



Research article

Ecology and phenology of plant communities of Gentianaceae in Montane Grasslands of Karnataka, Southern India

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[Accepted: 14 November 2014]

Abstract: The Gentianaceae family represents 33 species of plants belonging to nine genera with a sub species reported in India. The studies on diversity, distribution and phenology of this family in montane grasslands of Karnataka have been under taken. A total of 60 quadrats of 50 m line transect with alternate 1×1 m subquadrats were laid for enumeration. A total of 12 species of the family Gentianaceae were occurred. Where, *Swertia lawii* is one of the dominant species in the study area. Important value index (IVI) of *S. lawii* represents 50.62. Most of these species are restricted in distribution particular habitat and they are highly seasonal. All these species are in threatened condition due to anthropogenic pressure.

Keywords: Gentianaceae - Montane - Grasslands - Herbs.

[Cite as: Ashwini HS, Avinash KS, Shravanakumar S & Krishnamurthy YL (2014) Ecology and phenology of plant communities of Gentianaceae in Montane Grasslands of Karnataka, Southern India. *Tropical Plant Research* 1(3): 43–48]

INTRODUCTION

Karnataka, one of the Southern states of India has 3.83 million hectares of the recorded forest area which is around 20 per cent of its geographical area. The Western Ghats of Karnataka are one of the 35 global priority hotspots for conservation and one of the two in Indian subcontinent (Conservation International 2005). The state is endowed with great diversity of climate, topography and soil. The forest types such as deciduous, semi evergreen, evergreen, scrub, shola and grasslands commonly called montane grasslands. The montane grasslands are located on the high plateau. The valleys of hills contain forests with stunted evergreen trees. The coexistence of two contrasting vegetation types creates a landscape of interest to ecologists (Thomas & Palmer 2007). Where forests are found in the depressions or folds of the mountains and are separated by grasslands. Tropical montane habitats exhibit high endemism with several species restricted to narrow elevational bands (Robin & Nandine 2012).

The plant species in the family Gentianaceae are distributed in hilly regions particularly in grassy patches. The family has nine genera and 33 species and 1 sub species (Shahina 2014). Now the genus *Limnanthemum* S.P.Gmel., has been excluded from this family and placed in Menyanthaceae. The plants of Gentianaceae family distributed in wide habitat ranges starting from coastal regions to high elevation montane grasslands. They are delicate herbs highly seasonal which are ironically facing threatened conditions due to mining, grazing and other anthropogenic disturbances. Hence, in this study an attempt had been made to explore plant species belong to Gentianaceae in montane grasslands of Karnataka.

MATERIAL AND METHODS

Diversity and Distribution

The study area has been spread in Chikmagalur, Shimoga and Kodagu district's montane grasslands namely Kemmannugundi, Bababuden giri, Mullayyana giri, Kodachadri and Pushpagiri (Fig. 1). The area comprised the edge of the forest and montane grasslands which are having iron rich rocky plateau. These places mainly contain iron and boxite ores. Field exploration in different grasslands has been carried out from 2011 to 2013. A size of 50 m long transects with five 1×1 m quadrat alternating with an interval of 10 m is used for survey by following the method of Bhatt & Utkarsh (1999). From the 60 quadrats all the Gentianaceae plant species were listed and identified with available taxonomic literature (Gamble 1935, Yoganarasimhan & Razi 1981, Saldanha 1984,

Ramaswamy *et al.* 2001, Inghalhalikar 2007, Gowda 2004, Bhat 2003) and voucher specimens were prepared and deposited in herbarium of Department of Applied Botany, Kuvempu University, Shankaraghatta, Karnataka. The habitat characteristics of each area were noted. Meso-habitat details were maintained with respect to exposure of sunlight, wind, slope, and humidity and their habitat were also noted. Meso habitat levels were sorted based on ordinal scaling (Jongman *et al.* 1987, Negi & Gadgil 1997). The pooled quadrat information for each transect was analysed compositional features including diversity, density, frequency and abundance by using standard literature (Simpson 1949, Shannon & Weiner 1963, Misra 1968, Brilliant *et al.* 2012).

