

# THE LEGUMINOSAE OF DELHI—SOME STUDIES ON THEIR MORPHOLOGY AND TAXONOMY

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## ABSTRACT

The status of the taxon Leguminosae is not univocally decided. Towards a critical evaluation of the existing views, a survey of the leguminous plants of Delhi was undertaken and studies on their comparative morphology made. An interesting result of this work is the new record of four taxa for Delhi.

## INTRODUCTION

Most works on taxonomy describe the Leguminosae as a family comprising the three subfamilies: Mimosoideae, Caesalpinioideae and Papilionoideae. Often, however, the taxon Leguminosae is treated as an order including the families Mimosaceae, Caesalpinaceae and Papilionaceae and sometimes also a fourth family, viz. the Krameriaceae. Opinion is still divided and both systems continue to be in vogue. With a view to assessing their relative merits, the leguminous plants of Delhi were surveyed and observations made on their comparative morphology. For a critical reappraisal, information from as many fields of botany of the Leguminosae as possible has also been collected.

## MATERIALS AND METHODS

Field trips were made during July 1963 to June 1964. During the collections observations were made of the following:

(a) the presence or absence of bacterial nodules on the root system, and (b) the retention or shedding of fruits of the previous bearing.

Carefully uprooted specimens of herbaceous and shrubby forms served as the material for examination of bacterial root nodules. In some tree forms and in annuals which had already completed their life cycle at the time of collection, seedlings were raised in the Botanical Garden of the Department and examined when the first pair of leaves unfolded. For an effective comparison a 'nodule index' (NI for short) was calculated after the formula:  $NI = B/R$ , where  $R$  represents the average length of root system of 10 individuals and  $B$  the average number of nodules borne on them. For *Alysicarpus longifolius* Wt. & Arn., *Arachis hypogaea* L. and *Clitoria ternatea* L. only one specimen each was examined and, therefore, the 'nodule quotient', that is number of root nodules/length of root system, was calculated. Some observations were also made on the morphology of root nodules.

Towards a consideration of the systematics of

the group comparative studies were also made of the morphology of seeds, embryos and seedlings. Both fresh and dry seeds were examined. Embryos were chiefly studied from dissected whole mounts. Some preparations of radicle-plumular axes were cleared following the technique of Foster (1950) and stained in a 1% solution of safranin, prepared in a mixture of absolute alcohol and xylol (1:1) and mounted in Canada balsam.

All the specimens enumerated were collected by Bharati Chakrabarty; they are deposited in the Herbarium, Department of Botany, University of Delhi, Delhi-7.

## OBSERVATIONS

**Bacterial Root Nodules:** Out of 78 species examined, 24 turned out to be nodule-bearing. With the solitary exception of *Mimosa pudica* the other 23 belong to the Papilionaceae. None of the Caesalpinaceae examined by us revealed any root nodules.

The nodules showed variations in size, shape and number. In the majority of instances they are spherical, in others such as *Melilotus indica* All. and *Mimosa pudica* L. they are elongated and in still others like *Cicer arietinum* L., *Lathyrus sativus* L., *Pisum sativum* L. and *Trigonella foenum-graecum* L. they are palmately lobed (Fig. 1). No



Fig. 1. Semi-diagrammatic representation of root systems of bacterial nodule-bearing legumes. A. Spherical nodules of *Arachis hypogaea*. B. Elongated nodules of *Melilotus alba*. C. Palmately lobed nodules of *Trigonella foenum-graecum*.

specificity could be observed in their distribution on the root system. They were borne equally well on the primary root and on the secondary and tertiary roots. Young nodules as well as those which suggested normal activity looked vigorous and rather pink. 'Old' nodules appeared yellowish brown.

Nodule indices (NI) were calculated for all the noduliferous species (Table I). The highest NI (0.92) was obtained for *Trigonella polycerata* L. in

which the length of the root system was only 8.45 cm. Similarly *Pisum sativum* which showed the highest average length of roots (177.03 cm) gave an average nodule number of 7.60 and the lowest NI, 0.042. In some instances the total volume of nodules (NV) borne on a known length of root as well as its volume (NR) was determined by water displacement method and the ratio of the two values (NV/NR) was represented as NQ.

TABLE I  
BACTERIAL ROOT NODULES IN THE LEGUMINOSAE

| Family        | Species                          | Average length (cm)<br>of root system<br>(R) | Average number<br>of root nodules<br>(B) | Nodule index<br>(NI=B/R) |
|---------------|----------------------------------|----------------------------------------------|------------------------------------------|--------------------------|
| PAPILIONACEAE |                                  |                                              |                                          |                          |
| Tribe         |                                  |                                              |                                          |                          |
| Trifoliceae   | <i>Medicago denticulata</i>      | 37.59                                        | 12.20                                    | 0.32                     |
|               | <i>M. lupulina</i>               | 19.71                                        | 8.40                                     | 0.42                     |
|               | <i>Melilotus alba</i>            | 31.75                                        | 13.00                                    | 0.41                     |
|               | <i>M. indica</i>                 | 46.22                                        | 30.70                                    | 0.66                     |
|               | <i>Trigonella foenum-graecum</i> | 40.90                                        | 9.00                                     | 0.22                     |
|               | <i>T. polycerata</i>             | 8.45                                         | 7.80                                     | 0.92                     |
| Galegeae      | <i>Sesbania bispinosa</i>        | 30.98                                        | 14.00                                    | 0.45                     |
|               | <i>S. sesban</i>                 | 24.20                                        | 7.00                                     | 0.29                     |
| Hedysareae    | <i>Aeschynomene indica</i>       | 44.19                                        | 23.20                                    | 0.52                     |
|               | <i>Alysicarpus vaginalis</i>     | 37.59                                        | 6.00                                     | 0.16                     |
|               | <i>A. monilifer</i>              | 17.39                                        | 5.00                                     | 0.28                     |
|               | <i>Desmodium triflorum</i>       | 21.84                                        | 8.80                                     | 0.40                     |
|               | <i>Zornia gibbosa</i>            | 7.26                                         | 3.10                                     | 0.42                     |
| Vicieae       | <i>Cicer arietinum</i>           | 28.67                                        | 3.40                                     | 0.12                     |
|               | <i>Lens culinaris</i>            | 73.15                                        | 22.90                                    | 0.31                     |
|               | <i>Pisum sativum</i>             | 177.03                                       | 7.60                                     | 0.042                    |
|               | <i>Lathyrus odoratus</i>         | 51.56                                        | 3.40                                     | 0.068                    |
|               | <i>L. sativus</i>                | 38.86                                        | 7.00                                     | 0.18                     |
|               | <i>Vicia hirsuta</i>             | 35.71                                        | 21.30                                    | 0.60                     |
|               | <i>V. sativa</i>                 | 46.22                                        | 30.70                                    | 0.66                     |
| MIMOSACEAE    | <i>Mimosa pudica</i>             | 24.81                                        | 1.50                                     | 0.06                     |

Only one specimen each of *Alysicarpus longifolius* Wt. & Arn., *Arachis hypogaea* L. and *Clitoria ternatea* L. (Fig. 2) were observed. All of them were more richly nodulated than the individuals of any other species studied.

**Fruit and Seed:** In the tree members such as *Delonix regia* (Boj.) Raf., *Dalbergia sissoo* Roxb. and *Cassia fistula* L. the fruits formed during one flowering season are retained on the parent plant through the next bearing also. Thus, the perennial parent simultaneously supports embryo-sporophytes of two successive generations. Generally, however, the fruits are shed or dehiscent soon after they reach maturity.

The seeds show remarkable variations in shape. In the Mimosaceae they are dorsiventrally flat and show a V-shaped marking on both surfaces. The two arms of the letter V converge at the chalazal

end. Such a marking has been termed a pleurogram (Corner, 1951). In *Pithecellobium dulce* (Roxb.) Benth., however, a pleurogram is wanting. All the species of *Acacia* examined by us showed a very well-developed, coiled funicle. In *A. auriculiformis* A. Cunn., for example, the seeds dangle down through funicles which are 2 cm in length (Fig. 3).

In the Caesalpiniaceae also the seeds are dorsiventrally flat except in *Parkinsonia* and *Delonix* in which they are cylindrical. Seeds of *Bauhinia* show a U-shaped mark on the side of the raphe.

In the majority of the Papilionaceae the seeds are kidney-shaped. However, in species of *Lathyrus*, *Pisum* and *Vicia* they are spherical, and in species of *Cajanus* and *Abrus* they are oval. Those of *Cicer arietinum* L. and *Trigonella foenum-graecum* L. are unlike the seeds of all other members of the Papilionaceae.

Additional structures such as aril and strophiole were encountered only in two species. *Pithecellobium dulce* (Mimosaceae) show arillate seeds and

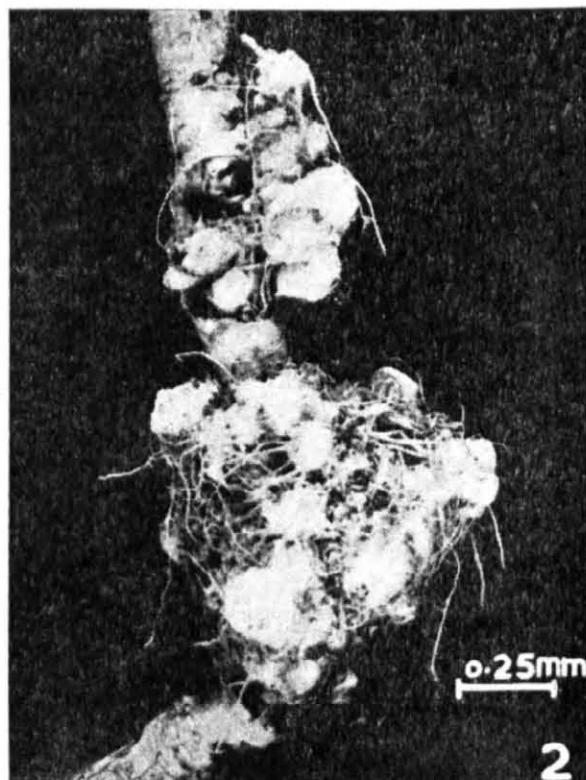


Fig. 2. Portion of root of *Clitoria ternatea* showing several bacterial nodules.

*Rhynchosia capitata* DC. (Papilionaceae) strophiole seeds.

