REPORT

Vol. 21, Issue 68, 2020

ISSN 2319–5746 EISSN 2319–5754

Species

Carpenter bee pollination in the Purple Orchid Tree, *Bauhinia purpurea* L. (Sub-family Cercidoideae: Family Fabaceae)

Ch. Bhaskara Rao

Department of Botany, Government College for Women (A), Guntur -522 001, Andhra Pradesh, India

✉**Corresponding author**:
Ch. Bhaskar Rao, Mobile: 91-7981805830, India; email: cheedellab.rao@gmail.com

Article History
Received: 23 May 2020
Accepted: 28 June 2020
Published: July 2020

Citation
Ch. Bhaskara Rao. Carpenter bee pollination in the Purple Orchid Tree, *Bauhinia purpurea* L. (Sub-family Cercidoideae: Family Fabaceae). *Species*, 2020, 21(68), 244-248

General Note
Article is recommended to print as color digital version in recycled paper.

ABSTRACT

Bauhinia purpurea is a medium-sized semi-evergreen tree species and seasonal bloomer. The flowers are typically caesalpinaceous and display hermaphroditism, dichogamy and nototribic pollination. Carpenter bees are exclusive pollinators of this plant and they effect nototribic pollination which is known for precision and economy in pollen transfer and promote cross-pollination by their swift-flying and nectar collection consistently throughout the flowering season by exhibiting flower fidelity. Other bees and butterflies occasionally visit the flowers but the former category act as nectar and pollen robbers while the latter category as nectar robbers.

Keywords: *Bauhinia purpurea*, hermaphroditism, dichogamy, nototriby, carpenter bees.

1. INTRODUCTION

Large carpenter bees of the genus *Xylocopa* (Family Apidae, Subfamily Xylocopinae and Tribe Xylocopini) are the most prominent members of the Indian bee fauna. They are very robust solitary bees with male and female individuals. Since they are very large, they have high energy expenditure and accordingly collect ample forage from their food plants in order to balance flight energy expenditure, body energy maintenance by both male and female bees and additionally food energy stored by female bees in their nests (Chappel 1982). The bees prefer medium-sized flowers but also use large-sized flowers, if available, accessible and rewarding by exhibiting flower fidelity (Dafni et al. 1997). Flower shape and symmetry are important for carpenter bees to make visits and subsequently exhibit flower fidelity (Solomon Raju and Purnachandra Rao 2006). In Visakhapatnam region, carpenter bees, *X. latipes* and *X. pubescens* utilize only thirty plant species as their nectar and/or pollen sources despite the presence of four hundred and forty two plant species in the area, indicating that the flowers they use are specialized with specialized nectar and pollen contents. Further, these bees are multivoltine if ample food resources are available throughout the year, if not, they are either bivoltine or univoltine depending on the availability of their forage plants at different times of the year (Solomon Raju and Purnachandra Rao 2006).

The flowers of caesalpinioid trees possess an open format in which nectar and pollen are easily accessible to both specialized and non-specialized pollen vectors (Arroyo 1981). The genus *Bauhinia* with 300-350 morphologically distinct species is one of the largest and most diversified pantropical genera in the sub-family Caesalpinioidea of the family Fabaceae (Sinou et al. 2009). *Bauhinia* spp. display a wide variety of pollination systems such as chiropterophily (Bobrowiec and Oliveira 2012), bees and hummingbirds (Santos et al. 1993), butterflies (Hokche and Ramirez 1990) and moths (Silberbauer-Gottsberger and Gottsberger 1975; Hokche and Ramirez 1990; Munin et al. 2008). Further, some species of this genus also show mixed pollination by bees and sphingid moths (Hokche and Ramirez 1990).

