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# Floral preferences for pollen by leaf cutter bees (Hymenoptera: Megachilidae) in Bangalore, India

**SD Pradeepa and VV Belavadi**

**Abstract**
Understanding the floral preferences of solitary bee is *sine qua non* for enhancing the knowledge on bee-flower association. Keeping this in mind, the present study was undertaken to assess the foraging preferences of leaf cutter bees belonging to the family Megachilidae. Floral species were identified by comparing the pollen samples (collected from the nest) with the reference pollen slides prepared beforehand. Further, with the help of scanning electron microscopic analysis (SEM), we written morphological description for all the pollen species collected from megachilid nests. The analysis of the pollen sample collected from 373 nests belonging to species revealed that, the bees preferentially foraged on the flowers of 18 species for pollen. Of this, majority (12 species) belonged to the family Fabaceae and accounted for more than 95 percent of the food provided to brood. The remaining species were from Asteraceae, Lamiaceae, Malvaceae, Convolvulaceae and Acanthaceae.

**Keywords:** leaf cutter bees, megachilidae, pollen morphology, floral-specialization

## 1. Introduction
Plants have evolved to protect against excessive pollen harvesting by bees, pollen of certain taxonomic groups possess protective properties that hamper digestion and thus challenge the general view of pollen as an easy-to-use protein source, such flowers narrow their window for access only to specialist bees for pollination [1].

Many solitary bees are resource specialists and depend on pollen often from a single plant species or from related species belonging to the same genus, or species of the same family because nutritional composition of pollen is very important in host-plant selection of bees. The composition of amino acids varied strongly among plant species, but taxonomically related species had similar nutritional compositions [2]. A study enlightening the bee-flower relationships through imprinting theory, tells that host recognition has a genetic basis in specialist bees [3]. But the risk of oligolectic bees declining is more due to its physiological adaptations to the fewer host range, such as short seasons, more or less synchronized with blooming [4, 5].

Leaf cutter bees (LCB) (Megachilidae) are solitary bees that nest in existing linear cavities. They are oligolectic [6, 7]. Scope located on the ventral aspect of their abdomen helps in better transfer of pollen in such plants which are specially adapted for pollination by LCB [8]. These bees are resource specialists have a short foraging range, demanding extreme patch fidelity [9, 10]. Hence, pollen from nests can be used for establishing a positive association of different bee species with the available flora in the vicinity [11].

The knowledge of palynology can be used as an instrument of multiple research for systematic botany. Pollen characters such as size, shape, colour and exine thickness, and aperture type are found to be considerably important [12]. By analyzing the diversity of pollen carried by the bees and by sampling pollen from the nests in different times of the year one can get an idea about the floral diversity and changes in flowering phenology in a given location. The present study was taken up with the hypothesis that examination of pollen from nests of leaf cutter bees (LCBs), would give an idea about their floral specialization.

## 2. Material and Methods
### 2.1 Study area
The study was conducted at the Gandhi Krishi Vignana Kendra (GKVK) campus of the University of Agricultural Sciences, Bangalore, Karnataka state, India. The campus is spread over 526 ha (5.3 $Km^2$) (13˚04' 37" N, 77˚ 34' 39.99" E; 930 msl) and receives a mean annual

rainfall of 915.8 mm. The study area comes under the eastern dry Agro-climatic zone of Karnataka state and it has diverse vegetation including cultivated crops (agricultural fields), plantations (horticultural blocks), medicinal plants, and several species of garden plants, wild trees, shrubs and weeds (Appendix 1) that would be sources of nectar and pollen for the bees.

### 2.2 Sampling and identification of pollen

Species of plants flowering in the study area was recorded at monthly intervals and reference pollen slides were prepared from pollen samples collected from freshly opened flowers. For each species a set of slides were prepared by the standard acetolysis method [13, 14, 15]. Photomicrographs of pollen were made using ZEISS Axio Scope A1 Trinocular Microscope and Scanning Electron microscope [16].

These are basically cavity nesting bees that construct a linear nest with a number of brood cells in preformed cavities using various materials like leaves, mud and resins etc. The mother LCB constructs a brood cell by lining the cell walls of the nest cavity with leaf pieces or soil or resin and then provisions this "cell" with a mixture of pollen and nectar above which an egg is laid before sealing the cell. New cells were added in front of completed cells. After completion of the nest, the mother closed the nest entrance by making a thick wall.

In ten selected locations on the campus, where there was LCBs activity, two artificial nesting materials were provided. Each artificial nest consisted of a 30 cm long PVC pipe (15 cm dia) containing 15 hollow reeds (one foot length) of *Ipomea carnea* and wooden blocks with number of holes having a width of 8-10mm (Table 1). Between August 2015 and June 2017, closed nests were collected (512 brood cells from 373 nests) at monthly intervals and in place of each collected nest an empty hollow read was kept for new nest construction. In the study period a total of 373 nests were collected and 512 brood cells were examined. The closed nests were brought to the laboratory and after cutting open the nests, observations were made on characterization and identification of pollen in the brood cells by comparing with pollen reference slides, under Olympus BX40 Trinocular Light Microscope. The Scanning Electronic Microscopic (SEM) studies were employed to provide the details of morphology beyond the resolution of Light Microscope and morphological description were written based on SEM images [14].

## 3. Results and Discussion

Though the study area had over 150 species of flowering plants, the LCBs preferentially collected pollen from only 18 species of plants of which 12 species belonged to Fabaceae, two species to Asteraceae and one species each to Convolvulaceae, Malvaceae, Lameaceae and Acanthaceae.

### 3.1 Description of pollen collected by LCBs

The detailed morphology of the pollengrains belonging to the 18 species are given below. Pollen taxa had been given along with SEM images, which are served significantly useful for characterization of species.

