

## Phytochemistry and taxonomy of a few species of Mimosoideae

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**Received:** November 29, 2015; **Revised:** December 12, 2015; **Accepted:** December 24, 2015.

**Abstract:** 5 genera of sub-family Mimosoideae of Fabaceae have been screened and analysed for the presence of chemical markers like flavonoids, phenolic acids, leucoanthocyanins, iridoids, saponins and tannins. The demarcation of various tribes of Mimosoideae has been discussed in terms of chemical data. A phylogram shows *Acacia*, *Prosopis*, *Xylia*, and *Calliandra* as primitive chemically due to the presence of leucoanthocyanins; whereas *Pithecolobium* is an advanced genus showing only flavonoids.

**Key Words:** Mimosoideae; flavonoids; chemical markers; phylogenetic relationships

### Introduction

Mimosoideae (syn. Mimosaceae) is a sub-family of Fabaceae with about 80 genera and 3200 species (en.wikipedia.org). They grow in tropical and warm temperate Asia and America. Fabaceae are characterised by compound, stipulate leaves and their legume fruits. It is the most common family found in tropical rain forests and in dry forests in the Americas and Africa. The Fabaceae have fused and five free petals, are hermaphrodite and usually have a short cup-shaped hypanthium. There are normally ten stamens and one elongated suspensor and ovary with a curved style. They are typically entomophilous plants. It has three subfamilies, the Papilionoideae, Caesalpinioideae and the Mimosoideae.

The three sub-families have been alternatively treated at the family level as in the Cronquist and Dahlgren systems but this is not supported by the 20<sup>th</sup> and 21<sup>st</sup> century evidences. Various evidences point to the Caesalpinioideae to be paraphyletic and Mimosoideae and Faboideae to be monophyletic (Wojciechowski *et al.*, 2006). Also, Fabaceae *sensu lato* is monophyletic (according to recent molecular and morphological evidence). This is supported by all the recent phylogenetic studies based on DNA consequences (Lewis *et al.*, 2005, Doyle *et al.* 2000: Kajita *et al.*, 2001) Mimosoideae yields a number of important economically important plants. *Xylia xylocarpa* Taub. is used for its hard reddish brown wood-for sleepers and building purposes; *Prosopis spicigera* L. has thick, grey and rough bark and purplish brown hard bark, which makes a good fuel. The pods are eaten by cattle. *Acacia arabica* Willd. or the Babul tree has dark brown bark and reddish brown hard and strong wood used for agricultural purposes; the pods are eaten by cattle. *Pithecolobium dulce* Benth. makes a good hedge; has pods for cattle and foliage for goats; and a strong reddish –white wood which is a good fuel.

In Mimosoideae, the flowers are actinomorphic and in globose inflorescences. They have ten or more long coloured filamentous stamens but the petals are small. The sub-family Mimosoideae is sub-divided into four tribes - Acacieae, Ingeae, Eumimoseae and Adenanthereae (Gamble, 1967). Five genera have been taken up for phytochemical study and are distributed over these tribes

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viz., *Acacia* in Acacieae; *Calliandra*, *Pithecolobium* in Ingeae; *Prosopis* and *Xylia* in Adenanthereae. Lots of controversies exist in the intra-tribal level between genera and within genera, regarding their delimitations. For eg., some species of *Acacia* the world over are polyphyletic and others are monophyletic in origin (en. wikipedia .com).

#### Adenanthereae

*Neptunia*

*Xylia*

*Entada*

*Adenanthera*

*Prosopis*

*Dichrostachys*

#### Eumimoseae

*Desmanthus*

*Leucaena*

*Mimosa*

#### Acacieae

*Acacia*

#### Ingeae

*Albizzia*

*Pithecolobium*

*Enterolobium*

*Inga*

The key features for identifying each of these genera are as follows (Gamble, 1967)

#### I Definite stamens; gland-crested anthers

##### Adenanthereae

Flowers in globose heads

Large trees with thick woody pods and large leaflets; all or nearly all the flowers perfect; seeds exalbuminous

----*Xylia*

Flowers in elongate spikes.

