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Conservation Essays and Phenology of Critically Endangered Endemic Plant *Erodium somanum*

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Abstract

The phenological events are very important to understand the life cycle of a plant species. Also understanding of the life cycle of a plant species is an essential step in order to design and implement an effective conservation program for an endangered species. The phenological characteristics of *Erodium somanum* (Geraniaceae), a critically endangered dioecious endemic species, were investigated at natural populations in Soma/Manisa from Turkey. All phenological characteristics are firstly determined in this study. Also, preliminary conservation essays were performed at habitat of the species. Shoot formation of plants begin first week in March and continue throughout March. The flowering season was 2 month long and peak flower production took place between mid-April and head-May. Initiation of fruit formation around first and second weeks in April. Fruit is a beak shape and leaving in mericarps. Fruits mature about four weeks and then mericarps suddenly throw away from plant. Seedling formation of scattered mericarps are occur in autumn (September- November). According to life cycle of this plant, germination period was found as autumn season. For better *in-situ* application program it was found that, seedling have to be applied at latest of the summer season.

Keywords: Conservation, *Erodium somanum*, flowering, Manisa, phenology.

1. Introduction

In studies related to the planning of conservation strategies that rarely species having narrow distribution area, it is essential to understand life history features. Because any life history feature refers to a series of responses that allow the organism to adapt to environmental conditions to ensure survival, reproduction, and genetic diversity [1-8]. Naturally, life history studies such as the timing to germination, survival of seedlings and adults, age at flowering, reproductive lifespan, and numbers of flowers and seeds should include various aspects of the life cycle of the species studied [8].

In this study, the duration of life cycle events of *Erodium somanum* H. Peşmen, a local endemic species from Turkey [9], [10], such as shoot formation, blossoming time, fruit formation, depend on the climatic and environmental conditions were investigated and the preliminary tests carried out for conservation biology.

2. Material and Methods

2.1. Study species and study sites

E. somanum is dioecious perennial plants forming very wide hard cushions. Basal leaves are bipinnatisect, oblong elliptic. Stems are erect, simple or scarcely branched, with bearing 2-4 peduncules. The umbel inflorescences have 3-5 flowers in female plants while the umbel inflorescences have 6-11 flowers in male plants. Petals are pale sulphur, broadly obovate. Nectaries are five and antipetalous. Sepals appearance are transparent, sepal veins are usually green and darker than the rest of the sepal. The sepals are not deciduous after the fruit formation. The ovary has five carpels, the long style is terminated by five furcated stigmas. Stigma color ranges from yellow to red in populations. Fruit

type is shizocarp and divided into five mericarps, Fruit is long-beaked [11].

E. somanum is a critically endangered endemic species [10]. It is distributed above tree line, in Soma/Manisa, at the western part of Turkey. Also, in a study carried out in 2019, it has been reported that the species has spread from Kadriye/Bursa, in addition to the previously known distribution area [12]. The investigations were conducted in Kocasivri hill. The general observations about phenological events of plants were carried out between 2007-2009 but data based on measurements at permanent sample area were carried out in 2008.

2.2. Flowering phenology

The monitoring of flowering phenology was conducted in the Soma, Kocasivri population in 2008. The data logger, integrated with air temperature and relative and absolute humidity sensors, for kept daily records, was placed on Kocasivri Mountain at 2008. To study the effect of climatic conditions on flowering, we analyzed data of mean temperatures and relative humidity at daily from April-May. Then these measurements and phenological data were integrated in a graphic.
For phenological data, before anthesis, it was randomly established one permanent 3x3 m^2 quadrat within population. Individuals inside the quadrat were marked, mapped, and measured the size of each plant. On each census day, the total number of individuals were recorded in flower and the number of open flowers and fruits on each individual. At regular intervals during the flowering period, the total number of stems, the total number of inflorescences, the total number of buds, the total number of opened flowers and the total number of dried flowers on all individual plants found inside the quadrat were counted. These values recorded over the whole flowering period and was plotted against calendar day. The number of flowers for each individual in quadrat between each two-census day were counted. In this way it was calculated the number of flowers produced between each two-census day. Flowering peak date was defined as the number of days between the date when the first flowering begins and the date that the maximum number of open flowers was reached. Flowering duration was estimated as the number of days the plants remained in bloom.

In another part of the study [13], it was also reached important information about duration of the different flower phases, through the flowers that examined daily for maturity tests. For this, 10 to 30 randomly chosen buds in the population and examined these flowers at regular every day (14-19 April).

2.3. Conservation essays

In the framework of *ex-situ* conservation applications an amount of seed material was protected within Celal Bayar University.

In the framework of *in-situ* conservation applications 75 pieces seeds were sown in natural habitat in the first week of March in the spring. In the same way 25 pieces seeds were sown in the natural habitat first week of November in the autumn. Then the plants were examined on a weekly basis the status of the individual life values have been tried to be determined.

