A COMPARATIVE STUDY ON THE MORPHOLOGICAL AND PALYNOLOGICAL ASPECTS OF SELECTED SPECIES OF FABACEAE

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ABSTRACT

Twelve members of the Fabaceae were collected from different parts of Kollam and subjected to detailed morphological and palynological studies. The Fabaceae presents a well-knit group of closely related plants with several major floral and foliar characters conserved as such. These include pinnate and alternate leaves, racemose inflorescence, absence of epigyny, monocarpellary ovary with marginal placentation, leguminous fruits.

From the morphological and palynological standpoints, the Mimosoideae stand apart from the other two. The exclusive bipinnate nature of the compound leaves, aggregation of small regular and polygamous flowers into umbels or heads, presence of lomentum, 3-colporate pollen grains without zonal distribution of apertures, presence of tetrads and polyads etc. substantiate this.

The Faboideae stands apart from the Mimosoideae with exclusively pinnate leaves, irregular bisexual flowers in simple racemes, papilionaceous corolla, diadelphous or monadelphous stamens without any polyandry, hypogynous or perigynous condition, fruit exclusively a legume, zonal distribution of the three pollen apertures, existence of pollen grains as monads, variability with regard to pollen size and shape etc.

The Caesalpinioideae however, exhibit several intermediate features, although it appears to be more closer to the Faboideae, with pinnate as well as bipinnate leaves, irregular bisexual flowers clustered into corymbose racemes, exclusively polyandrous stamens, hypogynous or perigynous condition, fruit exclusively a legume, zonal distribution of the three pollen apertures, existence of pollen grains as monads, predominance of prolate-spheroidal pollen shape, absence of small pollen etc. The data gathered from the present study favours the treatment of the three groups as subfamilies under the single large family Fabaceae.

The Fabaceae Lindely or Leguminosae Adanson, are a large and economically important family of flowering plants, which are commonly known as the legume family, pea family, bean family or pulse family. The name 'Fabaceae' comes from 'Faba', the Latin name for Broad bean (Simpson, 2006). Leguminosae is an older name still considered valid (ICBN, Vienna Code) and refers to the typical fruit of these plants which are called legumes.

KEY WORDS: Faboideae, Caesalpinioideae, Mimosoideae, Palynology

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INTRODUCTION

The Fabaceae Lindely or Leguminosae Adanson, are a large and economically important family of flowering plants, which are commonly known as the legume family, pea family, bean family or pulse family. The name 'Fabaceae' comes from 'Faba', the Latin name for Broad bean (Simpson, 2006). Leguminosae is an older name still considered valid (ICBN, Vienna Code) and refers to the typical fruit of these plants which are called legumes.

The species of this family are found throughout the world. In terms of economic importance the family Leguminosae are the most important family in the Dicotyledonae (Harborne, 1994), second only to the Grasses (cereals) in providing food crops for world agriculture (Judd *et al.* 2002). The seeds of Legumes are rich in high quality protein, providing man with a highly nutritional food resource. The total world value for leguminous crops is thought to be approximately two billion US dollars per annum. The important agricultural plants include *Arachis hypogaea* (peanut), *Glycine max* (soya bean), *Phaseolus* spp. (beans), *Pisum sativum* (pea), *Cicer arietinum* (chickpeas), *Medicago sativa* (alfalfa), and *Tamarindus* (tamarind) and several others. Legumes are used as fodders, forages and green manures e.g. *Lupinus* (lupin), *Medicago* (alfalfa) and *Trifolium* (clover).

The Fabaceae are placed in the order Fabales according to most taxonomic systems, including the APG system. The Fabaceae comprise three subfamilies (Bentham, 1865; Taubert, 1894; Rendle, 1925; Lawrence, 1951; Engler, 1964; Polhill and Raven, 1981; Mabberly, 1997; APG II 2003):