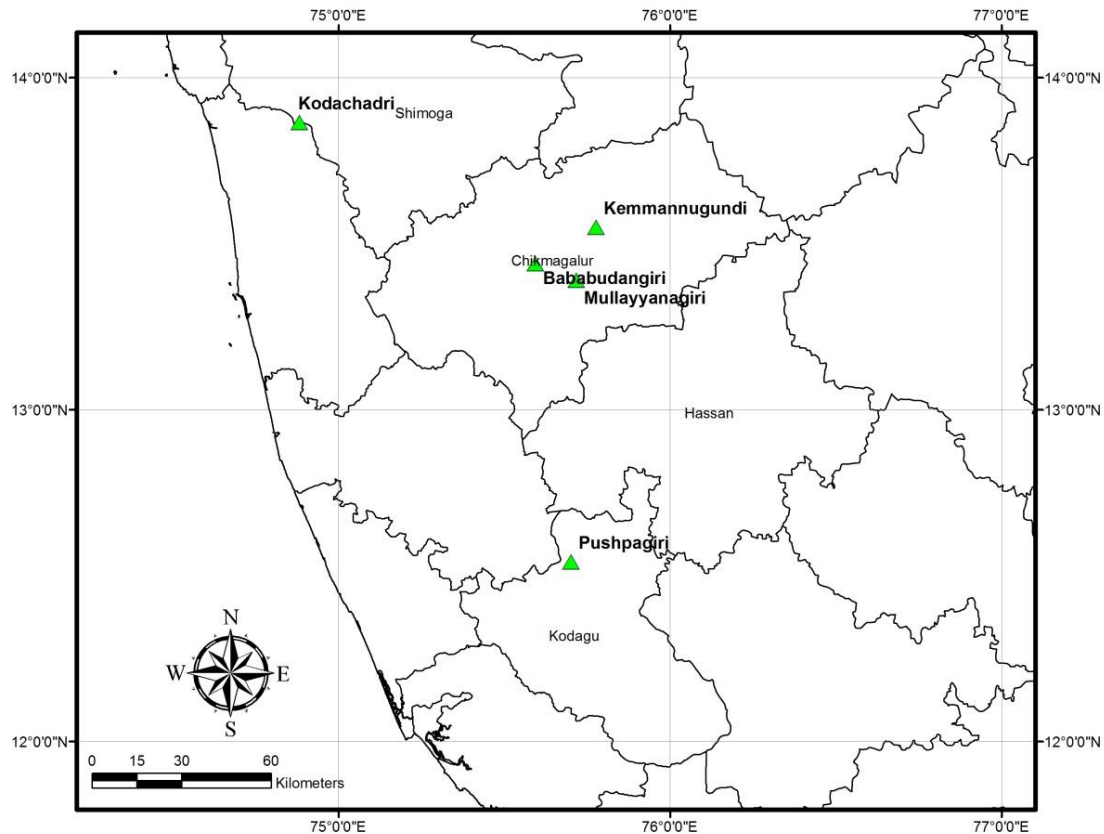


Figure 1. Map showing locations of study sites in three districts of Karnataka.

Phenology

Detailed phenological records of the 12 species of Gentianaceae namely phenophases of vegetative growth, flowering stage, and fruit set stage, seed set, and dispersion were observed from June 2013 to January 2014 because these species occur only during this season of the year. Observations were made at monthly intervals and during peak periods fortnightly. The data was collected by selecting 30 individuals from each species in all the study sites. Phenological observations were marked in about 10 per cent of individual under observation and considered it as initiated and peaked when it occurred in more than 80 per cent of individuals (Jeeshna & Paulsamy 2011).

RESULTS AND DISCUSSION

Diversity of Gentianaceae members in montane grasslands of Karnataka

A total of 12 species among 4 genera were occurred in 3 districts of Western Ghats of Karnataka (Table 1). The plant species here require high amount of moisture content in the soil for seed germination. The plant species thus grow up after the first precipitation in the month of June, slight increase in the temperature in the month of September they undergo reproductive stage. On the onset of summer they undergo dispersion. Most of this genus prefers montane grasslands as their natural habitat where the precipitation and wind effect is high during monsoon. Most of these species prefer high altitude grasslands due to high precipitation and atmospheric humidity.

Swertia lawii is one of the dominant species in the study area, which showed higher density (3.58) followed by *S. beddomi* (2.50), *Exacum bicolor* (0.90) and *S. minor* with lower density (0.07). The data showed that *S.*

Table 1. Distribution, habitat type and meso- habitat levels of study sites in montane grasslands of Karnataka.