**Fabaceae**

***Medicago sativa* (Plate-1a, A)**

Monad, medium (28µm), isopolar, prolate, polar view traingular, tricalporate, calpi broad and taper to the end and exine microreticulate/porous.

***Cajanus cajan* (Plate-1a, B)**

Monad, medium (31µm), isopolar, prolate, polar view triangular, tricalporate, calpi long and broad at pore, exine thicker and striate reticulate.

***Cassia auriculata* (Plate-1a, C)**

Monad, medium (28µm) isopolar, prolate, spheroidal, tricalporate, calpi long and taper to end, exine fossulate and perforate.

***Crotalaria juncea* (Plate-1a, D)**

Monad, small (19µm), heteropolar, prolate, dumble shaped, tri-zonocalporate, calpi long and tapered, exine perforate/coarsely reticulate.

***Caesalpinia decapetala* (Plate-1a, E)**

Monad, large (51 µm), isopolar, prolate, polar view triangular/spheroid, tricalporate, calpi long and broad, exine reticulate.

***Cicer arietinum* (Plate-1a, F)**

Monad, small (19 µm), polar view triangular, oblate, tricalporate, exine striated.

***Dolichos lablab* (Plate-1b, A)**

Monad, small (21 µm), isopolar, prolate, tricalporate, calpi long, exine punctate.

***Mimosa pudica* (Plate-1b, B)**

Tetrad, very small (7µm), oblate/spheroid, inaperturate, exine areola/psilate.

***Peltophorum pterocarpum* (Plate-1b, C)**

Monad, medium (39 µm), isopolar, oblate, tricalporate, calpi broader near pores, calpi broader in center, exine heterobractase reticulate.

***Millettia pinnata* (Plate-1b, D)**

Monad, small (23 µm), isopolar, oblate, tricalporate, calpi broad near pores, exine regulate and punctate.

***Senna siamea* (Plate-1b, E)**

Monad, medium (40 µm), isopolar, spheroid, tricalporate, calpi broader at center, exine punctate/perforate.

***Vigna sinensis* (plate-1b, F)**

Monad, medium (38 µm), isopolar, polar view triangular, tricalporate, exine homobrachete reticulate.

**Asteraceae**

***Helianthus annuus* (Plate-1c, A)**

Monad, small (14 µm), spheroid, tricalporate, exine is echinate, spines are short and sharp.

***Guizotia abyssinica* (Plate-1c, B)**

Monad, medium (29 µm), spheroid, tricalporate' exine is echinate, spines are long with conical base.

**Convolvulaceae**

***Ipomoea sp*. (Plate-1c, C)**

Monad, large (108 µm), spheroid, pantaporate, exine echinate, blunted spines had funnel base with perforations.

**Malvaceae**

***Abelmoschus esculentus* (Plate-1c, D)**

Monad large (120 µm), spheroid, pantaporate, exine is echinate, spines are blunted, cylindrical and wider apart.

**Lameaceae**

***Ocimum sp.* (Plate-1c, E)**

Monad medium (35 µm) spheroid, hexacalpate, calpi broad at midlle and tapered towards end, exine is heterobrachate reticulate.

**Acanthaceae**

***Justicia sp.* (Plate-1c, F)**

Monad, medium (30 µm), prolate, dicalporate, calpi longer than wide, Exine is perforate.

**3.2 Foraging preference**

During the study period 512 brood cells from 373 nests were analyzed. From these 76.87 per cent brood cells contained pollen grains from only one plant species per nest and 19.96 per cent brood cells had pollen from two plant species per nest (Fig. 1). Whenever the cells had two species of pollen there was a clear demarcated deposition in the cells, which could be due to shortage of pollen of one species in the local area which was compensated by foraging on a taxonomically related plant species [17] because nutritional composition in closely related plant species might be similar to the first species [2]. Only 3.17 per cent brood cells contained more than two species of pollen in mixed condition, among these one was present in a trace amount and it might have come along with nectar source. Because, these bees rarely specialize on nectar collection and they are expected to collect nectar from many plants species [17]. In this study, we observed LCBs nests containing trace amounts of pollen from unrelated species like, *Justicia*, *Ocimum*, *Ipomoea*, *Abelmoschus* pollen species as the bees may have visited these species for collecting nectar.

Pollen collected by LCBs gives valuable information on bee floral association. Among the floral family encountered in the LCBs nest Fabaceae was the dominant one accounting for 67 per cent followed by Asteraceae (11%) and each of the remaining families accounted for 6 per cent each (Fig. 2). This was probably because, many LCB species are pollen specialists (oligolectic) and restrict their pollen foraging to few taxonomically related plant species [17, 18]. Which is supported by an earlier study [19] found that *M. lanata* was an oligolectic solitary bee mainly associated with some leguminous crops.

Among the Fabaceae family, *Millettia pinnata* was seasonal in flowering from end of the January to June and peak flowering in *Peltophorum* was observed in April but it continued to flower staggardly till the end of year and crops like *Crotalaria juncea*, *Cajanus cajan* and *Dolichos lablab* were available year around in patches accounting for 86.50 per cent of total flora frequently encountered by bees. The remaining species were found to be meager/low (Fig. 3). The frequency of remaining six species likes *Helianthus annuus*, *Guizotia abbysinica* constituted 11%, while species of *Ocimum*, *Abelmoschus*, *Ipomoea* and *Justicia* were present in trace amounts (<1%).

This indeed is expected because LCBs being solitary and having short life cycle, have a foraging distance of 100-200m with high patch fidelity [10]. Because, host shifting or new host finding is very expensive for an LCB and it has to complete its nest construction within a stipulated period of time. Otherwise, the nest might become prone to attack of biotic factors like predators and parasites.

Further, mass provisioning nature demands maintenance of nutritional status that leads to foraging LCBs on closely related species [2]. Many studies have showed that there is no interspecific competition with respect to foraging range and overlap in resource use of flower-visiting ground and trap-nesting wild bees with honey bees [20].

