



RESEARCH ARTICLE

Phenology of the Genus *Crotalaria* L. (Fabaceae-Papilionoideae) of Holalkere, Hosadurga and Chitradurga Taluks of Chitradurga District, Karnataka, India

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Abstract

The present study describes detailed distribution of the genus *Crotalaria* L. in a natural habitat. This research is carried out by extensive field survey and observation across all the 3 taluks of Chitradurga, area is botanized for *Crotalaria* species in all seasons and critically analysed the phenological features of all the documented species during the study period 2018-2021. We have recorded 11 species of *Crotalaria*, *Crotalaria calycina* Schrank., *Crotalaria globose* Wight & Arn, *Crotalaria goreensis* Guill. & Perr., *Crotalaria hebecarpa* (DC.) Rudd. *Crotalaria juncea* L., *Crotalaria orixensis* Willd., *Crotalaria pallida* Aiton., *Crotalaria prostrata* Willd., *Crotalaria pusilla* DC., *Crotalaria retusa* L., and *Crotalaria varicosa* Polhill. Data obtained through this research is the basis for the study of further characterisation of *Crotalaria* species; this research describes the importance of phenology in taxonomy and the behaviour biology of the *Crotalaria* species, as they are economically important group.

Keywords

Phenophases, Papilionoideae, Taxonomy, *Crotalaria*, Chitradurga

Introduction

Phenology is a branch of biology that studies the effects of seasons, climates and species on each other. The leafing, blooming and fruiting seasons of plants are timed to coincide with the moulting, mating and migration of the animals they support. Charles Morrens, a Belgian botanist, coined the term Phenology in 1853 (1). In Phenology, as in all environmental studies, quantitative methodologies are used to measure and describe the occurrence of events and patterns in the natural world. It is very interesting to note that when phenophases occur, their duration, and the space of transitions between phenophases, and these observations can occur on a variety of biological and geographic scales (2).

Taxonomic History of the Genus Crotalaria L.

There are 147 Genera, 805 species, 33 subspecies, 155 variations and 14 forms in the Fabaceae family (3). *Crotalariaeae* (Benth.) Hutch. (Fabaceae) is the largest tribe in the genistoid alliance, with 16 genera and 1204 species (51 % of genistoid legumes). With 702 species, the genus *Crotalaria* L. accounts for more than half of the tribe's diversity (4). *Crotalaria* was initially described by Carolus Linnaeus, who identified 13 species in his Species

Plantarum (5). With 93 species, 1 subspecies, 17 variations and 2 forms in India (6, 7) undertook a systematic revision of Indian species and reported 58 *Crotalaria* species in the country. The common name "Rattlepod" or "Rattlebox" comes from the fact that as the seeds grow, they become free in the pod and make a rattling sound when the pod is shook. The name comes from the Ancient Greek word (Crotalon), which means "castanet," and is derived from the same root as the rattlesnake's name (Crotalus) (8) *Crotalaria* is a genus of herbaceous or shrubby plants with simple or palmately compound leaves, 3, 5, 7 leaflets, yellow flowers, stipules and bracts that can be small or large, calyx 5 lobed, somewhat 2 lipped; the upper lip 2 and the lower lip 3-cleft, calyx 5 lobed, somewhat 2 lipped; the upper lip 2 and the lower lip 3-cleft, calyx -5 lobed, Corolla: 2 superior in labium superior, 3 inferior in labium inferior, vexillum orbiculatum, 1 callosum, alae obovate, carina in curva, legume globosum, oblongum, inflated, filaments all joined The upper section of the sheath is generally cleft. Turgid legumes, ventricose valves, expanded seed, reniform (7).

In plantations, the genus *Crotalaria* is utilized as green manure and cover plants. They're also fed to livestock as a source of nutrition. Many of the species are known to be nodulated by soil Rhizobia and are also capable of fixing nitrogen from the atmosphere. Soil fertility management is crucial to achieving sustainable crop production and cover crops play a key role in soil fertility by reduction in synthetic nutrients applied (8). *Crotalaria* species having above significance, Hence, it is thought worthwhile to describe all the phenophases, which are basis for their taxonomical description and characterization and also impacts on variation with respect to climate and environmental changes in different periods.

