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Report

Phenology of *Exacum bicolor* Roxb., an endangered medicinal herb of Kannur and Wayanad districts, Kerala, India

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Abstract: The deciduous herbaceous plant, *Exacum bicolor* Roxb. (Gentianaceae), is endangered in peninsular India and is distributed in grasslands and scrub forests of Kerala between the elevations of 50 and 1350 m. We investigated four variants on basis of leaf blade shape in the grasslands of Kannur and Wayanad districts, Kerala. The detailed study of these variants for various phenophases such as vegetative growth, leaf flushing, flowering, flowering with fruit development, fruiting and seed dispersal was done during May–November 2009. The development of tillers of all four variants happened in May and the leaf formation took place during June. The flowering period occurred generally during June and July. During August and September, flowering with fruit formation for all variants was followed by the fruiting stage and seed dispersal stage during October and November. As this species completes its flowers-to-seeds period within seven months, collection and sowing of seeds in appropriate time is suggested to enhance subsequent establishment and minimise extirpation.

Keywords: *Exacum bicolor* Roxb., phenophases, Kerala, Western Ghats

INTRODUCTION

Exacum bicolor Roxb. (Gentianaceae), an endangered plant species [1] locally called Ceti in Tamil and Kanamthali in Malayalam, is distributed in scrub forests and grasslands of Western Ghats and plateaus from Konkan coast to the southern tip of India. In northern Kerala, this species is distributed in nine districts which include Kannur and Wayanad. The plant is very popular in Kerala as it is one of the choice flowers to adorn *Trikkakkarayappan*, the earth deity worshipped during Onam, an important regional Hindu festival. It is used traditionally for the ailments from many diseases such as eye and skin problems and stomachic and urinary disorders [2–6]. On the basis of

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variation in leaf blade shape, four ecological variants, viz. linear-lanceolate, ovate-elliptic, oblanceolate and ovate, were identified in the population of *E. bicolor* in Kannur and Wayanad districts of Kerala [7] (Figure 1). This species is more common in seasonally dry grasslands in the plains of Kannur and Kasargode districts compared to high-elevation grasslands in Wayanad district. The population of this species is severely affected due to habitat destruction caused by urbanisation and plantation [7]. The over-exploitation of this species by complete uprooting for its medicinal uses by the local public and herb gatherers may also be a factor for its diminishing population size [2]. In addition, phenophases, particularly the fruit-seed phase, is essential for species distribution and perpetuation in natural communities [8–9]. Hence, to diagnose the factors apart from heavy exploitation, an attempt in analysing the phonological behaviour of this species is made in the present study. As the ecological variants are generally environment-controlled [9], all the four variants of *E. bicolor* were observed for phenophases.

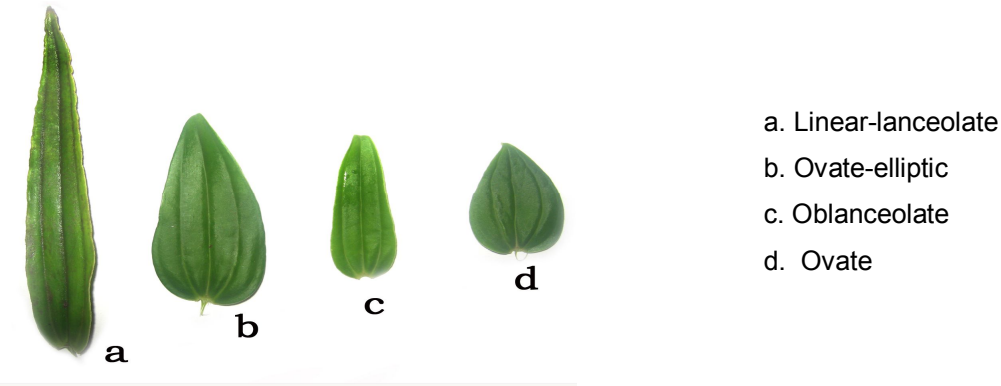

Figure 1. Leaf-shape variants of *E. bicolor*

STUDY AREAS AND METHODS

The study was carried out in the Paithal mala of Kannur district (12° 30'N and 75° 20'E) and Thirunelli forest in Wayanad district (11° 53'N and 76° 01'E) of Kerala, which are located in northern boundary of south-western Ghats at an elevation of 1375 and 1000 m respectively (Figure 2). The climatic data of the study areas are given in Table 1. The annual rainfall in Paithal mala and Thirunelli forest during the study period (2009) was c 2278 and 2554 mm respectively. The temperature ranged between 22-30°C in both areas. The soil was clay loam with a pH of 6.1 and 6.7 in Paithal mala and Thirunelli forest respectively.