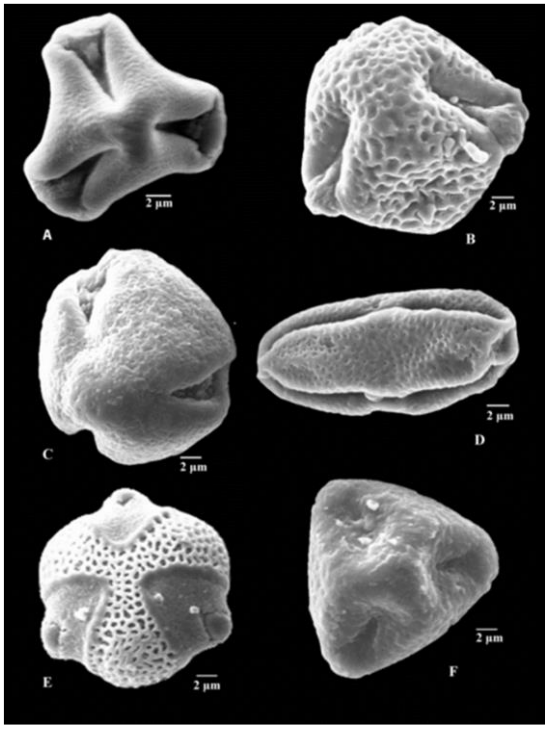


**Plate 1a:** (A) *Medicago sativa*, (B) *Cajanus cajana*, (C) *Cassia auriculata*, (D) *Crotalaria juncea*, (E) *Caesalpinia decapetala*, (F) *Cicer arientinum*

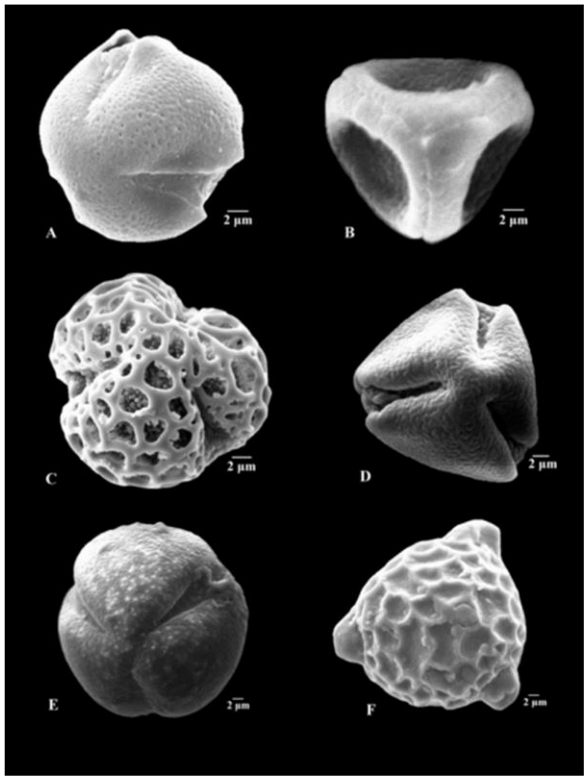


**Plate 1b:** (A) *Dolichos lablab*, (B) *Mimosa pudica*, (C) *Peltophorum pterocarpum*, (D) *Millettia pinnata*, (E) *Senna siamea*, (F) *Vigna sinensis*

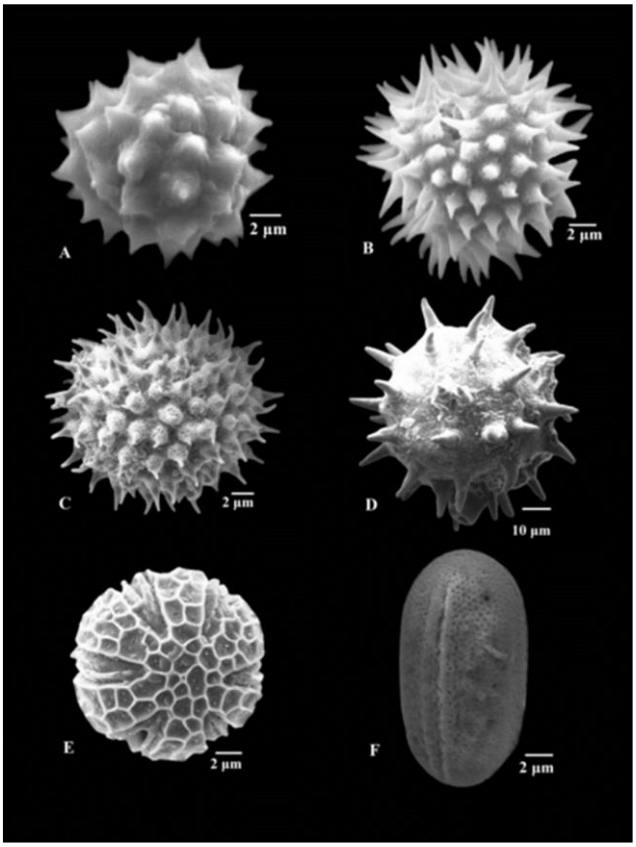


**Plate: 1c:** (A) *Helianthus anus*, (B) *Guizotia abyssinica*, (C) *Ipomoea sp.*, (D) *Abelmoschus sp.*, (E) *Ocimum sp.*, (F) *Justicia sp.*