Prickly trees or large shrubs with sessile flowers; pods turgid, straight; leaflets distant -----*Prosopis*

#### II Definite stamens, anthers not gland crested; albuminous seeds-----Eumimoseae

**III Indefinite stamens, exalbuminous seeds -----**

**Acaciae**

- free stamens, flowers capitate or spicate-----*Acacia*

**IV Stamens indefinite, monadelphous, rarely only 2-3 times as many as the petals; seeds exalbuminous-----**

**-----Ingeae**

curved or twisted pods with coriaceous leaves; leaves bipinnate and pods not septate between the seeds-----

-----*Pithecolobium*

simply pinnate leaves-----*Inga/Calliandra\**

Pollen morphology does not justify the sub-division of the family into the tribes generally adopted (Sorsa, 1969). And clearly some genera are heterogeneous (according to their pollen morphology). Taxonomic and phyletic relationships between several genera and species based on pollen morphology have been discussed. Mimosaceae has been treated as a family (Britton and Rose, 1928; Hutchinson, 1964) and as sub-family (Bentham and Hooker, 1867; Taubert, 1894; Melchior, 1964) and both ranks are in use today. Corner (1951, 1953) suggests fusion with Caesalpinieae to form a single family Leguminosae.

According to Bentham and Hooker (1867) and Engler (1964) the Leguminosae family consists of 3 sub-families. Many botanists have treated these sub-families as distinct families i.e., Mimosaceae, Caesalpinieae and the Papilionaceae. These families are even treated as a single order. Wood anatomy (Sen, 1943) does not separate them

into three separate families and cytological data are not available. The Mimosoideae sub-family is accepted as most primitive and the Papilionateae to be most evolved (Pandey, 1969). According to Singh (2004), Mimosoideae are largely monophyletic and are an advanced group of plants.

The sub-division of Mimosaceae is that of Bentham and Hooker (1867) and Taubert (1894). Neither the broad classification nor the placing of certain genera and species seem to be generally agreed upon. According to Brouchenak-Kelladi *et al* (2010), the tribal system of Mimosoideae needs a complete revision. The present work was taken up against the background of the above foreknowledge.

**Materials and Methods**

The various plant parts (especially leaves) were separated and dried. Voucher specimen were deposited in the Herbarium, Department of Botany, M.S. University of Baroda. All the dried plant parts were ground to a fine powder in a grinder or blender. Powders were stored in air-tight glass containers or in sealed plastic bags. Standardised analytical procedures for the various groups of compounds, flavonoids glycosides, flavonoid aglycones, phenolic acids, leucoanthocyanins, tannins, iridoids and saponins were followed (Harborne, 1967, 1984; Ibrahim and Towers, 1960; Paech and Tracey, 1955; Mabry *et al.*, 1970).

**Results and Discussions**

Results are compiled in Tables 1-9 and Figs 1-9.

**Table 1:** Distribution of chemical markers in the 8 species of Mimosoideae

S. No.	Name of the plant	*Flav.Glyco.	*Flav.agly.	*Glycofl.	*Phe acids	*Leucoantho.	*Tan	*Irid	*Sapo
1.	<i>Acacia auriculiformis</i> A. Cunn. ex Benth.	+7	-	-	+3	+	-	+	-
2.	<i>Acacia Arabica</i> Willd.	+4	+3	-	+2	-	-	-	-
3.	<i>Prosopis juliflora</i> (Sw.)DC.	+2	+5	-	+3	-	+	-	-
4.	<i>Prosopis spicigera</i> L.	+4	+1	-	+3	+	-	-	-
5.	<i>Xylia dolabriformis</i> Benth.	+2	+3	-	+4	+	+	+	-
6.	* <i>Calliandra tweedii</i> Benth.	+1	+1	-	+3	+	-	-	-
7.	<i>Pithecolobium dulce</i> (Roxb.)Benth.	+1	+1	-	+3	-	-	-	+
8.	<i>Pithecolobium saman</i> Benth.	+2	+2	-	+3	-	-	-	-

\*Flav. Glyc. -Flavonoid Glycosides  
 Flav. Agly. -Flavonoid Aglycones  
 Glycofl. - Glycoflavones  
 Phe. acids- Phenolic acids  
 Leucoantho. - Leucoanthocyanins  
 Tan. -Tannins  
 Irid.-Iridoids  
 Sapo. -Saponins

In the overall distribution of chemical markers in this sub-family, there seems to be a pre-dominance of flavonoids (glycosides and aglycones) and phenolic acids. Leucoanthocyanins, tannins and saponins are sporadic in occurrence. Iridoids are rare.