3. Results

3.1. Flowering phenology

Data of 17 adult individuals inside the permanent sample area (Table 1.) and phenological observations according to the field studies appear to be consistent when considered together. Shoot formation of plants begin first week in March and continue throughout March (Figure 1). Flowering period of plants are between the last week of March and May, however, the most density of flowering are between the last two weeks of April and first two weeks of May.

Table 1. Phenological data of flowering in permanent sample area.

On the day of the field study	10.04	17.04	27.04	04.05	11.05	18.05
Flowering between two field study day (Flower Count)	0	124	383	232	98	92
From the beginning until the specified date, total bloom (Flower Count)	0	124	507	739	837	929
Number of flowering plants in sample area	0	9	15	16	17	17
Flowering between two field study day (%)	0	13	41	25	11	10
Number of flowering plants in sample area (%)	0	52	88	94	100	100

It was seen that there was a sudden increase in flower production between 17–27 April of flowering period until the peak was reached and a slow descent until the end of flowering period (Table 1.). The most density term of blooming (%90) is the last half of April and the first half of May. The most density days of blooming was 41% and 25% for 27 April and 4 May, respectively. 54% of total flowers were produced until 4 May.

Celal Bayar University Journal of Science
Volume 16, Issue 2, 2020, p 237-243
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Figure 1. Phenological development in *Erodium somanum.*

Temperatures between 15-22 °C appear to be sufficient for blooming and pollination (Table 2). It is understood that the amount of light received should be above 200 lum.

Table 2. Belonging to the April-May 2008, weekly climate data.

Measurement		April - 2008 [a]											
		Temperature (°C)				Humidity (%)				Light (lum,sqf)			
Days	**N[b]**	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max
01–07	28	7,395	4,080	2,890	20,570	76,24	20,32	29,30	100,00	182,6	297,2	2,0	851,0
08-14	28	15,21	6,45	5,40	29,50	56,56	19,90	23,70	89,30	237,6	337,5	2,0	851,0
15-22	32	15,56	6,29	6,62	29,90	48,74	17,61	23,50	82,90	269,0	328,5	2,0	851,0
23-30	32	10,096	5,592	3,740	24,010	73,50	23,71	29,80	100,00	243,3	326,9	2,0	851,0

Celal Bayar University Journal of Science
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		May - 2008											
		Temperature (°C)				Humidity (%)				Light (lum,sqf)			
Days	**N[b]**	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max
01-07	28	13,44	5,65	6,22	25,17	60,78	21,38	24,90	94,40	332,8	326,3	2,0	851,0
08-15	32	12,750	5,596	5,400	24,400	54,43	20,55	23,90	89,40	301,8	316,2	2,0	851,0
16-23	32	21,07	6,16	8,63	33,17	34,99	13,29	23,60	72,50	380,6	312,7	2,0	851,0
24-31	32	21,94	6,51	10,21	35,70	41,47	15,56	23,40	72,40	404,8	311,8	2,0	851,0

[a] Data is recorded at intervals of 6 hours per day, during the month of April and May.
[b] N = It shows the number of weekly measurements
M= Average value, SD= Standard deviation, Min=Minimum value, Max= Maximum value.

Temperatures above 5 °C are stimulate shoot formation and budding of plants. It has seen that temperature values are decreasing during humidity values are increasing in the most density term of blooming period (Figure 2).

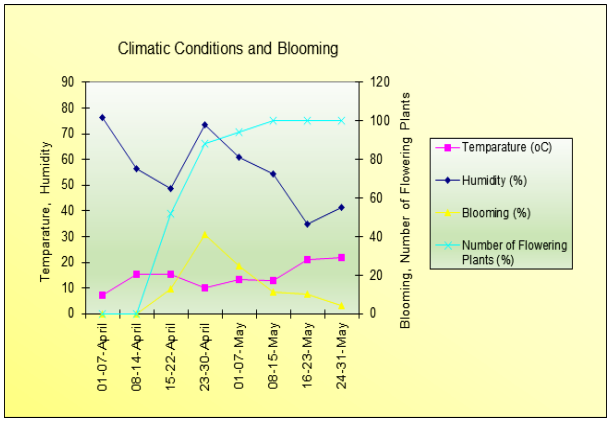

Figure 2. The relationship between climatic conditions and blooming.

In another part of the study, it was also reached important information about duration of the different flower phases. These are; it has not temporal separation between the male and female individuals. If a newly blooming bud is fertilized, it closes on the day of fertilization. A newly-blooming bud remains open even on day 5, unless it is fertilized.