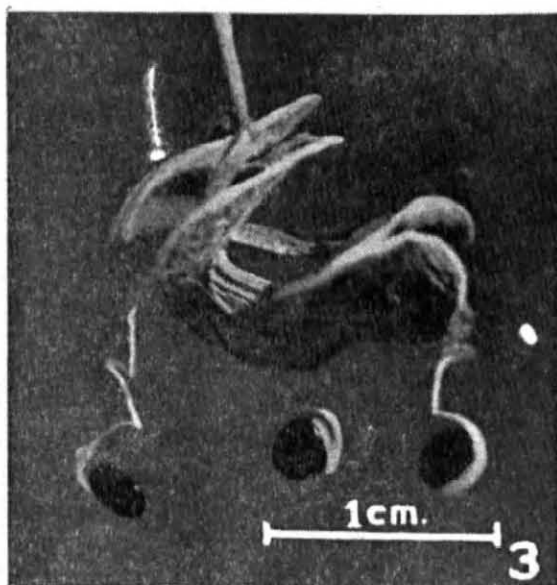


Fig. 3. Dehiscent fruit of *Acacia auriculiformis* showing the long funiculi which suspend the seeds.

**Embryo:** A general study revealed two basic patterns in the structure of embryos (Fig. 4). In the Papilionaceae the cotyledons are accumbent, i.e. the radicle lies against the margins of the cotyledons. Such embryos are described as pleurorhizal. Newman (1933) considered the members of the Leguminosae which possess pleurorhizal embryos as forming a group called the Curvembrice.

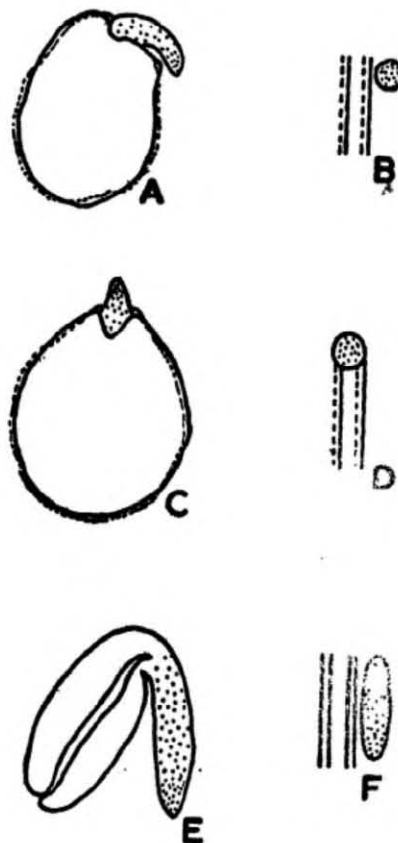


Fig. 4. Diagrammatic representation of patterns of embryos. A. Pleurorhizal embryo characteristic of the Papilionaceae; the radicle rests along the margins of the cotyledons. B. Index for A; stippled circle is radicle and the bars indicate cotyledons. C. 'Orthorhizal' embryo with its radicle lying straight along the longitudinal axis of the cotyledons. The Mimosaceae and the Caesalpiniaceae exhibit this pattern. D. Index for C; compare with B. E. Notorhizal embryo with its radicle bent over one of the cotyledons. This type is not found in the Leguminosae but is observed in some of the Cruciferae like *Capsella*. F. Index for E; compare with B and D.

In the Mimosaceae and Caesalpiniaceae the radicle is straight and lies in the plane of the longitudinal axis of the cotyledons. Newman (1933) has designated those taxa of the Leguminosae which are characterized by a straight radicle as Rectembrice. However, a contrasting term to distinguish this type from the pleurorhizal condition could not be found in the literature (see Jackson, 1960; Tweney & Hughes, 1961). The term 'orthorhizal' embryo has, therefore, been used to describe the

embryos of the Mimosaceae and Caesalpiniaceae in which the radicle is straight.<sup>1</sup>

**Seedling:** With a view to obtaining a comparative account for taxonomic considerations, seedlings were raised of representative members of the Mimosaceae, Caesalpiniaceae and Papilionaceae. With the exception of *Pithecellobium dulce* all the other subjects conformed to the epigeal mode of germination.

The first plumular leaf in the Caesalpiniaceae as well as in the Papilionaceae is usually simple unlike the foliage leaves which are compound. In the Mimosaceae, on the contrary, the first two plumular leaves resemble the adult leaves in being compound.

[ The star-mark before the genus indicates not collected during the present survey. ]

#### MIMOSACEAE

The Mimosaceae are represented by nine genera. They are predominantly trees and six of them are shrubs and none could be considered a herb.

***Acacia auriculiformis* A. Cunn.**

Cultivated in Lodi Gardens and Indian Agricultural Research Institute (IARI). Tree with glossy phyllodia. Flowers yellow in axillary, spicate racemes. Pods moniliform, coiled. Seeds black with long, coiled, orange-yellow funicle. Fl. October; Fr. November-December. 497.

***A. calamifolia* Sweet**

Native of Australia; cultivated in Indian Agricultural Research Institute (IARI). Phyllodia acicular with pointed tip. Flowers yellow in axillary spikes. Fruits flattened. Fl. November; Fr. December-March. 534.

***A. catechu* Willd.**

Common on New Delhi Ridge. Flowers white in axillary compact spikes. Fl. and Fr. July-September. 459.

***A. farnesiana* Willd.**

Cultivated in Indian Agricultural Research Institute (IARI). Flowers yellow in heads. Pods slightly recurved. Fl. April-November; Fr. May-December. 533.

***A. glaucescens* Willd.**

Planted in St. Stephen's College compound. Resembles *A. auriculiformis* from which it is distinguished by the presence of glabrous phyllodia and densely pubescent calyx and corolla. Fl. December; Fr. January-May. 506.

**\**A. jacquemontii* Benth.**

Cultivated in Azadpur. Small spiny tree. Flowers pale yellow, in axillary fascicled heads. Pods thin, flat and straight. Fl. December-February.

***A. leucophloea* (Roxb.) Willd.**

A common tree on Delhi Ridge. Flowers creamish in terminal panicles of heads. Fl. September-October; Fr. October-December. 449.

***A. modesta* Wall.**

Delhi Ridge. Small tree. Axillary spines 2. Flowers white, in lax axillary spikes. Seeds with a massive coiled funicle and a prominent pleurogram. Fl. April-September; Fr. May-October. 448.

***A. nilotica* (L.) Del.**

Found in Okhla and Najafgarh. Rare. Large tree. Flowers yellow in axillary fascicles. Pods moniliform. Fl. July-September; Fr. August-April. 463.

***A. senegal* Willd.**

Delhi Ridge. Axillary spines 3. Flowers white in lax axillary spikes. Pods reddish-brown. Fl. July-September; Fr. October-February. 500.

***Albizia amara* Boivin**

Cultivated on Delhi and New Delhi Ridge. Leaves and stems densely pubescent. Flowers sessile, yellow. Pods reddish-brown, tomentose. Fl. July-September; Fr. August-December. 535.

***A. lebbek* (L.) Benth.**

Tree; planted as avenue on Man Singh Road and Delhi Ridge. Flowers stalked, greenish yellow. Pods straw-coloured, glaucous. Fl. April-May & August-September; Fr. September-January. 431.

**\**A. odoratissima* (L. f.) Benth.**

Cultivated along roadsides. Tall, erect tree. Leaves bipinnate; midrib of leaflets nearer the upper edge. Flowers sessile, yellowish-white. Pods reddish-brown, thin, flexible, glaucous. Fr. November.

***A. procera* (Roxb.) Benth.**

Tree; planted as avenue in the University Campus. Leaves bipinnate; midrib of leaflets nearer the lower edge. Flowers sessile, yellowish white. Pods reddish-brown, shining. Fl. July-August; Fr. August-December. 478.

***Calliandra tweedii* Benth.**

Cultivated ornamental in Buddha Jayanti Park. Flowers red with violet filaments. Fl. and Fr. November. 508.

***Calliandra* sp.**

Cultivated ornamental in Buddha Jayanti Park. Flowers violet, filaments purple. Fl. November. 510.

<sup>1</sup> In addition to pleurorhizal and orthorhizal conditions, a third pattern called notorrhizal embryo occurs elsewhere in angiosperms. In such embryos the cotyledons are incumbent and the radicle is bent over and lies on the back of one of the cotyledons. Some members of the Cruciferae are good examples of this kind.

**Desmanthus virgatus** Willd.

Fields of Indian Agricultural Research Institute (IARI). Perennial shrub with angular stems. Flowers in solitary, axillary, globose, polygamous heads. Seeds nearly orbicular; pleurogram prominent. Fl. and Fr. October. 509.

**Dichrostachys cinerea** (L.) Wt. & Arn.

Common on New Delhi Ridge. Pendant spikes with neuter flowers below and perfect flowers above. Pods coiled. Seeds with pleurogram. Fl. July-September; Fr. August-February. 458.

**Leucaena leucocephala** (Lamk.) de Wit

Planted in Qudsia Gardens. Large shrub. Flowers white, in axillary heads. Seeds dark brown with prominent pleurogram. Fl. and Fr. July-December. 482.

**Mimosa hamata** Willd.

New Delhi Ridge. Spiny shrubs. Flowers purple. Pods bear large hooks on sutures. Fl. and Fr. September-October. 465.

**M. pudica** L.

Spreading undershrubs. Pinnae 4. Pods bristly on sutures. Fl. and Fr. August-November. 436.

**M. rubicaulis** Lamk.

New Delhi Ridge. Spiny shrubs. Pods unarmed. Fl. and Fr. June-September. 473.

**Pithecellobium dulce** (Roxb.) Benth.

Large, spiny tree pruned to form a common hedge plant. Leaves bipinnate, pinnules 4. Flowers white in axillary heads. Pods coiled, moniliform. Seeds with fleshy reddish aril. Fl. March-April; Fr. April-May. 425.

**Prosopis glandulosa** Torr.

New Delhi Ridge. Large tree with drooping branches. Rachis gland-tipped. Flowers creamish in long pendulous racemes. Fl. and Fr. April-June. 460.

**P. juliflora** (Sw.) DC.

The commonest tree of Delhi. Pinnae 4. Pods flat. Fl. April-September; Fr. April-October. 427.

**P. spicigera** L.

Very common on New Delhi Ridge, but less common than *P. juliflora*. Pods cylindrical. Fl. April-May; Fr. May-June. 446.

A general study of the anther and pollen revealed that several members of the Mimosaceae are characterized by the presence of pollinia. Fig. 5 is a diagrammatic representation of the variations encountered in the structure of anther and pollen. Out of nine, only three genera—*Acacia*, *Dichrostachys* and *Prosopis* possess gland-tipped anthers. In the first two, the gland is stalked owing to an extension of the connective; in all the three species of

*Prosopis*—*P. juliflora* (Sw.) DC., *P. glandulosa* Torr. and *P. spicigera* L.—the gland is sessile.

