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Report

Phenological observation and population dynamics of six uncommon medicinal plants in the grasslands of Nilgiris, Western Ghats, India

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Abstract: Phenological observation and a population density study for six uncommon medicinal plant species were made in four grasslands in Nilgiri Biosphere Reserve, Western Ghats, viz. Thiashola, Korakundah, Ebbenadu and Wenlockdown, at monthly intervals from April 2007 to March 2008. The six plant species were *Anaphalis elliptica* DC. (Compositae), *Ceropegia pusilla* Wight & Arn. (Asclepiadaceae), *Hedyotis articularis* R. Br. *ex* G. Don (Rubiaceae), *Heracleum rigens* Walli. *ex* DC. (Umbelliferae), *Leucas vestita* Benth. (Lamiaceae) and *Luzula campestris* (L.) DC. (Juncaceae). Generally, all six species exhibited peak bud formation between February and May and bud break in June. Most of the leaves were produced in a single flush. Leaf expansion continued up to August in *L. vestita*. Flowering phenophase was observed from July to October, but in *A. elliptica* it extended to December. The active period of fruit formation occurred during August to December for all species except *A. elliptica*, which was during January and February. Seed maturation and seed dispersal happened during December - February for all the species except *A. elliptica* which happened during May-June. The study of population dynamics shows that there was a net decrease in the population of *A. elliptica*, *L. vestita* and *L. campestris* over a period of one year at Korakundah, Ebbenadu and Wenlockdown grasslands. *C. pusilla*, *H. articularis* and *H. rigens* maintained their populations at the same level in the respective grasslands without any major change during the study period.

Keywords: phenology, population dynamics, medicinal plants, grasslands, Nilgiris, Western Ghats

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Introduction

Plants respond biologically to various parameters in the holocoenotic environment [1]. Besides this, many extrinsic factors, e.g. the time of phenophase and seed dispersal, are very important in distribution, survival and success in the establishment of a species in the community. Considering these facts, it is known that phenological studies are important for the conservation of genetic resources and forest management as well as for a better understanding of ecological capabilities of plant species and community-level interactions. Another important attribute which decides the establishment of a species is population size. This is regulated by an array of environmental factors. In this study we have observed the times of phenophase and determined the influence of environmental variables on the population density of six uncommon medicinal plants in four grasslands in Nilgiri Biosphere Reserve, Western Ghats. These are *Anaphalis elliptica*, *Ceropegia pusilla*, *Hedyotis articularis*, *Heracleum rigens*, *Leucas vestita* and *Luzula campestris*. Since no attempts have been made in the conservation of these six species in these grasslands, they have been selected for this study. The ecological and medicinal characters of these species are given in Table 1.

Table 1. Ecological and medicinal attributes of the six studied species

Species	**Family**	**Habit**	**Ecological status**	**Medicinal / economic uses** [2]
Anaphalis elliptica DC.	Compositae	Herb (annual)	Endemic	Antipyretic
Ceropegia pusilla Wight & Arn.	Asclepidaceae	Herb (annual)	Rare and threatened	Antidote for snake bite
Hedyotis articularis R. Br. *ex* G.Don	Rubiaceae	Shrub (perennial)	Endemic	Treatment of nervous disorders
Heracleum rigens Walli. *ex* DC.	Apiaceae	Herb (annual)	Endemic	Anticancer
Leucas vestita Benth.	Lamiaceae	Herb (annual)	Endemic	Treatment of rheumatism
Luzula campestris (L.) DC.	Juncaceae	Herb (annual)	Threatened	Agricultural indicator (indicates high possibility of agriculture practice by selecting any local crop)

Methods of Observation

Detailed phenological records of the six plant species were carried out from April 2007 to March 2008 at monthly intervals. During high activity periods, observations were made more frequently. Phenological observations of each species were made by marking 20 randomly selected individuals in one of the grasslands. Since all four grasslands are located at a more or less similar geographical position and elevation (11° 13’ N and 76° 39’ E, elevation between 2050-2200 m)

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(Figure 1) and under uniform macroclimatic conditions (1560-mm annual rainfall and temperature between 5°C during January and 26°C during April : Table 2), the phenological observations were made at only one grassland where the species was present. The associated species in the plots were generally grasses with a few dicot herbs. When a phenophase was noticed in about 10% of individuals under observation, it was considered to be initiated and considered at a peak when it occurred in more than 80% of individuals. The phenograms were drawn according to phenophases which occurred in more than 80% of individuals following the methodology of Lodhiyal et al [3].