*Acacia* of tribe Acaciae has several flavonoid aglycones and three phenolic acids and a few glycosides. *Acacia auriculiformis* differs from *Acacia arabica* in having no flavonoid aglycones and in the occurrence of special compounds like iridoids. *Prosopis* of tribe Adenanthereae has several flavonoid glycosides, and aglycones and three phenolic acids. *Prosopis juliflora* differs from *Prosopis spicigera* in having lesser flavonoid glycosides, more number of flavonoid aglycones and shows the presence of tannins.

**Table 2:** Chromatographic and UV spectral data of *Acacia auriculiformis* A. Cunn.ex Benth. flavonoids.

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
A 1	LY-	Y-	Y	254/267/290/ 320/367	Vanillic, syringic and p-OH Benzoic acids
A2	Y-	YBr-	Y	265/318/355	
A3	Y-	Gr Y-	Y	264/290/318/ 361	
A4	FIY-	FIY-	Y	254/268/300/ 369	
A5	•	LY-	Y	----- --	
A6	•	Bl-	P	274/281/322	
A7	•	Bl-	P	274	
G	-	-	-	-	-

**Table 3:** Chromatographic and UV spectral data of *Acacia arabica* Willd. flavonoids

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
G 1	LY-	Br-	Y	280	
G2	LY-	Br Y-	Y	278/328/354	
G3	LY-	LY-	Y	276	Vanillic and
A1	LY-	Y-	Y	254/289/370	Syringic acids
A2	Y-	LY-	Y	270/282/330/364	
A3	•	Bl- (russet)	Pink	271	
A4	•	LBl-	Gr	280	

**Table 4:** Chromatographic and UV spectral data of *Prosopis juliflora*(Sw.) DC. flavonoids

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
G1	LY-	LY-	LY	276/320	
G2	LY-	LBr-	LY	276/320	
G3	LY-	Y-	LY	-	Vanillic, Syringic, Gentisic acids
G4	LY-	Y-	LY	275/284 255/270/292/367	
A1	Y-	Y-	Y	1+AlCl <sub>3</sub> ---415 1+HCl-----410	

**Table 5:** Chromatographic and UV spectral data of *Prosopis spicigera* Linn. flavonoids

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
A1	Y-	BrY-	Y	254/296/368 +AlCl <sub>3</sub> 356/434 +HCl 356/424	
A2	LY-	LY-	Y	254/272/294/330/364 +AlCl <sub>3</sub> 420 +HCl 420 271/290/330 +AlCl <sub>3</sub> 279/303/342/384 +HCl	Vanillic Syringic and p-OH Benzoic acids
G1	LY-	Y-	Bri Y	278/300/344/390 +NaOAc No shift +NaOMe Increased intensity	

**Table 6:** Chromatographic and UV spectral data of *Xylia dolabriformis* Benth. flavonoids

Flavonoid aglycones (A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
A1	•	LBrY-	DG-Bl	253/268/302/370 +AlCl -450 +HCl---3429 253/266/334/369	
A2	•	FIY -	Y	+AlCl <sub>3</sub> -436 +HCl -424	Vanillic Syringic p-OH Benzoic acids
G1	LY-	LY-	Y	275 280,352	
G2	LY-	Br-	Y	+AlCl <sub>3</sub> -426 +HCl- 395 278/344	
G3	LY-	Br-	Y	AlCl <sub>3</sub> - 422 +HCl- 392	

**Table 7:** Chromatographic and UV spectral data of *Pithecolobium dulce* (Roxb.) Benth. flavonoids

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
A1	LY-	Br-	Y	252/314/336 262/322/386 262/290/320/366	
A2	Y-	Y-	YGr	+AlCl <sub>3</sub> -420,426 +NaOAc-445 +HCl- 420	
G1	Y-	Y-	Y	264/292/330 +AlCl <sub>3</sub> 272/300/342/392 +HCl	Vanillic, Syringic, Gentisic acids
G2	LY-	Y-	Y	272/298/340/395 264/292/316/338 +AlCl <sub>3</sub> 270/300/342/396 +HCl 272/298/339/392	

