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The Taxonomic Significance of Pollen and Seed Morphology in The Mimosoideae and Caesalpinoideae (Leguminosae)

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POLLEN and seed morphology of 19 species representing 12 genera of the Mimosoideae and Caesalpinioideae was studies using light and electron microscopy. Observed variations were recorded comparatively in a data matrix and analyzed numerically by the PRIMER Ver.6 program package for cluster analysis. The ensuing dendrogram indicates the division of the species into two main groups. One group includes all members of the Mimosoideae together with all three species of *Senna* from the Caesalpinioideae. The remaining eight species of the latter subfamily constitute the second group. Apart from the deviation of *Senna* from the Caesalpinioideae, the distinction between the two subfamilies seems corroborated by differences in pollen and seed morphology. *Senna* is distinct from *Cassia* and deserves generic rank. The generic concept in the two subfamilies is taxonomically sound since the group of species representing one genus are attached together before joining those of other genera. Individual genera (such as *Calliandra*) can be singled out by their pollen aggregations.

Keywords: Caesalpinoideae, Mimosoideae, Pollen morphology, Seed characters, Taxonomy.

Introduction

With 917 genera and 23535 accepted names of species, the Fabaceae (Leguminosae) are decidedly one of the largest five families of Angiosperms (www.theplantlist.org, 2022). They inhabit every conceivable habitat type worldwide and are equally adapted morphologically and anatomically. Numerous species are of global economic importance as legume crops and fodder plants with high nutritive value. From the taxonomic standpoint, the Leguminosae were originally divided by De Candolle (1825) into two major "suborders" with four subordinate taxa:

"Suborder" 1. Curvembrieae (with curved embryo axis)

"Suborder" 2. Rectembrieae (with straight embryo axis), which includes:

a. Mimoseae, with valvate sepals and petals and hypogynous stamens

b. Caesalpinieae, with imbricate petals and perigynous stamens.

This system was accepted only by Loudon (1841). Soon afterwards, Lindley (1853) avoided the difference in embryo axis shape and classified the Fabaceae (Leguminosae) into three "suborders" of equal rank (Papilionaceae, Caesalpinieae and Mimoseae), based solely on differences in floral configuration. Lindley's modified arrangement was accepted by Bentham & Hooker (1862) and was subsequently followed by most taxonomists until the three "suborders" were treated as subfamilies by Taubert (1894) with the proper name terminations (Papilionoideae, Caesalpinioideae, and Mimosoideae; respectively). The three subfamilies were later treated as distinct families within order Leguminales (Fabales) by some authors (e.g. Jones, 1955; Hutchinson, 1964; Dahlgren, 1975). Taxonomic evaluation of the three groups of leguminous plants was later performed by El-Gazzar & El-Fiki (1977) in terms of seed structure, the distribution of a range of chemical groups (alkaloids, flavonoids, and the amino acid canavanine) and the plants' susceptibility to rust fungi. The study emphatically supported the two "suborders" arrangement by De Candolle (1825) where his Curvembrieae

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coincided neatly with the Papilionoideae while the Rectembrieae encompassed both Mimosoideae and Caesalpinioideae which seemed much closer to each other than either of them to the Papilionoideae. More recently, the Legume Phylogeny Working Group (LPWG, 2017) proposed a vastly different scheme for the classification of the Leguminosae in which six subfamilies are recognized (Caesalpinioideae, Cercidoideae, Detarioideae, Dialioideae, Duparquetioideae, and Papionoideae) based on plastid matK gene sequences, while the traditional concept of the Mimosoideae was provisionally treated as a clade within the Caesalpinioideae pending further investigations.

The multitude of similarities between the two subfamilies Mimosoideae and Caesalpinioideae seemed to indicate the need for fresh evidence to decide whether they should be distinct within the coalition of the Rectembrieae, treated as two separate subfamilies, or as two families. Hence the flurry of studies on pollen and seed morphology of representative samples of their genera and species. Studies on pollen morphology of the Mimosoideae include those by Rosanoff (1865), Dhyansagar (1955), El Ghazali et al. (1997), Tantawy et al. (2005), and Elazab (2005). Similarly, pollen morphology of the Caesalpinioideae was studied in detail by El Ghazali et al. (1997), Elazab (1998) and Tahavi et al. (2004), as well as of individual genera by Larsen (1974) and Pu et al. (2003) on *Bauhinia*, by Fernandez-Pacella (2014) and Doty et al. (2020) on *Senna*, by Fitri & Des (2018) on *Caesalpinia*, by Wani et al. (2015) on *Delonix*, and by Maw et al. (2020) on *Parkinsonia*. Seed morphology and structure in the Leguminosae as revealed by light and scanning electron microscopy has been the subject of numerous studies by Hussein et al. (2002a, b), Al-Gohary & Mohamed (2007), Moawed (2009), Rashid et al. (2018, 2021), Khan et al. (2020), and Waheed et al. (2021).

To date, none of these studies attempted to deal simultaneously with the rich variation in pollen and seed morphology of the Mimosoideae and Caesalpinioideae. Furthermore, any taxonomic conclusions drawn from the results of these studies were based mostly on variation in single or very few characters.

