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Floral biology and pollination of *Jasminum angustifolium* Willd. and *J. cuspidatum* Rottler (Oleaceae)

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ABSTRACT

J. angustifolium is a herbaceous vine while *J. cuspidatum* is a woody vine. The flowers of both species are hermaphroditic, dimorphic, distylous, fragrant and nectariferous. The sphind diurnal hawkmoths are the only visitors that collect nectar efficiently effecting pollination following flower-opening during late evening hours and they disappear from the flowers after sunset. The same hawkmoths appear collecting nectar again during dawn hours on the following day and disappear after sunrise. The carpenter bee, Xylocopa latipes is the only visitor that occasionally visits the flowers of both species during daytime. It could collect pollen from only pin flowers whereas this bee resorts to nectar-robbing by making punctures at the lower half of the corolla tube but it is known whether it successful to gather nectar or not. *J. angustifolium* flowers are highly fragrant than *J. cuspidatum* flowers; the former are used for hair adornments by women and also in religious offerings or rituals.

Keywords: *Jasminum angustifolium, Jasminum cuspidatum,* distyly, hawkmoths, carpenter bees.

1. INTRODUCTION

Jasminum is a genus of shrubs and vines in the olive family (Oleaceae). It contains around 200 species native to tropical and warm temperate regions of Eurasia, Africa and Oceania with center of diversity in South Asia and Southeast Asia. Of these, only one species is native to Europe (Townsend and Guest 1980; Panda 2005). In India, 47 species of this genus and 3 subspecies and 4 varieties occur and also 16 of these species are endemic which are mostly distributed in Eastern and Western Himalaya, Deccan Peninsula and Andaman and Nicobar Islands (Green 2004). *Jasminnum* species are widely cultivated for the characteristic fragrance of their flowers for use in essential oil production and cosmetic uses. *J. auriculatum* and *J. grandiflorum* are summer blooming species and *J. multiflorum* and *J. malabaricum* are winter blooming species. All four species emit fragrance; the highest concentration of volatile organic compounds that contribute to fragrance is noted during night time in summer bloomers and at noon time in winter bloomers (Barman and Mitra 2019). In *J. sambac, J.*

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auriculatum, J. grandiflorum and *J. multiflorum*, the terpenoid and benzenoid compounds predominate in the scent volatile chemical composition. This knowledge is important to elucidate the enzyme and genes responsible for the biosynthesis of fragrance in jasmines in order to improve scent quality in these species (Bera et al. 2015). Guitian et al. (1998) reported that *J. fruticans* is a distylous, self-incompatible species and its flowers are foraged by bees *Anthophora acervorum, Melecta* sp. and *Bombus pascuorum* in Spain. Dommee et al. (1992) reported that *J. fruticans* is frequently pollinated by a dipteran species of *Bombylius* in France. Thompson (2001) reported that *J. fruticans* is a distylous shrub in which there is a positive relation between the number of open flowers and the number of visits made by insects. A positive relationship exists between flower-visitation rate of short-tongued bees and the number of open flowers available. Hawkmoths and butterflies pay more visits to plants with larger flowers. The variation in flower-visitation rates by these different insect types as a function of floral design and display may function to diversify the selection on floral traits and constrain floral specialization to particular pollinators. Heiling and Herberstein (2004) reported that *J. mesnyi* produces two types of flowers, one with two productive stamens and the other with one productive stamen and one non-pollen producing petaloid stamen on the same plant. Fully rewarding flowers use visual or olfactory or both to lure flower visitors and accordingly honey bees have been found to prefer flowers with two productive stamens over the other flower type. Learn2grow (2016) mentioned that *J. multiflorum* flowers with a mild, sweet fragrance is pollinated by moths. Ganguly and Barua (2020) reported that *J. malabaricum* is heterostylous which is functional through distyly. In the studied populations of this species, both long and short-tyled morphs display equal fitness. Herkogamy is very prominent in the short-styled morph while reciprocity is prominent between long and short-styled anthers. This species is pollinated by long- and short-tongued pollinators. The pollination information stated above on *Jasminum* species studied indicate that there is paucity of information on many *Jasminum* species and there is a need to investigate the pollination ecology information in order to use the same for the cultivation of these species for their floral fragrance and also to improve scent quality for their commercial exploitation. With this backdrop, the present study is designed to describe the floral features, sexual system, pollination and pollinators of *J. angustifolium* and *J. cuspidatum*.