**Table 8:** Chromatographic and UV spectral data of *Pithecolobium saman* Benth. flavonoids

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
Flavonoid aglycones	LY-	LY-	Y	absent	Vanillic Syringic p-OH Benzoic acids
G1	LY-	LY-	Y	256/320	
G2	LY-	Bl-	Y	276/317	

**Table 9:** Chromatographic and UV spectral data of *Calliandra tweediei* Benth. flavonoids

Flavonoid aglycones(A)/ flavonoid glycosides(G)	Fluorescence			λ maxima	Phenolic acids
	Vis	UV	Na <sub>2</sub> CO <sub>3</sub>		
A1	Y-	Y-	Y	252/300/372 +AlCl <sub>3</sub> 427 +HCl 432	Vanillic, Syringic, p-OH Benzoic acids
G1	Y-	Br-	Y	263/298/350	

*Prosopis spicigera* has no tannins but shows presence of leucoanthocyanins. It differs from *Prosopis juliflora* in having fewer aglycones. *Xylia dolabriformis* of Adenanthereae is unique in showing the presence of flavonoid glycosides, flavonoid aglycones, phenolic acids in combination with leucoanthocyanins, tannins and iridoids.

*Pithecolobium* of tribe Ingeae has flavonoid aglycones and glycosides, phenolic acids and no leucoanthocyanins, tannins and iridoids. The two species of *Pithecolobium* studied here show similarity in this pattern. However, *P. dulce* differs from *P. saman* in having lesser number of flavonoids and the presence of saponins. *Pithecolobium saman* can be raised and segregated into a separate genus or tribe and renamed due to the total absence of leucoanthocyanins, tannins and iridoids.

*Calliandra tweediei* of Ingeae shows just one flavonoid glycoside and one flavonoid aglycone and 3 phenolic acids and shows total absence of the accessory chemical markers like tannins, iridoids and saponins.

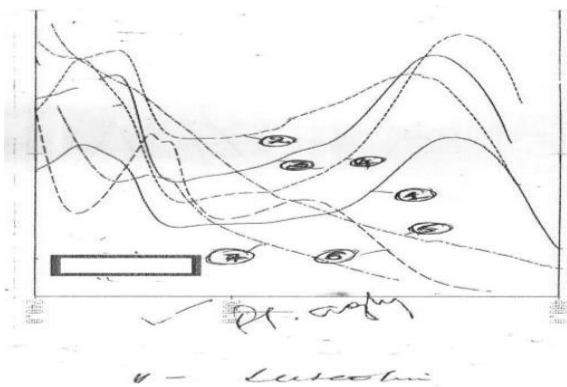


Figure 1: UV spectral graph of *Acacia auriculiformis* A. Cunn.ex Benth. flavonoids