In the present study an attempt is made to settle the decades-long controversy over the inter-relationships of the two subfamilies by combining as many characters from pollen and seed morphology as can be revealed by light and scanning electron microscopy in a unified data matrix and subjecting the results to numerical analysis using a suitable program for taxonomic purposes.

Materials and Methods

The present study is based on fresh and herbarium specimens of the 19 species belonging to 12 genera of the Mimosoideae (8 spp. from 6 genera) and Caesalpinioideae (11 spp. from 6 genera) listed in Table 1. Fresh specimens were collected from different parts of Egypt and the specimens kept in the herbarium of Cairo University was inspected. The plants were identified according to Boulos (1999, 2009).

For light microscopic analysis (LM) after acetolysis, pollen grains were mounted in glycerin jelly and observations were made with a Leitz Labourlux LM using the 100x oil immersion objective. Ten measurements per specimen were taken for polar axis (P), equatorial diameter (E), colpus length (CL), colpus width (CW), exine thickness (Ex.th.), apocolpium and mesocolpium diameters. P/E, CL/P and CL/CW ratios were calculated.

For scanning electron microscopic analysis (SEM), acetolysed grains were dehydrated in 70% ethanol and then transferred with pipette to a clean slide. Once air-dried they were transferred into metallic stubs using double-sided adhesive tape and coated with gold in a JEOL JFC 1100E ion sputtering device and examined in a JEOL JSM 5400LV scanning electron microscope, operated at accelerated voltage of 15KV at the Scanning Electron Microscopy Unit, Alexandria University.

Acetolysed pollen grains were dehydrated in 70% ethanol then treated with ultra-sounds (35kc/s, for 1h). The action of ultrasound, in addition to removing impurities, effectively increased the frequency of fractures in the pollen exine, allowing for a deeper examination of the details of the exine and apertures, Fractured grains were prepared and examined by scanning electron microscopy. The terminology of pollen descriptions by Punt et al. (2007) was followed.

For seed morphology 2-5 mature seeds for each

TABLE 1. List of 11 species representing the Caesalpinioideae and referred to tribes according to Irwin and Barneby (1982), and eight species representing the Mimosoideae and referred to tribes according to (Luckow et al., 2005). Collection data of the specimens of every species are shown against its name. * = cultivated. **= herbarium specimens

Subfamilies-tribes	Species	Collection data
Caesalpinioideae-Cassieae	**Cassia fistula* L.	Al-Azhar University, Cairo, 24/7/219; Doaa El-Kholy.
	**Cassia javanica* L. subsp. *nodosa* (Roxb.) K. & S. Larsen	Al-Azhar University, Cairo, 22/5/2019
	**Ceratonia siliqua* L.	Al-Azhar University, Cairo, Faculty of Agriculture Garden, 12/3/2019; Doaa El-Kholy.
	**Senna didymobotrya* (Fresen.) H.S. Irwin & Barneby	Garden of Ain Shams University, Cairo, 24/3/2019; Doaa El-Kholy.
	**Senna occidentalis* (L.) Link	Nasr City, Cairo, 24/4/201. Doaa El-Kholy.
	**Senna surattensis* (Burm.f.) H.S. Irwin & Barneby	Al-Azhar University Cairo, and Al-Orman Garden, 5/7/2019. Doaa El-Kholy.
Caesalpinioideae-Caesalpinieae	**Caesalpinia gilliesii* (Hook.) D. Dietr.	El-Shrouk City, Cairo, 18/3/2019. Doaa El-Kholy.
	**Caesalpinia sappan* L.	Garden of Ain Shams University, Cairo 15/6/2019; Doaa El-Kholy.
	**Peltophorum pterocarpum* (DC.) K. Heyne	Nasr City, Cairo,15/6/2019; Doaa El-Kholy
	***Delonix elata* (L.) Gamble	Cairo University Herbarium (CAI)
	**Delonix regia* (Hook.) Raf.	Nasr City, Cairo, Al-Azhar University, Cairo, 4/6/2019; Doaa El-Kholy.
Mimosoideae-Acacieae	**Leucaena leucocephala* (Lam.) de Wit	Nasr City, Cairo, 5/4/2019; Doaa El-Kholy.
	Acacia farnesiana (L.) Willd.	Nasr City, Cairo, 20/5/2019 and Al- Menoufia, 15/8/2019; Doaa El-Kholy.
	Acacia nilotica (L.) Delile subsp. *nilotica*	Nasr City, Cairo, 9/8/2019 and Al- Menoufia 15/5/2019; Doaa El-Kholy.
	Acacia saligna (Labill.) H. L. Wendl.	Al-Azhar University, Cairo, 22/4/219 and Cairo-Alexandria Road, 100Km, 25/4/2019; Doaa El-Kholy.
Mimosoideae-Ingeae	**Calliandra haematocephala* Hassk	Al-Azhar University, Cairo and Al-Orman Garden, 20/7/2019; Doaa El-Kholy.
	**Albizia lebbeck* (L.) Benth.	Al-Azhar University, Cairo, Faculty of Agriculture Garden and Al-Menoufia, 15/8/2019; Doaa El-Kholy.
Mimosoideae-Mimoseae	*Dichrostachys cinerea* (L.) Wight & Arn.	Al-Orman Garden, Cairo, 22/3/2019; Doaa El-Kholy.
	Prosopis juliflora (Sw.) DC.	Nasr City, Cairo, 15/7/2020; Doaa El-Kholy.