Detailed phenological records of the four variants of *E. bicolor*, viz. phenophases of vegetative growth, leaf flushing, flowering, flowering with fruiting, fruiting and seed setting, were prepared from May to November 2009. (The species only appears during this time of the year.) The observations were made at monthly intervals, but during high activity periods, observations were made weekly. Observations for each variant were made on each sampling date by marking 20 randomly selected individuals in the two study areas. When a phenophase was noticed in about 10% of individuals under observation, it was considered to be initiated and peaked when it occurred in more than 80% of individuals, when phenograms were drawn [10].

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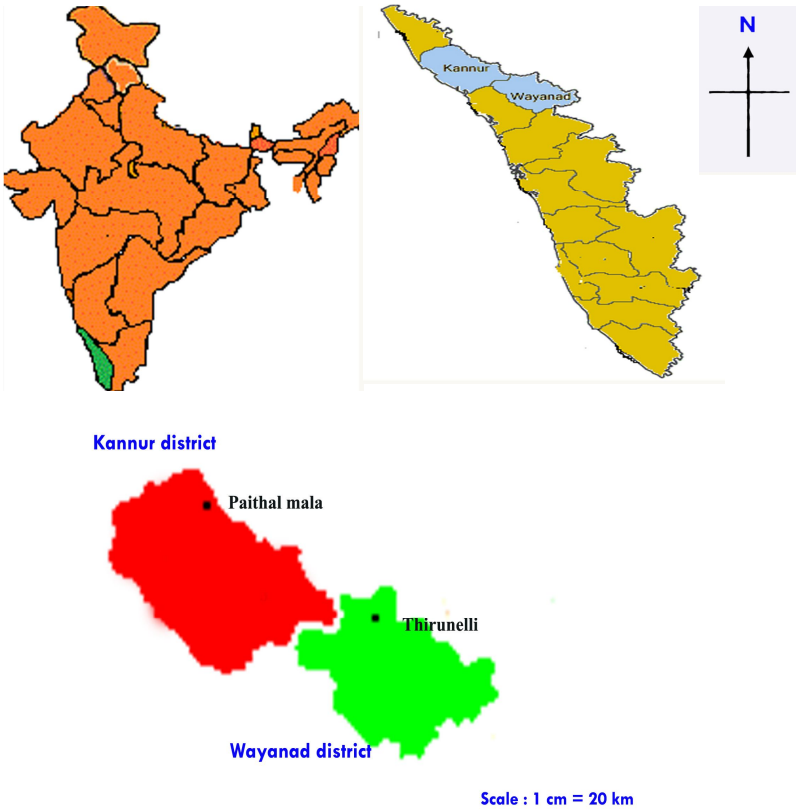

Figure 2. Location of the study areas

RESULTS AND DISCUSSION

The phenophases studied for the four variants of *E. bicolor* are shown in Figure 3. The phenophases of all four variants occurred in the same months in both study areas, indicating that all variants have responded uniformly to the environment [11] regardless of the little difference in elevation. All four variants sprouted tillers during May. Adequate rainfall at around 100 mm with more rainy days during April (Table 1) initiates tillering from the shallow root stock. Oberbauer and Billings [12] pointed out that more abundant shallow roots in the upper soil layers of certain plants favour the rapid development of tillers immediately after the occurrence of adequate rainfall.

The appearance of only 3 seedlings out of 75 individuals was noted after seed setting in the month of November for all the variants. A probable explanation is that the high rainfall occurring during November, the month of seed setting, and subsequent seed dispersal during December by severe monsoon in both study areas could not permit the seeds to complete the dormancy. Indeed, the substantial soil moisture available during this period might deteriorate the tiny seeds of *E. bicolor*. The high rainfall during this season might also wash out the seeds along the slopes of the hilly terrain, which resulted in a low appearance of seedlings in the study areas when compared to individuals recruited through rhizome sprouting. A similar kind of low seedling count has also been noted for certain Shola grassland species such as *Anaphalis elliptica, Drosera pultata* and *Ceropegia pussila* in the high hills of Nilgiris in Western Ghats [13]. A low percentage (less than 5%) of seed germination of *E. bicolor* might also be attributed to low seedling count [1].

