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Flowering and flower-visitors of deciduous plant species in the dry deciduous forest ecosystem in Andhra Pradesh

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ABSTRACT

The dry deciduous ecosystem harbors only a few tree species but supports a luxuriant growth of grasses during wet season. This ecosystem is highly fire-prone during dry season. Wet season is important vegetative growth and late winter and entire dry season for flowering and fruiting in all tree species. *Croton scabiosus* is monoecious and displays anemophily, myrmecophily and thripsophily. All other tree species are bisexual and pollinated by bees and/or bats and birds. *C. scabiosus* also serves as a food plant for an unidentified butterfly and the larvae of this butterfly as a food plant for sunbirds.

Key words: Deciduous forest, trees, monoecy, hermaphroditism, anemophily, bees, ants, thrips, bats, sunbirds.

1. INTRODUCTION

Dry deciduous forests display characteristic environments and species traits which are different from evergreen forests. The traits displayed by trees in dry deciduous forests such as lower height to diameter ratios, leaves with lower specific leaf areas, higher wood densities and higher relative bark thickness (Ratnam et al. 2019) indicate that they grow slowly and adopt conservative strategies due to lower nutrient-environments and possibly less competitive ability. Seasonal water stress is highly pronounced in dry deciduous forests (Poorter and Bongers, 2006; Chave et al. 2009; Miatto and Batalha, 2017). Further, these forests burn more frequently and extensively than other forest types (Ratnam et al. 2019). As a consequence, plants display certain traits such as production of thick bark, the ability of healing fire scars, seed adaptations and re-sprouting capability (Khan and Tripathi 1986, 1989). In fact, forest fires are very common in the forests of India and most of them are human-made; the dry deciduous forests therefore are highly vulnerable to forest fires not only in India but also across the world (Murphy and Lugo, 1986). In India, dry deciduous forest types are dominant in certain pockets of south India. They have been investigated mainly for adaptive characters of plants with reference to water stress and forest fires. Since there is negligible information on the phenology and sexual reproduction aspects of plants

occurring in these forest types, the present has been contemplated to provide certain information on flowering season, sexual system and flower-visitors of some plant species occurring in dry deciduous forest in Kadapa District, Andhra Pradesh, because it is useful for future workers to take up further investigations on the reproductive ecology and regeneration aspects of plant species of this deciduous forest.

2. MATERIALS AND METHODS

Palakondalu Hill Range (14°28.39 N Lat. and 78°49.71 E Long.) (Figure 1a) and Idupulapaya Reserve Forest (14°19.418 N Lat. and 78°31.468 E Long.) (Figure 1b) in Kadapa District, Andhra Pradesh, India were selected for the study during 2018-2020. These two sites are situated 50 km apart. These two forest sites typically represent dry deciduous type with rocky and gravel terrain consisting of scattered occurrence of deciduous plant species, especially trees dominated by C4-grass growth, especially during wet season. A field survey was made to note important plant species distributed in this forest type. After the survey, these plant species were observed continually to record the flowering season. During flowering season, the flowers of each plant species were collected to record the functional sexual system and the flower visitors that use them as food source. Field observations coupled with the recorded information were evaluated to provide the true situation of the reproductive status of these plant species.

3. RESULTS

The dry deciduous forest investigated in this study is of open type and well exposed to direct sunlight. This forest typically represents drought conditions and experiences frequent fires which are mostly human-made, especially during dry season. The forest consists of scattered occurrence of a few tree species which are in principle deciduous nature and display water stress traits. Among trees, *Cleistanthus collinus*, *Pterocarpus santalinus* and *Gardenia* species occur relatively in good numbers when compared to other tree species. During wet season, the terrain is densely covered with C4 grass species but with the approach of winter season, the grasses gradually show signs of withering and finally wither away during dry season. But, the dry aerial stalks and above ground root system persist and cause escalation of fire during dry season. The seeds of flowering plants usually sprout from the cracks, crevices and caves of the rocky terrain or open areas of gravel rocks during rainy season. But, the continued growth and development of seedlings from natural germination depends on the availability levels of nutrients and moisture around seeding environment.

In this forest, *Mimosa intsia* is a straggler growing throughout the year in areas where soil availability is relatively more in the rocky terrain. It blooms year-long with profuse flowering during wet season. All other species are trees and bloom for two seasons which typically represent dry season followed by winter season. In wet season, sporadic flowering occurs in *Maerua apetala*, *Cochlospermum religiosum*, *Cleistanthus collinus* and *Ochna obtusata*. However, even this flowering is subject to precipitation levels during wet season (Table 1). This pattern of flowering indicates that these trees use wet season for leaf flushing, production of photosynthate and storage of resources for use during flowering and fruiting phase.

