<td>+</td>
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<tr>
<td>ZYGOPHYLLACEAE</td>
<td>+</td>
<td>2-celled</td>
<td>Anatrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>DILLENTACEAE</td>
<td>+</td>
<td>2-celled</td>
<td>Anatrop. to Amphitrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>GERAINTACEAE</td>
<td>+</td>
<td>3-celled</td>
<td>Anatrop. to Campylotrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>NURSEACEAE</td>
<td>+</td>
<td>2-celled</td>
<td>Hemianatrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>CUNOBONEAE</td>
<td>Not reported</td>
<td>--</td>
<td>Anatropousto to Hemianatrop.</td>
<td>Bitegmic</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ovary</td>
<td>Opuntiales</td>
<td>Rosales</td>
<td>Parietales</td>
<td>Myrtiflorae</td>
<td>Umbelliferae</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>---------</td>
<td>------------</td>
<td>-------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Inferior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior</td>
<td>(Connaraceae)</td>
<td>Rhamnales</td>
<td>Malvales</td>
<td>Geraniales</td>
<td>Sepindales</td>
<td>Rhoeales</td>
</tr>
</tbody>
</table>
cytological informations from cytological point of view.

Palynological Evidences: Present palynological investigations is not full agreement with other evidences discussed earlier. To some extent it supports the wood anatomical and carpological evidences and some of the phylogenetic classifications proposed time to time by different authors, for resolving the better understanding of affinity and relationship of the family. Palynologically the family Connaraceae shares the characters with the families of Sapindales, Geraniales and Rhoedales rather than Rosales. For better understanding the affinities and relationship of the family on pollen morphological characters, pollens of some other families have been studied.

AFFINITIES OF CONNARACEAE WITH OTHER FAMILIES OF ANGIOSPERM ON POLLEN CHARACTERS

To proceed into this chapter it is necessary to mention that, the pollen morphology of the families described here are those which have been considered as related taxa by different taxonomists or other workers in different times and their argument in different aspects have been discussed elsewhere. The taxa which have similarity in pollen morphology with Connaraceous members have been described in details and other species studied but having no palynological similarities with Connaraceae are mentioned only at the end of this chapter.

Averrhoaceae:

Pollen grains of this family represented by the type genus Averrhoa from India, is very much similar to that of Rourea, Roureopsis, Cnestis & Agalaea of Connaraceae in oblate to oblate-spheroidal shape with comparatively thin exine.
provided with rugulo-reticulate to micro-reticulate exine ornamentation. Most interesting and outstanding similar feature is the characteristic endoapertural granules. Pollen grains of the genus *Sarcotheca* of the family reported by Erdtman (1952), Gltman (1971) & Huynh (1969 a,b) has much resemblance with Connaraceous pollen. I agree with Airy Shaw (1973) for a close relationship between the families. A point of interest is to be mentioned here that Darwin (1877) and Hildebrand (1866) have reported heterostyloous condition for the family Oxalidaceae (s.l. - where Averrhoaceae was included) and which is also a common feature for the family Connaraceae.

**MATERIALS STUDIED:**

*Averrhoa carambola* Linn. Assam: Rao, R.S. - 9873; W. Bengal: Naskar 173; Mondal, M.S. - 10 (fresh).

**Burseraceae:**

Erdtman (1952), Riollet (1974), Lobreau - Callen et al. (1975), and Mitra et al. (1977) studied pollen grains of Burseraceae. Some of the taxa of Burseraceae are similar palynologically with that of Connaraceae in respect of rugulose to rugulo-reticulate exine, prolate spheroidal to prolate shape and granulated aperture membrane. But pollen grains of Burseraceae in general are larger than the major pollen size in Connaraceous members, except the Santiria type (sensu Mitra et al. - l.c.) where the pollen size are smaller, prolate to prolate spheroidal shape and the size range resembles Connarus type pollen of the Connaraceae. Coarse granules in the endocaperture in *Boswellia*, tooth-like granules in the endocaperture in *Dacryodes* and both the genera having rugulose exine ornamentation resembles *Cnestis* and *Agelaea* of the family Connaraceae.
MATERIALS STUDIED:


C. littorale Bl. Malay: King - 345. det - P.W. Leenhouts, June 1954;


C. sikkimense King. Sikkim Himalaya, King, G. - s.n. (14.6.1881).

C. strictum Roxb. Peninsular India, CAL - 78203; det. P.W. Leenhouts 42(7)-11; Coimbatore: Gamble J.S. 8864; N. Kanara: Talbot, W.A. 2751; Assam: without Col. Name & no., CAL - 78243;


S. multiflora A.W. Benn, Malacca: without Col. Name & no., CAL - 78636.

S. oblongifolia Bl. Malaya: Dr. King's Col. 6602; Dr. King's Col. - 10448.


S. rubiginosa Bl. var. rubiginosa = Camarium planchi King, Malaya: Dr. King's Col. 78285. det. C. Kalkman Sept. 1954.

Capparidaeae:

Pollen grains of Capparidaeae are very much similar with that of Connaraceae, by its small to medium pollen class, rugulose to rugulo- reticulate exine ornamentations, slit like ectoaperture and distinct or indistinct endoaperture with fine, coarse or teeth-like granules (operculoid) to classical operculum. Distribution of granules sometimes extends beyond the endoapertural area covering some more of colpa as in some of the spp. of Ageles and Connerus of the family Connaraceae. A number of taxa in this family especially the Cleome are very much alike with Connaraceous pollen types in respect to shape, size, exine characters, lumina size range and apertural details.

Furthermore it is to be mentioned that distally is known to occur from the family Capparidaeae (Vogel 1954), & this feature is frequently common for the Connaraceae as described earlier.

Material studied:

Capparis acuminata Lindl. Indian Botanic Garden, fresh. 9.11,66.
C. viminala Hk. f. NEFA: Rao, R.S. - 7582.
C. chelidonii L.f. Poona: W.C. BSI - 91779; without Col. Name, No. - 279;
Coimbatore: Sebastine, K.M. 2521.
C. felina L.f. Nagarjun valley; Tothathri, K. 9651.
Name, No. - 256.
= Gynanchopsis pentaphylla DC. Indian Botanic Garden, fresh, 18.10.66;
Hooghly: Hazra, P.K. - 63.
C. rutidosperma DC. Coimbatore: S.C. BSI - 11838.
C. viscosa Linn. W. Bengal. without Col. Name, No. - 563; Indian Botanic Garden,
fresh, 18.10.1966.
C. religiosa Forsk., Indian Botanic Garden, fresh. 25.10.66.

Maerua apetala (Roth.) Jacobs. = Neibuhria apetala


M. ovalifolia Camb. = M. arenaria Hk. f. & T.

Indian Botanic Garden, Howrah, fresh, 24.12.68; Shillong: E.C. BSI, NIL.


Resedaceae:

The family Resedaceae, chiefly confined to the Mediterranean region and abundant in calcareous soils (Andrews (1950), Durand and Schinz (1898), Hooker, (l.c.) Hutchinson (l.c.), Post (1932), Rendle (1959) and Thonner (1915)).

This family extends eastwards through Persia to Northwest India and Southwards to the mountain of Abyssinia and Somaliland. Northwards its limit up to central Russia, North Germany and Scotland. In South Africa only one species of Oligomeris Capensis is wild and Reseda alba and R. odorata have been found under cultivation (Marloth 1913). The European species Reseda lutea extends eastwards up to Afghanistan.

Pollen grains of Resedaceae are small-sized generally, prolate to prolate spheroidal in shape, 3-colporate with characteristic endoaperture granules. Sometimes these granules extends beyond the endoapertural area covering most of the colpal area. On the above mentioned characters the family show similar pollen morphoforms with Connaraceae.

Material Studied:

Astrocarpus sesamoides (L.) Duby. Europe: NIL, CAL - 29885.


Obradenus baccatus Delile. Syria: NIL, CAL - 30087.


Paseda alba Linn. India: NIL, CAL - 29872; Indian Botanic Garden, NIL, CAL - 29956.


R. lutea Linn. Asia: NIL, CAL - 29832.

R. luteola Linn. India, N.W. Frontier, NIL, CAL - 29868.

R. mediterranea Willd. Europe: NIL, CAL - 30016.

R. odorata Linn. Indian Botanic Garden, CAL - 29854.


R. pruinosa Del. India, N.W. Frontier, NIL, CAL - 29857.


Sapindaceae:

This is also a tropical family. Merville (1965) found that it is more or less common character of Sapindaceae is the presence of granules on the aperture membrane. This is also found in Hippocastanaceae, which Engler placed near Sapindaceae and included in the Sapindaceae by many authors including Hallier and Hutchinson.