**Table 1:** Flora collected by bee species

| Sl. No. | Flora | Family |
|---|---|---|
| 1 | *Millettia pinnata* | Fabaceae |
| 2 | *Cajanus cajan* | Fabaceae |
| 3 | *Crotalaria juncea* | Fabaceae |
| 4 | *Peltophorum pterocarpum* | Fabaceae |
| 5 | *Dolichos lablab* | Fabaceae |

| | | |
|---|---|---|
| 6 | *Vigna sinensis* | Fabaceae |
| 7 | *Mimosa pudica* | Fabaceae |
| 8 | *Senna siamea* | Fabaceae |
| 9 | *Cicer arietinum* | Fabaceae |
| 10 | *Medicago sativa* | Fabaceae |
| 11 | *Casia auriculata* | Fabaceae |
| 12 | *Caesalpinia decapetala* | Fabaceae |
| 13 | *Justicia sp* | Acanthaceae |
| 14 | *Helianthus annuus* | Asteraceae |
| 15 | *Guizotia abyssinica* | Asteraceae |
| 16 | *Ocimum sp* | Lamiaceae |
| 17 | *Ipomoea sp* | Convolvulaceae |
| 18 | *Abelmoschus esculentus* | Malvaceae |

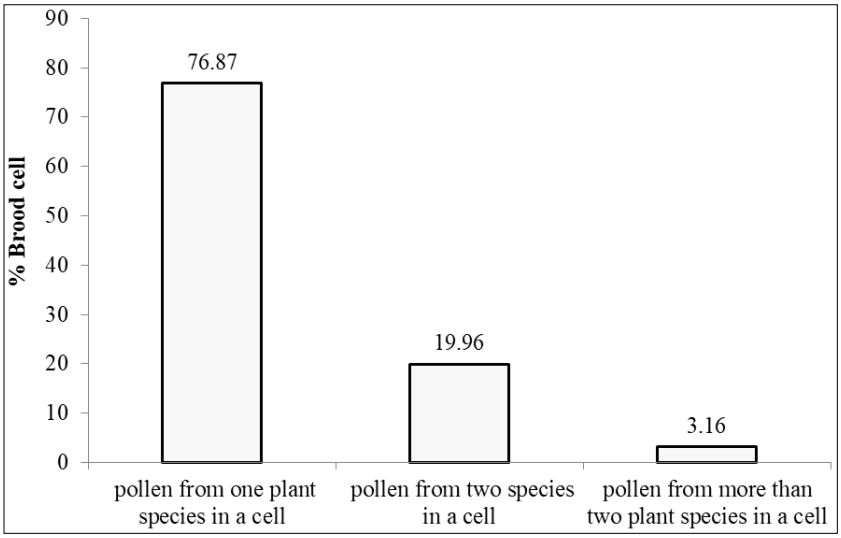


**Fig 1:** Pollen species in a brood cell of LCBs

**Note: -** Pollen from one plant species- At the time of sampling all the cells of each nest contained with pollen from any one plant species.
Pollen from two plant species- At the time of sampling all the cells of each nest contained with pollen from any two of the plant species and had a cleared demarcated deposition.
Pollen from more than two plant species- At the time of sampling all the cells of each nest contained with pollen from more than two plant species.