All plant species except *C. collinus* are hermaphroditic while *C. collinus* is monoecious; all are nectariferous and nectar is measurable in all of them except *M. intsia* which produces only traces of nectar. Bats forage for nectar and/or pollen of *Ceiba pentandra* and *Gardenia* species during night time. During day time, all plant species were foraged consistently by bees, *Boswellia serrata* also by butterflies and *Maerua apetala* and *Gardenia latifolia* also by birds (Table 1; Figure 2a-e, Figure 3c-i). In *C. scabiosus*, the inflorescence is a terminal simple raceme consisting of female flowers at the base and male flowers above them (Figure 2f,g). But, some inflorescences bear either male or female flowers but not both. The male and female flowers are sepalous but they are small in the former sex while they are larger in the latter sex. The male flowers are petaliferous and nectariferous while female flowers are apetaliferous and nectarless. All the three types of inflorescences flower synchronously and acropetally; this pattern of flower production facilitates the occurrence of geitonogamy. The floral characters in *C. scabiosus* indicate that it is typically anemophilous. But, *Camponotus* ants use nectar of female flowers as resident foragers and in search of nectar, they invariably visit male flowers effecting pollen transfer and pollination. Further, the flowers are breeding and feeding sites for *Haplothrips* sp. (Thysanoptera: Thripidae); their feeding on pollen and nectar of male flowers and indiscriminate visits to both male and female flowers on the same plant contribute to self-pollination (geitonogamy) (Table 1). The sunbirds, *Nectarinia asiatica* and *N. zeylonica* collect instar stages of larva of a butterfly species from the leaves of *C. scabiosus* as a source of food (Figure 3a,b). These birds were regular and busily engaged in the collection of the butterfly larvae during flowering season. As this plant is available in considerable population size, the sunbirds used this as an important source of solid food, especially during dry season because this is the only plant species which displays both new foliage and flowering simultaneously. The sunbirds never visited the flowering inflorescences of this plant although male flowers provide nectar in traces which is a valuable liquid source during dry season.

Table 1. Flowering season and foragers of deciduous plant species of a deciduous forest ecosystem in Kadapa District, Andhra Pradesh

Family	Plant species	Habit	Study sites		Flowering season	Foragers
			Palakondalu	Idupulapaya		
Burseraceae	<i>Boswellia serrata</i> *	Deciduous tree	+	-	March-June	Bees, butterflies
Capparaceae	<i>Maerua apetala</i>	Deciduous tree	-	+	April -July	Bees, birds
Cochlospermaceae	<i>Cochlospermum religiosum</i> *	Deciduous tree	+	+	February-August	Bees
Euphorbiaceae	<i>Cleistanthus collinus</i> *	Deciduous tree	+	-	February-October	Bees
	<i>Croton scabiosus</i>	Deciduous tree	+	+	January-June September-October	Thrips, ants
Fabaceae	<i>Pterocarpus santalinus</i>	Deciduous tree	+	-	March-May	Bees
Bombacaceae	<i>Ceiba pentandra</i>	Deciduous tree	+	-	December-April	Bats, bees
Mimosaceae	<i>Mimosa intsia</i>	Deciduous straggler	+	-	Year-long	Bees
Ochnaceae	<i>Ochna obtusata</i>	Deciduous tree	+	-	March-July	Bees
Rubiaceae	<i>Gardenia gummifera</i>	Deciduous tree	+	+	December-May	Bats, bees
	<i>Gardenia latifolia</i>	Deciduous tree	-	+	December-May	Bats, birds, bees

*Leafless during flowering season; *Cleistanthus collinus*, *Pterocarpus santalinus* and *Gardenia* species represent consideration population while all other species represent a few individuals with scattered distribution.

**Figure 1.** a. Palakondalu site, b. Idupulapaya site.



Figure 2. a. & b. *Maerua apetala* flowers being foraged by the carpenter bee, *Xylocopa latipes*, b. *Maerua apetala* flowers being foraged by *Nectarinia asiatica* (sunbird), c. *Cochlospermum religiosum* flowering, d. *Cleistanthus collinus* mature buds being foraged by *Apis florea*, e. *Cleistanthus collinus* flowers being foraged by *Ceratina simillima*, f. *Croton scabiosus* female flowers at the bottom of the inflorescence, g. *Croton scabiosus* male flowers above female flowers on the same inflorescence.



Figure 3. a. & b. *Croton scabiosus* - *Nectarinia asiatica* (male) probing and finally picking up butterfly larva from the leaves, c. *Pterocarpus santalinus* flowers being foraged by rock honey bee, *Apis dorsata*, d. *Pterocarpus santalinus* flower being foraged by Indian honey bee, *Apis cerana*, e. *Ceiba pentandra* buds and flowers, f. *Ochna obtusata* flowering stage, g. *Ochna obtusata* flower being foraged by digger bee, *Anthophora* sp., h. *Gardenia latifolia* flower being foraged by carpenter bee, *Xylocopa latipes*, i. *Gardenia latifolia* flowers being foraged by *Nectarinia zeylonica* (sunbird).