Species belonging to six out of nine genera were found to possess pollinia. In some members the microspores failed to separate after meiosis and this resulted in the formation of pollen tetrads. The tetrads found in the species of *Mimosa* are the smallest for the family. In *M. pudica* L. they are 9-10 $\mu$  in diameter (see Erdtman, 1952). Still others showed octad and polyad conditions of pollen. *M. hamata* Willd. shows octads. In *Acacia auriculiformis*, *A. farnesiana* Willd., *Dichrostachys cinerea* (L.) Wt. & Arn., *Pithecellobium dulce*, *Albizia procera*, *A. lebbek* (L.) Benth. and *Calliandra tweedii* Benth. the pollinium comprises more than eight pollen grains.

*Desmanthus virgatus* Willd., *Prosopis juliflora*, *P. glandulosa* and *P. spicigera* and *Leucaena leucocephala* (Lamk.) de Wit are characterized by the presence of free pollen grains (Fig. 5).

## CAESALPINIACEAE

During the survey 18 species belonging to eight genera of the Caesalpiniaceae were collected. Most of these are dendroid in habit. A few of them are shrubs and fewer are herbs.

**Bauhinia purpurea** L.

Planted in Indian Agricultural Research Institute. Large, unarmed tree. Leaves simple. Flowers purplish or violet. Pods indehiscent. Fl. September-November; Fr. December-July. 453.

**B. racemosa** Lamk.

Delhi Ridge. Small tree with a crooked trunk. Flowers small, white. Pods indehiscent. Fl. and Fr. October-November. 464.

**B. tomentosa** L.

Grown in gardens as an ornamental shrub. Stem and leaves velvety pubescent. Flowers sulphur-yellow. Fl. August-October. 455.

**B. variegata** L.

Small tree. Flowers pinkish or white. Pods dehiscent. Fl. February-April; Fr. July-October. 454.

**\*Caesalpinia crista** L.

Talkatora Gardens. Straggling, prickly shrub, prickles hook-like. Flowers yellow. Pods thickly armed with sharp prickles. Fl. and Fr. September-October.

**Cassia artemisioides** Gaud.

Cultivated, University Botanical Garden. Small shrub with finely divided leaves. Flowers yellow. Fl. January-March; Fr. March-May. 512.

**C. fistula** L.

Common avenue tree with attractive yellow blossoms in pendant racemes. Pods cylindrical, 30-45 cm long. Fl. and Fr. April-January. 430.

**Cassia javanica** L.

Lodi Gardens. Large tree with velvety pubescent stems and leaves and pink flowers. Fl. May-June. 456.

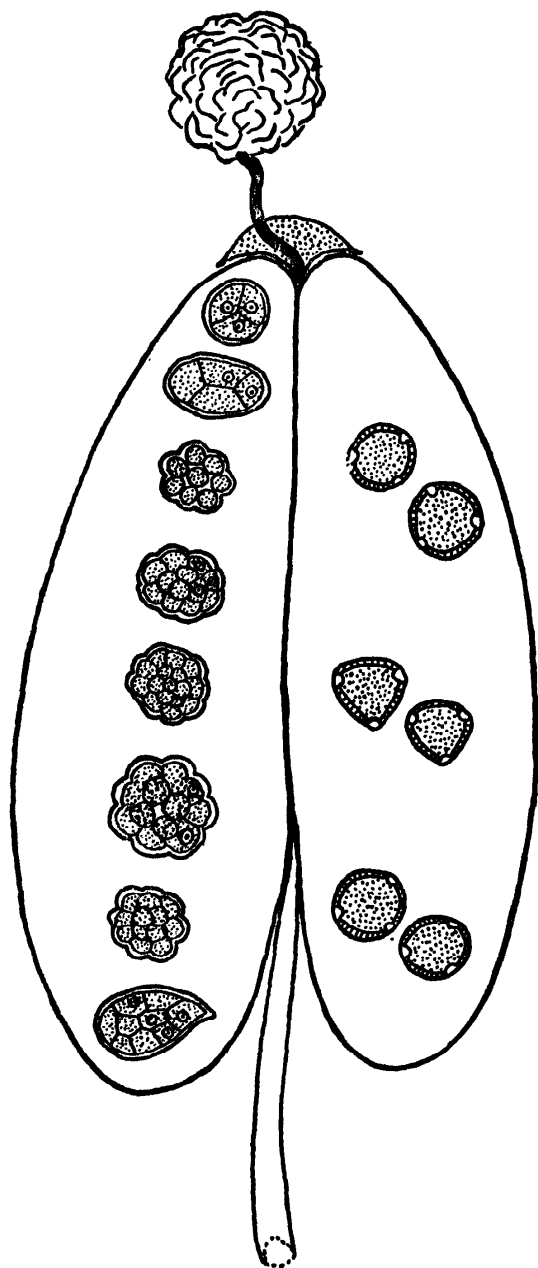


Fig. 5. Diagrammatic representation of structure of stamen and pollen in the Mimosaceae. *Prosopis* (3 species), *Dichrostachys cinerea* and *Acacia* (9 species) have gland-tipped anthers. Gland is sessile only in *Prosopis*. Right lobe of anther shows pollen grains of 3 genera and left lobe pollinia of 6 genera. The series from bottom to top indicate the decrease in number of pollen grains constituting the pollinia.

**\*C. nodosa** Buch.-Ham. ex Roxb.

Planted in lawns and gardens. Tree. Bark reddish brown. Flowers pink, fading to white. Pods cylindrical, 30-40 cm long. Fl. May-August.

**\*C. obtusa** Roxb.

Diffuse herb. Flowers pale yellow. Pods much curved, flexible, glabrous.

**C. occidentalis** L.

Common weed of the rainy season. Rachis with a red, sessile gland at the base and also ending in a gland. Leaves foetid-smelling. Flowers yellow. Fl. and Fr. July-September. 434.

**C. pumila** Lamk.

Common on New Delhi Ridge. Small, prostrate herb. Leaves with a stipitate gland at the base of petiole. Flowers small, yellow. Fl. and Fr. September-October. 487.

**\*C. renigera** Wall. ex Benth.

Planted in gardens. Tree. Branches leafless at the time of flowering. Sepals red. Pods smooth. Fl. May-June.

**\*C. siamea** Lamk.

Planted as avenue tree. Bark grey. Flowers yellow in corymbose racemes. Pods nearly straight, flat with thickened sutures. Fl. April-June.

**C. sophora** L.

Qudsia Gardens. Large shrub. Leaflets 8-12 pairs. Flowers dark to pale-yellow. Fl. and Fr. July-February. 481, 495.

**C. surattensis** Burm. f.

Grown in University Campus. Small tree. Leaflets pale green. Flowers in axillary corymbs. Pods straight, flat and thin. Fl. September-October. 492.

**C. tora** L.

University Campus. Herb. Flowers yellow. Stamens 10, posterior 3 reduced to staminodia. Pods obliquely septate. Fl. and Fr. August-November. 471.

**Delonix regia** (Boj.) Raf.

Common avenue tree. Flowers large and showy; one of the petals spotted red and yellow. Fl April-September; Fr. May-April. 424.

**Haematoxylon campechianum** L.

Lodi Gardens. Thorny shrub. Flowers yellow. Pods straw-yellow, flat, tapering at ends. Fl. March; Fr. April. 513.

**\*Hardwickia binata** Roxb.

Planted near Udyog Bhavan, New Delhi. Large tree. Branches drooping. Leaflets 2. Flowers greenish yellow in panicles. Pods flat, oblong, parallel-veined. Fr. July.

**Parkinsonia aculeata** L.

Grown in gardens. Spiny tree. Rachis reduced to a stout spine; pinnae 2 pairs. Flowers yellow. Pods moniliform. Fl. November-June; Fr. December-August. 433.

**\*Peltophorum** sp.

Cultivated tree in Rajghat. Flowers yellow, petals rusty tomentose on midrib. Fl. July.

**Phanera vahlii** (Wt. & Arn.) Benth.

Grown in Sunder Nursery, Nizamuddin, Liana. Leaves 15-20 cm broad. Stipules tendrillar. Flowers yellow, small. Fl. May. 511.

**Poinciana pulcherrima** L.

Safdarjung's Tomb, New Delhi. Glabrous shrub with sparsely prickly branches. Flowers in erect lax racemes. Filaments red, hairy at base. Fl. and Fr. April-December. 451.

**\*Saraca indica** L.

Grown in Gulab-Bagh near Sabzi Mandi, Delhi. Small tree bearing a dense crown. Flowers in dense corymbs, orange to orange-yellow, changing to vermilion. Calyx petaloid. Fl. April.

**Tamarindus indica** L.

Grown as avenue tree in New Delhi. Large tree with drooping leaves. Young twigs tomentose. Fl. May-August; Fr. June-December. 450.

## PAPILIONACEAE

As many as 38 genera comprising 68 species of the Papilionaceae were gathered during the survey. They included a large number of herbs, a few trees and two twining shrubs, one xerophytic species and one hydrophyte. Of special interest are the four new findings.

The embryo is pleurorhizal and is unlike that of the Caesalpiniaceae and the Mimosaceae.

**Abrus precatorius** L.

Delhi Ridge. Large twining shrub. Nodes swollen. Flowers light pink in dense fascicled racemes. Seeds scarlet with a black hilum. Fl. August; Fr. September-January. 432.

**Aeschynomene indica** L.

Najafgarh pools; partly submerged in water. Stem nodulated like root. Pods 6 to 10-jointed, joints readily separable. Fl. and Fr. July-November. 476.

**Alhagi pseudalhagi** (Bieb.) Desv.

Forms gregarious populations in Model Town and in Okhla. Spiny xerophytic herb. Axillary branches end in a subulate spine. Flowers pinkish. Pods moniliform, beaked, brown, and ridged along sutures. Fl. May; Fr. June-July. 461.

**\*Alysicarpus bupleurifolius** DC.

Najafgarh. A diffuse or ascending herb. Leaves shortly petiolate. Pods moniliform, stalked. Fl. and Fr. August-October.

**\*A. glumaceus** (Vahl) DC.

Grown in Indian Agricultural Research Institute (IARI). Ascending herb. Leaves oblong or lanceo-

late. Pods nearly concealed by calyx, apiculate, 2 to 5-jointed, transversely ribbed. Fl. and Fr. September.

**A. longifolius** Wt. & Arn.

St. Stephen's College compound. Rare, about 1 meter tall, shrubby annual. Flowers in terminal spikes. Calyx almost ensheathing the pod. Fl. and Fr. September-November. 533.

**A. monilifer** DC.

Delhi Ridge. Prostrate, hairy herb. Pods turgid, moniliform, hairy. Hairs hooked. Calyx as long as the first joint of the pod. Fl. and Fr. September-November. 444.