In India, Ali (1993) reported that *Bauhinia racemosa* and *B. purpurea* have been reported to be pollinated by birds. Solomon Raju et al. (2004) reported that *B. purpurea* shows variation in the number and size of stamens. Further, these authors also noted the presence of fertile and sterile stamens with the latter type evolved to meet the pollen requirement by honey bees and stingless bees. Solomon Raju et al. (2008) reported that *B. variegata* is pollinated bees and passerine birds. In this study, the floral biology of *B. purpurea* producing only 3-stamened flowers with reference to carpenter bee pollination has been reported and discussed in the light of relevant works.

2. MATERIALS AND METHODS

Ten *Bauhinia purpurea* trees growing wild in near Amaravathi road in Guntur District (Latitude 16° 27' N and Longitude 80°20' E), Andhra Pradesh, India, were used for the present study during October-December 2018 and 2019. Field visits were made at weekly intervals during this period to record flowering season and make observations on floral biology and foragers with reference to pollination. Twenty inflorescences were tagged to record flower-opening schedule and anther dehisce time and mode. Ten flowers were used to note whether they were nectariferous or not. After determining the presence of nectar, attempts were made to measure nectar volume but failed due to production of nectar in traces at flower level. The floral characters were examined to understand the sexual system and pollination system. Pollen output per anther and flower and stigma receptivity duration were recorded using the protocols described in Dafni et al. (2005). The flower visitors collecting pollen and nectar were recorded and identified. Further, the regularity and consistency of foragers were also separately observed to state the principal pollinators. Body washings of two regularly and consistently foragers, *Xylocopa latipes* and *X. pubescens* (carpenter bees) were done to record the pollen carryover efficiency and its role in pollination. For this purpose, ten bees of each species were captured from the flowers at 1100-1200 h, brought to the laboratory, washed in ethyl alcohol, stained with aniline-blue on a glass slide and observed under microscope to count the number of pollen grains present. From this, the range in the number of pollen grains carried by each bee species was calculated to know the pollen carryover efficiency. All other foragers were not captured since they were occasional and found to have negligible and no role in pollination.

3. OBSERVATIONS

Bauhinia purpurea is a medium-sized semi-evergreen tree species which blooms seasonally during October-February. Individual trees bloom for an average period of 63 days (Range 44-87). The inflorescence is variable, it is either a raceme with few flowers or a panicle with a mean number of 43 flowers (Range 35-45) borne in axillary and terminal position of the branches. The flower buds are clavate and angled towards the apex. The mature buds open completely in a very short time during 0400-0600 h. During anthesis process, the staminal filaments are curved upwards. The anthers dehisce by longitudinal slits approximately 30 minutes prior to

anthesis. The style positions itself horizontally and gradually moves downwards to keep away from the dehisced anthers until noon and thereafter it moves back attaining the position of stamens and receptivity to pollen by which time the anthers are almost empty and free from pollen grains during post-anthesis period. The stigma receptivity extends until the evening of the 2nd day of the flower life and at this time the flower is exclusively in female phase. The flowers are pedicellate, large, fragrant, bisexual, zygomorphic, attractive and nectariferous (Figure 1a). The calyx is 2-lobed, one lobe with 2 teeth and another with 3-toothed, and opens as a spathe during anthesis to expose corolla and the sex organs. The corolla is pink to purple with five petals, the posterior part of the corolla is with three free narrow petals while the anterior part of the corolla is with two free broad petals. The stamens are 3, free and the anthers produce tricolpate, ornamented and 82.35-93.65 µm size pollen grains. Individual anthers produce an average number of 21,986 pollen grains (Range 18,568-25.290) of which about 3.2% are sterile and all the remaining ones are fertile. The pollen grains produced against a ovule is approximately 5,498. The ovary is monocarpellate, monolocular, compressed, grooved with 12 ovules arranged on marginal placentation, the style is simple, 40-50 mm long with peltate to capitate stigma.