S.N.	Locality name	Altitude (in ft)	Habitat type	Meso habitat level*				Name of species
				Sn	Wn	Sl	Hm	
1	Kodachadri	3750–4000	Exposed grasslands, soil rich areas, along with grass	3	3	3	3	<i>Exacum bicolor</i> <i>E. sessile</i> <i>E. petiolare</i> <i>Hoppea fastigiata</i> <i>Canscora diffusa</i> <i>Swertia beddomi</i>
2	Kemmannugundi	4676–4872	Exposed surface, soil rich areas, along with grass	3	3	2	3	<i>Exacum bicolor</i> <i>Canscora diffusa</i> <i>Swertia lawii</i> <i>S. beddomi</i> <i>Canscora pauciflora</i>
3	Bababuden giri	5300–5500	Exposed surface, iron rich rocky plateau, exposed grasslands	3	3	2	2	<i>C. decussata</i> <i>Swertia lawii</i> <i>S. beddomi</i> <i>S. minor</i> <i>Gentiana quadrifaria</i>
4	Mullayyana giri	6000–6050	Exposed surface, iron rich rocky plateau, exposed grasslands	3	3	3	2	<i>Canscora diffusa</i> <i>C. pauciflora</i> <i>C. decussata</i> <i>Swertia lawii</i> <i>S. beddomi</i>
5	Pushpa giri	≥4090	Exposed grasslands, soil rich areas, along with grass	3	3	2	2	<i>Canscora diffusa</i> <i>C. perfoliata</i> <i>C. pauciflora</i> <i>C. decussata</i>

Note: Sn- Exposure to sun, Wn- Exposure to Wind, Sl- Habitat slope, Hm- Humidity.

* 1,2,3 represents low, moderate and high levels of meso-habitat condition ranked based on ordinal scaling.

lawii species are abundant (7.17) and it is followed by *Exacum sessile* (5.83), *S. beddomi* (4.29). The frequency of *S. beddomi* (0.58) and *S. lawii* (0.50) showed higher frequency of occurrence whereas *S. minor* with lower frequency of occurrence. The equitability is the evenness with which the individuals were spread out among the species in a community, the value in the study area is 0.79. Important value index (IVI) of *S. lawii* is 50.62, which is higher when compared with all other species (Table 2).

Table 2. Species composition with their diversity parameter of the Gentianaceae members of montane grasslands of Karnataka.

S.N.	Species name	Density	Frequency	Abundance	IVI
1	<i>Exacum bicolor</i>	0.90	0.33	2.70	19.80
2	<i>Exacum sessile</i>	0.58	0.10	5.83	8.87
3	<i>Exacum petiolare</i>	0.33	0.08	4.00	5.97
4	<i>Hoppea fastigiata</i>	0.33	0.10	3.33	6.53
5	<i>Canscora diffusa</i>	0.67	0.25	2.67	14.77
6	<i>Canscora perfoliata</i>	0.22	0.12	1.86	6.01
7	<i>Canscora pauciflora</i>	0.13	0.10	1.33	4.66
8	<i>Canscora decussata</i>	0.70	0.33	2.10	17.93
9	<i>Swertia lawii</i>	3.58	0.50	7.17	50.62
10	<i>Swertia beddomi</i>	2.50	0.58	4.29	43.32
11	<i>Swertia minor</i>	0.07	0.07	1.00	2.90
12	<i>Gentiana quadrifaria</i>	0.67	0.37	1.82	18.76

Simpson's diversity index is a measure of diversity that takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so does diversity. The value of Simpson's index ranged between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity (Simpson 1949). The Simpson's index of the montane grasslands of Karnataka is calculated as 0.80 and the Dominance Index ($D = 1 - \text{Simpson}$) of the study area is 0.192 which indicated moderate biodiversity in the area even though these are grasslands. Shannon index (Shannon & Weiner 1963) is a diversity index, taking into account the number of individuals as well as number of taxa, which is 1.98.