taxon were chosen to cover the range of variation. Seed macro- and micro-morphological details (outer shape, color, topography, and dimensions) were photographed by an Olympus SC100 digital camera attached to an Olympus SZ61 stereomicroscope. Seed micro-morphological details (epidermal cell shape in addition to shape, position, and dimensions of the hilum) were examined and photographed using JEOL JSM 5400 LV SEM located at the Scanning Electron Microscope Unit, Alexandria University, Egypt. Dry seeds were coated with a thin layer of gold in an ion-sputtering device (JEOL JFC 1100E), The Terminology of Barthlott (1981), Stearn (1992) was adopted. The data obtained from macro and micromorphology of pollen grain and seed characters of the investigated taxa were subjected to numerical analysis using the PRIMER Ver.6 program.

Results

Pollen grains of the Caesalpinioideae are invariably in monads, whereas those of the Mimosoideae are either in monads or polyads. The number of units in the polyad of a given species may be 8, 12, or 16 in one plane, or 32 in two planes [Table 2 and Plate 1 (Figs. 11-15)]. Variation in monad morphology included their shape, measurements of polar and equatorial views, number and type of apertures, measurements of colpi, type of aperture membrane, the presence of costae and margo [Table 3 and Plates 1 & 2 (Figs. 1-10)], as well as the following five patterns of exine ornamentation:

(i) Perforate [e.g: *Leucaena leucocephala* (Plate 2, Fig. 1), *Cassia javanica* subsp. *nodosa* (Plate 2, Fig. 3), *Acacia farnesiana* (Plate 3, Fig. 6)].

(ii) Psilate [e.g: *Senna surattensis* (Plate 2, Fig. 2), *Acacia saligna* (Plate 3, Fig. 3)].

(iii) Psilate- foveolate [e.g: *Prosopis juliflora* (Plate 2, Fig. 5), *Acacia nilotica* subsp. *nilotica* (Plate 3, Fig. 4)].

(iv) Reticulate [(e.g.: *Caesalpinia sappan* (Plate 2, Fig. 8); *Delonix regia* (Plate 2, Fig. 9); *Peltophorum pterocarpum* (Plate 2, Fig. 10)].

(v) Fossulate [e.g: *Calliandra haematocephala* (Plate 3, Fig. 1), *Dichrostachys cinerea* (Plate 3, Fig. 5)].

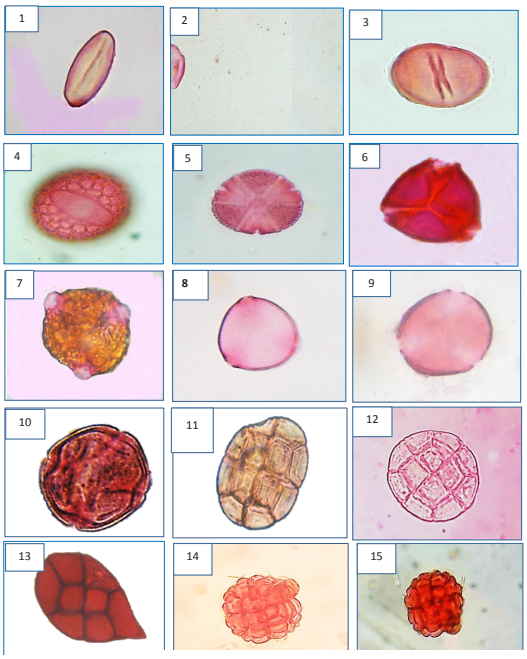

Plate 1 (Figs.1-15). Light photomicrographs of pollen grains of studied taxa

(1) *Cassia fistula,* (2) *Senna occidentalis,* (3) *Senna surattensis,* (4) *Delonix regia,* (5) *Caesalpinia sappan,* (6) *Caesalpinia gilliesii,* (7) *Peltophorum pterocarpum,* (8) *Cassia javanica* subsp. *nodosa,* (9) *Leucaena leucocephala,* (10) *Ceratonia siliqua,* (11) *Albizia lebbeck,* (12) *Acacia farnesiana,* (13) *Calliandra haematocephala,* (14) *Acacia saligna,* (15) *Acacia nilotica* subsp. *nilotica.*