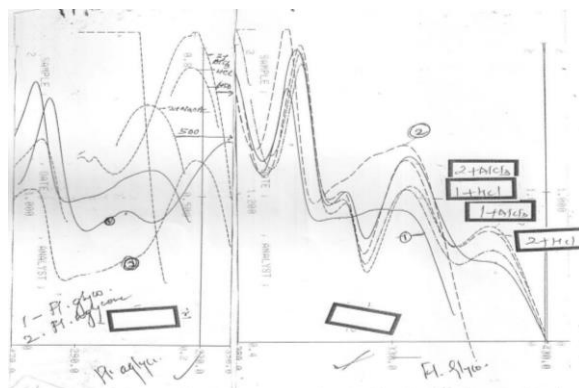


Figure 5: UV spectral graph of *Pithecolobium dulce* (Roxb.) Benth. flavonoids

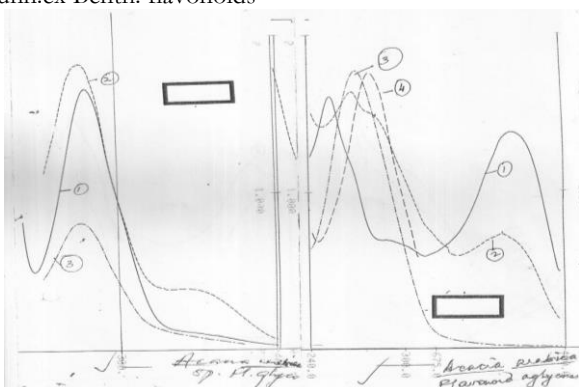


Figure 2: UV spectral graph of *Acacia arabica* Willd. flavonoids

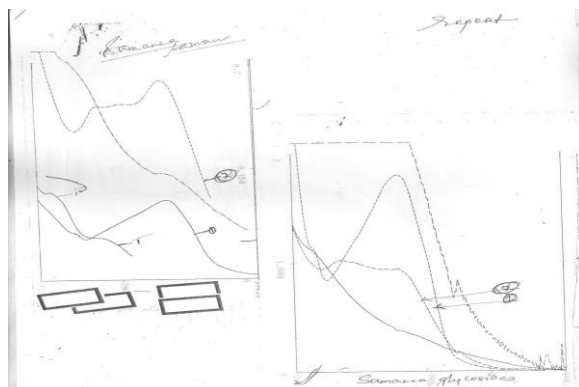


Figure 6: UV spectral graph of *Pithecolobium saman* Benth. flavonoids

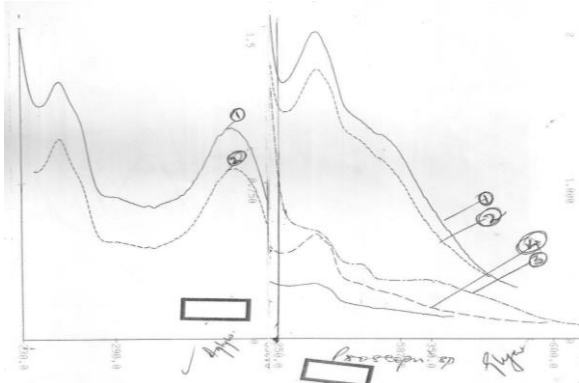


Figure 3: UV spectral graph of *Prosopis juliflora* Linn. flavonoids

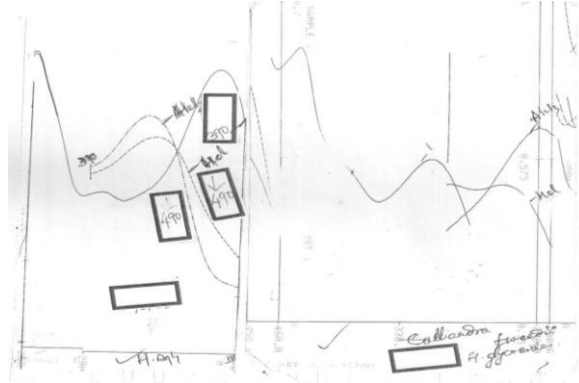


Figure 7: UV spectral graph of *Calliandra tweediei* Benth. flavonoids

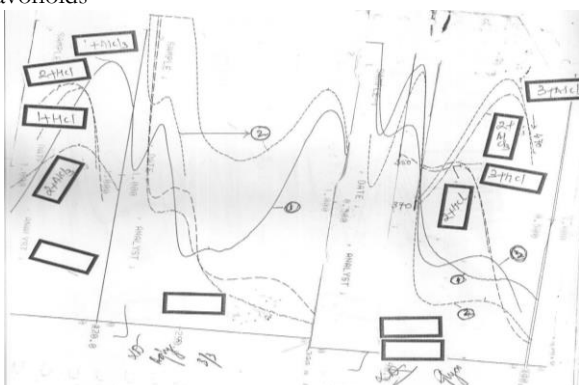


Figure 4: UV spectral graph of *Xylocarpus dolabriformis* Benth. flavonoids

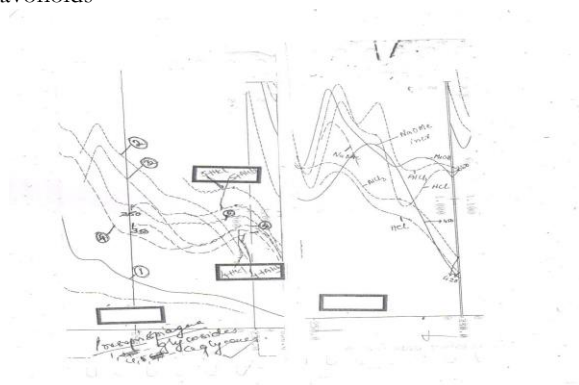


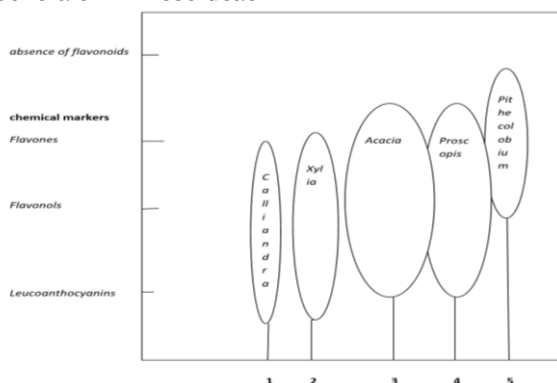
Figure 8: UV spectral graph of *Prosopis spicigera* Linn. flavonoids

An analysis of Tables 2-9 and Figs 1-8 depicts most of the compounds eluted from the chromatograms as yellow fluorescing with maxima in the range of 250-380 indicating that they are flavonoids. The commonly occurring phenolic acids are vanillic, syringic, gentisic and p-OH benzoic acids.

Evolution of flavonoids has followed a pattern of progress from the primitive leucoanthocyanins to flavonols and flavones and their total absence (Harborne *et al*, 1975; Harborne, 1977). Following this line of contention, *Acacia auriculiformis* and *Acacia arabica* are advanced