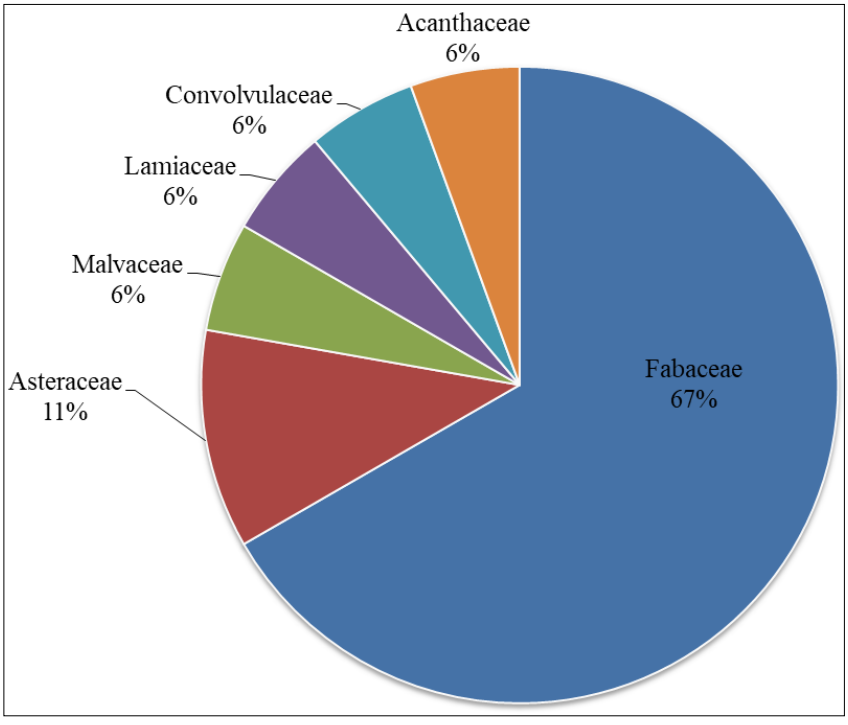


**Fig 2:** Frequency of floral family found in LCB nests

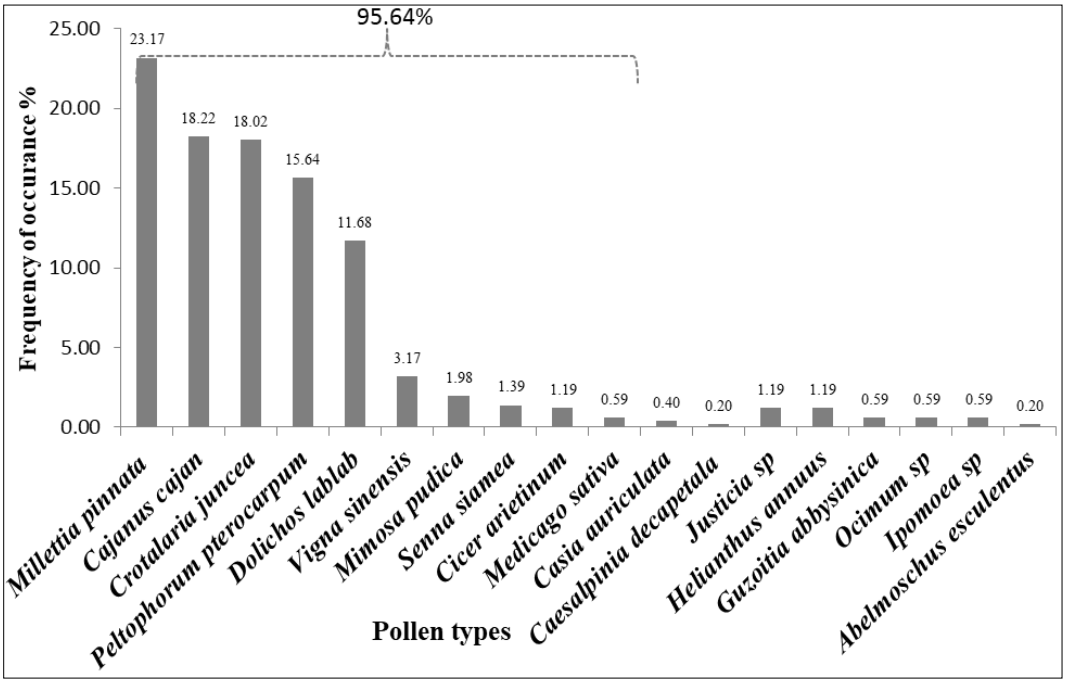


**Fig 3:** Frequency of floral species found in LCB nests

**Appendix 1:** Flora of GKVK Bengaluru.

| Sl. No. | Common name | Scientific name | Family | Flowering period | Life form |
|---|---|---|---|---|---|
| 1 | Coconut | *Cocos nucifera* | Arecaceae | Year round | T |
| 2 | Royal palm | *Roystonia regia* | Arecaceae | Year round | T |
| 3 | Eucalyptus | *Eucalyptus obliqua* | Myrtaceae | Aug-Jan | T |
| 4 | Bottle brush | *Calistamen viminalis* | Myrtaceae | Year round | T |
| 5 | Jamun | *Syzegium cumini* | Myrtaceae | Feb-Apr | T |
| 6 | Rose apple | *Syzygium jambos* | Myrtaceae | May-July | T |
| 7 | Teek | *Tectona grandis* | Lamiaceae | Jun-Oct | T |
| 8 | Soap nut | *Sapindus emarginatus* | Sapindaceae | Oct-Nov | T |
| 9 | Pichkari/Nandi flame | *Spathodea companulata* | Bignoniaceae | Year round | T |
| 10 | Yellow trumpetbush | *Tecoma* capensis | Bignoniaceae | Year round | T |
| 11 | Sky jasmine | *Millingtona hortensis* | Bignoniaceae | Sept-Jan | T |
| 12 | Trumpet tree | *Tabebuia rosea* | Bignoniaceae | Nov-Jan | T |
| 13 | Trumpet tree | *Tabebuia argentia* | Bignoniaceae | Feb-May | T |
| 14 | Nile tulip | *Markhamia platycalyx* | Bignoniaceae | Aug-Sept | T |
| 15 | Indian-almond | *Terminalia catapa* | Combretaceae | Aug-Oct | T |
| 16 | Arjun tree | *Terminalia arjuna* | Combretaceae | Mar-May | T |
| 17 | Amla | *Phyllanthus emblica* | Phyllanthaceae | Feb-Mar | T |
| 18 | Breadfruit | *Artocarpus sp* | Moraceae | Dec-Jan | T |
| 19 | Copper pod | *Peltophorum ptreocarpum* | Fabaceae | Mar-Jan | T |
| 20 | May flower | *Delonix regia* | Fabaceae | Apr-Jun | T |
| 21 | Cassia tree | *Senna siamea* | Fabaceae | July-Nov | T |
| 22 | Tamarind | *Tamarindus indica* | Fabaceae | Mar-Jun | T |
| 23 | Camel's foot tree | *Bauhinia varigata* | Fabaceae | Oct-Dec | T |
| 24 | Camel's foot tree | *Bauhinia perpurea* | Fabaceae | Feb-Sept | T |
| 25 | Baage mara | *Albizia lebbeck* | Fabaceae | Mar-Nov | T |
| 26 | Bilvaara | *Albizia odoratissima* | Fabaceae | Mar-Nov | T |
| 27 | Earleaf acacia | *Acacia auriculiformis* | Fabaceae | Aug-Sept | T |
| 28 | Bili jaali | *Acacia leucophloea* | Fabaceae | Jul-Nov | T |
| 29 | Kaadu seege | *Acacia pennata* | Fabaceae | Jul-Oct | T |
| 30 | Mugali | *Acacia polyacantha* | Fabaceae | Sept-Dec | T |
| 31 | Avarice tree | *Cassia auriculata* | Fabaceae | Year round | T |
| 32 | Honge | *Millettia pinnata* | Fabaceae | Feb-Apr | T |
| 33 | Rosewood | *Dalbergia* sp | Fabaceae | Feb-Mar | T |
| 34 | Siver oak | *Grevillea robusta* | Proteaceae | Mar-Apr | T |
| 35 | Neem | *Azadirachta indica* | Meliaceae | Jan-Mar | T |
| 36 | Singapore cherry | *Muntingia calabura* | Muntingiaceae | Year round | T |
| 37 | Drumstick | *Moringa oleifera* | Moringaceae | Year round | T |
| 38 | Sandal wood | *Santalum album* | Santalaceae | Dec-June | T |
| 39 | Cinnamon tree | *Cinnamomum sulphuratum* | Lauraceae | Nov-Feb | T |
| 40 | Copper-wood | *Bursera simaruba* | Burseraceae | Dec-Jan | T |