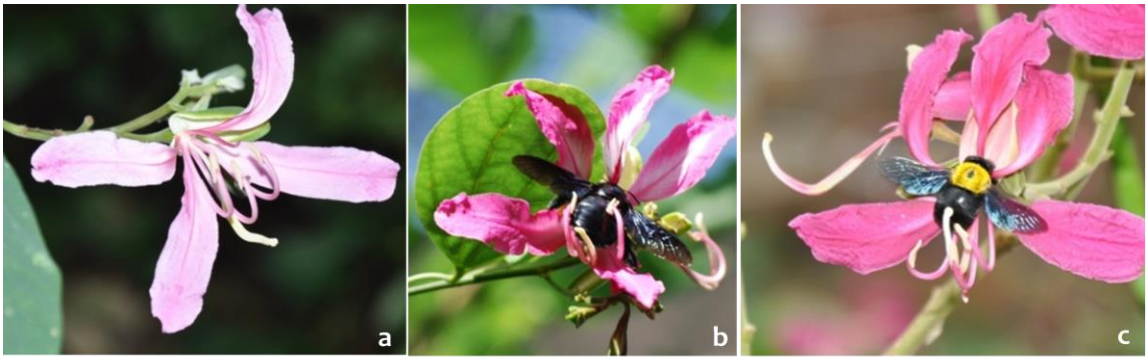

Figure 1. *Bauhinia purpurea*: a. Flower, b. *Xylocopa latipes* collecting nectar, c. *Xylocopa pubescens* collecting nectar.

The foragers were found to visit the flowers during daytime from 0730 to 1700 h. They visited both fresh and 1-day old flowers indiscriminately. The foragers included bees and butterflies. The bees were *Xylocopa latipes* (Figure 1b), *X. pubescens* (Figure 1c), *Amegilla* sp., *Ceratina simillima*, and *Trigona iridipennis* while the butterflies included *Papilio polytes* (Papilionidae), *Danaus chrysippus, Euploea core* (Nymphalidae) and *Borbo cinnara* (Hesperiidae). Among bees, only *Xylocopa* spp. were regular and consistent foragers for nectar collection while all other bees foraged occasionally for nectar and pollen collection. All butterflies were also occasional foragers for nectar collection. *Xylocopa* bees were large-bodied and approached the flowers in upright position, landed on staminal filaments and the stylar portion prior to probing the corolla base for nectar collection. Then, they inserted their tongues into the nectary part of the corolla to collect nectar during which their dorsal side had definite contact with the dehisced stamens and receptive stigma resulting in pollination. During forenoon period, the stigma stood away from the anthers and occupied the position of anthers by early afternoon in day-1 flowers; this positional shift resulted in contact by *Xylocopa* bees only with the anthers in the forenoon period during which anthers were with full of pollen and also with stigma during afternoon period of day-1 as well as day-2 flowers. This positional shift of style in the flowers contributed to pollen transportation by visiting *Xylocopa* bees to other flowers without any pollination in the forenoon period and with pollination in the afternoon period of day-1 flowers and day-long in day-2 flowers. The body washings of *Xylocopa* bees captured from flowers for pollen recovery showed that the pollen grained recovered from *X. latipes* varied from 65 to 730 and from *X. pubescens* varied from 113 to 532. The body washings for other bees and butterflies were not done due to their occasional foraging visits to the flowers. All other bees were either medium-sized or small-sized ones and their visits for nectar collection never contributed to contact with either anthers or the stigma making them as nectar robbers. Further, they used the staminal filaments to move towards the anthers to collect pollen during which also there was no contact between them and the stigma making them as pollen robbers. Since their visits were occasional, the forage depletion rate as forager robbers was considered to be minimal and negligible. Among butterflies, the papilionid and nymphalids had contact with both anthers and stigma with their wings during nectar collection effecting pollination but their role as pollinators was negligible due to their occasional foraging activity.