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Table 1. Climatic data of the two study areas for 2009 [14]

Month	Temperature (^{o} C)				Rainfall (mm)		No. of rainy days		Relative humidity (%)	
	Max.		Min.							
	Paithal mala	Thirunelli	Paithal mala	Thirunelli	Paithal mala	Thirunelli	Paithal mala	Thirunelli	Paithal mala	Thirunelli
Jan	25.2	28.1	17.2	15.1	0	0	0	0	64.6	64.8
Feb	29.1	30.8	19.6	17.8	8.4	13.1	2	2	73.4	69.4
Mar	30.2	30.3	20.2	19.7	24.1	32.4	6	6	76.6	73.8
Apr	30.6	31.4	21.4	21.8	98.1	110.4	11	12	82.4	75.2
May	29.4	29.7	21.5	21.9	255.8	320.1	16	18	89.4	77.1
Jun	24.8	26.1	20.2	21.3	350.4	394.5	25	26	88.6	79.6
Jul	23.4	25.1	19.4	20.1	405.8	461.2	30	30	95.4	85.4
Aug	24.2	26.1	19.6	21.2	390.3	400.1	29	28	98.4	86.7
Sep	25.4	26.6	20.1	21.3	284.8	300.5	26	25	94.4	83.4
Oct	28.6	27.4	20.6	20.5	199.6	224.1	15	16	86.2	74.8
Nov	28.2	25.4	20.4	19.4	162.4	198.2	10	11	66.4	64.1
Dec	23.1	22.4	19.4	18.4	98.6	99.5	6	4	69.5	68.6

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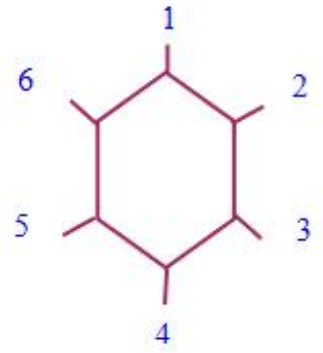
Leaf-blade variant shape	2009 May	Jun	Jul	Aug	Sep	Oct	Nov
Linear-lanceolate							
Ovate-elliptic							
Oblanceolate							
Ovate							



Phenophases

1. Germination and vegetative growth
2. Leaf flushing
3. Flowering
4. Flowering with fruit development
5. Fruiting
6. Seed setting

Figure 3. Phenograms for the leaf-blade variants of *Exacum bicolor* in the grasslands of Western Ghats, Kerala

Leaf maturation and expansion for all variants continued to June. The availability of adequate soil moisture by the effective south-west monsoon in this region during June facilitates leaf development. The high reserve stock of the rhizomatous part of this species might have induced leaf development in the presence of adequate soil moisture during this period with the advent of monsoon. The *Gaultheria fragrantissima* and *Ulex europaeus* species were reported [15] to have a vigorous leaf blade expansion after effective rain during south-west monsoon period in the Shola forest of high-altitude Nilgiris, the hill ranges adjoining the present study areas.

Flowering time for the four variants was during June and July. The four variants also had uniform photoperiodic responses for the other phenophases. High humidity in June and July in both study areas might influence flowering of the studied species. It has been explained that humidity as a secondary trigger may affect flowering and in combination with soil moisture induces earlier flowering in many plant species [16-18]. Similar flowering trends in New Guinea *Impatiens* with the influence of humidity were observed [19]. August-September was the period for fruit formation for all variants. Seed maturation and seed dispersal happened during October and November. The lack of seed germination in December, the month of seed setting, despite enough rainfall (above 95

mm) might be attributed to incomplete dormancy after seed dispersal. The non-matching of seed setting and seed dispersal period after proper completion of dormancy during the monsoon as well as seed deterioration by excess rain might thus account for the threatened extirpation of *E. bicolor* apart from over-exploitation. It was also reported that in Gentianaceae members, the temperature generally prevailing between 10ºC during nighttime and 30ºC during daytime is a major environmental barrier significantly reducing the seed germination process [20]. It is evident from Table I that the two study areas recorded the temperature generally between 15–31ºC throughout the year, which is considered to be an unfavourable environmental factor for seed germination of *E. bicolor*, a member of the Gentianaceae family.

CONCLUSIONS AND RECOMMENDATIONS

All four leaf-shape variants of *E. bicolor* showed no specificity in the expression of phenophases and they responded uniformly. Conservation measures adopted can therefore be non-specific. The length of dormant period of the seeds should be determined so as to find out the seed sowing time. After the completion of seed-setting period in November-December, healthy matured seeds should be collected, dried adequately and stored in a conducive environment until the completion of dormant period. Then they should be sown randomly in the soils of the plant's natural habitats to enhance its population. As enough rainfall occurs from February, moisture would not be the limiting factor in the study areas. Further, protection of the habitats of *E. bicolor* would also facilitate conservation of this species.

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