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|---|---|---|---|---|---|
| 41 | Star-fruit | *Averrhoa carambola* | Oxalidaceae | Year round | T |
| 42 | Phalsa | *Grewia asiatica* | Malvaceae | Feb-Mar | T |
| 43 | Mango | *Mangifera indica* | Anacardaceae | Nov-Jan | T |
| 44 | Hebbevu | *Melia dubia* | Meliaceae | Mar-Feb | T |
| 45 | Yenna Mara | *kingiodendron pinnatum* | Fabaceae | Apr-Aug | T |
| 46 | Indian rose chestnut | *Mesua ferrea* | Calophyllaceae | Mar-July | T |
| 47 | Cashew | *Anacardium occidentale* | Anacardaceae | Dec-Jan | T |
| 48 | Rain tree | *Samania saman* | Fabaceae | Mar-June | T |
| 49 | White teak | *Gmelina arborea* | Verbenaceae | Feb-Apr | T |
| 50 | Blue jacaranda | *Jacaranda mimosifolia* | Bignoniaceae | Apr-Oct | T |
| 51 | Pride of India | *Lagerstroemia speciosa* | Lythraceae | Mar-Apr | T |
| 52 | Red sandle | *Pterocarpus santalinus* | Fabaceae | Mar-Apr | T |
| 53 | Badminton Ball Tree | *Parkia biglandulosa* | Fabaceae | Dec-Jan | T |
| 54 | Bendi | *Kydia calycina* | Malvaceae | Sept-Nov | T |
| 55 | Kadamb tree | *Anthocephalus cadamba* | Rubiaceae | Sept-Oct | T |
| 56 | Baeladamara | *Limonia acidissima* | Rutaceae | Mar-May | T |
| 57 | Arasina buruga | *Cochlospermum religiosum* | Bixaceae | Feb-Apr | T |
| 58 | Andimurugalu | *Carallia brachiata* | Rhizophoraceae | Dec-Jun | T |
| 59 | Garudaphala | *Hydnocarpus wightianus* | Achariaceae | Jan-Apr | T |
| 60 | Indian Elm | *Holoptelea integrifolia* | Ulmaceae | Feb-Mar | T |
| 61 | Bombay ebony | *Diospyros montana* | Ebenaceae | March-April | T |
| 62 | True indigo | *Indigofera sp* | Fabaceae | May-Aug | SH |
| 63 | Indian Redwing | *Pterilobium* sp | Fabaceae | Sept-Oct, Mar-Apr | SH |
| 64 | Sun hemp | *Crotalaria juncea* | Fabaceae | Year round | SH |
| 65 | Pigeon pea | *Cajanus cajana* | Fabaceae | July-Mar | SH |
| 66 | Powder puff plant | *Calliandra haematocephala* | Fabaceae | Year round | SH |
| 67 | Feather-leaved Cassia | *Chamaecrista mimosoides* | Fabaceae | Nov-Mar | H |
| 68 | Field bean | *Dolichus lablab* | Fabaceae | Sept-Mar | H |
| 69 | Cow pea | *Vigna sinensis* | Fabaceae | June-Aug, Feb-Mar | H |
| 70 | Touch-me-not | *Mimosa pudica* | Fabaceae | Year round | H |
| 71 | Alfa alfa | *Medicago sativa* | Fabaceae | Mar-Apr | H |
| 72 | Chick pea | *Cicer arietinum* | Fabaceae | Oct-Dec | H |
| 73 | Mysore thorn | *Caesalpinia decapetala* | Fabaceae | Year round | SH |
| 74 | Peacock flower | *Caesalpinia pulcherima* | Fabaceae | Year round | SH |
| 75 | Divi Divi | *Caesalpinia coriaria* | Fabaceae | Jul-Aug | SH |
| 76 | Subabul | *Leucaena leucocephala* | Fabaceae | Year round | SH |
| 77 | Natkadeodar | *Erythroxylum monogynum* | Erythroxylaceae | Aug-Sep | SH |
| 78 | Chilly | *Capsicum annum* | Solanaceae | Year round | H |
| 79 | Brazilian Nightshade | *Solanum seaforthianum* | Solanaceae | Year round | C |
| 80 | Butterfly Pea | *Clitoria ternatea* | Fabaceae | Apr-Jun | C |
| 81 | American black nightshade | *Solanum americanum* | Solanaceae | Year round | H |
| 82 | Egg plant | *Solanum melongena* | Solanaceae | Year round | SH |
| 83 | Bavanchi | *Psoralea corylifolia* | Fabaceae | Jul-Aug | H |
| 84 | Purple bush-bean | *Macroptilium atropurpureum* | Fabaceae | Year round | C |
| 85 | Calico-plant | *Alternanthra bettzickiana* | Amaranthaceae | Year round | H |
| 86 | Cock's comb | *Celosia argentea* | Amaranthacea | Year round | H |
| 87 | Amaranth | *Amaranthus sp. 1* | Amaranthacea | Year round | H |
| 88 | Amaranth | *Amaranthus sp. 2* | Amaranthacea | Year round | H |
| 89 | Indian plum | *Flacourtia sp* | Salicaceae | Nov-Mar | SH |
| 90 | Loranthus | *Dendropthoe falcata* | Loranthaceae | Year round | E |
| 91 | Mexican clover | *Richardia scabra* | Rubiaceae | Year round | H |
| 92 | Fameflower | *Talinum portulacifolium* | Portulacaceae | Year round | H |
| 93 | Moss roses | *Portulaca sp.* | Portulacaceae | Year round | H |
| 94 | Wireweed | *Sida sp* | Malvaceae | Year round | H |
| 95 | Bagflower | *Clerodendrum sp* | Lamiaceae | Year round | SH |
| 96 | Tulsi | *Ocimum sp* | Lamiaceae | Year round | H |
| 97 | Spurge | *Euphorbia hypericifolia* | Euphorbiaceae | Year round | C |
| 98 | Wild Poinsettia | *Euphorbia heterophylla* | Euphorbiaceae | Year round | H |
| 99 | Croton | *Croton sp.* | Euphorbiaceae | Year round | H |
| 100 | Castor | *Ricinus cummunis* | Euphorbiaceae | Dec-July | SH |
| 101 | Croton | *Codiaeum variegatum* | Euphorbiaceae | Year round | SH |
| 102 | Yellow bells | *Tecoma stans* | Bignoniaceae | Year round | SH |
| 103 | Orange trumpetvine | *Pyrostegia venusta* | Bignoniaceae | Jan-Feb | H |
| 104 | Goat weed | *Ageratum conyzoides* | Asteraceae | Year round | H |
| 105 | Blazing star | *Maulua spicata* | Asteraceae | Year round | H |
| 106 | Cosmos | *Cosmos sp* | Asteraceae | Year round | H |
| 107 | False Mallow | *Malvestrum coromandelianum* | Malvaceae | Year round | H |
| 108 | Bhendi | *Abelmoschus esculentus* | Malvaceae | Year round | H |