- **Faboideae:** 470 genera and 14,000 species, cosmopolitan. The majority of the species are herbaceous, although there are some trees and shrubs, e.g. Laburnum and Gorse (*Ulex*), easily recognised by their characteristic papilionaceous (butterfly-like) flowers. The flower is irregular (zygomorphic) and is made up of five petals; a 'banner' petal (standard or vexillum), two wing petals (alae) and two keel petals partially fused together along one margin to form a boat-shaped keel or carina. The keel encloses the stamens and carpel, which are not visible externally.
- **Caesalpinioideae:** 170 genera and 2,000 species, cosmopolitan. The majority of the Caesalpinioideae are tropical or subtropical trees and shrubs. The flowers of the Caesalpinioideae are irregular (zygomorphic) with five petals which are not differentiated into standard, wings and keel. The stamens are visible externally. Several species in this subfamily are well-known tropical ornamentals such as Flamboyant (*Delonix regia*) and Barbados Pride (*Caesalpinia pulcherrima*). Alexandrian Senna (*Senna alexandrina*) is a commercially grown medicinal plant, known for its purgative qualities.
- **Mimosoideae:** 80 genera and 3,200 species. Mostly tropical and warm temperate Asia and America. The Mimosoideae are characterised by their small, regular (actinomorphic) flowers crowded together, generally into spikes or globose heads. The stamens have become the most attractive part of the flower, as the petals are inconspicuous. The leaves are predominately bipinnate. Examples of genera within this subfamily are *Acacia* and *Mimosa*. Certain *Acacia* species are extremely important economically. An extract from the bark of the Golden Wattle (*Acacia pycnantha*) is used in tanning. Several species, such as Australian Blackwood (e.g. *Acacia melanoxylon*) provide useful timbers and some (e.g. *Acacia senegal*) yield commercial gum arabic, which is used in a wide range of industrial processes.

Pollen morphology has been well recognized as a potential supplementary tool in dealing with taxonomic problems, systematic relationships and phylogeny of angiosperms at all taxonomic levels (Taylor and Levin, 1975; Dayanandan, 1979). The present investigation in the Fabaceae covers two aspects of study (A) Morphological and (B) Palynological and accordingly the results are presented in two sections. The main **objectives** and lines of work envisaged are:

- To make a comprehensive study on the exomorphology of twelve members of the Fabaceae incorporating maximum number of foliar and floral characters, with appropriate illustrations.
- To study the pollen morphology of all the selected members of the family.

- To make a preliminary analysis of the systematic inter-relationships between the three subfamilies of the Fabaceae in the light of palynological and morphological data.

Bentham and Hooker (1865) divided the Leguminosae into three suborders (subfamilies) viz. Papilionaceae, Caesalpineae and Mimoseae. The Papilionaceae included 295 genera under eleven tribes, Caesalpineae seven tribes and the Mimoseae five tribes. Taubert (1894) also recognized three subfamilies – the Mimosoideae, Caesalpinioideae and Papilionatae. This was supported by Rendle (1925). Wettstein (1933-1935) had a different approach and recognized two families – the Mimosaceae and the Papilionaceae, including Caesalpinioideae as a subfamily under the latter.

Polhill and Raven (1981) administered an interdisciplinary approach amassing evidences from various disciplines such as anatomy, phytochemistry, palynology, serology, cytology etc. They considered the three subgroups as subfamilies under a single major family – the Leguminosae. Mabberley (1997) recognized the three subfamilies as three independent families.

Recent phylogenetic analyses of morphological characters (Chappill, 1994; Tucker and Douglas, 1994) and DNA sequences (Doyle *et al.* 1997; Bruneau *et al.* 2001; Kajita *et al.* 2001) have shown that the “Caesalpinioideae” are paraphyletic, with some genera closely related to Mimosoideae and others more closely related to Faboideae than they are to one another. The temperate herbaceous species of the Faboideae are considered to be more recent derivatives of the tropical woody groups (Judd *et al.* 2002).

Palynological Studies

Hemsley and Ferguson (1985) reported considerable variation in pollen type as well as exine ornamentation in *Erythrina*. Kuriakose (2000) and George (1995) studied the South Indian taxa of Papilionaceae and Caesalpineaceae respectively and observed that the subfamilies share many pollen features.

The pollen grains of the Mimosoideae have received much attention. Rosanoff (1865) subdivided the Mimosoideae into three groups: those having single pollen grains or monads, those with eight-celled polyads and those with more than eight-celled polyads. Dhyanagar (1955) subdivided the family Mimosaceae into two subfamilies – the mimoseae with compound pollen grains and the Prosopideae with simple pollen. Bentham (1875) reported that the most archaic species of *Calliandra* have up to 16-celled polyads showing weak heteromorphism and high degree of symmetry compared to the other members of the genus. The eight-celled polyads are considered to be neotropical, possessing a strongly dissymmetrical shape and a large calymmed exine.

Systematic Studies

The Fabaceae have been differently subdivided in the different systems of classification, with some taxonomists treating the three subgroups as subfamilies viz. Papilionoideae, Caesalpinioideae and Mimosoideae under a single large family – the Fabaceae or Leguminosae, while several others regard them as individual families viz. Papilionaceae, Caesalpineaceae and Mimosaceae. The earliest classification of the family Fabaceae was by de Candolle (1825 a, b), who grouped the members under two orders – the Curvembryae and Rectembryae, the former consisting of the Papilionaceae and Swartzieae and the latter of the Caesalpineae and Mimoseae.