The study on population density and the results were expressed in a 100-m^2 scale. In the grasslands of the species occurrence, five 1-m^2 quadrats were made. In the case of adults, each plant with a height of 30 cm was considered as an individual. For the study of seedling population, seedling cohorts were marked in each of the quadrats in April 2007 and February 2008. Individuals arising from seeds were marked with dots of different colours. The survival of adults and seedlings were recorded at monthly intervals.

Results and Discussion

Phenological observations of bud formation, vegetative growth, flowering, fruiting, seed maturity and seed dispersal for each species are presented in Figure 2. Generally, for all species studied, bud formation occurred during February and May. For *Anaphalis elliptica* and *Leucas vestita* bud formation extended to June. It has been noted that more abundant and shallow roots in the upper soil layers contributed by herbs favour the sudden appearance of buds immediately after adequate rain in dense forests [4]. Bud aestivation started during June and most leaves were produced in a single flush. For *Anaphalis elliptica,* phenophase happened during September and October. Continued leaf expansion for *Leucas vestita* was until August. This may be explained due to the need of high temperature thresholds [5-6]. It has been observed that the rainy season was most favoured for the vegetative growth of all six species. Similar patterns on bud formation and vegetative growth have been observed for certain grassland and forest understorey species [7-9]. Flowering period after vegetative growth was mostly from July through October. For *Anaphalis elliptica*, this happened during November and December. The flowering response of plants is related to the high elevation and temperature factors and is species specific [10]. Generally, from August to December fruit formation occurred for all six species except *Anaphalis elliptica*, whose fruiting period was during January and February. In the months after fruiting, seed maturation happened for all six species. Seed dispersal was noted during December and February except for *Anaphalis elliptica*, which was in May and June. Seed maturation and seed dispersal generally happened with the onset of the cold, dry season (December-February) when growth cessation in plants normally happens in the area [11].

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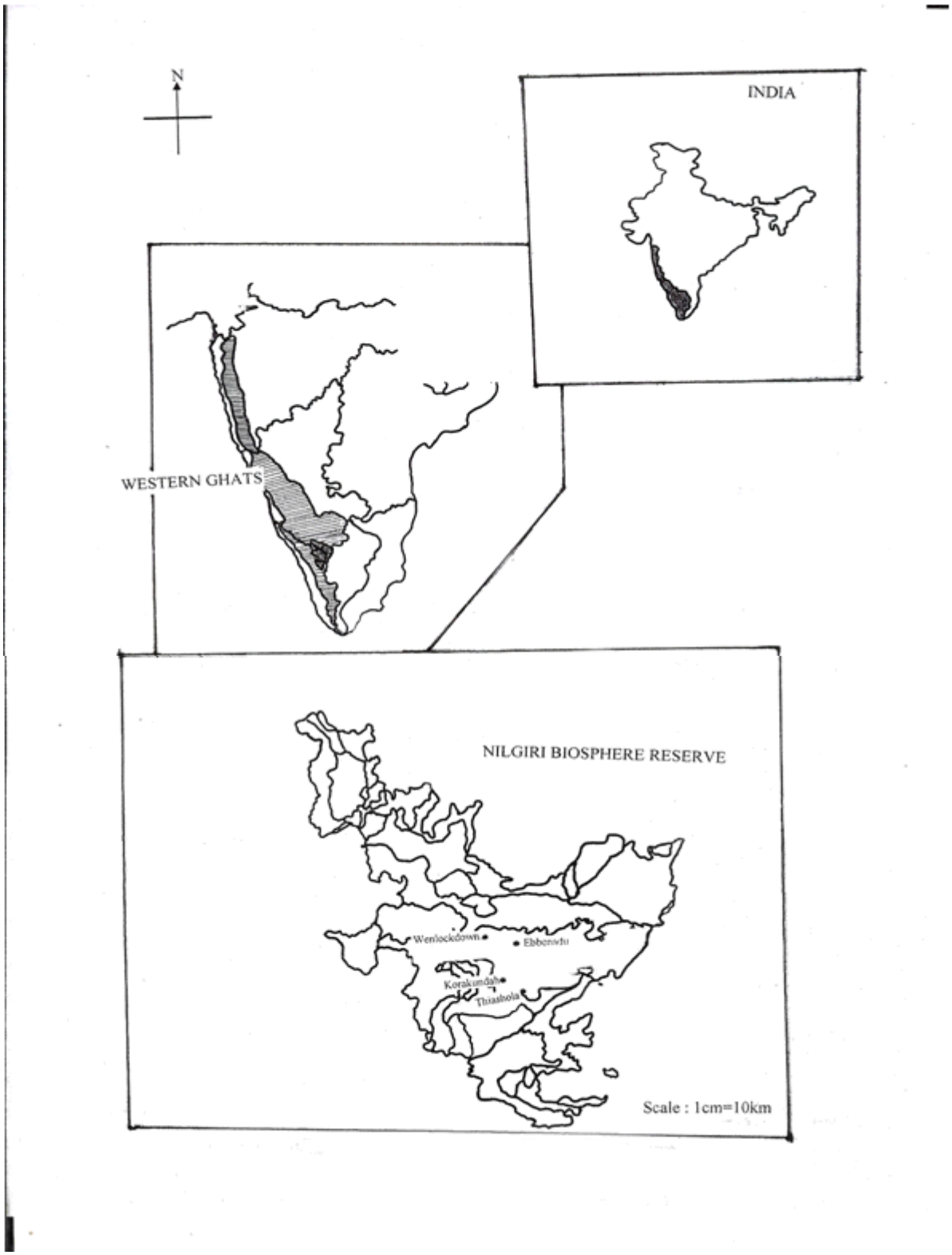