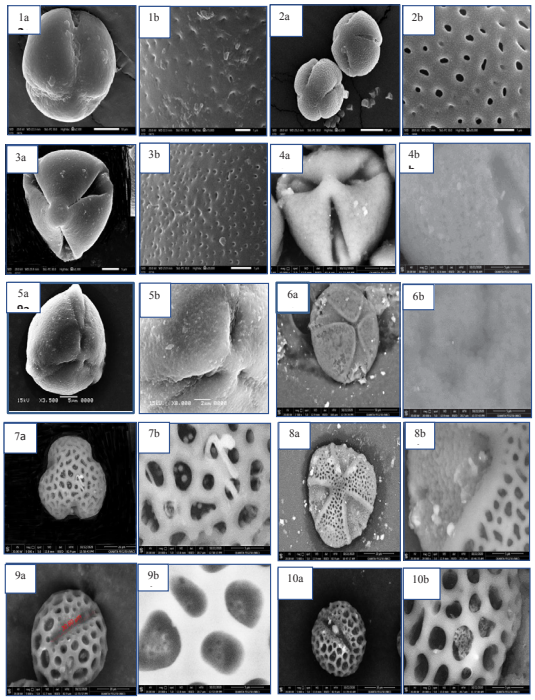

Plate 2 (Figs. 1-10). Scanning electron micrograph

of single pollen grains of studied taxa

a: Polar view, b: exine surface:
(1) *Leucaena leucocephala*, (2) *Ceratonia siliqua*, (3) *Cassia javanica* subsp. *nodosa,* (4) *Senna surattensis*, (5) *Prosopis juliflora*, (6) *Caesalpinia gilliesii*, (7) *Delonix elata*, (8) *Caesalpinia sappan,* (9) *Delonix regia*, (10) *Peltophorum pterocarpum.*

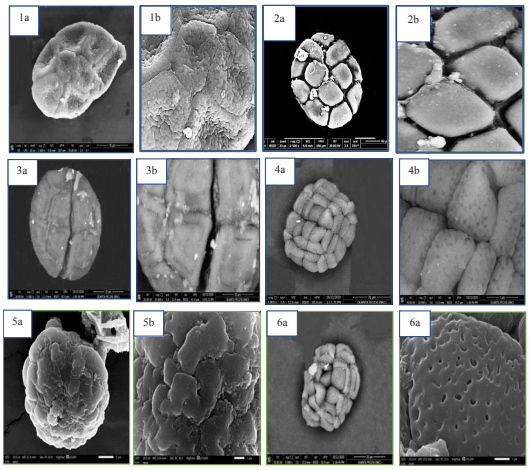

Plate 3 (Figs. 1-6). Scanning electron micrograph of compound pollen grains of studied taxa

a: polar view, b: exine surface:
(1) *Calliandra haematocephala,* (2) *Albizia lebbeck,* (3) *Acacia saligna,* (4) *Acacia nilotica* subsp. *nilotica,* (5) *Dichrostachys cinerea,* (6) *Acacia farnesiana*

Variation in seed morphology included seed shape, measurements, coat color and texture, number per fruit, hilum position, presence of seed pleurogram [summarized in Table 4 and Plate 4 (Figs. A-Q)], as well as the following eight patterns of coat ornamentation as revealed by SEM:

(i) Scalariform: e.g.: *Calliandra haematocephala* (Plate 5, Fig. 1).

(ii) Fossulate: e.g.: *Albizia lebbeck* (Plate 5, Fig. 2)

(iii) Favulariate: only in *Ceratonia siliqua* (Plate 5, Fig. 6).

(iv) Ruminate: e.g.: *Peltophorum pterocarpum* (Plate 5, Fig. 8).

(v) Reticulate-foveate: e.g.: Caesalpinia sappan (Plate 6, Fig 1).

(vi) Reticulate: e.g.: *Cassia javanica* subsp.*nodosa* (Plate 6, Fig 2)

(vii) Rugose: e.g.: *Senna occidentalis* (Plate 6, Fig. 3).

(viii) Psilate: e.g.: *Acacia saligna* (Plate 6, Fig. 6).

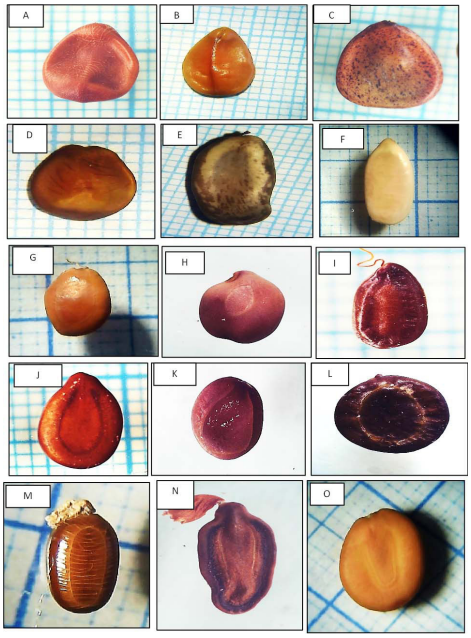

Plate 4 (Figs. A-Q). Light photomicrographs of seed of studied taxa

A= *Cassia fistula,* B= *Cassia javanica* subsp. *nodosa,* C= *Caesalpinia gilliesii,* D= *Ceratonia siliqua,* E= *Delonix regia,* F= *Peltophorum pterocarpum,* G= *Prosopis juliflora,* H= *Senna occidentalis,* I= *Senna surattensis,* J= *Leucaena leucocephala,* K= *Acacia farnesiana,* L= *Acacia nilotica* subsp. *nilotica,* M= *Acacia saligna,* N= *Calliandra haematocephala* and O= *Albizia lebbeck.*