Materials and Methods

During January 2018 to January 2021, a detailed phenological study of *Crotalaria* species in different types of forest, including Southern Tropical Dry Deciduous and Southern Tropical Thorn Forests, was conducted in 3 taluqs of Chitradurga district, Holalkere, Hosdurga and Chitradurga. The coordinates of Chitradurga district 14°13' 21.43" N latitude and 76° 24' 1.37" E longitude (10, 11) (Fig. 1). Ex-

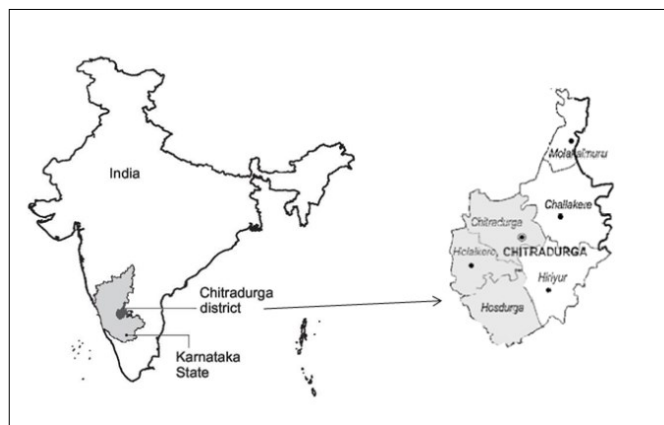


Fig. 1. A. Position of Chitradurga district ; B. Detailed map of study area.

tensive field visits were conducted during different seasons of the year to collect flowering and fruiting stages. Field data on habit, habitat, phenology and other relevant information was collected. *Crotalaria* species were collected from 3 taluqs of Chitradurga district for the phenological observation viz., *Crotalaria calycina* Schrank., *Crotalaria globose* Wight & Arn, *Crotalaria goreensis* Guill. & Perr., *Crotalaria hebecarpa* (DC.) Rudd. *Crotalaria juncea* L., *Crotalaria orixensis* Willd., *Crotalaria pallida* Aiton., *Crotalaria prostrata* Willd., *Crotalaria pusilla* DC., *Crotalaria retusa* L., *Crotalaria varicosa* Polhill, all the plant specimens were identified with the help of regional floras, monographs on legumes (3, 12, 13) and biodiversity checklist (14) Field visit was carried out periodically to note the changes in the phenophases of *Crotalaria* sp., photographs (Fig. 5) were also taken for every phases during field visits. The plants are collected from their natural habitats and maintained in the net house of Sahyadri Science College, Shivamogga, for further observation if they were available or not seeds are used. Here, all the parameters are categorized into 2 parts that are vegetative and reproductive characters. Vegetative phase includes the leafing period of the plant and reproductive is represented by the flowering and fruiting period of the plant (4). Herbarium was prepared as described (15). The specimens are preserved in the herbarium of the Sahyadri Science College in Shivamogga, Karnataka.

Results and Discussion

The genus *Crotalaria* are economically significant group, widely used in veterinary pharmacy, grown as intercropped to provide nitrogen to the crops through root-nodules (16). All documented species are economically important, they are found to contain alkaloids (17), and seeds as source of fibers, silage and green manure and oil can also be derived from some species (18). Hence, it was thought worthwhile to extend phenological observation of the taxon in the study area. The current investigation provided detailed report of phenophases (leafing, flowering, fruiting and leaf fall) occurring throughout the year.

In the present study, 11 species are documented from the study area. As shown in the Fig. 5, among the documented 11 species 6 were herbaceous species followed by undershrubs (5) which is 1.5% and 11.8 % respectively of the total *Crotalaria* herbaceous and undershrub species as appeared in India. Some *Crotalaria* species are habitat specific and found very rarely in India. *C. globose* Wight & Arn. is endemic to India (Tamil Nadu) (19) which is found as a rare species (13). *C. pusilla* Roxb. ex Wight & Arn., found to be growing on rocky and sandy areas is endemic to southern peninsular India (20). Study reveals that *C. hebecarp* and *C. prostrata* starts leafing, from the month of June and grows upto July, 3 *Crotalaria* species begins leafing from July and extends upto August (*C. juncea*, *C. pallida* and *C. varicosa*), *C. calycina* starts leafing in the month of August and extends upto September. *C. globosa*, a rare species starts plant starts producing leaf from October and extends upto November, in 2 *Crotalaria* species (*C. goreensis* and *C. orixensis*) germina-