Figure 1. Location of study areas in Western Ghats

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Table 2. Climate in the study area

Year and month	Temperature (°C)		Rainfall (mm)	No. of Rainy days	Relative humidity (%)
	Max.	Min.			
2007					
Apr	26.1	15.6	25	7	95
May	25.3	17.6	68	6	94
Jun	22.8	17.6	212	15	90
Jul	21.5	16.8	210	14	95
Aug	19.4	17.4	161	13	95
Sep	21.8	16.6	86	15	94
Oct	16.9	15.8	298	19	97
Nov	16.6	15.6	240	13	96
Dec	15.3	9.8	82	4	92
2008					
Jan	14.6	5.3	0	0	85
Feb	15.6	11.7	51	7	78
Mar	16.8	13.1	85	11	75
Apr	21.9	14.7	42	6	83

Data Source: Government Meteorological Station, Ootacamund, the Nilgiris

Variation in population density of the six species is presented in Table 3. *Anaphalis elliptica* and *Ceropegia pusilla,* which were only present in Thiashola and Ebbenadu grasslands varied between 0.03 (in Ebbenadu during April 2008) and 0.21/m^2 (in Thiashola during November 2007), and 0.04 (in both Ebbenadu and Thiashola during June and February) and 0.21/m^2 (in Thiashola during September, 2007). *Hedyotis articularis,* which was present in Thiashola, Korakundah and Ebbenadu grasslands, had population density variations between 0.02 (during May, 2007 in Korakundah and Ebbenadu) and 0.17/m^2 (during October, 2007 in Korakundah). The species density of *Heracleum rigens* ranged between 0.04 (during June, 2007 in Ebbenadu and Wenlockdown) and 0.19/m^2 (during October, 2007 in Ebbenadu). *Leucas vestita* also showed great variation in population size with between 0.03 and 0.21/m^2 in the grasslands of its occurrence. *Luzula campestris*, which was present only in Wenlockdown grassland, had its population sizes between 0.04 (in March, 2008) and 0.25/m^2 (in October, 2007). The overall low population of all six species (0.02-0.21/m^2) in the grasslands is due to the collective influence of several factors such as limited natural distribution and variation in microclimatic conditions [12]. Dry and cold conditions after seed dispersal during February and March can be a reason for the low population density for these species. In spite of severe habitat protection, illegal exploitation by local people and other herb gatherers for medicinal plants also have reduced their population sizes.