The genus Jasminum L. (Oleaceae) includes approximately 200 species, distributed in the tropical and warm temperate regions of the Old World [1, 2]. In India, the genus is represented by 47 species, three subspecies and four varieties, of which 16 species are endemic. The majority of the endemic species have been reported from Eastern and Western Himalaya, Deccan Peninsula, and Andaman and Nicobar Islands [3]. The genus has been subdivided into five sections viz. Unifoliolata, Alternifolia, Jasminum, Trifoliolata, and Primulina [4, 5]. There is much ambiguity within the sectional classification owing to frequent over-lapping of the species boundaries as well as phenotypic plasticity arising from the extensive reticulation of exo- morphological features (Fig. 1). Jeyarani et al. [6] also concluded in their work on Indian Jasmines that the morphology-based sectional classification is not monophyletic. This in-turn calls for an in-depth systematic analysis of the group, employing different marker systems.

2. MATERIALS AND METHODS

Jasminum angustifolium growing wild on the Andhra University campus and *J. cuspidatum* at Rushikonda surroundings in Visakhapatnam city, India were used for the study during June 2021-May 2022. Twenty inflorescences were tagged and followed to record the flower-opening schedule. The floral features were recorded in detail to record the sexual system and traits that constitute pollination syndrome. The flowers were examined to record whether they produce nectar or not, if so its placement in the flower. The timing of flower visitors at the flowers for forage collection was noted and also the role individual insect species in effecting pollination is also recorded. Based on the foraging activity and flower probing, the pollination aspect was described.

3. RESULTS AND DISCUSSION

Jasminum angustifolium is a deciduous climber which stays leafless during summer season and displays leaf flushing, flowering and fruiting during wet season from June/July to October (Figure 1a,b). The leaves are borne in opposing arrangement. The inflorescence is a cyme bearing 3-4 flowers and also also produces solitary at the ends of branchlets; the flowers are open late afternoon from 1630 to 1830 h. The anther dehiscence occurs by longitudinal slits. The flowers are white, sweet scented, dimorphic with thrum and pin type. Individual plants produce either thrum or pin type morphs but not both. In pin flower morph, the style extends beyond the height of stamens and even protrudes out of the corolla tube while in thrum flower morph, the style is short and placed below the height of stamens. The calyx is green, campanulate with 5-7 lobes and minutely puberulent on inner side. The corolla is white, funneliform with 6-9 narrow and acute lobes. The stamens are 2, with short filaments and dorsifixed introrse anthers and epipetalous. The ovary is bicarpellary and bilocular and each locule with 2 ovules. The style is filiform and tipped with a capitate stigma. Nectar is secreted in minute volume and is placed around the ovary inside the narow corolla tube. The fruit is a berry which is black when ripe.

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Figure 1 a. & b. *Jasminum angustifolium* in flowering phase, c-e. *Jasminum cuspidatum* – c. Flowering phase, d. Flower, e. *Xylocopa latipes* in mating - robs nectar by puncturing the corolla base.

J. cuspidatum is an erect evergreen woody shrub with glabrous somewhat climbing stem. The leaves are lanceolate with rounded base and pointed at apex. The flowering occurs during March-December with concentrated flowering from March to June (Figure 1c). Mature buds are pink in appearance and open during late evening emitting sweet fragrance (Figure 1d). The flowers are pedicellate, fragrant, nectariferous, dimorphic with long and short-styled flowers, borne in leaf-axils and also at branch-tips; they are produced in few-flowered sessile cymes. The calyx tube is green, campanulate, hairless and lobed. The corolla is fragrant and tubular with 6-7 pointed white lobes; the corolla tube is either pink or white The stamens are 2 or 3 with 2-stamened flowers as most common. The pistil is exerted and slightly extend out of the corolla throat. The ovary is bilocular with linear style and slightly divided clavate stigma. The nectar is placed around the ovary inside the base of the corolla tube. The fruit is a ovoid and glabrous berry.