In Sapindaceae the pollen grains are both brevialxial and longiaxial, colporate and porate, brevicolpate or colpate, granulated colpi membrane and the exine ornamentation psilate, finely reticulate to coarsely reticulate, striatoreticulate etc. Muller, J. (1970, 1971) studied the pollen grains of the genus Lepisanthes and Dimocarpus species are uniquely similar palynologically with that of Connaraceous members specially with the Rourea type (Rourea Complex) pollen. The similarity between the two groups lies in small to medium pollen size class, oblate, suboblate or spheroidal in shape, P/E ratio around 0.91, polar outline ± circular, finely reticulate tectum, lumina ± 0.5 μm in diam., finer near aperture, reduction of columella height near apertures, ectoaperture distinct with granules.

In the genera like Blighia, Glenia, Harpalia, Nephaliuim and Euphoria also, the typical character of Rourea type pollen grains have been observed. Some other pollen grains of Sapindaceae are prolate-spheroidal to prolate in shape, isopolar, tricolporate, finely reticulate to coarsely reticulate type. These pollen types remind the pollen types of Fabiaceae (Part I).

MATERIAL STUDIED:

Allophylus cobbe Bl. Assam: Panigrahi, G. 3052; Maldiv: J.S. Gardinar - s.n.


-:( 98 ):-

A. cobbe Bl. var. rheedii - Shillong: NIL, CAL - 94373.
A. cobbe Bl. var. varritus - Australia: NIL, CAL - 94088.
A. longifolius - Maharashtra: NIL, CAL - 94127.
A. rheedii Radik. - Maharashtra: J. Fernandes - 2420; Mahabaleshwar:
Dr. J. Cooke s.n.
A. rheedii Radik. = A. cobbe (Bl) var. rheedii - Kerala: Calder, C.C.
& M.S. Ramaswami s.n., CAL - 94070.
A. serratus (Roxb.) Kurz. Nilgiri: K. Subramanyam - 1082; Wallichian
sheet s.n. CAL - 93947; Hooghly: Sen, Subir - 748;
A. Simplifolius Radik. - Philippines: NIL, CAL - 94141.
A. tripilus (Burm.f.) Merr. Andaman: NIL, CAL - 93980. Karnataka: NIL,
CAL - 94080.
A. tripilus = A. cobbe var. glaber - Sundarbans: NIL, CAL - 93908; S.
Andaman: Dr. King's Col. s.n.
A. villosus (Roxb.) Bl. Assam: NIL, CAL - 94066.
A. villosus (Roxb.) Bl. f. apperticus W. Bengal: S.C. Banerjee, s.n. Manipur
Mukherjee, S.K. s.n. CAL - 93947; Wallichian Sheet.
s.n.; S. Andaman: N.C. Nair - 511.
A. villosus (Roxb.) Bl. f. villosus - Wallichian Sheet s.n. CAL- 93972.
A. zeylanicus Linn. - Assam: Dr. King's Col. s.n.
Arytera littoralis Bl. IBG: Mondal, M.S. (fresh) 16. (10.11.75).
Blighia sapida C. Kon. - IBG: Mondal, M.S. (fresh) 20. (1.11.76).
Dodonaea viscosa Linn. - Bihar: Rao, G.V.S. - 23211.
Eriglossum edule Bl. - IBG, NIL, 7.11.66. IBG, NIL, 21.3.67; Jalpaiguri:
Mukherjee, S.K. - 5499; IBG, NIL, fresh, (17.5.66).
Euphoria longana Lamk. IBG, NIL, fresh, (16.5.67).
Gleniea zelanica Kh. f. - IBG, NIL, fresh (9.11.66).
Litchi chinensis Sonner. - IBG, NIL, fresh, 29.10.66.
Nephalium leiocarpum F. Muell. IBG, NIL; fresh, 21.3.67.
Sophorac trifoliatus Linn. IBG, NIL, fresh, 18.1.68.
Serjania meridionalis Combess. IBG, NIL, fresh, 16.10.69.

Meliaceae:

The family is distributed over tropics and subtropics of the new
and the old world. Jussieu (1830), Mohl (1834) Erdtman (l.c-), Ikuse
(1956), Chang & Wang (1956), CcvoiA,
Rao & Lee (1970) and Mitra (unpublished, 1974, part of Ph. D. Thesis) have studied the pollen grains of Meliaceae.