Phenology

The phenophases observed for the 12 species are shown in table 3. The phenophases of all these species occurred in different time. Most of these species have responded differently to the environment based on the elevation. The species *Exacum* and *Swertia* sprouted tillers during June. These species produced tillers during rainfall and longer rainy days influence sprouting. A very slight raise in temperature with little shower frequently in the month of September lead to flowering of the *Exacum bicolor*, fruit set starts in October where atmospheric temperature is going to raise. In the winter months, wind blow is higher in these open grasslands and also under fully sunny days lead to seed set and dispersion of seeds.

Whereas, other two species of *Exacum* such as *E. sessiles* and *E. petiolare* the photoperiod or flowering stage started during October subsequently fruiting within a week. Seed set and dispersion of these species occur until cool month of December. Similarly, all the *Swertia* species underwent vegetative phase in the month of June as they require high amount of rainfall. The population of *Swertia* start blooming in the month of October where they required high amount of sunlight to initiate the flowering. The mass blooming of these flowers make these areas as a botanical paradise. The flowers remain blooming for 2 to 3 days. Seed set occurred, and dispersion occurs until the month of January. *Hoppea fastigiata* is a small weak herb found along the foothills. The vegetative phase starts at the month of August and flowering and fruiting, and dispersion occur in the month of October.

Gentiana quadrifaria is a small perennial, herbaceous plant with very attractive blue coloured flowers. Vegetative phase of these plants was observed during the warm month of May when pre-monsoon showers starts. Due to scarcity of water and desiccation, flowers of this plant were not found during February to May. Fruiting and dispersion succeeded immediately after flowering. The members of the genus *Canscora* showed their vegetative phase in the rainy month of September where they require small amount of sunlight and little moisture. In this species, flowering phase was observed in the month of October and it followed by fruit set and dispersal.

Preference of sunlight

Plant species of Gentianaceae prefer about 80 per cent exposed habitats followed by shade (19 per cent) or partial shade (1 per cent) and high sun light influence for growth and flowering (Fig 2). The light is a very necessary factor for blooming, where most of the species are ephemerals and last for few hours to one day. Only few species like *Exacum bicolor*, *Swertia lawii*, *S. beddomi* and *Canscora diffusa* have extended their flowering time to 2 to 4 days, where sufficient sunlight and humidity is available. We observed that the major preferred habitats are exposed grasslands, which have sufficient amount of sunlight, humidity and wind effect.

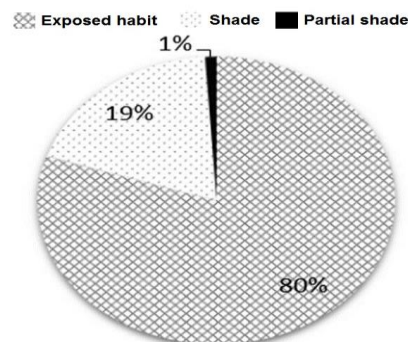


Figure 2. Population status of different habitats of species of Gentianaceae in montane grasslands of Karnataka.

CONCLUSION

The flowers of the family Gentianaceae are well known for their attractive, colourful and varied forms. Most of the species prefer high altitude grasslands with high amount of sun light, wind, and humidity for flower blooming and seed dispersion and also required high amount of soil moisture content. The rock surface covered by cryptogamic plants and tall grasses, are the most suitable habitats for species survival and distribution. However, *Exacum petiolare*, *Canscora diffusa*, *Swertia lawii*, *S. beddome* and *S minor* have made adaptation to survive on the rocky plateau where water and moisture availability is low in blooming season. Gentianaceae members adopt exposed surfaces for the survival, because most of the species prefers anemophily and seed dispersal by wind; it requires open exposed high elevation grasslands. Population of these species facing threat now days because of human interference. Tourists existing activities exploit the very rare endemic plant species

by trampling, littering plastic, glass, tin materials all along and invasion of many exotic plant species are the main threats for these local land blooms. Most of these plant species have high medicinal value. Hence, conservation of these species in their natural habitat is an urgent need.

ACKNOWLEDGEMENTS

Authors are gratefully acknowledging the financial support by the University Grants Commission, New Delhi (File.no.41-388/2012 (SR) for studies. Both authors are grateful to Dr. Gopalakrishna Bhat, Poorna Prajna College, Udupi, Karnataka who have helped identification of plant species. Thanks are also due to Karnataka Forest Department, Bengaluru for giving permission for field studies.

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