Shrivastava et al. (2011) reported that *Jasminum* flowers are evening and night blooming and pollinated by only a single hawkmoth species. These authors also noted that ants occur as resident foragers and there is no possibility for them to collect nectar due to long and narrow corolla tube and deeply seated nectar. Different authors reported on the floral features, sexual system and pollinators of *J. fruticans*. This species is foraged by bees (Guitian et al. 1998), pollinated by *Bombylius* fly (Dommee et al. 1992) and short-tongued bees, hawkmoths and butterflies (Thompson 2001). *J. mesnyi* lures honeybees with visual and olfactory cues to its flowers which offer different levels of pollen reward due to production of two productive stamens in some flowers and one productive stamen in some other flowers on the same plant. *J. multiflorum* is pollinated by moths only (Learn2grow 2016). *J. malabaricum* is pollinated by long- and short-tongued insects (Ganguly and Barua 2020).

Solomon Raju (1988) reported that *J. angustifolium* is bimorphic with pin and thrum flower morphs producing on separate plants. The flowers receive visits from the diurnal hawkmoth, *Macroglossum gyrans* as soon as the flowers are open in late afternoon and visit them until sunset and again it visits the flowers at dawn hours on the following day for nectar collection. Other insects consisting of butterflies, the digger bee *Amegilla* and the fly *Musca* sp. visit the flowers only on the following day; of these, the butterflies collect only nectar while the bee and the fly only pollen. The pollen collecting foragers do not have access to deeply seated nectar inside the long and narrow corolla tube in both pin and thrum flower morphs. Further, these foragers collect pollen only from pin flower morphs. All butterflies collect nectar easily from both pin and thrum flower morphs due to their long proboscis. Field observations in this study indicated that in both *J. angustifolium* and *J. cuspidatum*, the sphingid diurnal hawkmoths, *Macroglossum gyrans* and *Cephonodes hylas* visit the distylous flowers as soon as the flower-opening occurs in the evening and continue their nectar collection activity until sunset. Again, the following day, they visit flowers during dawn hours and then disappears. The bee species, *Xylocopa latipes* occasionally visits both thrum and pin flower morphs indiscriminately but it could

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collect pollen only from pin flower morphs. This bee rarely tried to rob nectar from the corolla base by making puncture at the lower half of the corolla tube but it is not clearly known whether it is able to collect nectar illegitimately. This bee uses the flowering branches of *J. cuspidatum* for copulation and the fragrant flowers appear to serve as a cue for this bee to indulge in mating activity (Figure 1e). Further, this bee never displayed its mating activity on the flowering branches of *J. angustifolium* despite the fact that this plant also produces fragrant flowers. The absence of mating activity on this plant could be attributable to the weak climbing herbaceous branches which are not ideal for landing by this bee which is large-bodied whereas the woody stem of *J. cuspidatum* is quite ideal for this bee for landing and indulging in mating activity.

The present study indicated that *J. angustifolium* growing in the wild habitats is regularly visited during its flowering season by locals to collect its sweet fragrant flowers which are subsequently used for making garlands and/or strings of flowers for hair adornments by women and also in religious offerings or rituals. *J. cuspidatum* has limited distribution in the study area and locals do not have any knowledge about this species for using its flowers in the way used in case of *J. angustifolium*. Therefore, the study warrants for detailed field studies on floral biology, sexual system, breeding system, pollination, pollinators and fruiting ecology of all species assigned to *Jasminum* genus for subsequent use in the cultivation of its species with highly fragrant flowers and also to improve scent quality for commercial exploitation and provide livelihood opportunities in rural areas.

4. CONCLUSIONS

J. angustifolium is a herbaceous vine while *J. cuspidatum* is a woody vine. In both species, the flowers are hermaphroditic, dimorphic, distylous, fragrant and nectariferous. They attract only the diurnal hawkmoths on the day of anthesis due to the occurrence of flower-opening during late evening hours and the flowers attract the same visitors again during dawn hours on the following day. The hawkmoths cease their nectar-feeding activity after sunrise hours but the carpenter bee, *Xylocopa latipes* begins its pollen and nectar-feeding activity occasionally; it could collect pollen only from pin flowers by legitimate probing whereas this bee resorts to nectar-robbing by making punctures at the lower half of the corolla tube but it is known whether it successful to gather nectar or not. *J. angustifolium* flowers are highly fragrant than *J. cuspidatum* flowers; the former are used for hair adornments by women and also in religious offerings or rituals.

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Both authors contributed equally.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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