4. DISCUSSION

In the genus *Bauhinia,* different pollination systems such as chiropterophily (Bobrowiec and Oliveira 2012), melittophily, ornithophily (Santos et al. 1993), psychophily (Hokche and Ramirez 1990), sphingophily (Silberbauer-Gottsberger and Gottsberger 1975; Hokche

and Ramirez 1990; Munin et al. 2008) and a combination of both melittophily and sphingophily (Hokche and Ramirez 1990) have been reported. Previously, *B. racemosa* and *B. purpurea* have been reported to be ornithophilous (Ali 1993). In *B. purpurea*, the existence of variation in the size and number of stamens, and also of the production of fertile and sterile stamens of which the latter is intended to feed the pollen collecting honey bees and stingless bees to manage the availability of fertile pollen for the actual pollinators (Solomon Raju et al. 2004). *B. variegata* has been reported to be both melittophilous and ornithophilous (Solomon Raju et al. 2008). In the present study, it is found that *B. purpurea* is hermaphroditic, dichogamous with marked protandry, the function of which facilitates the promotion of cross-pollination with which the plant produces fruits with viable and quality seeds (Proctor and Yeo 1972; Bawa and Beach 1981). Further, the extension of duration of stigma receptivity until the evening of the 2nd day in *B. purpurea* clearly indicates that the plant is preferentially out-crossing. But, andromonoecy has been reported in the allied species, *B. pauletia* (Heithaus et al. 1974) and *B. benthamiana* (Ramirez et al. 1984). Further, *B. purpurea* shows anthesis during early morning hours and produces traces of nectar as evidenced in the present study. But, in *B. pauletia* and *B. benthamiana*, the flowers open at dusk and produce a large volume of nectar (Heithaus et al. 1974; Ramirez et al. 1984). Solomon Raju et al. (2008) reported that *B. variegata* shows morning anthesis and produces a small volume of nectar. The differences in anthesis schedules of these *Bauhinia* species are reflected in the class of pollinators. Phyllostomatid bats are the pollinators in *B. pauletia* and B. *benthamiana* (Heithaus et al. 1974; Ramirez et al. 1984) bees and passerine birds in *B. variegata* (Solomon Raju et al. 2008) and carpenter bees in *B. purpurea* as observed in the present study.

The present study shows that *B. purpurea* with its pink attractive flowers is highly specialized for carpenter bees which utilize its nectar by exhibiting fidelity until the cessation of its flowering. The body size of these bees is a perfect fit to probe the flower for nectar collection as a consequence of which nototribic pollination occurs. In this mode of pollination, the stigma and pollen strike the back of the probing bee resulting in pollination. Further, this mode is known for precision and economy in pollen transfer and pollination as the bee is not able to groom its back to clear the pollen deposited area, and hence is reckoned as an advanced pollination mechanism (Faegri and van der Pijl 1979). The plants evolved for nototribic pollination mechanism are expected to produce flowers that minimize pollen production. But, *B. purpurea* with nototribic pollination produces more pollen per anther/flower and hence does not comply with this expectation. Such high pollen production could be a selective pressure (Cruden 1976) that has evolved over a period of time to compensate the pollen loss by pollen robbing bees which constitute all bees other than carpenter bees recorded in this study. Further, the production of traces of nectar by *B. purpurea* might also be strategy to avoid nectar-robbing bees and also butterflies which have limited pollen carrying capacity with their nectar collection behavior on this plant in order to protect nectar for the actual pollinators and save pollen source and increase pollination rate by carpenter bees. Therefore, *B. purpurea* with specialized pollination mechanism is adapted for carpenter bee pollination.

5. CONCLUSION

Bauhinia purpurea is a semi-evergreen tree species and seasonal bloomer. The flowers are typically caesalpinaceous and produce traces of nectar and ample pollen; their sex organs display specialized orientation due to the function of dichogamy and achieve nototribic pollination by highly efficient and more pollen carrying carpenter bees. Nototribic pollination mechanism evolved in this species is intended for precision and economy in pollen transfer and promote cross-pollination by swift-flying and nectar collecting carpenter bees. Other bees that use the flowers occasionally act as pollen and nectar robbers while butterflies that visit the flowers occasionally act as nectar robbers only.

Funding

This research received no external funding.

Conflict of interest

No potential conflict of interest regarding the manuscript.