Lawrence (1951) divided the Leguminosae into three subfamilies – Mimosoideae, Caesalpinioideae and Lotonoideae, of which the last one was redesignated as the Papilionatae or Papilionoideae. Engler (1964) also considered them as three

subfamilies under the Leguminosae and named them Mimosoideae, Caesalpinioideae and Faboideae. Hutchinson (1964) however treated them as individual families– the Caesalpineaceae, Mimosaceae and Papilionaceae, under the order Leguminales. Cronquist (1968) also identified them as three families – Mimosaceae, Caesalpineaceae and Fabaceae, placing the three under Fabales.

Robertson and Lee (1976) opined it ideal to preserve the three groups as subfamilies under the Leguminosae as they form a mere natural assemblage. This was supported by Dickinson (1981) based on the similarity of the three groups in seed and fruit characters, and also by Cristofolini (1981) and Senn (1943) who gathered evidence from serological data and wood anatomy respectively. El-Gazzar and El-Fiki (1977) studied the seed morphology, distribution of alkaloids, non-protein canavanine, flavanoids and susceptibility to *Uromyces* rusts. They identified two major groups – Group A including the Mimosoideae and Caesalpinioideae, and Group B including Papilionaceae and Swartzieae.

Takhtajan (1959, 1980) elevated Leguminosae to the status of an order – the Leguminales with the families Mimosaceae, Caesalpineaceae and Fabaceae nested in it. Dahlgren (1975, 1983) has also shared Takhtajan's view, but named the order Leguminales as the Fabales.

MATERIALS AND METHODS

Materials for the Study

Twelve members of the Fabaceae were collected from different parts of Kollam (Figures.1-20). They include:

I. Faboideae

- *Clitoria ternatea* L.
- *Crotalaria pallida* Aiton var. *pallida*
- *Gliricidia sepium* (Jacq.) Kunth ex Walp.
- *Sesbania grandiflora* (L.) Poir.

II. Caesalpinioideae

- *Bauhinia acuminata* L.
- *Caesalpinia pulcherrima* (L.) Swartz.
- *Cassia fistula* L.
- *Delonix regia* (Bojo. Ex Hook.) Raf.
- *Saraca asoca* (Roxb.) de Wilde

III. Mimosoideae

- *Calliandra surinamensis* Benth.
- *Mimosa pudica* L.
- *Samanea saman* (Jacq.) Merr.

A. Morphological Characters

A detailed morphological study was conducted collecting data from the foliar and floral parts of fresh plants. The morphological characters were studied under two heads-quantitative and qualitative characters. The study includes twenty-five quantitative and twenty-seven qualitative characters.

For each quantitative character studied, observations from five plants per member were taken, and the average was used for the analysis. In the case of lamina characteristics, measurements relating to individual leaflets were taken as all the selected members possess compound leaves. The qualitative foliar characters were studied following the classification of leaf characters by Hickey (1973). The colour of the lamina was determined by comparing with the Colour Chart by Wilson (1938; 1941). Variability of all the quantitative characters studied was estimated by comparing the mean, range and standard deviation (Panse and Sukhatma, 1985).

B. Palynological Characters

Polliniferous materials around the time of anthesis were collected from live plants and fixed in glacial acetic acid. Pollen preparations were made by the acetolysis method standardized by Erdtman (1952) outlined as below.

The polliniferous materials in the glacial acetic acid were crushed with glass rods and sieved through a brass mesh with 48 divisions per square centimetre, into centrifuge tubes of 20ml capacity. The contents in the centrifuge tubes were centrifuged at 2400 rpm for 3 minutes. The supernatant was decanted and to each tube 5ml of freshly prepared acetolysis mixture (9 acetic anhydride : 1 concentrated sulphuric acid) was added. The centrifuge tubes were then heated in a water bath at 70°C, repeatedly stirring the contents with glass rods. After 20 minutes, when the pollen turned light brown, the tubes were taken out and allowed to cool. The contents were then centrifuged at 2400 rpm for 3 minutes and the supernatant decanted. This was followed by the addition of 5 ml of glacial acetic acid to each tube. The mixture was then centrifuged for 3 minutes at 2400 rpm and the supernatant decanted. The sediment was then washed thrice in distilled water as was standardized by Nair (1970). The acetolysed pollen was stored in 1:1 glycerine and distilled water for two weeks to attain a lighter shade of brown. The contents were then centrifuged, the supernatant decanted and the tubes containing the sediment were placed upside down on a filter paper to drain off the excess glycerine. Permanent slides for light microscopic studies were prepared by mounting the acetolysed pollen in glycerine jelly and sealing with paraffin wax.