Initiation of fruit formation around first and second weeks in April. Fruit is a beak shape and leaving in mericarps. Fruits mature about four weeks and then mericarps suddenly throw away from plant. So, fruit residues are present on plants in June. Upper soil parts of plants are green first weeks of December if permitting the weather conditions (Figure 1.). In the coming days, the weather temperature falling down, leaf and other shoots dry and plants enter rest phase. Dried leaves conserve of under soil stem of plant at the same time. Resting phase of plants continued from December to March. Seedling formation of scattered mericarps are occur in autumn, September- November (Table 3).

Table 3. Phenological phases of *Erodium somanum*.

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Agu.	Sept.	Oct.	Nov.	Dec.
Vegetative Phase												
Leaf Fall												
Leaf Initiation												
Bud Initiation												
Flowering												
Fruiting												
Fruit Maturing												
Seedling Formation												

3.2. Conservation essays

To summarize study in the March; 32 from sowing seeds were germinated in 75 pieces seeds in the first week of month (Figure 3.). 11 from germinating seedlings died within four weeks, remaining 21 seedlings survived the first half of the month of May. In the first two weeks of June, all the seedlings died. The success of seed germination is 43%.

To summarize study in the November; 19 from sowing seeds were germinated in 25 pieces seeds in the first week of month. Planted seeds not germinated after two weeks. It was observed that 19 planted seeds were germinated and formed seedling in the next year. These seedlings were lived to the end of May (Figure 3.). But all the seedlings died in the end of July. The success of seed germination is 76%.

Also, it was seen that the seedlings have low mortality rate within the scope of demographic studies in permanent sample areas. The reason of this, germination time of seedlings is autumn in nature. In the study, the high mortality rate of seedlings from seeds sown in November is due to the germination in spring.

4. Discussion

4.1. Flowering phenology

Flowering period of *E. somanum* are between the last week of March and May, however the most density of flowering is shown between the last two weeks of April and first two weeks of May. *E. somanum* has short flowering duration so individual's fertilization chance may decrease because of inadequate number of pollinators. The effects of unpredictable pollinators traffic and climatic conditions can increase the risk of reproductive failure. Similarly, Albert *et al.* [14], have reported that flowering period of *Erodium paularense* Fern. Gonz & Izco. is 3 mount and the highest percentage of flowering plants and the largest mean number of flowers per plant were reached between mid-April and mid-May. Also they were contrasting differences in the two microhabitats.