**A. procumbens** (Roxb.) Schindl.

Delhi Ridge. A new record for Delhi (Fig. 6). Deep-rooted, prostrate, hairy herb. Calyx much shorter than the first joint of pod. Pods 2 to 5-jointed, torulose, hairy and reticulately veined. Fl. and Fr. October. 484.

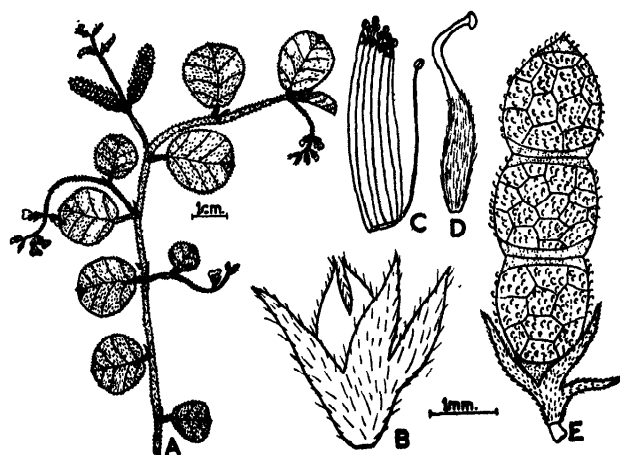


Fig. 6. *Alysicarpus procumbens* (Roxb.) Schindl.

A. Twig showing flowers and fruits. B. Calyx tube enlarged; note the nearly complete fusion of two lobes at the rear. C. Stamens showing 9+1 condition; note staminal tube is complete. D. Pistil showing elongated hairy ovary, bent style and capitate stigma. E. Fruit; note hooked bristles, short beak, distinct seed compartments and surface network.

**A. vaginalis** DC.

New Delhi Ridge. Erect or prostrate herb. Leaflets polymorphic. Pods reticulately veined and clothed with straight hairs. Fl. and Fr. September-November. 479, 486.

**Arachis hypogaea** L.

Cultivated annual. Pods geocarpic. Fl. and Fr. August-November. 437.

**\*Atylosia elongata** Benth.

University Campus, Delhi. Herbaceous twiner clothed with fine spreading hairs. Flowers long-peduncled. Pods oblong. Fl. August-September.

**Butea monosperma** (Lamk.) Taub.

Planted on New Delhi Ridge. Small tree. Leaflets tomentose. Flowers red. Pods 1-seeded. Fl. April-May; Fr. June-July. 457.

**Cajanus cajan** (L.) Druce.

Cultivated. Pods obliquely septate, tomentose. Fl. and Fr. November-July. 514.

**Cicer arietinum** L.

Herb; clothed with gland-tipped hairs. Pods turgid, 1 or 2-seeded. Fl. and Fr. January-March. 515.

**Clitoria ternatea** L.

Twining shrub. Flowers blue or white. Pods beaked, many-seeded. Fl. June-November; Fr. November-February. 439.

**\*Crotalaria burhia** Buch.-Ham. ex Benth.

Najafgarh. Xerophytic undershrub. Leaves simple. Flowers yellow, petals with reddish veins. Pods villous. Fl. May-September.

**C. juncea** L.

Cultivated in Najafgarh. Leaves simple. Flowers yellow. Pods many-seeded. Fl. and Fr. September-October. 506.

**C. medicaginea** Lamk.

A rainy-season herbaceous weed. Leaves trifoliate. Pods 2-seeded. Fl. and Fr. July-November. 491.

**Cyamopsis tetragonoloba** (L.) Taub.

Cultivated for its edible pods. Leaves trifoliate. Flowers purple, in axillary spikes. An adhesive from the seeds is used extensively in Indian Postal Service. Fl. and Fr. July-November. 475.

**Dalbergia sissoo** Roxb.

Large avenue tree. Leaflets alternate. Flowers creamish. Pods thin, flat, 2 or 3-seeded. Fl. May-September; Fr. July-August. 426.

**Derris scandens** (Roxb.) Benth.

Planted in Indian Agricultural Research Institute. Intense climber. Flowers pinkish with a brown calyx. Pods flat, winged unilaterally. Fl. May-September; Fr. October-December. 472.

**Desmodium gangeticum** (L.) DC.

Roshnara Garden. Shrub. Leaves unifoliate, hairy. Flowers purplish or white. Pods 5 to 7-jointed, margin indented on the inner side only. Fl. and Fr. August-November. 505.

**D. triflorum** (L.) DC.

Lodi Gardens. Safdarjung's Tomb. Common weed. Leaves trifoliate. Flowers purplish. Fl. July-October; Fr. August-December. 452.

**\*D. triquetrum** (L.) DC. subsp. **pseudo-triquetrum** Prain

Diffuse undershrub. Leaves unifoliate, petioles

broadly winged. Pods flat with a line of appressed hairs along the sutures. Fl. July-September.

**Dolichos lablab** L.

Cultivated for edible pods. Climber. Leaves trifoliate, leaflets stipulate. Keel not spiral. Fl. and Fr. September-December. 516.

**\*Erythrina blakei** Hort. ex Parker

Cultivated in gardens. Large shrub. Leaflets rhomboid, deltoid, abruptly acuminate. Flowers bright scarlet. Fl. March-May.

**\*E. crista-galli** L.

Planted in Rajghat. Small, bushy shrub. Flowers crimson. Fl. April.

**\*E. saberosa** Roxb.

Cultivated as an ornamental. Large prickly shrub. Flowers appear with leaves. Calyx campanulate. Fl. April-May.

**\*E. variegata** var. **orientalis** (L.) Merr.

Large tree. Flowers appear on leafless branches. Calyx spathaceous. Fl. March-April.

**Heylandia latebrosa** DC.

Collected once from University Lawns. Rare. Diffuse, hairy herb. Flowers solitary, axillary. Pods 2-seeded. Fl. October. 534.

**\*Indigofera astragalina** DC.

Delhi Ridge. Hairy undershrub with grey or brown pubescence. Pods densely hairy and pointing downward. Fl. and Fr. September-November.

**I. cordifolia** Heyne ex Roth.

New Delhi Ridge. Prostrate, hairy herb with cordate opposite leaves. Flowers deep red in axillary sessile racemes. Pods 1-seeded. Fl. and Fr. October-November. 485.

**I. hochstetteri** Baker

Diffuse, prostrate herb clothed with appressed hairs. Flowers pinkish. Pods flat, reflexed, 6 to 8-seeded. Fl. and Fr. July-September. 490.

**I. linifolia** Retz.

Herb. Leaves simple, linear. Flowers reddish. Pods globose, white, velutinous and 1-seeded. Fl. and Fr. May-September. 440.

**I. linnaei** S. I. Ali

Common on Delhi Ridge. Deep-rooted, prostrate herb. Flowers vermilion red. Pods 2-seeded. Fl. and Fr. May-September. 441.

**\*I. oblongifolia** Forsk.

On way to Gurukul Indraprastha. Rare woody undershrub. Leaves unifoliate on lower branches. Flowers vermilion red. Pods purplish, distinctly torulose, pointed, deflexed. Fl. and Fr. September-November.

**I. tinctoria** L.

Sunder Nursery; Mehrauli. Erect herb with a woody base. Flowers dull red in axillary racemes.

Pods curved toward inflorescence axes, tapering at tip, many-seeded. Fl. and Fr. July-September. 470.  
**Indigofera trita** L. f.

Roshanara Garden. Undershrub. Branches 4-angular. Flowers pink. Pods firm, tetragonous ending in a pointed tip. Fl. and Fr. September-November. 504.

**Lathyrus aphaca** L.

Sunder Nursery. Climbing herb. Stipules foliaceous. Leaves tendrillar. Flowers solitary axillary, yellow. Fl. and Fr. January-March. 517.

**L. sativus** L.

Occurs as a winter weed on the banks of Yamuna. Stems winged. Flowers purplish. Pods winged, compressed. Fl. and Fr. January-March. 520.

**Lens culinaris** Medic.

Cultivated. Twining herb. Flowers purplish in axillary, long peduncled racemes. Pods 2-seeded, compressed. Seeds lenticular. Fl. and Fr. January-March. 518.

**Lotus corniculatus** L.

Shalimar Gardens, Model Town. A new record for Delhi (Fig. 7). Small herb. Lowermost pair of leaflets suggests stipules. Flowers yellow, solitary, terminal. Pods dorsiventrally flattened.

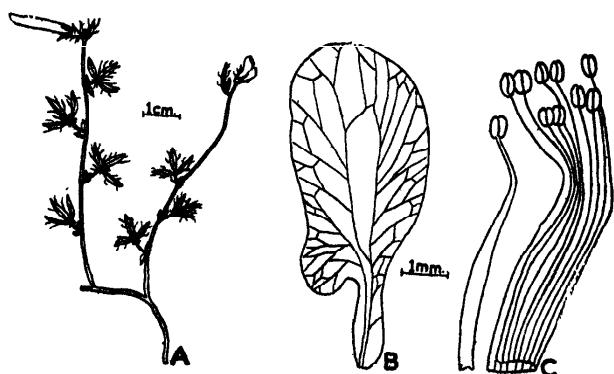


Fig. 7. *Lotus corniculatus* L.

A. Twig showing 5-foliate leaves, flowers and fruits; note lower pair of leaflets stipule-like. B. Wing petal. C. Diadelphous androecium.

The occurrence of *Lotus corniculatus* in Delhi is of interest. It is restricted to high altitudes and has been rarely found in the plains of Sind (Hooker, 1879). It was found growing amongst grasses in association with *Alhagi pseudalhagi* (Papilionaceae) and *Phyla nodiflora* (Verbenaceae). Fl. and Fr. July-August. 462.

**Medicago denticulata** Willd.

Winter weed in fallow and cultivated fields. Flowers yellow. Pods spiny, spirally coiled. Fl. and Fr. December-March. 519.

**M. lupulina** L.

Yamuna River Bank. A newly recorded plant

from Delhi. Diffuse prostrate herb. Racemes compact and resembling heads. Pods 1-seeded. Fl. and Fr. October-March. 507.

**M. sativa** L.

Cultivated herb. Stem fistular. Flowers purplish. Pods 2 or 3-coiled. Fl. and Fr. March-July. 435.

**Melilotus alba** Desr.

Yamuna River Bank. Winter weed. Erect herb. Flowers in axillary racemes. Pods 1-seeded. Fl. and Fr. December-April. 521.

**M. indica** All.

Herbaceous weed. Flowers yellow, smaller than those of *M. alba*. Pods also smaller, 1-seeded. Fl. and Fr. December-May. 522.