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|---|---|---|---|---|---|
| 109 | White Buttercup | *Turnera subulata* | Passifloraceae | Year round | H |
| 110 | Yellow Buttercups | *Turnera ulmifolia* | Passifloraceae | Year round | H |
| 111 | Passion Flowers | *Passiflora sp.* | Passifloraceae | Year round | C |
| 112 | Morning Glories | *Ipomea sp.* | Convolvulaceae | Year round | H |
| 113 | Creeping-Oxeyes | *wedelia sp.* | Asteraceae | Year round | H |
| 113 | Coat buttons | *Tridax procumbens* | Asteraceae | Year round | H |
| 114 | Knapweeds | *Centaurea sp* | Asteraceae | Year round | H |
| 115 | Black-jack | *Bidens pilosa* | Asteraceae | Year round | H |
| 116 | Quick Weed | *Galinsoga parviflora* | Asteraceae | Year round | H |
| 117 | Node weed | *Synedrella vialis* | Asteraceae | Year round | H |
| 118 | Node Weed, Pig Grass | *Synedrella nodiflora* | Asteraceae | Year round | H |
| 119 | Tassel flower | *Emilia sanchifolia* | Asteraceae | Year round | H |
| 120 | Niger | *Guizotia obyssinia* | Asteraceae | July-Nov, Jan-Mar | H |
| 121 | Sunflower | *Helianthus annus* | Asteraceae | Year round | SH |
| 122 | Congress weed | *Parthanium hysterophorus* | Asteraceae | Year round | H |
| 123 | Dandotapala | *Vernonia* sp | Asteraceae | Year round | H |
| 124 | Blanketflower | *Gaillardia* sp | Asteraceae | Year round | H |
| 125 | Spider flowers | *Cleome monophylla* | Cleomaceae | Year round | H |
| 126 | Mustard | *Brasica sp* | Brassicaceae | Jun-July, Dec-Jan | H |
| 127 | Nut grass | *Cyprus sp.* | Poacea | Year round | S |
| 128 | Maize | *Zea maize* | Poaceae | Year round | SH |
| 129 | Buffalo grass | *Bouteloua* sp | Poaceae | Year round | H |
| 130 | Horsewood | *Clausena* sp | Rutaceae | Jun-July | SH |
| 131 | Coriander | *Coriandrum* sp | Apiaceae | Year round | H |
| 132 | False heather | *Cuphea* sp | Lythraceae | Year round | H |
| 133 | Chuparosa | *Justicia* sp | Acanthaceae | Year round | H |
| 134 | Chinese violet | *Asystasis* sp | Acanthaceae | Year round | H |
| 135 | White-lady | *Thunbergia fragrans* | Acanthaceae | Year round | C |
| 136 | Coral vine | *Antigonum leptopus* | Polygonaceae | Year round | C |
| 137 | Narrow-Leaved Milkwort | *Polygala elongata* | Polygalaceae | Year round | H |
| 138 | Puncture Vine | *Tribulus terrestris* | Zygophyllaceae | Year round | H |
| 139 | Bana Chakunda | *Senna occidentalis* | Fabaceae | Year round | SH |
| 140 | Pomegranate | *Punica granatum* | Punicaceae | Apr-July | SH |
| 141 | Rattlebox Plant | *Crotalaria pallida* | Fabaceae | June-Nov | H |
| 142 | One leaf Senna | *Cassia uniflora* | Fabaceae | Year round | H |
| 143 | Pencil-Flower | *Stylosanthes fruticosa* | Fabaceae | Year round | H |
| 144 | Carpetweed | *Mollugo pentaphylla* | Molluginaceae | Year round | H |
| 145 | Snakeweed | *Stachytarpheta indica* | Verbenaceae | Year round | H |
| 146 | Girdlepod | *Mitracarpus hirtus* | Rubiaceae | Year round | H |
| 147 | Silkleaf | *Lagascea mollis* | Asteraceae | Year round | H |
| 148 | Golden dewdrop | *Duranta repens* | Verbenaceae | Year round | SH |
| 149 | Divi Divi | *Caesalpinia coriaria* | Fabaceae | Year round | SH |
| 150 | Burnet-saxifrage | *Pimpinella sp* | Apiaceae | Year round | H |
| 151 | Rosemary | *Rosmarinus officinalis* | Lamiaceae | Year round | H |
| 152 | Physic nut | *Jatropha curcas* | Euphorbiaceae | Year round | SH |
| 153 | Globe amaranth | *Gomphrena sp* | Amaranthaceae | Year round | H |
| 154 | Gliricidia | *Gliricidia sepium* | Fabaceae | Feb-Mar | SH |
| 155 | Ridge guard | *Luffa acutangula.* | Cucurbitaceae | Sept-Nov | C |
| 156 | Bitter guard | *Momordica charantia* | Cucurbitaceae | Sept-Nov | C |
| 157 | Dwarf Morning Glory | *Evolvulus alsinoides* | Convolvulaceae | Year round | C |
| 158 | Roundleaf Bindweed | *Evolvulus nummularius* | Convolvulaceae | Year round | C |
| 159 | Skyblue Clustervine | *Jacquemontia pentanthos* | Convolvulaceae | Year round | C |
| 160 | Shatavari | *Asparagus racemosus* | Asparagaceae | Year round | H |
| 161 | Sweet Clock-Vine | *Thunbergia fragrans* | Acanthaceae | Year round | H |
| 162 | Nelaberu | *Andrographis paniculata* | Acanthaceae | Sept-Oct | H |
| 163 | Indian mallow | *Abutilon hirtum* | Malvaceae | Year round | H |
| 164 | Thumbai | *Lucas sp* | Lamiaceae | Year round | H |
| 165 | Dayflowers | *Commelina sp* | Commelinaceae | Year round | H |
| 166 | Pignut | *Hyptis sp* | Lamiaceae | Year round | H |
| 168 | Coffee | *Coffea arebica* | Rubiaceae | Jan-Mar | SH |