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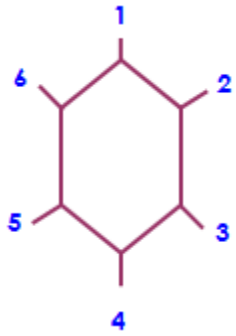
Species	2007 Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	2008 Jan	Feb	Mar
Anaphalis elliptica												
Ceropegia pusilla												
Hedyotis articularis												
Heracleum rigens												
Leucas vestita												
Luzula campestris												



Phenophases

1. Budding
2. Vegetative growth (stem and leaves)
3. Flowering
4. Fruiting
5. Seed maturity

Figure 2. Phenograms for the six uncommon medicinal plant species studied

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Table 3. Population density (individuals/m^2) of the six species studied in the four grasslands

Year and month	Grassland												
	Thiashola			Korakundah		Ebbenadu					Wenlockdown		
	Anaphalis elliptica	*Ceropegia pusilla*	*Hedyotis articularis*	*Heracleum rigens*	*Leucas vestita*	*Anaphalis elliptica*	*Ceropegia pusilla*	*Hedyotis articularis*	*Heracleum rigens*	*Leucas vestita*	*Heracleum rigens*	*Leucas vestita*	*Luzula campestris*
2007													
Apr	-	-	0.04±0.00	0.04±0.00	0.04±0.00	0.04±0.00	-	0.04±0.00	-	0.04±0.00	-	0.04±0.00	0.07±0.00
May	-	-	-	0.02±0.00	0.03±0.00	-	-	0.02±0.00	-	0.03±0.00	-	0.03±0.00	0.05±0.00
Jun	0.08±0.00	0.06±0.00	0.07±0.00	0.05±0.00	0.05±0.00	0.06±0.00	0.04±0.00	0.05±0.01	0.04±0.00	0.05±0.01	0.04±0.00	0.05±0.00	0.10±0.00
Jul	0.11±0.01	0.12±0.00	0.09±0.00	0.06±0.01	0.06±0.00	0.09±0.01	0.05±0.00	0.06±0.00	0.07±0.00	0.06±0.01	0.06±0.01	0.08±0.01	0.14±0.01
Aug	0.15±0.00	0.18±0.00	0.10±0.00	0.11±0.02	0.12±0.01	0.15±0.01	0.08±0.00	0.10±0.01	0.12±0.00	0.13±0.00	0.10±0.01	0.12±0.00	0.17±0.02
Sep	0.17±0.00	0.21±0.03	0.12±0.00	0.13±0.00	0.17±0.02	0.12±0.01	0.12±0.01	0.13±0.01	0.16±0.02	0.18±0.02	0.15±0.00	0.14±0.01	0.21±0.01
Oct	0.19±0.02	0.17±0.02	0.14±0.01	0.17±0.02	0.21±0.02	0.18±0.00	0.14±0.01	0.15±0.01	0.19±0.02	0.20±0.00	0.14±0.01	0.17±0.02	0.25±0.03
Nov	0.21±0.00	0.14±0.01	0.12±0.01	0.13±0.01	0.14±0.01	0.17±0.02	0.12±0.00	0.12±0.02	0.14±0.01	0.14±0.02	0.17±0.02	0.16±0.01	0.19±0.01
Dec	0.14±0.01	0.10±0.01	0.11±0.00	0.11±0.01	0.11±0.01	0.13±0.00	0.09±0.00	0.11±0.00	0.12±0.01	0.12±0.01	0.10±0.00	0.09±0.00	0.12±0.01
2008													
Jan	0.11±0.00	0.08±0.00	0.09±0.01	0.08±0.00	0.08±0.00	0.11±0.01	0.07±0.00	0.09±0.01	0.08±0.00	0.08±0.00	0.08±0.00	0.05±0.00	0.10±0.00
Feb	0.09±0.00	0.04±0.00	0.08±0.00	0.07±0.00	0.07±0.00	0.07±0.00	0.06±0.00	0.07±0.00	0.06±0.00	0.07±0.00	0.07±0.00	0.06±0.00	0.08±0.00
Mar	0.05±0.00	-	0.05±0.00	0.05±0.00	0.04±0.00	0.06±0.00	-	0.05±0.00	-	0.04±0.00	0.05±0.00	0.04±0.00	0.04±0.00
Apr	-	-	0.04±0.00	0.04±0.00	0.03±0.00	0.03±0.00	-	0.04±0.00	-	0.04±0.00	-	0.03±0.00	0.05±0.00

Note: - indicates the absence of the species.

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Recommendations

Based on the results of this study it is suggested that the seeds of all six species be collected and kept in cold storage until the next growing season. These seeds can be air sown in the grasslands to augment population levels. To confirm this concept, experiments on seed germination as influenced by cold storage must be conducted.

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