**Millettia ovalifolia** Kurz.

Qudisia Garden. Tree. Leaves pale green. Flowers purplish. Pods lanceolate with a recurved pointed tip and a warty surface. Fl. April; Fr. May-August. 483.

**Mucuna prurita** Hook.

University Botanical Garden; Indian Agricultural Research Institute. An extensive twiner. Standard petal shorter than the wing. Pods woolly tomentose. Fl. and Fr. August-February. 488.

**Phaseolus aconitifolius** Jacq.

Safdarjung airport grounds; Mehrauli. Twining, hairy annual. Stipules small, lanceolate; leaflets lobed. Fl. and Fr. July-October. 499.

**P. aureus** Roxb.

Cultivated. Suberect annual. Leaves dark green. Pods clothed with long, silky hairs. Seeds green. Fl. and Fr. September-October, 523.

**P. calcaratus** Roxb.

Cultivated. Twining annual. Stipules lanceolate. Pods glabrous. Fl. and Fr. September-October. 498.

**P. lunatus** L.

Grown in Indian Agricultural Research Institute. Twiner. Flowers greenish yellow. Pods flat, sharply beaked. Seeds thin, white or mottled. Fr. November. 526.

**P. mungo** L.

Cultivated. Twining, hairy annual. Flowers yellow. Pods hairy, terete. Seeds black, oblong. Fl. and Fr. July-September. 493.

**P. radiatus** L.

Safdarjung airport grounds. Twining herb. Stipules large and cover the pulvinus. Pods straight, long, clothed with short, reddish hairs. Fl. and Fr. August-September. 467.

**P. trilobus** Ait.

Mehrauli. Trailing, glabrous herb. Stipules large, oval. Pods glabrous, subcylindrical. Fl. and Fr. September-November. 466.

**\*Phaseolus vulgaris L.**

University Botanical Garden. Twining glabrous annual. Flowers white, red or lilac. Pods linear, straight, glabrous.

**\*Pisum arvense L.**

Yamuna River Bank. Smooth, glaucous annual. Standard petal pinkish, wings deep purple. Pods reticulate. Seeds angled, greenish yellow, mottled with red. Fl. and Fr. January-March.

**P. sativum L.**

Yamuna River Bank. Climber. Stem fistular. Stipules foliaceous. Leaflets tendrillar. Pods glabrous. Fl. and Fr. January-March. 524.

**Pongamia pinnata (L.) Pierre**

Tree. Leaves glabrous, shiny. Flowers purplish. Pods thick, pointed at ends, 2-seeded. Fl. and Fr. March-July. 428.

**Psoralea corylifolia L.**

Indian Agricultural Research Institute (IARI). Erect shrub. Inflorescence compressed and head-like. Pods pitted, 1-seeded. Fl. February-March. 525.

**\*P. plicata Delile.**

Railway Chowki, Karnal Road. A bushy, much branched undershrub with violet flowers. Fl. and Fr. May.

**\*Pueraria thunbergiana Benth.**

Twining hairy perennial shrub with purplish flowers.

**Rhynchosia capitata DC.**

Najafgarh. Large, prostrate herb (Fig. 8). Pods rounded, beaked and 2-seeded. Seeds strophiolate. Fl. and Fr. September-November. 474.

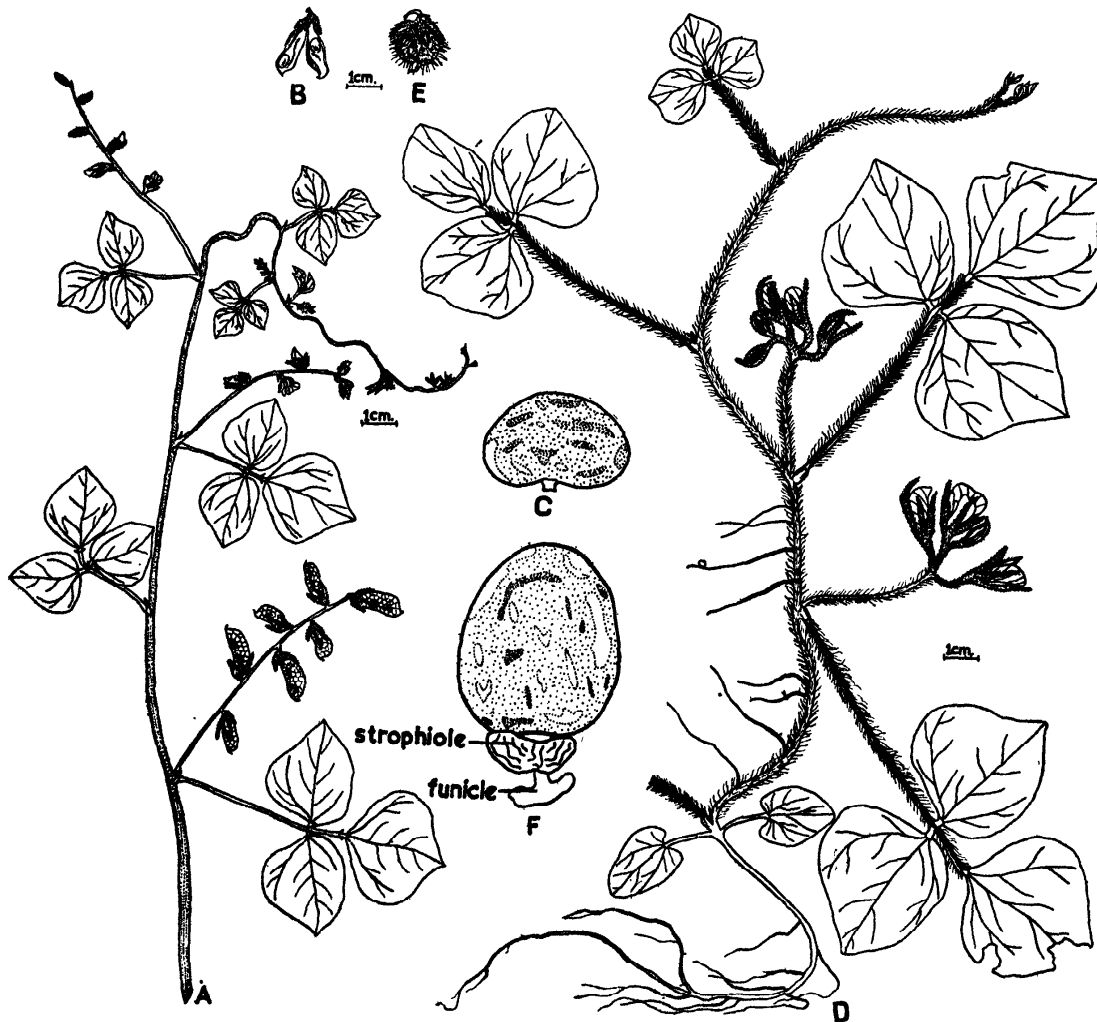


Fig. 8 : A-C. *Rhynchosia minima* DC., D-F. *Rhynchosia capitata* DC.  
A. Twig showing twining habit and reproductive shoot; observe lowermost peduncle bearing fruits and impression of seeds on the pods. B. Dehiscent fruit showing 2 seeds. C. Magnified view of seed; strophiole wanting (semi-diagrammatic). D. Plant; note roots on lower internodes. E. Fruit. F. Enlarged view of seed showing a distinct strophiole; compare with C (semi-diagrammatic).

**Rhynchosia minima** DC.

Common twining, annual herb (Fig. 9). Flowers yellow. Pods 2-seeded. Seeds estrophiolate. Fl. and Fr. May-November. 429.

**Sesbania bispinosa** (Jacq.) Fawcett & Rendle

Safdarjung airport grounds. Shrub with prickly branches and rachis. Racemes 3 to 6-flowered. Pods falcate with a sharp spinous tip. Fl. and Fr. September-October. 496.

**S. sesban** var. **bicolor** (Wt. & Arn.) F. W. Andr.

University Campus. Rare. Erect shrub. Flowers dark yellow; standard petal dark violet or purple on outer surface. Fl. and Fr. October-April. 443a.

**S. sesban** var. **picta** Santapau

University Campus. Flowers pale yellow; standard petal spotted grey on outer surface. Fl. and Fr. October-April. 443b.

**Sophora secundiflora** (Ortega) Lag. ex DC.

Talkatora Gardens. Small tree. Leaflets 7-11, sessile, coriaceous, shiny. Racemes unilateral and terminal. Pods moniliform. Fl. February; Fr. June. 525.

**\*S. tomentosa** L.

Shrub with yellow flowers and hoary pods.

**Tephrosia pumila** Pers.

University compounds. Deep-rooted, suberect herb, growing hidden amongst grasses. Flowers yellowish in axillary racemes. Pods 2.5 cm long, 5 to 7-seeded. Fl. and Fr. August-October. 445.

**T. purpurea** (L.) Pers.

Very common on Delhi Ridge. Erect herb. Flowers purplish in long terminal racemes. Pods glabrous. Seeds variegated. Fl. and Fr. May-October. 442.

**T. pauciflora** Grah. ex Baker

Mehrauli. Newly recorded plant from Delhi (Fig. 9). Prostrate herb. Flowers purplish, usually gemiculate in axillary racemes. Fl. August. 469.

**T. strigosa** (Dalz.) Sant. & Mah.

Sunder Nursery. Annual herb with filiform stem. Leaves simple. Flowers bluish. Pods thin, flattened, many-seeded. Seeds orbicular. Fl. and Fr. August-October. 489.

**T. villosa** Pers.

Delhi Ridge. Woody herb. Stem and leaflets woolly tomentose. Calyx and pods also tomentose. Fl. and Fr. July-September. 447.

**Teramnus labialis** (L. f.) Spreng.

Roshanara Garden. A wide spreading slender climber. Flowers white in axillary, lax racemes. Pods with persistent style. Fl. and Fr. September-November. 503.

**Trifolium alexandrinum** L.

Indian Agricultural Research Institute (IARI).

Annual herb. Flowers greenish-yellow in globular heads with an involucre of bracts. Fl. and Fr. October-February. 527.

**\*Trigonella corniculata** L.

Branched, suberect annual with yellow flowers.

**T. foenum-graecum** L.

Cultivated winter crop. Leaflets toothed. Flowers subsessile, pale yellow. Pods long, flattened, falcate and long beaked. Fl. and Fr. February-March. 530.

**T. polycerata** L.

Prostrate herb. Comes up as winter weed. Flowers dark yellow. Pods falcate, flat, reticulately veined. Fl. and Fr. December-March. 532.

**Vicia faba** L.

Erect herb. Flowers large, white with a dark purplish spot. Pods large and fleshy. Fl. and Fr. January-March. 531.