**Note:** T-Tree, H- Herb, SH- Shrub, C- Creeper/Climber

## 4. Conclusion

Our study has pointed out that megachilids exhibit floral preference to the members of the family Fabaceae. Flowers of these plants have keel petals, a structure that might have evolved to protect against pollen theft by generalists bees. And probably in some plant species flowers and pollen were structurally or chemically protected and accessed only by a specialized pollinator. Hence generalist bees do not or avoid foraging on the flora preferred by specialist bees. We postulate that the enormous pollen requirements of bees might have led to selection of flowers and pollen with such protective properties. These conclusions open a new field of

research in the study of insect–flower relationships.

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**6. References**

1. Praz CJ, Muller A, Dorn S. Host recognition in a pollen-specialist bee: evidence for a genetic basis. Apidologie. 2008b; 39:547-557.
2. Weiner CN, Hilpert A, Werner M, Linsenmair KE, Bluthgen N. Pollen amino acids and flower specialization in solitary bees. Apidologie. 2010; 41:476-487. DOI: 0.1051/apido/2009083.
3. Praz CJ, Muller A, Dorn S. Specialized bees fail to develop on non-host pollen: do plants chemically protect their pollen? Ecology. 2008a; 89(3):795-804.
4. Linsley EG. The ecology of solitary bees. Hilgardia. 1958; 27:564-565.
5. Winfree R. The conservation and restoration of wild bees. Annals of the New York academy of Sciences. 2010; 1195:169-197.
6. Robertson C. Phenology of oligolectic bees and favorite flowers. Psyche. 1929, 112-118.
7. Cane JH. The oligolectic bee *Osmia brevis* sonicates Penstemon flowers for pollen: a newly documented behavior for the Megachilidae. Apidologie. 2014; 45:678-684.
8. Willmer PG, Bataw AAM, Hughes JP. The superiority of bumblebees to honeybees as pollinators: insect visits to raspberry flowers. Ecological Entomology. 1994; 19:271-284. doi: 10.1111/j.1365-2311.1994.tb00419.x.
9. Franzen M, Larsson M, Nilsson SG. Small local population sizes and high habitat patch fidelity in a specialised solitary bee. Journal of Insect Conservation. 2009; 13:89-95. Doi: 10.1007/s10841-007-9123-4.
10. Zurbuchen A, Landert L, Klaiber J, Müller A, Hein S, Dorn S. Maximum foraging ranges in solitary bees: only few individuals have the capability to cover long foraging distances. Biological Conservation. 2010; 143:669-676.
11. Armbruster WS, Guinn DA. The Solitary Bee Fauna (Hymenoptera: Apoidea) of Interior and Arctic Alaska: Flower Associations, Habitat Use, and Phenology. Journal of the Kansas Entomological Society. 1989; 62(4):468-483.
12. Meo AA, Khan MA. Pollen morphology as an aid to the identification of scorzonera (cichorieae-compositae) from Pakistan. Pakistan Journal of Botany. 2004; 36(4):701-710.
13. Wodehouse RP. Pollen Grains their structure, identification and significance in science and medicine. Hafner Publishing Co. New York. 1959; 574.
14. Erdtman G. Handbook of palynology, morphology, taxonomy and ecology. Munksgaard Copenhagen. 1969, 473.
15. Kearns CA, Inouye DW. Techniques for pollination biologists. University Press of Colorado. 1993, 583.
16. Adams RJ, Morto NJK. An improved technique for examining pollen under the scanning electron microscope. Pollen Spores. 1972; 14:203-2, 12.
17. Wcislo WT, Cane JH. Floral resource utilization by solitary bees (Hymenoptera: Apoidea) and exploitation of their stored foods by natural enemies. Annual Review of Entomolog. 1996; 41:2S736.
18. Westrich P. The wild bees of Baden-Wurttembergs. Book*:* Die Wildbienen Baden-Wurttembergs. Eugen Ulmer, Stuttgart, Germany, 1989, 972.
19. Chaudhary JP, Jain KL. Nesting and foraging behaviour of a mason bee, Megachile lanata Lepel (Megachilidae, Hymenoptera). Indian Journal of Entomology. 1978; 40(4):405-411.
20. Steffan-Dewenter I, Tscharntke T. Resource overlap and possible competition between honey bees and wild bees in central Europe. Oecologia. 2000; 122:288-296.