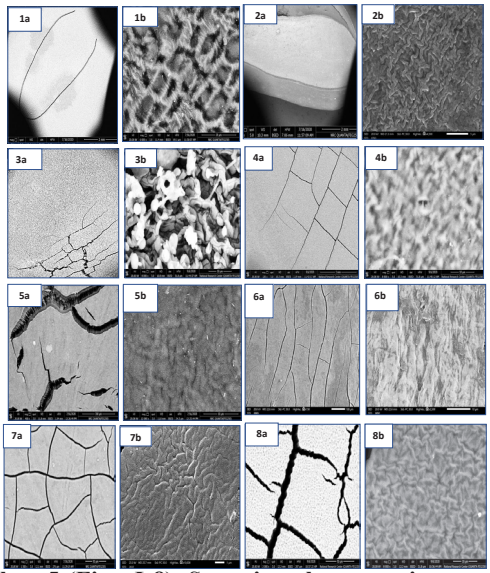

Plate 5 (Figs. I-8). Scanning electron micrograph of seed of studied taxa

Magnification: a:200x - b:6000x
1= *Calliandra haematocephala*, 2= *Albizia lebbeck*, 3= *Delonix elata*, 4= *Delonix regia*, 5= *Dichrostachys cinerea*, 6= *Ceratonia siliqua*, 7= *Prosopis juliflora*, 8= *Peltophorum pterocarpum*

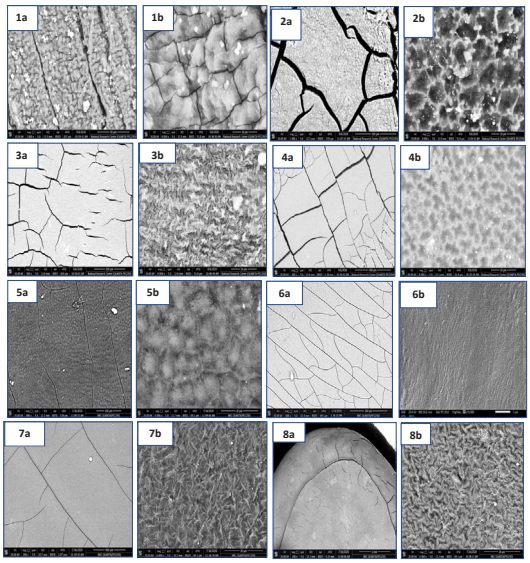

Plate 6 (Figs. 1-8). Scanning electron micrograph of seed of studied taxa

Magnification: a:200x - b:6000x
1= *Caesalpinia sappan,* 2= *Cassia javanica* subsp. *nodosa,* 3= *Senna occidentalis,* 4= *Senna didymobotrya,* 5= *Leucaena leucocephala,* 6= *Acacia saligna,* 7= *Acacia farnesiana,* 8= *Acacia nilotica* subsp. *nilotica.*

Variation observed in the 13, 8 and 15 characters of monad, polyad and seed morphology, respectively, and their character-states were scored comparatively for individual species and infra-specific taxa in Tables 2-4, prior to being subjected to numerical analysis which resulted in the construction of the dendrogram in Fig. 1.

Main conclusions: (1) Mimosoideae separate from Caesalpinioideae, except the 3 *Senna* species; (2) the generic concept in the two groups is taxonomically robust since the species of every genus emerged intact.

Discussion

Recognition of the two major groups in the present study is clearly supportive to the distinction between the Mimosoideae and Caesalpinioideae as two separate subfamilies of equal rank and is in sharp contrast with the phylogenetic classification proposed by LPWG (2017) in which the former subfamily is reduced to a clade within the latter. The only exception is the migration of the three *Senna* species from the latter subfamily to the former. Furthermore, of the 12 genera covered by the present study, *Cassia*, *Senna* and *Delonix* (of the Caesalpinioideae) and *Acacia* (of the Mimosoideae) are represented by two or more species each. Representatives of each of all four genera emerged together in the same low-level group, thus indicating that the generic concept in the Mimosoideae and Caesalpinioideae is as taxonomically sound as can be judged by the small numbers of their representative species.