Morphological features of pollen grains including those relating to the aperture, exine ornamentation, pollen size and shape were studied from LM observations. Average pollen size was calculated from measurements of a random sample of 100 grains in each taxon. The measurements relating to the pollen size for both polar (P) and equatorial (E) views were taken using an ocular micrometer. The characters relating to the aperture have been considered primary, those of exine ornamentation secondary and other characters including size and shape tertiary (Tewari and Nair, 1978). The value of $P/E \times 100$ was found in each case for ascertaining the shape class.

For describing the aperture types and exine ornamentation pattern of the pollen grains, the terminologies suggested by Punt *et al.* (1994) have been used. Photomicrographs of the pollen preparations were taken using an Olympus CH - 20 Research Microscope with Digital camera attachment facility.

DISCUSSIONS

The members of this family exhibit wide variation in morphological and palynological features. The major aspects of

morphological study carried out in a selected group of twelve members of Fabaceae comprise detailed taxonomic study and analysis of foliar and floral characters covering 25 quantitative and 27 qualitative characters.

a) Quantitative Characters

The overall mean values for the different quantitative characters studied are given in Table-1. The internode length was high in *Clitoria ternatea* (10.4 cm), *Caesalpinia pulcherrima* (8.68 cm) and *Saraca asoca* (7.21 cm). The lowest value was recorded in *Sesbania grandiflora* (1.69), with *Mimosa pudica* (2.83 cm) and *Samanea saman* (2.97) following closely behind. The leaflets were large in *Saraca asoca* (21.3 x 5.54 cm), *Bauhinia acuminata* (11.03 x 8.64 cm) and *Cassia fistula* (9.0 cm x 5.09 cm). Similarly, smaller leaflets were observed in *Mimosa pudica* (0.78 cm x 0.16 cm) and *Caesalpinia pulcherrima* (1.43 cm x 0.72 cm). The area of lamina was high in *Saraca asoca* (70 cm²), *Bauhinia acuminata* (50.99 cm²) and *Cassia fistula* (47.55 cm²). Lower values for this character were seen in *Mimosa pudica* (0.40 cm²), *Calliandra surinamensis* (1.3 cm²) and *Caesalpinia pulcherrima* (1.3 cm²). Lamina perimeter was very high in members of Caesalpinioideae – *Saraca asoca* (43.9 cm), *Bauhinia acuminata* (32.89 cm) and *Cassia fistula* (29.9 cm), and low in *Mimosa pudica* (2.03 cm), *Caesalpinia pulcherrima* (2.5 cm) and *Calliandra surinamensis* (2.84 cm).

b) Qualitative Characters

The qualitative character pertaining to the leaf and flower showed wider variation among the 12 members. A perusal of the distribution of character states pertaining to the qualitative morphological characters reveals that 50% of the members studied were trees, while 17% were shrubs. *Clitoria ternatea* is a climber and *Mimosa pudica* a diffused undershrub. The leaves were pinnate or bipinnate in more than 80% members, while *Bauhinia acuminata* and *Crotalaria pallida* exhibited bilobed and trilobed compound leaves respectively. Majority (83%) of the plants studied had alternate leaves. The leaf colour was predominantly spinach green (42%) or schieles green (42%). The leaf shape showed much variation with nearly 42% of the members having oblong leaflets followed closely behind by ovate and elliptic in 17% cases each. Nearly 92% of the members possessed leaves with entire margins with *Cassia fistula* alone showing slightly wavy margins. The leaf apices were rounded (in 25%), mucronate, emarginate, acuminate, acute or reflex. The leaf bases also exhibited wide variation with obtuse (25%), acute, cuneate, truncate, rounded, oblique or elliptic types. More than 83% had chartaceous leaf texture while *Cassia fistula* and *Samanea saman* showed submembranous and velvety leaves respectively. The leaf surface was glabrous in 92% of the cases. The leaflets were pubescent in *Samanea saman*.

Palynological Characters

The pollen in general were tricolpate or triporate (Table-4). *Clitoria ternatea* had 3-4 zonoporate pollen while those in *Bauhinia acuminata* were inaperturate. The remaining members of the Caesalpinioideae had 3-zonocolporoidate grains, while the members of the Mimosoideae had tricolporate pollen. The zonal and global positions are restricted to the angiosperms (Nair, 1979). Tewari and Nair (1979) have suggested that the 3-zonocolpate pollen is the fundamental one in the evolutionary scheme of the Ranalian dicotyledons. Nair (1979) has suggested that all the angiosperm level, the trimorphous situation suddenly changed with the origin of several new apertural forms starting with the tricolpate followed by the tricolporoidate-tricolporate and other forms, the highest level of which being the monoporate aperture.