Pollen grains of the tribe Swietenieae and Cedrelleae of the family Meliaceae are to some extent similar with that of Connaraceous pollen types in respect of distinct or indistinct, comparatively small columna; long slit-like colpi and distinct or indistinct endoaperture with granules. But major difference lies in the fact that there is a tendency in Meliaceous pollen grains towards brevicolporate or brevisimicolporate apertures and with 3-4-5 porate or 3-4-5 brevicolporate types of apertures.

MATERIALS STUDIED:

Chisocheton divergens Bl. Malayas CAL-79943; Bogor. CAL-79940.; var. robustus Valeton


C. divergens Bl. var. genuinus Valeton. Malaya: CAL- 79941.

C. dysokylifolius Kurz. Assam: CAL - 79875.

C. paniculatus Hiern. Assam: Panigrahi, G. - 18711.


Chukrasia tabularis A. Juss.: Sikkim: CAL- 81821.

Cipadesa fruticosa Bl. : Rao, R.S. 18402.

Diosoxylum andamanicum King. Anadaman: CAL - 79551.


D. cunningianum C. DC. Philippine: CAL - 81291.


D. hamiltonii Hiern. : IBG, Cult.

D. pallens Hiern. : Assam: CAL - 79436.

D. procerum Hiern. Assam: CAL - 79320.


D. procerum Hiern. Sikkim; Rao, R.S. 19.


D. thyrsoidesm Griff. var. andamanicum: Andaman: CAL - 79300.

Guarea humilis Bert. C. America : CAL - 81279.

Guarea humilis Bert. C. America : CAL - 81270.


L. decandrum Harmb. Sikkim: CAL - 311 60.


Melia azedarach Linn. IBG. NIL (13.10.76); IBG, NIL, (26.5.74): Assam: Panigrahi, G. 5482; Coimbatore: Subramanyam, K. 2505, Nepal: Puri, V. - 195.


Munronia wallichii Wight.: Sikkim: CAL - 78839; Tripura - Deb, D.B-27133.


Sandoricum indicum Cav., Andaman: CAL-80077.
S. roettcheri Merr., Philippine - CAL-80137.
Swietenia humilis Zucc. IBG, Cult. 2.8.67.
S. macrophylla King. IBG, NIL, fresh.
S. mahagoni Jacq. S. Circle, NIL; Madras: Tinney valley, Subramanya, K. - 2830.
Toona ciliata M.J. Roem, var. Gamblei C. Dc. Upper Gangetic plain:
CAL-82004.
T. ciliata M.J. Roem, var. deccana C. Dc., Deccan: CAL-81996.
T. ciliata M.J. Roem, IBG. 25.5.68.
T. febrifuga M.J. Roem, var. assamensis C. Dc., Assam: CAL-82052.
T. microcarpa Harms. Thothathri, K. s.n., CNH.
T. rubescens Oliver. Kamerun: CAL-81625.
Turrea villosa Benn. Travancore: CAL-7877.
T. concinna Benn. Malaya: CAL-78780.
Walsura candollei King. Andaman: CAL-81480.
W. gardnerii Thw. NIL, CAL-81302.
Icacinaceae:

This is a tropical family of approximately 60 genera embracing about 300 species largely confined to the tropics of both the old and new world. Dahl (1952) made a comprehensive study on the pollen morphology of the family.

Dahl (l.c.) categorised the pollen grains of Icacinaceae into three major groups and ultimately into fifteen pollen types on the basis of exine and germinal apertures. He mentioned the family as heterogeneous on the basis of pollen data together with anatomical and exomorphic data. It is interesting to note that some of the taxa under pollen type-A (sensu Dahl-l.c.) are similar to Connaraceous pollen grains in having oblate, oblate spheroidal or prolate pollen grains with similar array of size ranges and with distinct or indistinct endo-aperture. Similar heterobrochate condition of exine, either towards colpal area or in the apocolpium and presence of granules in the endo-aperture area are common.
palynological features in both the family. An interesting palynological feature is the exinous bridge or "shouldering" (sensu Dahl, l.c.) in the endoaperture area, reminds the same typical condition in Connaraceus pollen grains particularly in the genus Connarus.

Pollen morphological similarities between the Connaraceae and Icacinaceae support the alignment of these families in a single order either in Sapindales (Engler, 1893) or in Terebinthales (Warming, 1964).