**V. hirsuta** (L.) S. F. Gray

Yamuna River Bank. Twining herb. Common winter weed. Flowers small, white. Pods 2-seeded. Fl. and Fr. December-March. 528.

**V. sativa** L.

Yamuna River Bank. Twining herb. Flowers purplish, long-peduncled. Pods 8 to 10-seeded. Fl. and Fr. January-March. 529.

**Vigna sinensis** (L.) Savi ex Hassk.

Twining annual with glabrous stem. Racemes with long peduncles. Flowers yellow on the inner surface and purplish on the outer. Pods long terete, many-seeded. Fl. and Fr. June-October. 468.

**Zornia gibbosa** Span.

New Delhi Ridge. A small erect or prostrate herb. Leaflets 2. Bracts geminate. Flowers yellow. Pods moniliform, densely prickly. Fl. and Fr. August-October. 480.

According to Mohlenbrock (1961) the plant commonly known as *Zornia diphylla* in Northern India should be named *Z. gibbosa*. With the discovery of the type material and typification of *Hedysarum diphyllum* by Dandy & Milne-Redhead (1963) on which the binomial *Z. diphylla* (L.) Pers. is based, it has now been found that it represents the species which is erroneously known as *Z. conjugata*. Therefore, the binomial *Z. diphylla* (L.) Pers. should represent only the plants which have so far been known as *Z. conjugata* (Willd.) Smith. The binomial *Z. conjugata* which is now changed to *Z. diphylla* is restricted to plants occurring in Ceylon and South India. *Z. gibbosa* Span. is pantropical in distribution.

*New Records:* Maheshwari (1963) has enumerated 57 genera and 125 species of the Leguminosae.

During the present survey (July 1963-June 1964) 109 species representing 55 genera were collected. Of these, four species: *Lotus corniculatus* L., *Tephrosia pauciflora* Grah. ex Baker, *Alysicarpus procumbens* (Roxb.) Schindl. and *Medicago lupulina* L. are new records. All the new findings are wild species of the Papilionaceae. *Medicago lupulina* was collected from two localities: the Univer-

sity Campus and the banks of the Yamuna. The Shalimar Gardens in Model Town, *Alysicarpus procumbens* from Delhi Ridge and *Tephrosia pauciflora* from Mehrauli.

**Cultivated Plants:** A large number of leguminous plants are under cultivation in Delhi for their food and forage value, or as ornamentals or for other commercial uses. *Cyamopsis tetragonoloba*

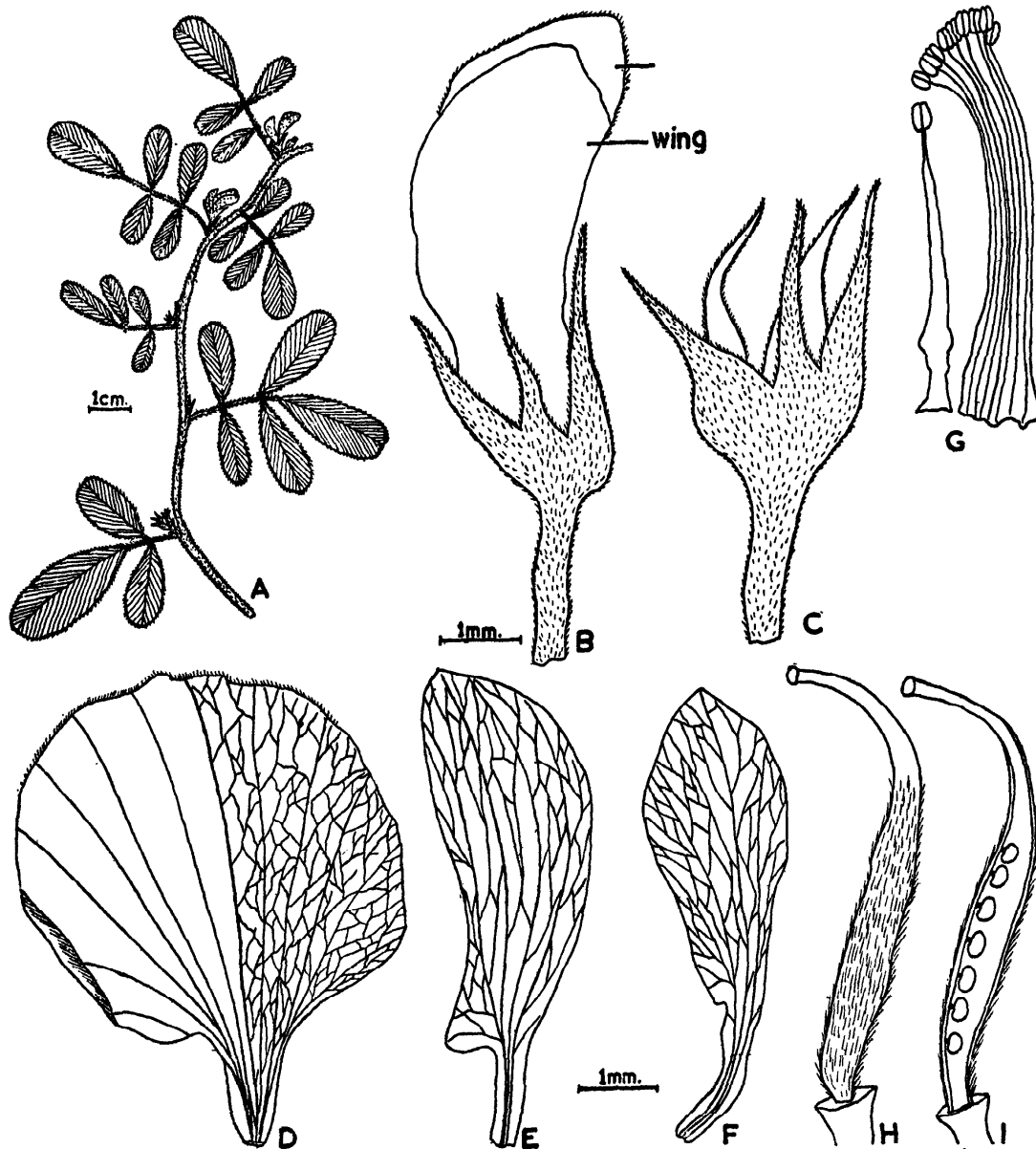


Fig. 9. *Tephrosia pauciflora* Grah. ex Baker

A. Twig showing flowers in upper two axils on left. B. Flower enlarged. C. Magnified view of calyx; note glabrous interior of tube. D. Standard petal; claw is broad and limb is hairy along upper margin. Network of veins is shown in right half only. E, F. Wing and keel; claw is narrow and long. Compare with D. G. Staminal bundles; the tenth free stamen shows dilated base. H, I. Entire pistil and its longitudinal section.

(L.) Taub., *Phaseolus aureus* Roxb., *P. mungo* L., other three representatives were of restricted occur-

rence. *Lotus corniculatus* was collected from *Cajanus cajan* (L.) Druce, *Vigna sinensis* Savi ex

Hassk. are some of the vegetable crops of the rainy season. The seeds of *Cyamopsis tetragonoloba* are rich in an adhesive and, therefore, extensively used in Indian Postal Service.

The winter crop of Delhi also includes a large number of legumes such as *Cicer arietinum*, *Lens culinaris* Medic., *Trigonella foenum-graecum* and *Pisum sativum*. In addition to the cultivars the fields abound in many leguminous weeds which are used as stock feed. *Medicago polymorpha* L., *Melilotus alba* Desr., *M. indica* All., *Lathyrus sativus* L., *Vicia sativa* L., *V. hirsuta* (L.) S. F. Gray are only a few of them.

Valuable timber is obtained from *Dalbergia sissoo* (Papilionaceae) and *Hardwickia binata* Roxb. (Caesalpiniaceae). The latter is the source of the strong, hard and heavy timber of commerce, namely 'anjan'.

The Leguminosae are not less important in aesthetic value. *Bauhinia*, *Cassia* and *Delonix* are some of the elegant ornamentals. During the winter season the gay-coloured sweet pea (*Lathyrus odoratus*) and the attractive lupin (*Lupinus annuus*) add grandeur to the gardens and parks of the city. *Acacia nilotica*, *Albizia lebbek*, *Dalbergia sissoo*, *Tamarindus indica*, *Pithecellobium dulce* are only a few of the more commonly preferred trees for avenues.

## DISCUSSION

*General Considerations:* The Leguminosae constitute one of the largest taxa embracing 600 genera and nearly 13,000 species of cosmopolitan distribution. The members show a great variety in habit and ecological adaptations.

Many are characterized by the presence of bacterial root nodules. According to Wydler (1860, see Arora, 1956) the presence of nodules is a distinguishing character of the entire Leguminosae. However, Allen & Allen (1947) and all the later investigators (cf. Arora, 1956) could not corroborate this view. The data available on 1,200 species reveal that only 887 species (belonging to 167 genera) are nodule-bearing. Of these the majority represents the Papilionaceae.

The fruit is a legume which is formed of a single carpel and dehisces by both the sutures so as to separate into two valves. Hutchinson (1959), however, reports that "the fruit is often anything but a legume". In *Alysicarpus monilifer* DC., *Zornia gibbosa* Span. and some other members, the fruit is constricted into indehiscent, 1-seeded parts and is called a lomentum.

Table II presents a comparative account of the botany of the Leguminosae. In addition to the present work, information has been collected from other available investigations.