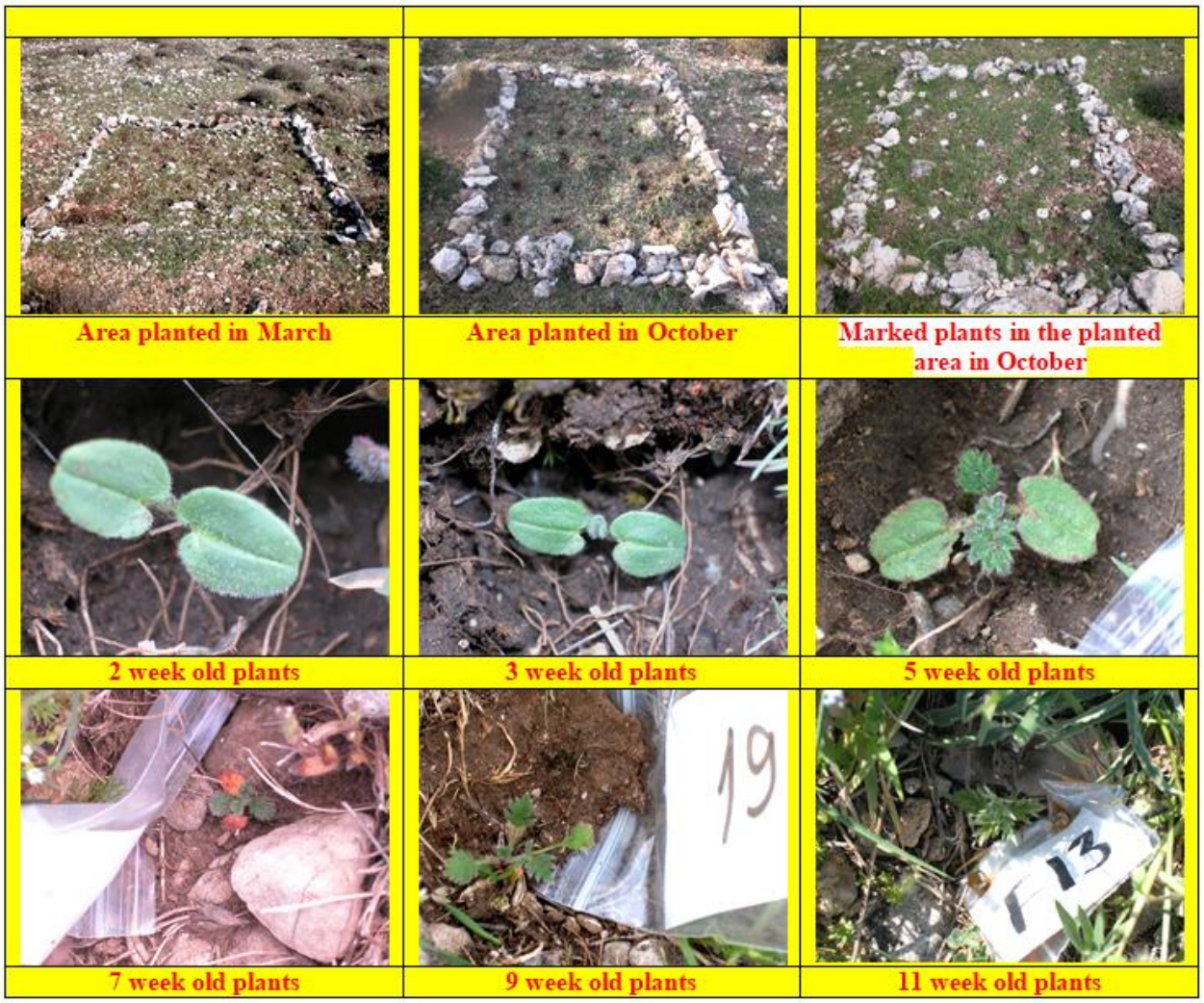

Figure 3. Different development stages of germinated seeds and seedlings in conservation areas.

The flowering period was clearly longer and more intense in the lithosol than in rock. But as a result, in both microhabitats of *E. paularense*, neither flowering moment nor intensity had a meaning effect on fruit set. They attributed to the lack of a significant difference in total seed production as the presence of a pollinator is not a limiting factor.

Temperatures between 15-22 °C appear to be sufficient for blooming and pollination in *E. somanum*. It has seen that temperature values are decreasing during humidity values is increasing in the most density term of blooming period. The foraging rate of free-flying bumblebees was positively associated with air humidity has been reported by Peat & Goulson, [15]. They have thought that the amount of nectar secretion is high and

nectar evaporation is low in high humidity. The results of current study also support this view. Because *E. somanum* is a dioecious and nectariferous. On the days when flowering is the most intense, it seen that the air temperature decreases and relative humidity increases. Naturally, during this short vegetation period, the more the pollinator visit and the more flowers benefit from this situation, the continuity of the species is ensured. Also, Aldosoro *et al*. [16], have been reported that nectar is the main gift for insects in the Geraniaceae, being exhibited in different way. In the current study, the flowering peak overlaps with the period of activity of *Malachidae* species which are the most important pollinators was observed. On the other hand, even if the temperature and relative humidity are sufficient in this period, other conditions must also be appropriate. Because very strong winds or precipitation reduce the insect activity, thus resulting in reduced pollen transport.

4.2. Germination

Germination time of *E. somanum* was determined as autumn in the natural environment. It was thought that the seedlings that germinating in spring, could not survive because of the summer drought. But seedlings that spontaneously germinate in the autumn, can overcome the summer drought, as they reach a certain size and their roots can extend deeper into the soil. Similarly, Gonzales-Benito *et. al*. [17] have reported that *E. paulerense* might be germinating in autumn due to the germination temperature range of the seeds of the species. Because in this season the average temperature falls and water is available.

Also, detecting the *E. somanum* germinates in autumn in the natural environment will be a very important step for future research. Besides, it needs to be development of a suitable methodology for spreading of this species, growing and vegetative propagation of species, including germination and micropropagation of seeds.

4.3. Conservation needs and significance

E. somanum is in critically danger of extinction mainly due to its restricted distribution and its small population size. This makes the species very vulnerable to any event, either from natural causes or human activities.

One of the reason for the threat of extinction in *E. somanum* is human impact in its distribution area during construction of fire lookout tower, radio station buildings and especially wind turbines. Such anthropogenic pressure causes the destruction of mature individuals, fragmentation habitat size and narrowing the distribution area. Therefore, construction of new buildings around distribution area should be prohibited and logistical activities should be implemented with great care. Additionally, grazing activities in this area seem to be harmful as the cattle eat fruit of plants. Further monitoring should assess the grazing activities of distribution area and long-term effect in populations. The people who living there engaged in livestock, should be better informed of the situation.

Phenological factors, play an important role as determinants of reproductive success, also, this species depends on the pollinators for reproduction because of dioecious species. This fact should be taken into account in the conservation and management plans of the species. Because long-term changes in climatic conditions can indirectly affect the reproduction of this species with changes in its phenological properties and pollinators.

In conclusion, the collection of life history information of an endangered species, that is an important and necessary step in designing and implementing an effective protection program.

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Author's Contributions

D. Oskay: Responsible of all processes; planning the study, conducting field studies, obtaining and analyzing data, drafted and writing the article.

Ethics

There is no ethical issues after the publication of this article.

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