4. DISCUSSION

Ratnam et al. (2019) stated that the suite of traits of dry deciduous forest type indicate the habitats of this forest type are represent open, well lit, drought- and fire-prone traits. In the present study, the forest sites representing dry deciduous type also represent similar traits. But, drought conditions are amplified by rocky terrain here. Further, fires are frequent during dry season, most of which occur due to human factor. The tree species use wet season primarily for vegetative growth and development. They use late

winter and the entire period of dry season for flowering and fruiting events. Such a pattern of phenological events is attributable to the resource environment under which these trees grow and also indicates the adaptability of these trees to the water and moisture stress conditions that exist in the area. The functionality of hermaphroditism and nectariferous flowers of trees except *C. scabiosus* indicate that they are mainly adapted for biotic pollinators. Bees play an important flower foragers-cum-pollinators for *B. serrata*, *M. apetala*, *C. religiosum*, *C. collinus*, *P. santalinus*, *M. intsia* and *O. obtusata* as they offer both pollen and nectar as floral rewards during dry conditions of the habitat. *B. serrata* also attracts butterflies while *M. apetala* attracts birds to its flowers. *C. pentandra*, *G. gummifera* and *G. latifolia* are, in principle, bat-pollinated but bees also pollinate while collecting the floral rewards. Further, *G. latifolia* attracts birds also to its flowers and the birds while collecting nectar contribute to pollination. In case of *C. scabiosus*, the floral characters such as the presence of terminal spiciform racemose inflorescence with small male flowers at the distal portion facilitating effective pollen dispersal by wind, light, non-sticky, spheroidal pollen grains with clavate ornamentation, and apetalous female flowers with reduced sepals and well exposed free styles and stigmas constitute anemophily (Faegri and van der, Pijl 1979; Webster, 1994). The open state of habitat facilitates pollen flow and the occurrence of anemophily. Additionally, nectar feeding activity by ants and thrips, and pollen feeding activity by thrips contribute to the occurrence of geitonogamy to the maximum extent and xenogamy to the minimum extent. An unidentified butterfly species uses *C. scabiosus* as its larval host plant. But, the larval instars present on the leaves of this tree attract sunbirds which use them as their food source. Therefore, *C. scabiosus* acts as an important food source for ants and thrips at flower level and as food source for butterfly larvae at leaf level, and the larvae in turn becomes food source for sunbirds, and hence acts as a keystone species in this deciduous ecosystem.

5. SUMMARY AND CONCLUSIONS

The dry deciduous ecosystem in the present study is favorable for a few tree species only but it is highly favorable for a luxuriant growth of grasses during wet season, the situation of which is attributed to water and nutrient stress conditions. The dry state of grass cover and also leafless state of trees during dry season is highly fire-prone and accordingly fires are frequent but the fire event is mostly human-made. The trees use wet season for vegetative growth while late winter and the entire dry season for flowering and fruiting. All trees recorded except *Croton scabiosus* are hermaphroditic and pollinated by animals which include bees, bats and birds with the first category as the important pollinator class. *C. scabiosus* is monoecious and pollinated by wind, ants and thrips; it also serves as a food plant for an unidentified butterfly and the larvae of this butterfly as a food plant for sunbirds. Therefore, the trees in this dry deciduous ecosystem are typically adapted for biotic pollination.

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Authors contributions

All authors contributed equally.

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Ethical approval

The ethical guidelines for plants & plant materials are followed in the study for species collection & identification.

Conflicts of interest:

The authors declare no conflict of interest.

Data and materials availability

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

REFERENCES AND NOTES

1. Chave, J., Coomes, D., Jansen, S., Lewis, S.L., Swenson, N.G. and Zanne, A. 2009. Towards a worldwide wood economics spectrum. *Ecol. Lett.* 12: 351-366.
2. Faegri, K. and L. van der Pijl. 1979. *The principles of pollination ecology*. Second Edition. Pergamon Press, Oxford.
3. Khan, M. L. and Tripathi, R.S. 1986. Tree regeneration in a disturbed sub-tropical wet hill forest of north-east India: effect of stump diameter and height on sprouting of four tree species. *Forest Ecol. Manag.* 17: 199-209.
4. Khan, M.K. and Tripathi, R.S. 1989. Effects of stump diameter, stump height and sprout density on the sprout growth of four tree species in burnt and unburnt forest plots. *Acta Oecol.* 10: 303-316.
5. Miatto, R.C. and Batalha, M.A. 2017. Are the cerrado and seasonal forest woody forest floras assembled by different processes despite their spatial proximity? *J. Plant Ecol.* 11: 740-750.
6. Murphy, P.G. and Lugo, A.E. 1986. Ecology of tropical dry forest. *Ann. Rev. Ecol. and Syst.* 17: 67-88.
7. Poorter, L. and Bongers, F. 2006. Leaf traits are good predictors of plant performance across 53 rain forest species. *Ecology* 87: 1733-1743.
8. Ratnam, J., Chengappa, S.K., Machado, S.J., Nataraj, N., Osuri, A.M. and Sankaran, M. 2019. Functional traits of trees from dry deciduous "forests" of southern India suggest seasonal drought and fire are important drivers. *Frontiers Ecol. and Evol.* 7: 1-6.
9. Webster, G.L. 1994. Classification of the Euphorbiaceae. *Ann. Missouri Bot. Gard.* 81: 3-32.