The pollen grains existed as monads in the Papilionoideae and Caesalpinioideae. In the Mimosoideae, various types of pollen associations such as dyads, tetrads (*Mimosa pudica*) and polyads (*Calliandra surinamensis* and *Samanea saman*) were seen. The pollen shape was predominantly prolate spheroidal in the Caesalpinioideae. However, this shape category was

observed in only one member of the Papilionoideae (Clitoria ternatea). Here other categories of pollen shape such as prolate and suboblate were seen. The Mimosoideae with tetrads and polyads showed tetrahedral, or oval or bilaterally symmetrical clusters. The shape and size of pollen and spores do not possess much phylogenetic significance (Walker, 1976). Clarke (1980) has suggested that oblate grains are more advanced than the prolate among related species of dicotyledons.

The pollen were mostly large in size. Medium-sized pollen grains were observed in Sesbania grandiflora and Cassia fistula. The pollen in Crotalaria pallida ($24.6\text{ }\mu\text{m} \times 14.5\text{ }\mu\text{m}$) and Gliricidia sepium ($20.8\text{ }\mu\text{m} \times 22.5\text{ }\mu\text{m}$) were small-sized. The largest pollen were seen in Bauhinia acuminata ($133.38\text{ }\mu\text{m}$). Though large-sized pollen is generally considered as primitive (Walker and Walker, 1984); some authors like Punt (1991) have opined that small-sized pollen are primitive.

Systematic Considerations

As regards the subfamilial classification of the Fabaceae, the data gathered from the present study favours the treatment of the three groups as subfamilies under the single large family. From the morphological and palynological standpoints, the Mimosoideae stand apart from the other two. The exclusive bipinnate nature of the compound leaves, aggregation of small regular and polygamous flowers into umbels or heads, presence of lomentum, 3-colporate pollen grains without zonal distribution of apertures, presence of tetrads and polyads etc. substantiate this.

The Faboideae stand apart from the Mimosoideae with exclusively pinnate leaves, irregular bisexual flowers in simple racemes, papilionaceous corolla, diadelphous or monadelphous stamens without any polyandry, hypogynous or perigynous condition, fruit exclusively a legume, zonal distribution of the three pollen apertures, existence of pollen grains as monads, variability with regard to pollen size and shape etc.

The Caesalpinioideae however, exhibit several intermediate features, although it appears to be more closer to the Faboideae, with pinnate as well as bipinnate leaves, irregular bisexual flowers clustered into corymbose racemes, exclusively polyandrous stamens, hypogynous or perigynous condition, fruit exclusively a legume, zonal distribution of the three pollen apertures, existence of pollen grains as monads, predominance of prolate-spheroidal pollen shape, absence of small pollen etc. Recent phylogenetic analyses of morphological and DNA sequence data show that the Caesalpinioideae are paraphyletic, with some genera closely related to the Mimosoideae and others more closely related to the Faboideae than they are to one another. (Chappil, 1994; Chase et al. 1993; Kajita et al. 2001)

Table 1: Overall Mean Values of Quantitative Morphological Characters in 12 Members of the Fabaceae