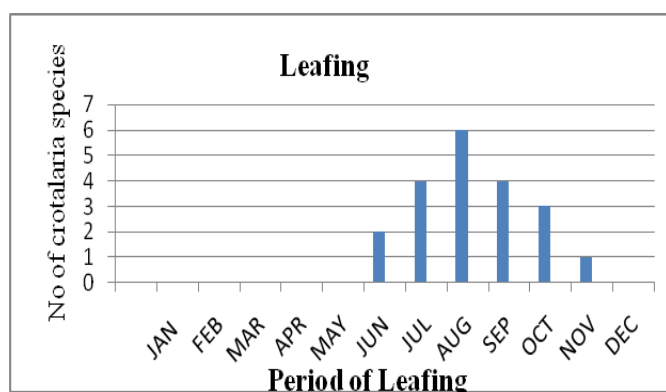
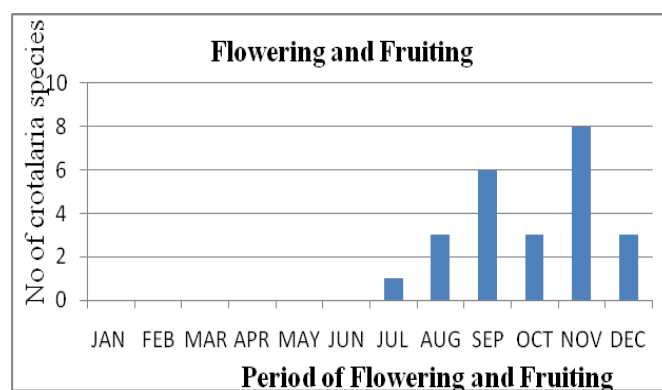
Fig 5. A. *Crotalaria varicosa*, B. *Crotalaria retusa*, C. *Crotalaria pusilla*, D. *Crotalaria pallida*, E. *Crotalaria prostrata*, F. *Crotalaria goreensis*, G. *Crotalaria orixensis*, H. *Crotalaria hebecarpa*, I. *Crotalaria calycina*, J. *Crotalaria juncea*, K. *Crotalaria globosa*.

tion, leaf production start in the month of September upto October, *C. pusilla* a rare plant found in mineral rich area starts leafing in the month of August while in *C. retusa* leafing observed from August to September (Table 1). The peak period of leafing is in the month of August. The leafing period found variable in the study area which is clearly mentioned in the Fig 2. Which describes changes and explains plasticity, intact related to photosynthetic ability, may be affected by seasonal changes and environmental changes.

Reproductive phase is an important phase of plant life cycle, since it is directly involve in the perpetuation of species, this phase is represented by flowering and fruiting, these two processes in plant life cycle takes place one after other. In the documented species of *Crotalaria*, flowering period start from the month of July upto December even though plants belong to the same genus, they are quite variable and found the variability among all 11 species in all phenophases, which is clearly documented in Table 1, In *C. hebecarpa* flowering observed in the month of July extends upto September, *C. pusilla* and *C. prostrata* flower-

Table 1. Phenology of the species under the genus *Crotalaria* L.

Sl. No.	Plant name	Habit	Voucher number	Native	Leafing	Flowering & fruiting	Leaf falling
1.	<i>Crotalaria calycina</i> Schrank	Herb	KKRCJ 040	Paleotropics	August-September	October-November	November-December
2.	<i>Crotalaria globosa</i> Wight & Arn.	Herb	KKRCJ 044	Peninsular India	October-November	November-December	December-January
3.	<i>Crotalaria gorensis</i> Guill. & Perr.	Under-shrub	KKRCJ 022	Tropical Africa & Australia	September-October	November-December	January-February
4.	<i>Crotalaria hebecarpa</i> (DC.) Rudd.	Herb	KKRCJ 038	South Asia	June-July	July-September	September-October
5.	<i>Crotalaria juncea</i> L.	Under-shrub	KKRCJ 022	South east asia and china	Jul-Aug	September-November	December-January
6.	<i>Crotalaria orixensis</i> Willd.	Herb	KKRCJ 024	East India	September-October	October-December	December-February
7.	<i>Crotalaria pallida</i> Aiton	Under-shrub	KKRCJ 031	Tropical Africa to Taiwan	July-August	September-November	December-January
8.	<i>Crotalaria prostrata</i> Willd.	Herb	KKRCJ 049	Indo-Malesia	June-July	August-September	October-December
9.	<i>Crotalaria pusilla</i> DC.	Herb	KKRCJ 041	India	August	August-September	September
10.	<i>Crotalaria retusa</i> L.	Under-shrub	KKRCJ 047	Tropics	August-September	October-November	November-December
11.	<i>Crotalaria varicosa</i> Polhill	Under-shrub	KKRCJ 035	Tropics	July-August	September-November	December-January