In addition to the previously discussed families, pollen grains of Anacardiaceae, Sabiaceae (Part I of the Thesis), Rosaceae, Dilleniaceae and Leguminosae (Fabaceae) have been studied but not discussed here as these taxa have no significant palynological similarities with Connaraceous pollen types. Only the no. of material studied from respective families are given here.

Anacardiaceae: 29 materials from 25 species have been investigated in detail in chapter 7 in Part I. Pollen grains of Anacardiaceae are different from common Connaraceous pollen grains.

Sabiaceae:

222 materials from 31 species have been studied for Part I of this thesis. Pollen grains of Sabiaceae differ from Connaraceous pollen types in thick exine, coarse reticulate ornamentation, distinct columellae with distinct heads and distinct & large endoaperture. Takhtajan (l.c.) and Cronquist (l.c.) provide evidences for their reasonable separateness in diverging from a possibly common origin in ancestors of the order Saxifragales.
Rosaceae:

5 materials from 4 species of Spiraea have been studied. Spiraea is sometimes mentioned as the connecting link in between Rosaceae & Connaraceae. Pollen grains of Spiraea vanhouttei Zabel have been studied and the pollen type is quite different.

Fabaceae:

276 materials from 193 species have been studied. Pollen grains of this family is very different from Connaraceous pollen type. Exine is very much thicker with very distinct ornamentation in comparison to Connaraceous pollen grains. The species of Smithia have granules in the apertures but the characteristics of these granules is different being arranged in a single row.

Dilleniaceae:

Only 6 materials from 3 genera have been studied. Pollen type is different from Connaraceous pollen types.

CORRELATION OF POLLEN CHARACTERS WITH TAXONOMICAL AND OTHER EVIDENCES AND DISCUSSION

From the foregoing discussion it is quite apparent that the family Connaraceae is very closely related to Sapindaceae, Capparidaceae, Resedaceae, Icacinaceae and Averrhoaceae palynologically. It shows little or insignificant affinity to Meliaceae, Burseraceae on pollen morphology. Pollen grains of Leguminosae. (Fabaceae)
Anacardiaceae are different with a few exception and that of Rosaceae and Dilleniaceae are different from the characteristic pollen types of Connaraceae.

All the foregoing observations and comparative analysis of morphological and taxonomical characters have helped in drawing certain conclusion on the phylogeny of the family.

Division of the family Connaraceae into two subfamilies I. Jolydoroideae (includes only one genus Jollydora) and II. Connaroideae (include all other genera) sensu Schellenberg (1938) is justified. Palynologically, Jollydora is apparently isolated and distinct from all other members of the family.

Pollen morphological data provide no obvious scheme for subdividing the family into tribes as delimited by Bentham & Hooker (l.c.) and Schellenberg (l.c.) -- an opinion of Dr. Leenhouts (1958) which I support.

Specific and even generic segregation on pollen characters is not possible in most of the cases.

Pollen morphological data provide a scheme for grouping the family into three pollen types. I. The Cnestis type --- which is comparatively primitive type in the family. II. The " Roura complex " with the genera like Roura, Roureopsis, Taeniochlaena (s.l.) and Agelaea and III. Connarus type with Connarus and Ellipanthus. Agelaea stands as the connecting link between IInd and IIId pollen types. Pollen-morphologically, the type I and type II are very close, and sometimes overlapping though possess some distinctiveness. These pollen types fairly correspond with some taxonomic characters (Fig. 5) as well as with some morphological, anatomical and seed characters. (Fig.6).

* The genus Jollydora is not studied personally. Palynological findings of Erdtman (l.c.) and Dickison (l.c.) have considered for this conclusion in relation to other genera observed in the present study.
Figure - 5. CORRELATION OF PALYNONOLOGICAL CHARACTERS WITH TAXONOMIC CHARACTERS

Abbreviations used:

A. : Stamen
Cir. : Circular
Ectoap. : Ectoaperture
Endoap. : Endoaperture
Epi. : Epidermis
Ex. : Exine
gr. : granules
ob. : oblate
obosph. : oblatespheroidal
op. : operculum
ov. : ovule
P. : Pollen
pol. : polar
Pro. : Prolate
Proosph. : Prolate spheroidal
ret. : reticulate
rugret. : ruguloreticulate
Semicir. : Semicircular
Sph. : Spheroidal
St. : Stomata
Subang. : Subangular
P. prosph. to pro., semicir.-cir. in pol. outline, medium to large sized; Ex. coarsely ret. rarely rugret. lumina large; Endoap. indistinct or distinct with coarse gr. or patch streak or classical op. Ectoap. Complex. A. 10, 5 obsolete, connate at the base, St. surrounded by circle of small cells; Epi. without mucilaginous cells.