TABLE II  
BOTANY OF THE MIMOSACEAE, CAESALPINIACEAE AND PAPILIONACEAE

| CHARACTER                  | MIMOSACEAE                                                                     | CAESALPINIACEAE                                                             | PAPILIONACEAE                                                    |
|----------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------------------------------------------------------------|
| HABIT                      | Predominantly arborescent, xerophytes more common, some hydrophytes also known | Predominantly arborescent, xerophytes less common and hydrophytes not known | Predominantly herbaceous, xerophytes and hydrophytes less common |
| BACTERIAL ROOT NODULES     | Occur very rarely                                                              | Occur only sporadically                                                     | Commonly present                                                 |
| STEM                       | Mostly spiny                                                                   | Mostly glabrous                                                             | Mostly hairy, rarely spiny                                       |
| Periderm                   | Data wanting                                                                   | Sub-epidermal in origin (Rendle, 1952)                                      | Epidermal or subepidermal in origin (Rendle, 1952)               |
| Sieve tube                 | Much longer, shows narrow scalariform plates (Rendle, 1952)                    | Shorter, shows several coarsely fitted plates (Rendle, 1952)                | Short, shows simple transverse plates (Rendle, 1952)             |
| Anomalous secondary growth | Not reported                                                                   | Known only in <i>Bauhinia</i> (Rendle, 1952)                                | Common in lianas (Rendle, 1952)                                  |
| LEAF                       |                                                                                |                                                                             |                                                                  |
| Type                       | Bipinnate, sometimes reduced to phyllodia                                      | Bipinnate, rarely unipinnate                                                | Unipinnate, rarely simple                                        |
| Rachis                     | Pulvinate, generally gland-bearing                                             | Pulvinate, rarely gland-bearing as in <i>Caesia</i>                         | Pulvinate, gland-bearing                                         |
| Stipule                    | Less variable in structure, commonly spiny, foliaceous condition unknown       | Variable, but not spiny                                                     | Variable, spiny in <i>Robinia</i> (hence the name pseudo-acacia) |

| CHARACTER                 | MIMOSACEAE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CAESALPINIACEAE                                                                                                                                                                                                                                                                                                                                                         | PAPILIONACEAE                                                                                                                                                                                                                                                                                                   |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>MOVEMENT OF LEAVES</b> | Show sleeping movement, some sensitive to touch                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Show sleeping movement                                                                                                                                                                                                                                                                                                                                                  | Show sleeping movement, sensitive to temperature                                                                                                                                                                                                                                                                |
| <b>INFLORESCENCE</b>      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                 |
| Type                      | Usually a head, spikes also known                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Generally a corymb                                                                                                                                                                                                                                                                                                                                                      | Generally a raceme                                                                                                                                                                                                                                                                                              |
| Bract                     | Forms an involucre                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Present for individual flowers                                                                                                                                                                                                                                                                                                                                          | Present for individual flowers                                                                                                                                                                                                                                                                                  |
| Sex                       | Polygamous condition occurs in a few                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Polygamous condition unknown                                                                                                                                                                                                                                                                                                                                            | Polygamous condition unknown                                                                                                                                                                                                                                                                                    |
| <b>FLOWER</b>             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                 |
| Calyx                     | Inconspicuous, cup-shaped, valvate, odd sepal anterior                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Conspicuous, distinct, descendingly imbricate, odd sepal anterior, posterior sepal outermost                                                                                                                                                                                                                                                                            | Conspicuous, connate, campanulate, ascendingly imbricate, odd sepal anterior, posterior sepal innermost                                                                                                                                                                                                         |
| Corolla                   | Actinomorphic, sometimes sympetalous, valvate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Zygomorphic, petals dissimilar, often clawed, ascendingly imbricate                                                                                                                                                                                                                                                                                                     | Zygomorphic, papilionaceous, descendingly imbricate                                                                                                                                                                                                                                                             |
| Androecium                | Stamens $\infty$ or = 2C, rarely $< 10$ , free or monadelphous, all fertile<br><br>Anther gland-tipped, in some subterminal pore absent<br><br>Filaments free, not massive gaudily coloured<br><br>Tapetum secretory, cells uninucleate (Dnyansagar, 1952)<br><br>Microspore tetrads tetrahedral when pollen grains are simple (Dnyansagar, 1952)<br><br>Pollen granular, in some agglutinated into tetrads or polyads (see Fig. 5)<br><br>No striking differences are known among the pollens of the three families though some variations occur within the Leguminosae (Erdtman, 1952). | Stamens 10, free, diadelphous in <i>Amherstia</i> , often reduced to staminodia<br><br>Anther not gland-tipped, subterminal pore present<br><br>Filaments free, massive, sometimes dilated at base<br><br>Tapetum secretory, cells bi-, tri- or tetra-nucleate (Nair & Kahate, 1961)<br><br>Microspore tetrads tetrahedral (Nair & Kahate, 1961)<br><br>Pollen granular | Stamens 10 or rarely $< 10$ , mon- or dia-dadelphous, all fertile<br><br>Anther not gland-tipped, subterminal pore absent<br><br>Filaments fused, staminal column free near the top<br><br>Tapetum secretory, cells uninucleate<br><br>Microspore tetrads tetrahedral (Maheshwari, 1950)<br><br>Pollen granular |
| Gynoecium                 | Style long, filiform<br><br>Stigma truncate<br><br>Carpel solitary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Style not filiform, slightly recurved<br><br>Stigma capitate<br><br>Carpel solitary                                                                                                                                                                                                                                                                                     | Style not filiform, reflexed at base<br><br>Stigma brushy, sometimes capitate<br><br>Carpel solitary                                                                                                                                                                                                            |
| Ovule                     | Semicampylotropous or more commonly anatropous                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Campylotropous or anatropous                                                                                                                                                                                                                                                                                                                                            | Mostly campylotropous, variations known                                                                                                                                                                                                                                                                         |
| Micropyle                 | Formed by outer integument only                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Formed by both integuments or less commonly by outer integument only                                                                                                                                                                                                                                                                                                    | Formed by outer integument only                                                                                                                                                                                                                                                                                 |
| Archisporium              | Archisporial cell 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Archisporial cell mostly 1, sometimes more than 1                                                                                                                                                                                                                                                                                                                       | Archisporial cell 1                                                                                                                                                                                                                                                                                             |
| Embryo sac                | Polygonum type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Polygonum type                                                                                                                                                                                                                                                                                                                                                          | Polygonum type                                                                                                                                                                                                                                                                                                  |
| Antipodals                | Persist until fertilization (Martin, 1914)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Persist until fertilization (Martin, 1914)                                                                                                                                                                                                                                                                                                                              | Disintegrate before fertilization (Martin, 1914)                                                                                                                                                                                                                                                                |
| Endosperm                 | Polar nuclei fuse before (Martin, 1914) or at the time of fertilization (Maheshwari, 1931)<br><br>Nuclear, chalazal haustorium present (Johri & Garg, 1959)                                                                                                                                                                                                                                                                                                                                                                                                                               | Polar nuclei fuse before fertilization<br><br>Nuclear, chalazal haustorium present (Johri & Garg, 1959)                                                                                                                                                                                                                                                                 | Polar nuclei fuse before fertilization (Rau, 1951)<br><br>Nuclear, chalazal haustorium present (Johri & Garg, 1959)                                                                                                                                                                                             |

| CHARACTER             | MIMOSACEAE                                                                                     | CAESALPINIACEAE                                                                                                            | PAPILIONACEAE                                                                     |
|-----------------------|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Endosperm             | A few layers persist in seed                                                                   | A few layers may or may not persist in seed                                                                                | Entirely absorbed in seed                                                         |
| Embryo                | Division of zygote transverse                                                                  | Division of zygote transverse                                                                                              | Division of zygote transverse                                                     |
|                       | Proembryo massive without any differentiation into embryo proper and suspensor (Pantulu, 1951) | Asterad type (Pantulu, 1951)                                                                                               | Variation of Onagrad type (Pantulu, 1951)                                         |
|                       | Suspensor absent (Dnyansagar, 1952)                                                            | Suspensor present (Pantulu, 1951)                                                                                          | Suspensor present (Cooper, 1933)                                                  |
|                       | Orthorhizal (present work). Cotyledons not massive, venation visible (present work)            | Orthorhizal (present work). Cotyledons rarely massive, venation inconspicuous (except in <i>Poinciana</i> ) (present work) | Pleurorhizal (present work) Cotyledons massive, venation conspicuous              |
| SEED                  | Radicle straight. Plumular leaves well-differentiated                                          | Radicle straight. Plumular leaves not well-differentiated                                                                  | Radicle curved. Plumular leaves only sometimes well-differentiated                |
|                       | Dorsiventrally flattened or oval                                                               | Dorsiventrally flattened                                                                                                   | Reniform or bloated                                                               |
|                       | Hilum small, round or shortly oblong without a median groove                                   | Hilum small, round or shortly oblong without a median groove                                                               | Hilum large and oblong with a median groove                                       |
|                       | Funicle much longer than seed, coiled                                                          | Funicle longer than seed                                                                                                   | Funicle shorter than seed                                                         |
|                       | Pleurogram present (except in <i>Pithecellobium</i> )                                          | Pleurogram wanting                                                                                                         | Pleurogram absent                                                                 |
| Germination           | Epigeal                                                                                        | Epigeal                                                                                                                    | Epigeal, rarely otherwise                                                         |
|                       | Cotyledonary leaves occur only in a few. First as well as second plumular leaf compound        | Cotyledonary leaves develop only in a few. First plumular leaf simple                                                      | Cotyledonary leaves develop First plumular leaf simple                            |
| Chemical constituents | Amino acid canavanine absent (Anonymous, 1961)                                                 | Canavanine absent                                                                                                          | Canavanine present except in tribes, Sophorieae and Podalyrieae (Anonymous, 1961) |

Pipecolic acid has been isolated from beans and it occurs in most other legumes also (Grobelaer *et al.*, 1954).

*Systematic considerations:* From the data presented in Table II it is not surprising if the status of the taxon Leguminosae has been often debated. Whether the taxon Leguminosae represents a family comprising three subfamilies or an order embracing three families (and even four according to some systematists) is still disputed (see Table III). Lindley (1853)<sup>1</sup>, Bentham & Hooker (1865)<sup>1</sup>, Taubert (1891-1894)<sup>1</sup>, Rendle (1952) as well as some recent authors like Wilbur (1963) have considered the Leguminosae as a family divisible into three subfamilies, namely the Mimosoideae, the Caesalpinioideae and the Papilionoideae.

That the three subfamilies enjoy the rank of individual families and, therefore, the Leguminosae constitute an order is not, however, the latest view. As early as 1814 Brown<sup>1</sup> reported that "This extensive tribe, i.e., Leguminosae may be considered as

a class (that is, an order in the present day terminology<sup>2</sup>) divisible into at least three orders (that is, families according to the nomenclature now in vogue<sup>2</sup>)" namely Mimoseae, Lomentaceae or Caesalpiniceae and Papilionaceae. Warming (1879)<sup>1</sup>, Hutchinson (1926), Metcalfe & Chalk (1950) and a few others have also treated the Leguminosae as an order. Following the International Code of Botanical Nomenclature, Jones (1955) proposed the new ordinal name—the Leguminales—instead of the Leguminosae.

The genus *Krameria* has received much attention in considerations on the systematics of the Leguminosae. It comprises 13 species distributed in Mexico, Chile and the West Indies (Hutchinson, 1959; Willis, 1960). They are shrubs or perennial herbs characterized by the posteriorly placed odd petal and four stamens opening by pores.

<sup>1</sup> For literature see Jones (1955).

<sup>2</sup> Matter in parentheses ours.