Characters	<i>Clitoria ternatea</i>	<i>Crotalaria pallida</i>	<i>Gliricidia sepium</i>	<i>Sesbania grandiflora</i>	<i>Bauhinia acuminata</i>	<i>Caesalpinia pulcherrima</i>	<i>Cassia fistula</i>	<i>Delonix regia</i>	<i>Saraca asoca</i>	<i>Calliandra surinamensis</i>	<i>Mimosa pudica</i>	<i>Samanea saman</i>
Internode length	10.4	3.49	4.18	1.69	3.92	8.68	3.41	5.02	7.21	3.82	2.83	2.97
Petiole length	0.19	4.76	0.54	0.77	1.52	1.08	0.74	0.40	0.54	1.74	2.98	0.82
Lamina length	3.82	5.46	6.01	2.28	11.03	1.43	9.0	0.68	21.3	1.19	0.78	3.22
Lamina breadth	2.11	3.35	2.43	0.84	8.64	0.72	5.09	0.30	5.54	0.28	0.16	1.70
Area of lamina	10.75	15.94	11.40	1.75	50.99	1.30	47.55	1.35	70	1.3	0.40	6.25
Perimeter of lamina	6.9	15.12	13.24	6.11	32.89	2.50	29.9	2.93	43.9	2.84	2.73	8.73
Pedicle length	0.45	0.36	0.58	1.27	1.11	4.71	3.73	6.15	0.48	0.30	1.83	0.14
Length of calyx	1.19	0.31	0.62	1.83	3.45	0.86	0.86	2.97	0.69	0.33	0.11	0.61
Width of calyx	1.05	0.42	0.35	1.27	0.98	0.34	0.54	0.94	0.62	0.14	0.09	0.23
No. of petals	5	5	5	5	5	5	5	5	0	4	4	5
Length of standard petal	3.98	1.19	2.08	8.05	4.26	2.14	2.75	5.88	0	0.72	0.27	1
Width of standard petal	3.26	0.78	1.95	4.57	2.34	1.47	1.94	3.99	0	0.25	0.10	0.28
Length of wing petal	2.88	1.04	2.10	8.28	-	-	-	-	-	-	-	-
breadth of wing petal	1.05	0.36	0.56	1.92	-	-	-	-	-	-	-	-
Length of keel petal	2.18	1.41	1.78	9.06	-	-	-	-	-	-	-	-
Breadth of keel petal	0.44	0.57	0.36	1.83	-	-	-	-	-	-	-	-
No. of stamens	10	10	10	10	10	10	10	10	7	10	4	19.1
Length of St. Col/ Filament	1.31	1.37	0.63	9.06	1.58	5.95	3.43	3.95	3.15	3.22	0.69	2.55
Length of anther	0.1	0.09	0.10	0.34	0.34	0.10	0.33	0.46	0.16	0.01	0.01	0.01
Length of style	1.51	0.81	0.54	2.52	1.92	5.16	0.28	4.06	2.19	3.93	0.30	3.01
No. of stigmatic lobes	1	1	1	1	1	1	1	1	1	1	1	1
No. of carpels	1	1	1	1	1	1	1	1	1	1	1	1
Length of ovary	1.05	0.59	1.70	4.68	1	1.21	3.13	1.51	0.59	0.25	0.10	0.27
Pod length	10.05	2.91	9.09	37.5	8.49	7.98	53.6	54.2	18.8	7.28	1.24	15.39
Pod breadth	0.91	0.61	1.39	0.69	1.35	1.55	1.20	3.94	4.38	0.89	0.33	1.76

Table 2: Qualitative characters in 12 members of the Fabaceae

Characters	<i>Clitoria ternatea</i>	<i>Crotalaria pallida</i>	<i>Gliricidia sepium</i>	<i>Sesbania grandiflora</i>	<i>Bauhinia acuminata</i>	<i>Caesalpinia pulcherrima</i>
Habit	Climber	Undershrub	Tree	Softwooded Tree	Shrub	Shrub
Leaf type	Pinnately compound	Trifoliately compound	Pinnately compound	Pinnately compound	Bilobed compound	Bipinnately compound
Phyllotaxy	Opposite	Alternate	Alternate	Alternate	Alternate	Alternate
Leaf colour	Scheeles green	Spinach green	Pale green	Scheeles green	Spinach green	Scheeles green
Leaf shape	Ovate	Obovate emarginate	Elliptic	Oblong	Bilobed	Ovate
Leaf margin	Entire	Entire	Entire	Entire	Entire	Entire
Leaf apex	Rounded	Emarginate	Acuminate	Emarginate	Acuminate	Retuse
Leaf base	Acute	Cuneate	Cuneate	Obtuse	Truncate	Oblique
Leaf texture	Chartaceous	Chartaceous	Chartaceous	Chartaceous	Chartaceous	Chartaceous
Leaf surface	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous
Inflorescence type	Solitary	Simple raceme	Simple raceme	Lax axillary raceme	Panicles of cymules	Subcorymbose raceme
Flower nature	Irregular	Irregular	Irregular	Irregular	Irregular	Irregular
Sexuality	Bisexual	Bisexual	Bisexual	Bisexual	Bisexual	Bisexual
Calyx colour	Pale green	Pale green	Pink	Pale green	Pale green	Red with yellowish tinge
Calyx surface	Glabrous	Pubescent	Glabrous	Glabrous	Glabrous	Glabrous
Petal colour	Creamy white and dark blue	Bright yellow	Pink	White	White	Red with yellow margin
Stripes/ colouration	Present	Present	Present	Present	Absent	Present
Androecium nature	Diadelphous	Monadelphous	Diadelphous	Diadelphous	Polyandrous	Polyandrous
Staminal column/ filament colour	Creamy white	Pale green	Pale pink	Pale green	White	Red
Anther colour	Creamy white	Bright yellow	Yellow	Yellow	Yellow	Red with yellowish tinge
Anther shape	Oblong	Sagittate and discoid	Discoid	Slightly Sagittate	Slightly Sagittate	Discoid
Characters	<i>Clitoria ternatea</i>	<i>Crotalaria pallida</i>	<i>Gliricidia sepium</i>	<i>Sesbania grandiflora</i>	<i>Bauhinia acuminata</i>	<i>Caesalpinia pulcherrima</i>
Staminal dimorphism	Absent	Present	Absent	Absent	Present	Present
Ovary colour	Pale green	Green	Pale pink	Pale green	Yellowish green	Green
Style colour	Cream	Pale green	Pale pink	Green	Pale green	Red
Stigma colour	White	Pale green	Yellow	Green	Pale green	Red
Stigma type	Capitate	Capitate	Capitate	Capitate	Capitate	Capitate
Pod type	Legume	Legume	Legume	Legume	Legume	Legume