**Fig 2.** Period of leafing in *Crotalaria* L.**Fig 3.** Period of flowering and fruiting in *Crotalaria* L.

ing period can be observed from the month of August upto September, in some species flowering and fruiting period extends from September-November viz. in *C. juncea*, *C. pallida* and *C. varicosa*, which is followed by flowering in some species observed in October-November viz. in *C. calycina* and *C. retusa*, where as in *C. orixensis* it is observed from October-December. Some species of *Crotalaria* flowers and bears fruits during winter season, from November-December viz. in *C. globosa* and *C. gorensis*. Hence, about 8 *Crotalaria* species found flowering and fruiting in the month of November, followed by September with 6 *Crotalaria* species found flowering and fruiting. Where as 3 species were found in flowering and fruiting in the month of August, October and December each. One species were found in flowering and fruiting in the month of July. Hence, it is clearly represented that the peak period of flowering and fruiting in the *Crotalaria* species is in the month of November (8 species) (Fig. 3). It denotes the flowering and fruiting variation in that area within the genera, further helps to study the behavioural biology of flower and their dependence.

Reproductive phase is generally followed by senescent phase, which is represented by defoliation; as soon as the fruiting phase is over leaf fall begins. *Crotalaria* species leaf fall is also variable as mentioned in Table 1 for *C. calycina* and *C. retusa* starts defoliation from November and extends upto December, where as *C. pusilla*, a ephemeral herb completes life cycle soon after reproductive phase in the month of September. In some species leaf fall is observed in the month of December and extends upto January *C. globosa*, *C. juncea*, *C. pallida* and *C. varicosa*, but in *C. orixensis* leaf fall starts from December and extends upto February. In *C. hebecarpa* leaf fall is observed from September - October and in *C. prostrata* October-December, in *C. gorensis* leaf fall is observed after winter, in the month of January - February. It is clearly recorded that about 6 species found showing defoliation in the month of January and followed by December with 7 *Crotalaria* species showing defoliation, where as 2 species in February, September, October and November (Fig. 4). Hence, the peak period of the *Crotalaria* species showing defoliation in case of the

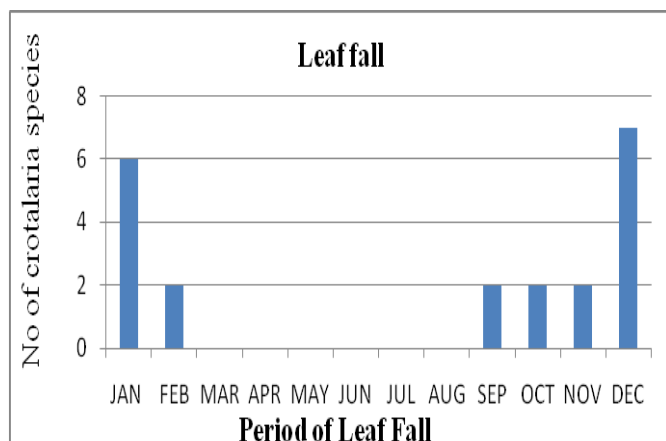


Fig. 4. Period of leaf fall in *Crotalaria* L.

Crotalaria species is in the month of January. This indicates that the members of *Crotalaria* complete its life cycle mostly in January.

Current study clearly reveals in which season we can observe the phenophases which is taxonomic basis and as these plants are known for their nitrogen fixing ability. Some are cultivated for different purpose and some are like weeds found in the plantations helps the crop plants to increase the yield of the crop, this result may help the farmers to select the crops seasonally matching with *Crotalaria* species.

All the eleven species are not showing same phenophases period even though found in same geographical region, that may be the sort of strategy to exist together, observation was also made on variations of phenophase period during the study period but are not showing recordable variation may be it is initiative of human activity on environment, particularly in this aspect of plant life cycle.

Conclusion

Study area represents good number of *Crotalaria* species showing variability in its phenophases are naturally selected hence found to be most adjusted. Understanding vegetation through plant functional types (PFTs) is critical at a time when there is growing international concern over deforestation and forest fragmentation caused by human activity (21). As mentioned human activities are most found in the study area it has scope for conservation of plants. Apart from human activities as a general reason for the destruction of biodiversity, additional variables such as climate and seasonal variation affects the phenophases, which also diminishes the yield of plants and hence affects posterity and yield of associated plants. Hence, all of these plants require strategy for conservation as they are both economically and ecologically vital and also to maintain the ecological balance of particular area.

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Authors contributions

RCJ carried out Field exploration, collection, herbarium preparation, identification, herbarium consultation, photography and manuscript writing. KK guided for data interpretation and manuscript writing. All authors have read and approved the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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