over other genera studied here due to a high occurrence of flavonoids. However, presence of leucoanthocyanins makes this genus primitive. *Prosopis* falls in line next with maximum number of flavonoids but leucoanthocyanins are a primitive trait here. *Xylia* is less advanced with 5 flavonoids and also leucoanthocyanins. *Calliandra* has even lesser number of flavonoids as well as leucoanthocyanins and is tagged here along with *Acacia*, *Prosopis*, and *Xylia* as primitive. Though *Pithecolobium* has fewer flavonoids, it is advanced over the other genera here in the total absence of leucoanthocyanins. A phylogram of these species based on flavonoid distribution would be as follows in Fig 9.

The chemical markers and their distribution and phylogeny (LA- flavonols-flavones-total absence of flavonoids) show that *Pithecolobium* with flavones is advanced over the other genera which contain leucoanthocyanins. The tribal limits of Acaciaeae, Adenathereae and Ingeae are justified because of their unique marker compositions.

### Genera of Mimosoideae



**Figure 9:** Evolutionary positions of the 5 genera based on flavonoids and other chemical markers.

### Acknowledgements

The above work was carried out as a part of Post Doctoral Work at Phytochemistry Lab, Dept. of Botany, M.S. University of Baroda. I acknowledge with thanks all the facilities and assistance provided by the department and the faculty.