P. prosph. to pro., semicir.-cir. in pol. outline, medium to large sized; Ex. coarsely ret. rarely rugret. lumina large; Endoap. indistinct or distinct with coarse gr. or patch streak or classical op. Ectoap. Complex.

A. 10, 5 obsolete, connate at the base, St. surrounded by circle of small cells; Epi. without mucilaginous cells.

P. obsph. to ob., semicir. in pol. outline, moderately medium sized; Ex. rugret./ ret.; Endoap. indistinct with coarse gr., Colpi slit like.

A. 10 or 5, connate at the base; ov. 3-5; St. anisocytic; Epi. with mucilaginous cells.

P. obsph. to ob., sub ang.-cir. in pol. outline, small sized, Ex. rugret.; Endoap. indistinct with fine gr. Colpi slit like.

A. 10, confluent at the base; ov. 5, St. paracytic, Epi. with mucilaginous cells.

P. obsph. to sph. subang. in pol. outline, small sized, Ex. micro ret. or rugret.; Endoap. indistinct with comparatively fine gr. Colpi slit like.

A. 10, free; ov. 5-7, St. paracytic; Epi. with mucilaginous cells.
<table>
<thead>
<tr>
<th>Stomata</th>
<th>Anisocytic</th>
<th>Paracytic</th>
<th>Anomocytic</th>
</tr>
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<td>Leaf Epidermis</td>
<td>With Mucilagenous cells</td>
<td>Without Mucilagenous Cells</td>
<td></td>
</tr>
<tr>
<td>Vascular bundles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Spiral Thickening</td>
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<td>Without Spiral Thickening</td>
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<td>5 or 7</td>
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<td>10 slightly confluent at the base</td>
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<td>10; 5 obsolete; connate at the base</td>
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<td>10; 5 obsolete or 1</td>
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<tr>
<td>(ELLIPANTHUS)</td>
<td>(CONNARUS)</td>
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<tr>
<td>(AGELAE)</td>
<td>(ROUREA)</td>
<td>(ROUREOPSIS)</td>
<td>(TAENIOCHLAENA)</td>
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<td>(CNESTIS)</td>
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Palynologically the genus Roureopsis and Taeniochlaena are similar. So, pollen morphological features support the reduction of Taeniochlaena into Roureopsis. --- an opinion of Dr. Leenhouts (l.c.) which I share.

A remarkable percentage of pollen grains of Roureopsis become crippled and folded after acetolysis, this may be due to nonviability of the pollens (Müller & Caratni 1977). So, a point to be mentioned that the plant may be enlisted in the list of endangered plants for its possibility of being in the way of extinction and this extinction is natural for its male sterility. Alternate methods of propagation of this plant other than the sexual means are suggested.

Agelaea bornensis exceptionally differs by its finely reticulate exine, lumina size range from 0.2 - 0.5μm from the general lumina range 0.5 - 2μm in the genus.

Different species of Rourea is very uniform and shows a very narrow range of variations in its pollen morphology. So, in this respect, reduction of number of species of Rourea into Rourea minor (Gaertn.) Leenh. nov. Comb. is noteworthy.

The genus Connarus is very important and interesting from its apertural characters and peculiarities. A series of apertural complexities can be seen in this genus. Number of interesting clues in respect to apertural evolution and operculum can be evidenced in different species of the genus (Fig. 2). A detailed microscopic observation for the characters is suggested for the future workers and for better understanding of the apertural evolution and complexities in Dicotyledonous plants.

Cnestis platantha Griff. is pollen morphologically different from rest of the Cnestis species in being 3-colpate grains and colpa devoid of
characteristic granules. In other species pollens are 3-colporate and endoapertures with characteristic granules. So, the placement of *Cnestis platantha* together with other species of *Cnestis* is questioned.