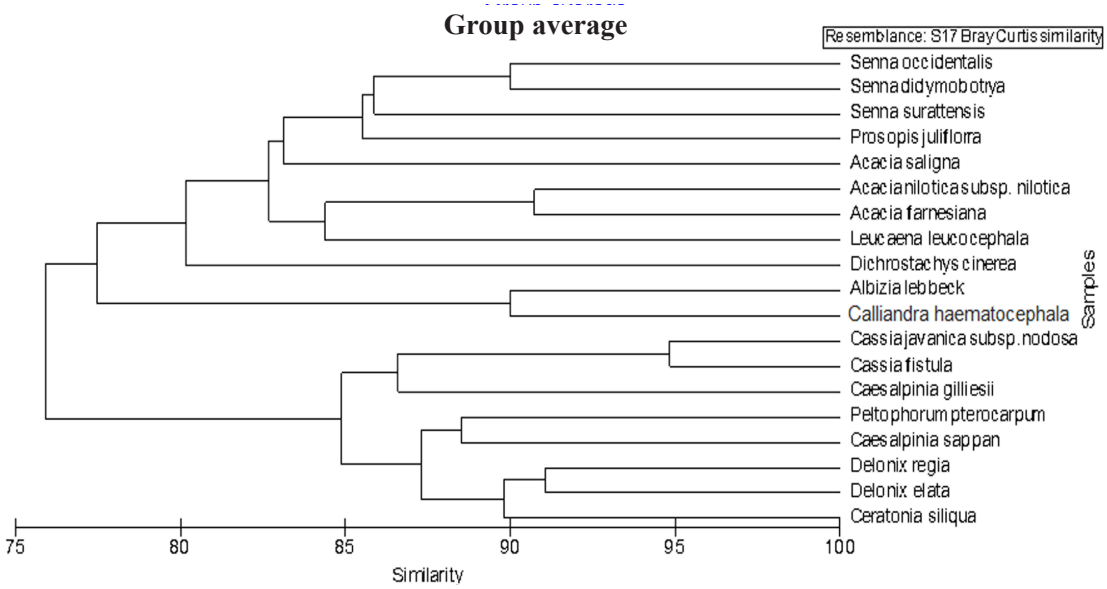

Fig. 1. Dendrogram showing the interrelationships between 19 taxa of Mimosoideae and Caesalpinoideae based on pollen grains and seed characters by using PRIMER program

TABLE 2. Polyad morphology of six species of the Mimosoideae as revealed by LM and SEM

Character \ Taxa		*Acacia farnesiana*	*Acacia nilotica* subsp. *nilotica*	*Acacia saligna*	*Calliandra haematocephala*	*Albizia lebbeck*	*Dichrostachys cinerea*
Pollen shape:1= prolate, 2= per-prolate, 3= sub-oblate		1	2	2	2	2	3
Pollen size: 1== Medium, 2= large, very large		1	1	1	3	2	3
Polyad outline: 1= quadrangulate, 2= spheroidal, 3= ovoid.		1	1	2	3	1	2
Polyad cells shape: 1= quadrangulate, 2= sub-globose in periphery and square in center, 3= sub globose		2	2	1	1	1	3
Outline in equatorial view: 1=elliptic, 2=oblong, 3=circular		3	3	1	2	2	1
Pollen unit: 1= massula with 10 units, 2= massula with 16 units, 3= massula with 32 units		3	3	2	1	2	2
Size	Polar diameter µm	29.6-40.1	33.03-39.7	48.9-50.9	90.5-155.3	71.1-87.8	174.5-196.1
	Equatorial diameter µm	4.48-31.2	4.17-9.33	14.8-16.6	38.7-67.4	15.6-28.8	167-188.6
	P / E	2.6	4.2	3.1	3	3.5	0.813
Ornamentation: 1= psilate, 2= psilate- foveolate, 3=perforate, 4= fossulate		3	2	1	4	2	4

TABLE 3. Monad morphology of the 13 species of the Caesalpinioideae and Mimosoideae as revealed by LM and SEM