Table 3: Qualitative characters in 12 members of the Fabaceae

Characters	<i>Clitoria ternatea</i>	<i>Crotalaria pallida</i>	<i>Gliricidia sepium</i>	<i>Sesbania grandiflora</i>	<i>Bauhinia acuminata</i>	<i>Caesalpinia pulcherrima</i>	<i>Cassia fistula</i>	<i>Delonix regia</i>	<i>Saraca asoca</i>	<i>Calliandra surinamensis</i>	<i>Mimosa pudica</i>	<i>Samanea saman</i>
Internode length	10.4	3.49	4.18	1.69	3.92	8.68	3.41	5.02	7.21	3.82	2.83	2.97
Petiole length	0.19	4.76	0.54	0.77	1.52	1.08	0.74	0.40	0.54	1.74	2.98	0.82
Lamina length	3.82	5.46	6.01	2.28	11.03	1.43	9.0	0.68	21.3	1.19	0.78	3.22
Lamina breadth	2.11	3.35	2.43	0.84	8.64	0.72	5.09	0.30	5.54	0.28	0.16	1.70
Area of lamina	10.75	15.94	11.40	1.75	50.99	1.30	47.55	1.35	70	1.3	0.40	6.25
Perimeter of lamina	6.9	15.12	13.24	6.11	32.89	2.50	29.9	2.93	43.9	2.84	2.73	8.73
Pedical length	0.45	0.36	0.58	1.27	1.11	4.71	3.73	6.15	0.48	0.30	1.83	0.14
Length of calyx	1.19	0.31	0.62	1.83	3.45	0.86	0.86	2.97	0.69	0.33	0.11	0.61
Width of calyx	1.05	0.42	0.35	1.27	0.98	0.34	0.54	0.94	0.62	0.14	0.09	0.23
No. of petals	5	5	5	5	5	5	5	5	0	4	4	5
Length of standard petal	3.98	1.19	2.08	8.05	4.26	2.14	2.75	5.88	0	0.72	0.27	1
Width of standard petal	3.26	0.78	1.95	4.57	2.34	1.47	1.94	3.99	0	0.25	0.10	0.28
Length of wing petal	2.88	1.04	2.10	8.28	-	-	-	-	-	-	-	-
breadth of wing petal	1.05	0.36	0.56	1.92	-	-	-	-	-	-	-	-
Length of keel petal	2.18	1.41	1.78	9.06	-	-	-	-	-	-	-	-
Breadth of keel petal	0.44	0.57	0.36	1.83	-	-	-	-	-	-	-	-
No. of stamens	10	10	10	10	10	10	10	10	7	10	4	19.1
Length of St.Col/ Filament	1.31	1.37	0.63	9.06	1.58	5.95	3.43	3.95	3.15	3.22	0.69	2.55
Length of anther	0.1	0.09	0.10	0.34	0.34	0.10	0.33	0.46	0.16	0.01	0.01	0.01
Length of style	1.51	0.81	0.54	2.52	1.92	5.16	0.28	4.06	2.19	3.93	0.30	3.01
No. of stigmatic lobes	1	1	1	1	1	1	1	1	1	1	1	1
No. of carpels	1	1	1	1	1	1	1	1	1	1	1	1
Length of ovary	1.05	0.59	1.70	4.68	1	1.21	3.13	1.51	0.59	0.25	0.10	0.27
Pod length	10.05	2.91	9.09	37.5	8.49	7.98	53.6	54.2	18.8	7.28	1.24	15.39
Pod breadth	0.91	0.61	1.39	0.69	1.35	1.55	1.20	3.94	4.38	0.89	0.33	1.76