Pollen morphological feature reminds the phylogenetic relationships traced by Hallier (1912, Fig. 1, Chapter - I) by its typical apertural characters. Treatment of the family near Sapindaceae by him is very justified and he traced its origin from Capparidaceae via Oxalidaceae (s.l., Averrhoaceae included). Present palynological study support this view. Airy Shaw (1973) pointed out its relationship with the Averrhoaceae.

Hutchinson in 1st edition (1959) of his book — "The families of flowering plants" was correct where he placed the family near Sapindaceae but perhaps misinterpreted in 3rd edition (1973) of this book and placed near Dilleniaceae. Pollen grains of Dilleniaceae are quite different from Connaraceae pollen types.

In summing up this work I like to mention that I prefer for the retention of the family in the order Sapindales, near Sapindaceae. Further I prefer to trace its phylogeny back from the Capparidaceous stock via Averrhoaceae (Oxalidaceae s.l.) possibly through the line proposed by Hallier (l.c.) or in reverse way. In support of my conclusion I present from Haywood (1978) — "In evolutionary terms it is considered to be rather more advanced than the Leguminosae, possibly on a line leading to the Oxalidaceae*".

There is much disagreement for placement of the family in the Sapindales and near to the Sapindaceae (Engler l.c., Bessey l.c., Wettstein l.c., Rendle l.c., Dahlgren l.c., Schulze - Mens (1964), Thorne l.c., Hutchinson l.c., Dickison l.c., Takhtajan l.c. etc.). Thorne in recent years

* Averrhoaceae is included in Haywood's Oxalidaceae
is of opinion for realignment of the family Connaraceae from Rosinae to a position near Sapindaceae. Eminent taxonomists supporting the relationship of the family with Sapindaceae are -- Bentham & Hooker l.c., Hutchinson (1926), Thorne (1979) & others. I conclude with the remark of a great taxonomist in favour of my conclusion. " --- their position in either order could be defended, but on balance I prefer to keep them with the Sapindales " --- Cronquist 1968.

SUMMARY

The family Connaraceae includes 24 genera and about 400 species sensu Schellenberg (1938) but in the latest work by Leenhouts (1958) it was estimated as 16 genera and 500-550 species distributed in tropics and subtropics of both worlds. Assessment by Airy Shaw (1973) in Willis' " A dictionary of flowering plants and Ferns " is same as recognised by Leenhouts. 7 genera occur in India (Treating Taeniochlaena and Houracepis as different taxa) have been studied in the present study. 217 materials from 59 species (s.l.) mainly from India with a few foreign materials have been investigated palynologically and illustrated with photomicrographs, figures and scheme. Taxonomically it is a distinct family, but disagreement lies as regards its origin, affinities and relationship within the general system of classification as well as its intrafamilial assessment also. Present study is an endeavour to interpret these diversities on pollen-morphological characters. Purpose of the present work is to make a critical evaluation of palynological characters in Indian Connaraceae and select those characters found to be taxonomically useful at sectional and generic levels. They are then together with other relevant informations, mainly contributed by other authors used for a taxonomic reorganisation of Connaraceae.
Palynology has succeeded in screening and strengthening some unsolved as well as previously proposed disputed aspects associated with the systematic assessment of the family. Conopurus and Ellipanthus are quite distinct and different from rest of the family pollen-morphologically. Other genera of the family are palynologically uniform to some extent. Pollen is of small size category, radially symmetrical, ruguloreticulate to reticulate exine; lumina size decreases towards aperture in most of the cases; predominantly 3-colporate; Ectoaperture slit like or tapering, extending up to poles, often show equatorial constriction or sexinous equatorial bridge covering endoaperture area. Outlines and orientations of ectoapertures are variable and complicated in Conopurus.

Endoaperture range from weakly to well-developed, always with characteristic granules, which ultimately leads to the formation of classical type of operculum via coarse granules and patch streak. Sporoderm clearly differentiated into tectum, columella & nexine layer, columella indistinct or distinct, height sometimes decreasing towards aperture.

Pollen morphology supports the division of the family into two subfamilies as proposed by Schellenberg (l.c.) and Melchior (1964) but provide no basis for subdivision into tribes. However, I support Leenhouts circumscriptions for reduction of Taeniochlaena into Roureopsis and withdrawal of delimitation of tribes proposed by earlier authors. Inclusion of some species of Rourea into a single species Rourea minor (Gartn.) Leenh. nov. Comb. is justified with very minor differences in pollen characters of these species.