Character \ Taxa		*Cassia fistula*	*Cassia javanica* subsp. *nodosa*	*Senna didymobotrya*	*Senna occidentalis*	*Senna surattensis*	*Caesalpinia gilliesii*	*Caesalpinia sappan*	*Delonix elata*	*Delonix regia*	*Peltophorum pterocarpum*	*Leucaena leucocephala*	*Prosopis juliflora*	*Ceratonia siliqua*
Pollen shape 1= prolate, 2= (sub prolate), 3=per-prolate, 4= spheroidal.		2	2	2	2	2	1	1	1	1	1	1	1	1
Pollen class1= tricolporate /2, = tetracoloporate		1	1	1	1	1	1	1	1	1	1	1	1	2
Pollen size: 1= small, 2= medium, 3= large		1	1	1	1	1	3	2	2	2	2	2	1	1
Outline in polar view(amb)	:1=circular, 2= convex-triangular, 3= straight-triangular	2	2	1	1	3	1	3	2	1	2	2	2	1
	1= lobate, 2= slightly lobate, 3= straight	1	1	2	2	1	3	3	2	2	2	2	2	2
	1= convex, 2= straight.	1	1	1	1	1	1	2	1	1	1	1	1	1
	1= angulaperturate, 2= planaperturate	1	1	1	1	1	1	2	2	1	2	1	1	1
Outline in equatorial view: 1=elliptic, 2=oblong, 3=circular.		2	1	3	3	2	1	1	3	2	3	2	2	2
Size	Polar diameter µm	27.6-40.5	24.9-27.1	24.8-25.0	28.8-30.1	29.8-30.9	86.1-93.8	44.9-47.8	36.4-37.7	36.5-37.7	38.4-40.5	34.-34.6	23.-23.8	22.-23.1
Equatorial diameter µm	19.0-23.8	19.6-23.5	19.9-21.7	21.8-25.5	22.9-23.1	56.1-65.3	24.2-26.1	22.5-26.0	23.0-26.8	23.8-31.2	26.2-28.8	16.1-18.1	12.4-16.2	
P / E	1.28	1.23	1.18	1.24	1.21	1.46	1.84	1.5	1.48	1.38	1.2	1.21	1.63	
Colpus	Length µm	29.71	22.58	27.85	27.93	29.57	29.44	42.35	29.6	36.51	25.84	1320.7	127.7	45.8
Width µm	7.036	4.66	4.53	3.92	4.72	15.78	19.6	3.41	4.54	3.12	88.09	151.2	13.61	
Ratio length / width	4.22	4.84	6.14	7.12	6.26	1.86	2.16	8.68	8.04	8.28	8.12	2.91	3.36	
Colpus: 1= short (1.86-2.9) µm, 2=long (3.36-7.12) µm, 3= very long (8.04-8.68) µm	2	2	2	2	2	3	3	1	1	1	2	2	2	
Aperture type (colpi): 1= zonocolpate, 2= syncolpate	1	1	1	1	1	2	1	1	1	1	1	1	1	
Aperture membrane: 1=Smooth, 2= ornamented	1	1	1	1	1	1	2	1	1	1	1	1	1	
Shape: 1= linear, 2=elliptic, 3=infolded, 4=rectangular.	3	1	3	3	3	3	3	4	4	2	1	2	2	
Width :1= narrow, 2=wide,3=medium.		3	1	2	3	3	2	2	3	2	2	1	2	1
Pore protrusion: 1=with, 2= without		2	1	2	2	2	2	2	2	2	1	2	2	2
Colpi tips: 1= raised, 2=sunken, 3=at level, 4=depressed.		1	2	1	2	2	3	3	4	3	3	4	1	4
Bervicolporus:1= present, 2= absent		2	2	2	2	2	2	2	1	1	1	2	2	2
Costae:1=present, 2= absent		2	2	2	2	2	1	1	2	2	2	2	2	2
Margo :1=present, 2=absent.		2	2	2	2	2	1	1	2	2	2	2	2	2
Ornamentation: 1= psilate, 2= psilate- foveolate, 3=perforate, 4= reticulate.		1	3	1	4	1	1	4	4	4	4	3	2	3

TABLE 4. Seed macro- and micro-morphological characters of 19 species of Caesalpinioideae and Mimosoideae as revealed by light microscopy

Character \ Taxa	*Cassia fistula*	*Cassia javanica* subsp.*nodosa*	*Caesalpinia gilliesii*	*Caesalpinia sappan*	*Ceratonia siliqua*	*Delonix elata*	*Delonix regia*	*Peltophorum pterocarpum*	*Senna didymobotrya*	*Senna occidentalis*	*Senna surattensis*	*Leucaena leucocephala*	*Acacia farnesiana*	*Acacia nilotica* subsp. *nilotica*	*Acacia saligna*	*Calliandra haematocephala*	*Albizia lebbeck*	*Dichrostachys cinerea*	*Prosopis juliflora*
Color: 1=monochromic, 2=mottled	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Color: 1= Brown, 2= dark brown, 3= yellowish	1	1	2	3	1	1	1	3	1	1	1	1	1	2	2	1	1	1	1
Length (mm): 1(3-6), 2(6-12), 3(15-20)	2	2	2	2	2	2	3	2	2	1	1	2	2	2	1	2	2	1	2
Width (mm): 1(2-5), 2(6-8), 3(9-11)	2	1	3	1	2	2	2	1	1	1	1	1	1	2	1	1	1	1	1
Shape: 1= ovate, 2= globose, 3= obovate, 4= oblong	1	1	1	4	1	1	4	4	1	2	2	1	4	2	4	3	4	1	2
Surface: 1= shiny, 2= dull	1	1	1	2	2	2	2	1	2	2	1	1	2	1	1	2	2	1	**1**
Texture: 1= smooth, 2= rough	1	1	1	2	1	2	1	1	2	1	1	1	1	1	1	2	1	1	1
Hilum position: 1= terminal, 2= subterminal	1	1	1	1	1	2	1	1	2	2	2	1	2	2	1	1	2	1	1
Hilar region :1= present, 2= absent	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
Funicle: 1= present, 2= absent	2	2	2	2	1	1	1	2	2	2	1	2	2	2	1	1	2	2	1
Line**:** 1= present, 2= absent	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Pleurogram: 1= opened, 2= closed,3= absent	3	3	3	3	3	3	3	3	2	2	2	1	1	2	2	1	1	1	**2**
Pleurogram shape: 1=U-shaped, 2=horse shoe shaped, 3= oblong, 4= elliptic, 5=absent	5	5	5	5	5	5	5	5	3	4	3	2	2	3	3	1	1	**2**	3
Areolate: 1= broad, 2= narrow, 3= absent	3	3	3	3	3	3	3	3	1	2	1	1	1	1	1	1	1	1	1
Areolate: 1= raised, 2=at level, 3= depressed, 4= absent.	4	4	4	4	4	4	4	4	3	2	1	2	2	2	2	2	2	2	2
Fracture lines Crack: 1-thin, 2-thick, 3-very thick, 4-absent	1	3	1	1	2	2	1	3	2	2	2	1	1	1	1	4	4	3	2
Fracture lines Crack: 1= regular, 2= irregular, 3= absent	2	2	1	1	1	2	1	2	2	2	2	2	2	2	2	3	3	2	1
Fracture lines Crack: 1= continuous, 2= discontinuous, 3= absent	1	1	1	2	1	2	2	2	1	2	1	2	2	2	1	3	3	2	1
Ornamentation:1= reticulate, 2= reticulate-foaeate, 3= favulariate, 4= rugose, 5= ruminate, 6= psilate, 7= fossulate, 8= scalariform	1	1	1	2	3	1	1	5	4	4	2	1	4	4	6	8	7	4	7