### References

- "Mimosoideae". Taxonomy. UniProt. Retrieved 2009-07-13.
- GRIN species records of Calliandra. Germplasm Resources Information Network. United States Department of Agriculture. Retrieved 2013-07-24.7-22.
- Bentham, G and Hooker, J. D. Genera Plantarum. A. Black, London, 1867.
- Bentham, G. and J. D. Hooker. Genera Plantarum 2. London, 1865.
- Bentham, G. Revision of the sub-order Mimosaeae. *Trans. Linn. Soc. London*, 1875, 30:335-650.
- Bouček-Kelladi Y, Maurin O, Hurte, J and Van der Bank M. The evolutionary history and biogeography of Mimosoideae (Leguminosae): an emphasis on African acacias. *Mol. Phylo-genet. and Evol.*, 2010, 57(23): 495-508.
- Britton, N. L. and Rose, J. N. Mimosaceae. North Amer. Flora, 1928, 23:1-94.
- Corner, E. J. H. The Leguminous seed. *Phytomorphology*, 1951, 1: 117-150.
- Corner, E. J. H. The seeds of Dicotyledons, Vol. I. Cambridge University Press, UK, 1953.
- Cronquist, A. An integrated system of classification of flowering plants. Columbia University Press, New York, 1981.
- Dnyansagar, V. R. Embryological studies in the Leguminosae. ii: embryological features and formula and taxonomy of the Mimosaceae. *J. Indian Bot. Soc.*, 1955, 34: 362-374.
- Doyle, J. J., J. A. Chappill, C.D. Bailey, & T. Kajita. Towards a comprehensive phylogeny of legumes: evidence from rbcL sequences and non-molecular data. Advances in legume systematics (P. S. Herendeen and A. Bruneau, eds.). Royal Botanic Gardens, Kew, UK, 2000, part 9, pp.1-20.
- en.wikipedia.org.
- Gamble, J. S. Flora of the Presidency of Madras. Ranunculaceae to Caprifoliaceae. Botanical Survey of India, Calcutta, 1967, V.1.
- Harborne, J. B. Flavonoids and the evolution of the Angiosperms. *Biochem. Syst. Ecol.*, 1977, 2:7-22.
- Harborne, J. B. Phytochemical methods (2nd ed.). Chapman & Hall, London, 1984.
- Harborne, J. B., Mabry, T. J. and H. Mabry. The flavonoids. Chapman and Hall, London, 1975.
- Hutchinson, J. The genera of Flowering Plants. Oxford Univ. Press, Oxford, England, 1964, V.1., 516pp.
- Ibrahim, R.K. and G.H.N. Towers. The identification by paper chromatography of plant phenolic acids. *Biochem. Biophys.*, 1960, 87: 125-128.
- Kajita, T., H. Ohashi, Y. Tateishi, C. D. Bailey, and J. J. Doyle. rbcL and legume phylogeny, with particular reference to Phaseoleae, Millettieae, and allies. *Systematic Botany*, 2001, 26: 515-536.
- Klitgård, B. B. & Lewis, G. P. Neotropical Leguminosae (Papilionoideae). In: Milliken, W., Klitgård, B. & Baracat, A. Neotropikey - Interactive key and information resources for flowering plants of the Neotropics, 2010.

22. [www.kew.org/science/tropamerica/neotropikey/families/Leguminosae\\_\(Papilionoideae\).htm](http://www.kew.org/science/tropamerica/neotropikey/families/Leguminosae_(Papilionoideae).htm)
23. Lawrence, G.H.M. Taxonomy of Vascular Plants. Oxford and IBH Publishing Co., New Delhi,1951.
24. Lewis G., Schrire B., Mackinder B. and Lock M. (eds.) Legumes of the world. The Royal Botanic Gardens, Kew, Reino Unido, 577 pages, 2005.
25. Mabry, T. J., Markham, K. R. and M. B. Thomas. The systematic identification of flavonoids Springer-Verlag, Berlin,1970.
26. Martin F. Wojciechowski, MJohanna Mahnm, and Bruce Jones. "Fabaceae". The Tree of Life Web Project,2006.
27. Melchior, H. Syllabus der Pflanzenfamilien (12th ed.). II Band. Angiospermen,1964.
28. Paech, K. and M. V. Tracey. Modern methods of plant analysis. IV, pp. 373-374 and 409-416. Springer-Verlag, Berlin,1955.
29. Pandey, B. P. Taxonomy of Angiosperms. S. Chand &Co. Ltd., New Delhi,1969.
30. Senn, H. A. The relation of anatomy and cytology to the classification of the Leguminosae. *Chron. Bot.*, 1943,7: 306-308.
31. Singh, G. Plant Systematics. Theory and Practice. (2nd edition). Oxford and IBH Publishing Co. Pvt. Ltd.,2004.
32. Sorsa, P. Pollen morphological studies on the Mimosaceae. *Annales Botanici Fennici*, 1969, Vol. 6. No.1, pp.1-34.
33. Taubert, P. Leguminosae. In Engler, A., and Prantl, K., Die Naturlichen Pflanzenfamilien, V.3, pt.3, pp.70-308. W. Engelmann, Leipzig, 1894.

**Cite this article as:**

Geetha G. Nair. Phytochemistry and taxonomy of a few species of Mimosoideae. *Annals of Plant Sciences* 4.12 (2015): 1223-1228.

**Source of support:** Dept. of Botany, M.S. University of Baroda, India

**Conflict of interest:** None Declared