REFERENCE

1. Ali, S. 1993. Flower-birds and bird-flowers in India. J. Bombay Nat. Hist. Soc. 35: 573-605.
2. Arroyo, M.T.K. 1981. Breeding systems and pollination biology in Leguminosae. In: Advances in Legume Systematics, R.M. Polhill and P.H. Raven (eds.), pp. 723-769, Kew, London.
3. Bawa, K.S. and Beach, J.H. 1981. Evolution of sexual systems in flowering plants. Ann. Mo. Bot. Gard. 68: 254-257.
4. Bobrowiec, P.E.D. and Oliveira, P.E. 2012. Removal effects on nectar production in bat-pollinated flowers of the Brazilian cerrado. Biotropica 44: 1-5.

5. Chappel, M.A. 1982. Temperature regulation of carpenter bees (Xylocopa californica) foraging in the Colorado desert of southern California. Physiol. Zool. 55: 267-280.
6. Cruden, R.W. 1977. Pollen-ovule ratios: a conservative indicator of breeding systems in the flowering plants. Evolution 31: 32-46.
7. Dafni, A., Lehrer, M. and Kevan, P.G. 1997. Spatial flower parameters and insect spatial vision. Biol. Reviews 72: 239-282.
8. Dafni, A., Kevan, P.G. and Husband, B.C. 2005. Practical Pollination Biology. Enviroquest Ltd., Ontario, 583pp.
9. Faegri, K. and van der Pijl, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
10. Hokche, O. and Ramirez, N. 1990. Pollination ecology of seven species of Bauhinia L. (Leguminosae, Caesalpinioideae). Ann. Mo. Bot. Gard. 77: 559-572.
11. Heithaus, E.R., Opler, P.A. and Baker, H.G. 1974. Bat activity in pollination of Bauhinia pauletia: plant-pollinator coevolution. Ecology 55: 412-419.
12. Munin, R.L., Teixiera, R.C. and Sigrist, M.R. 2008. Esfingofilia e sistema de reproducao de Bauhinia curvula Benth. (Leguminosae: Caesalpinoideae) em cerrado no Centro-Oeste brasileiro. Revista Brasilieira de Botanica 31: 15-25.
13. Proctor, M. and Yeo, P. 1972. The pollination of flowers. Taplinger Publishing Company, New York.
14. Ramirez, N., Sobrevila, C., De Enrech, N.X. and Ruiz-Zapata, T. 1984. Floral biology and breeding system of Bauhinia benthamiana Taub. (Leguminosae), a bat pollinated tree in Venezuelan "Llannos". Am. J. Bot. 71: 274-280.
15. Santos, G.M.T., Machado, V.L.L. and Giannotti, E. 1993. Visitantes florais de Bauhinia variegata L. (Leguminosae, Caesalpiniaceae). Revista Brasilieira de Entomologia 37: 737-750.
16. Silberbauer-Gottsberger, I and Gottsberger, G. 1975. Uber sphingophile Angiospermen Brasiliens. Plant Syst. Evol. 123: 157-184.
17. Sinou, C., Forest, F., Lewis, G.P. and Bruneau, A. 2009. The genus Bauhinia s.l. (Leguminosae): a phylogeny based on the plastid trnL-trnF region. Botany 87: 947-960.
18. Solomon Raju, A.J. and Purnachandra Rao, S. 2006. Nesting habits, floral resources and foraging ecology of large carpenter bees (*Xylocopa latipes* and *Xylocopa pubescens*) in India. Curr. Sci. 90: 1210-1217.
19. Solomon Raju, A.J., Purnachandra Rao, S. and Sree Durga, V. 2004. On stamen number and size in Bauhinia purpurea: a reply to S. Bandyopadhyay. J. Bombay Nat. Hist. Soc. 101: 477.
20. Solomon Raju, A.J., Purnachandra Rao, S. and Jonathan, K.H. 2008. Pollination biology of the Orchid Tree Bauhinia variegata L. (Caesalpiniaceae) in the Eastern Ghats, India. J. Bombay Nat. Hist. Soc. 105: 115-118.