Table 4: Important Palynological Characters in 12 Members of the Fabaceae

Plant Name	Aperture	Cohesion	Shape	Size Class	Size Range (µm)
Papilionoideae					
<i>Clitoria ternatea</i>	3-4 zonoporate	Monads	Prolate-spheroidal	Large	78.2 x 71.4
<i>Crotalaria pallida</i>	3- zonocolporoidate	Monads	Prolate	Small	24.6 x 14.5
<i>Gliricidia sepium</i>	3- zonocolporoidate	Monads	Suboblate	Small	20.8 x 22.5
<i>Sesbania grandiflora</i>	3- zonocolporate	Monads	Suboblate	Medium	26.3 x 31.0
Caesalpinioideae					
<i>Bauhinia acuminata</i>	Inaperturate	Monads	Oblate-spheroidal	Large	133.38 (diameter)
<i>Caesalpinia pulcherrima</i>	3- zonocolporate	Monads	Prolate-spheroidal	Large	84.9 x 81.2
<i>Cassia fistula</i>	3- zonocolporate	Monads	Prolate-spheroidal	Medium	41.6 x 33.6
<i>Delonix regia</i>	3- zonocolporate	Monads	Prolate-spheroidal	Large	81.6 x 73.9
<i>Saraca asoca</i>	3- zonocolporate	Monads	Prolate-spheroidal	Large	64.2 x 63.3
Mimosoideae					
<i>Calliandra surinamensis</i>	3-colporate	Polyad	8-celled polyad – some bilaterally symmetrical	--	179.35 (diameter)
<i>Mimosa pudica</i>	3-colporate	Tetrad	Tetrahedral	--	11.9
<i>Samanea saman</i>	--	Polyad	Oval	--	132.6 (diameter)

CONCLUSIONS

The work embodied in this includes morphological and palynological studies on twelve members of the Fabaceae from Kollam, and the salient findings are as follows:

- The leaves were pinnately compound and alternate with medium-sized leaflets in the Faboideae, while the Mimosoideae stand apart with small bipinnate and alternate leaves. The Caesalpinioideae present a mixture of the two groups, and are characterized by large, medium or small, pinnate or bipinnate alternate leaves.
- The inflorescence is a simple raceme in the Faboideae, simple or corymbose racemes in the Caesalpinioideae and umbel or globose heads in the Mimosoideae.
- The flowers were irregular and bisexual in the former two groups, while the Mimosoideae were quite distinct with small regular polygamous flowers. The flowers were hypogynous or perigynous in the former two groups, while the members of the Mimosoideae were exclusively hypogynous.
- The corolla was papilionaceous in the Faboideae, while the Caesalpinioideae showed irregular free petals of varying size, shapes and colouration patterns. The Mimosoideae had regular tubular corolla.
- The stamens exhibited cohesion (monadelphous or diadelphous) in all the members of the Faboideae. The Caesalpinioideae were characterized by polyandrous stamens, while the Mimosoideae had either polyandrous or monadelphous stamens with cohesion only half-way up the filaments.
- The ovary was monocarpellary with ovules on marginal placenta in all the members. The pod was exclusively a legume in the Faboideae and the Caesalpinioideae, while many members of the Mimosoideae produced lomentum.
- The pollen apertures were 3-zonocolporate or 3-zonocolporoidate in the Faboideae, 3-zonocolporate in the Caesalpinioideae and tricolporate in the Mimosoideae. The former two groups were characterized by monads alone, while the pollen in the Mimosoideae was aggregated into dyads, tetrads or polyads.
- The pollen shape was highly variable in the Faboideae (Prolate spheroidal, prolate or suboblate) and the Mimosoideae (tetrahedral, bilaterally symmetrical or cluster-like forms). However, the pollen in the Caesalpinioideae was mostly prolate-spheroidal.
- The individual pollen in the Faboideae belonged to all size classes, but the Caesalpinioideae did not possess small-sized grains with reference to the members presently studied.
- The Fabaceae present a well-knit group of closely related plants with several major floral and foliar characters conserved as such. These include pinnate and alternate leaves, racemose inflorescence, absence of epigyny, monocarpellary ovary with marginal placentation, leguminous fruits.
- The data gathered from the present study favours the treatment of the three groups as subfamilies under the single large family. From the morphological and palynological standpoints the Mimosoideae stand apart from the other two. The exclusive bipinnate nature of the compound leaves, aggregation of small regular and polygamous flowers into umbels or heads, presence of lomentum, 3-colporate pollen grains without zonal distribution of apertures, presence of tetrads and polyads etc. substantiate this.

- The Faboideae stand apart from the Mimosoideae with exclusively pinnate leaves, irregular bisexual flowers in simple racemes, papilionaceous corolla, diadelphous or monadelphous stamens without any polyandry, hypogynous or perigynous condition, fruit exclusively a legume, zonal distribution of the three pollen apertures, existence of pollen grains as monads, variability with regard to pollen size and shape etc.
- The Caesalpinioideae however, exhibit several intermediate features, although it appears to be more closer to the Faboideae, with pinnate as well as bipinnate leaves, irregular bisexual flowers clustered into corymbose racemes, exclusively polyandrous stamens, hypogynous or perigynous condition, fruit exclusively a legume, zonal distribution of the three pollen apertures, existence of pollen grains as monads, predominance of prolate-steroidal pollen shape, absence of small pollen etc.

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