The genus *Cassia* was established by Linnaeus (1753) with 26 species who arranged them into two series: Sennae and Chamaechristae. Soon afterwards, Miller (1754) divided the series Sennae into two genera (*Cassia s.s*. and *Senna* Mill.) while raising the other series into generic rank (*Chamaechrita* Mill.), which was later amended to *Chamaecrista* Moench. Irwin & Barneby (1981) utilized a few differences in floral structure to provide a key to distinguish between the three genera. However, some authors (e.g. Lindley, 1853; Bentham & Hooker, 1862) did not accept this separation and continued to deal with *Senna* as part of *Cassia s.l*. Notable among the results of the present study is the clear separation of *Cassia* and *Senna*. They not only diverged from each other in two minor groups within the same major group but are widely separated in the two major groups, with *Senna* joining the group corresponding to the Mimosoideae, whereas *Cassia* remained adhering to its close relatives in the second main group which includes the rest of the Caesalpinioideae. Therefore, our data on pollen and seed morphology seems to favor the segregation of *Senna* from *Cassia* by adding to the list of differences between them.

Ceratonia is a mono-specific genus (*C. siliqua*) which was described by Bentham and Hooker (1862; p. 574) as "anomalous" because it differs in numerous aspects from the rest of the genera in the Caesalpinioideae. Owing to these differences, *Ceratonia* is still monospecific. Furthermore, while its copious seed albumen indicates that it has some affinity with *Cassia*, its dilatated disc in the flower makes it distinct from all other genera of the Leguminosae (Taubert, 1894). The present study seems to corroborate the anomaly of *Ceratonia* within the Leguminosae, since it is the only genus in our sample with: (i) tetra-colporate monads, while the monads of all other genera are tri-colporate, and (ii) favulariate sculpture of the seed coat.

From the identificatory standpoint, pollen aggregation can be of immense value in the distinction between the morphologically closely similar species. For instance, the 8-celled polyads are uniquely characteristic of all *Calliandra* species which bear close resemblance to several *Albizia* species with 12-celled polyads. Within the rest of the Mimosoideae, the 16- and 32-celled polyads are characteristic of *Acacia* spp.

Conclusion

The results of the present study revealed several significant characters. the distinction between the two subfamilies seems corroborated by differences in pollen and seed morphology.

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الأهمية التصنيفية لمورفولوجيا حبوب اللقاح والبذور في تحت الفصيلتين الطلحية والبقمية (الفصيلة البقولية)

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تمت دراسة مورفولوجيا حبوب اللقاح والبذور لتسعة عشر نوعًا تمثل إثنا عشر جنسًا من تحت الفصيلتين الطلحية والبقمية باستخدام الفحص المجهري الضوئي والإلكتروني بهدف التوصل إلى طريقة دقيقة للفصل بينها.

تم تسجيل الاختلافات الملحوظة نسبيًا في مصفوفة بيانات وتم تحليلها عدديًا بواسطة حزمة برنامج برايمر الإصدار السادس للتحليل العددى. يشير المخطط الشجرى إلى تقسيم الأنواع إلى مجموعتين رئيسيتين. تضم مجموعة واحدة جميع أعضاء تحت الفصيلة الطلحية مع الثلاثة أنواع المدروسة من السينا (*Senna*) من تحت الفصيلة البقمية. الأنواع الثمانية المتبقية من تحت الفصيلة الأخيرة تشكل المجموعة الثانية. بصرف النظر عن انحراف السينا (*Senna*) عن تحت الفصيلة البقمية، يبدو أن التمييز بين تحت الفصيلتين مدعوم بالاختلافات في شكل حبوب اللقاح والبذور. تختلف السينا (*Senna*) عن الكاسيا (*Cassia*) وتستحق رتبة عامة.

المفهوم العام للأجناس تحت الفصيلتين سليم من الناحية التصنيفية لأن مجموعة الأنواع التي تمثل جنسًا واحدًا مرتبطة ببعضها البعض قبل الانضمام إلى تلك الخاصة بالأجناس الأخرى. يمكن تمييز الأجناس الفردية (مثل الكاليندرا *Calliandra*) من خلال مجموعات حبوب اللقاح الخاصة بهم.