Taubert (1891-1894) as well as Rendle (1952) treat *Krameria* as a solitary genus under the tribe Kramerieae of the subfamily Caesalpinioideae. In possessing the posteriorly placed odd petal and the monocarpellary gynoeceum, *Krameria* conforms to the floral pattern of the Leguminosae.

Bentham & Hooker (1865) place *Krameria* in the Polygaleae under the order Polygalinae, Series Thalamiflorae. However, *Krameria* is distinct from the Polygalaceae in the absence of the posteriorly oriented odd sepal and the bicarpellary gynoeceum.

Table III indicates that owing to the different assignments for the genus *Krameria* the circumscription of the order Leguminosae or Leguminales has also been changing. Small (1903), Britton & Brown (1913, cf. Jones, 1955) and Jones (1955) erect a monotypic family Krameriaceae and describe it as the fourth family of the order Leguminosae/Leguminales along with the usually recognized three families Mimosaceae, Caesalpinaceae and Papilionaceae. Hutchinson (1926, 1959) and Hallier (cf. Lawrence, 1951) also raise *Krameria* to family status but shift it to the order Polygalales.

TABLE III

THE LEGUMINOSAE—ITS STATUS AS CONSIDERED BY SOME INVESTIGATORS

| Leguminosae — A family          | Leguminosae — An order    | Leguminales — A new order |
|---------------------------------|---------------------------|---------------------------|
| Lindley (1853)                  | Brown (1814)              | Jones (1955)***           |
| Bentham & Hooker (1865)*        | Warming (1879)            |                           |
| Taubert (in Engler 1891-1894)** | Small (1903)***           | Hutchinson† (1959)        |
| Rendle (1952)**                 | Britton & Brown (1913)*** |                           |
| Wilbur (1963)                   | Hutchinson (1926)†        |                           |
|                                 | Hallier††                 |                           |

Jones (1955) considers that the new order Leguminales is closely allied to the Rosales in which the Leguminosae enjoyed the status of a family only. The resemblances and dissimilarities between the two orders are listed in Table IV. Although they

resemble each other in many features, yet they have retained certain distinctions. The presence of a posteriorly situated odd sepal is reasonably constant for the Rosales and separates it from the Leguminales where the odd sepal is anteriorly disposed. On the basis of these observations Jones (1955) reports (a) that the Leguminales are probably derived from the Rosales through the family Mimosaceae, and (b) that the subfamilies Prunoideae and Chrysobalanoideae of the Rosaceae bridge the two orders. According to Hutchinson (1959) the Leguminales are a highly successful taxon derived from the Rosales through the Mimosaceae and the Caesalpinaceae and ending in a very natural family the Papilionaceae.

TABLE IV

COMPARISON OF THE ORDERS LEGUMINALES AND ROSALES

| Order Leguminales                                              | Order Rosales                                                                                                |
|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Leaves alternate, stipulate                                    | Leaves alternate, stipulate                                                                                  |
| Flowers generally pentamerous and most frequently perigynous   | Flowers generally pentamerous and most frequently perigynous                                                 |
| Odd sepal anterior                                             | Odd sepal posterior                                                                                          |
| Odd petal posterior                                            | Odd petal anterior                                                                                           |
| Corolla more commonly zygomorphic, actinomorphic in Mimosaceae | Corolla more commonly actinomorphic, zygomorphic in subfamilies Prunoideae and Chrysobalanoideae of Rosaceae |
| Stamens 10, sometimes <10, usually indefinite in Mimosaceae    | Stamens indefinite, rarely definite                                                                          |
| Gynoeceum monocarpellary                                       | Gynoeceum polycarpellary, monocarpellary in Prunoideae and Chrysobalanoideae                                 |
| Fruit generally dehiscent                                      | Fruit generally indehiscent                                                                                  |

The present observations on the comparative morphology of the legumes of Delhi (especially from the view point of the structure of seed and embryo) and the data available on their botany suggest that the Leguminosae should be treated as an order comprising the three families Mimosaceae, Caesalpinaceae and Papilionaceae. The taxonomic assignment of the genus *Krameria* must await investigations on its embryology, anatomy and phytochemistry. Until then it is reasonable to retain *Krameria* in the Caesalpinaceae with which it bears close resemblances, instead of giving it the status of an independent family in the order Leguminosae or elsewhere.

\* Place the genus *Krameria* in the Polygaleae under the order Polygalinae of the Series Thalamiflorae.

\*\* Treats *Krameria* as a solitary genus under the tribe Kramerieae of the subfamily Caesalpinioideae.

\*\*\* Upgrade(s) *Krameria* to the family Krameriaceae and considers the latter to be the fourth family under the order Leguminosae/Leguminales (see Jones, 1955).

† Shifts the family Krameriaceae to the order Polygalales.

†† Excludes the family Krameriaceae from the order Leguminosae and places it as "derived from or within the Polygalaceae" (see Lawrence, 1951).

## SUMMARY AND CONCLUSIONS

For evaluating the systematics of the Leguminosae a survey of the leguminous plants of Delhi was undertaken and observations were made on their morphology. Towards this purpose data were also compiled on their comparative botany.

In studies on morphology emphasis has been given to bacterial root nodule, seed and embryo. Out of 78 species examined only 24 were nodule-bearing; with the exception of *Mimosa pudica* all the others belong to the Papilionaceae. No specificity could be observed in the distribution of the nodules and they showed variations in size, shape and number.

A study of the seeds and embryos revealed that their features can be used as one of the chief criteria in the classification of the Leguminosae. A pleurogram, for example, is characteristic of the seeds of the Mimosaceae. The pleurorhizal pattern of embryo observed in the Papilionaceae, does not recur in the Mimosaceae and the Caesalpiniaceae, in which the embryo is orthorhizal.

During the survey 109 species belonging to 55 genera were collected. No claim has been made for any exhaustive taxonomic description of all the taxa.

The Leguminosae represent a prominent group in the vegetation of Delhi. They are predominantly herbaceous. The results of this survey have been the addition of 3 genera (*Desmanthus*, *Lotus* and *Calliandra*) and 10 species to the existing list of legumes reported so far from Delhi.

In the brief discussion on systematic considerations evidence is presented to consider the Leguminosae an order comprising three families—Mimosaceae, Caesalpiniaceae and Papilionaceae. It has been suggested that the genus *Krameria* may be retained in Caesalpiniaceae, and that this provisional assignment calls for detailed studies especially on its morphology, embryology and anatomy.

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## LITERATURE CITED

- ALLEN, O. N. AND E. K. ALLEN. A survey of nodulation among leguminous plants. *Proc. Soil Sci. Soc. Amer.* 12 : 203-208, 1947.
- ANONYMOUS. Canavanine in Leguminosae. *Nature* 189 : 360, 1961.
- ARORA, N. *Morphological studies on the bacterial nodules of some Leguminosae*. Ph.D. Thesis, Univ. Rajasthan, 1956.
- COOPER, D. C. Macrosporogenesis and embryology of *Melilotus*. *Bot. Gaz.* 95 : 143-155, 1933.
- CORNER, E. J. H. The leguminous seeds. *Phytomorphology* 1 : 117-150, 1951.
- DANDY, J. E. AND E. MILNE-REDHEAD. The typification of *Hedysarum diphyllum* L. *Kew Bull.* 17 : 73-74, 1963.
- DNYANSAGAR, V. R. Embryological studies in Leguminosae IV. A contribution to the embryology of *Neptunia triquetra* Benth. *Proc. Indian Acad. Sci. Sect. B.* 36 : 1-11, 1952.
- ERDTMAN, G. *Pollen Morphology and Plant Taxonomy — Angiosperms*. 1952.
- FOSTER, A. S. Techniques for the study of venation patterns in the leaves of angiosperms. *Proc. 7th Internat. Bot. Congr. (Stockholm)*. 586-587, 1950.
- GROBBELAER, N., R. M. ZACHARIUS AND F. C. STEWARD. *J. Amer. Chem. Soc.* 76 : 2912-2915, 1954.
- HOOKE, J. D. *Flora of British India*. Vol. II. London, 1879.
- HUTCHINSON, J. *The Families of Flowering Plants*. Vol. I. *Dicotyledons*. (1st ed.) London, 1926.
- *The Families of Flowering Plants*. Vol. I. *Dicotyledons*. (2nd ed.) London, 1959.
- JACKSON, B. D. *A Glossary of Botanic Terms with their Derivation and Accent*. London, 1960.
- JOHRI, B. M. AND S. GARG. Development of endosperm haustoria in some Leguminosae. *Phytomorphology* 9 : 34-36, 1959.
- JONES, G. N. Leguminales : a new ordinal name. *Taxon* 4 : 188-189, 1955.
- LAWRENCE, G. H. M. *Taxonomy of Vascular Plants*. New York, 1951.
- MAHESHWARI, J. K. *Flora of Delhi State*. Council of Scientific and Industrial Research, New Delhi, 1963.
- MAHESHWARI, P. Contribution to the morphology of *Albizia lebbek* L. *J. Indian bot. Soc.* 10 : 241-264, 1931.
- *An Introduction to the Embryology of Angiosperms*. New York, 1950.
- MARTIN, J. N. The comparative morphology of some Leguminosae. *Bot. Gaz.* 58 : 154-167, 1914.
- MOHLENBROCK, R. H. A monograph of the Leguminous genus *Zornia*. *Webbia* 16 : 67, 1961.
- METCALFE, C. R. AND L. CHALK. *Anatomy of the Dicotyledons*. Vol. I. Oxford, 1950.
- NAIR, N. C. AND S. KAHATE. Floral morphology and embryology of *Parkinsonia aculeata*. *Phyton Rev. internat. Bot. exptl.* 17 : 77-90, 1961.
- NEWMAN, I. V. Studies in the Australian acacias — I. General Introduction. *J. Linn. Soc. (Bot.)* 49 : 133-143, 1933.
- PANTULU, J. V. Studies in the Caesalpiniaceae. II. Development of the endosperm and embryo in *Cassia occidentalis*. *J. Indian bot. Soc.* 30 : 95-99, 1951.
- RAU, M. A. The endosperm in some of the Papilionaceae. *Phytomorphology* 1 : 153-158, 1951.
- RENDLE, A. B. *The Classification of Flowering Plants*. Vol. II. *Dicotyledons*. Cambridge Univ. Press, 1952. (1st ed., 2nd reprint)
- TWENEY, C. F. AND L. E. C. HUGHES (eds.) *Chambers's Technical Dictionary*. London, 1961.
- WILBUR, R. L. The Leguminous plants of North Carolina. *Tech. Bull. North Carolina Agric. exp. Stn.* No. 151 : 1-294, 1963.
- WILLIS, J. C. *A Dictionary of the Flowering Plants and Ferns*. Cambridge Univ. Press, 1960.