Lagascalia 19(1-2): 579-582 (1997)

FLOWERING AND FRUITING PHENOLOGY OF ERODIUM PAULARENSE FERN. GONZ. & IZCO

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Abstract

Flowering and fruiting variables were studied in two populations of *Erodium paularense* Fern. Gonz. & Izco (*Geraniaceae*) for the 1995 season. In Population II, the maximum number of flowers and the maximum number of fruits per plant were higher in rocky microhabitats than in lithosol. On average, no significant effect of plant size was found on flower, fruit and seed production. Gene flow between the two populations was found to be severely limited by low flowering synchrony between them (0.18).

Introduction

The design of successful *in situ* conservation management plans for an endangered plant population requires thorough knowledge of the species' reproductive biology. *Erodium paularense* Fern. Gonz. & Izco (*Geraniaceae*) is a threatened plant species of Central Spain that grows on dolomitic rocks and on the shallow soil formed from them (lithosol). In this study, the effects of type of microhabitat and plant size on the phenological pattern and the reproductive potential of *E. paularense* were studied.

Materials and Methods

The study was performed from February to June 1995 on 121 plants belonging to two populations located in Valle del Paular (Madrid). Population I (PI) is found on the south-facing slope of a dolomitic hill whereas Population II (PII) is located 1150 m from PI on the NE side of a hill next to a water reservoir. In the last 4 weeks of the study, 27 of the plants selected in PII were damaged by cattle and thus discarded for the study.

Each individual was defined as a group of rosettes less than 2 cm apart at the soil level (GONZÁLEZ-BENITO & al., 1995). Individuals over 6 cm diameter (minimum cluster size to produce flowers, GONZÁLEZ BENITO & al., 1995), from both rocky and lithosol microhabitats were selected. The number of flower buds, open flowers, withered flowers, unripe and ripe fruits and well-formed seeds was assessed for each plant every 5-10 days. Flowering and fruit ripening synchrony were calculated for every pair of plants according to PRIMACK (1980).

Results and Discussion

Three plant size classes (class 1: 6-15 cm, n=46; class 2: 16-25 cm, n=36; class 3: >25 cm, n=12) were discerned by non-hierarchical (k-means) cluster analysis of the variables "length of the flowering period" (number of monitoring days in which open flowers were observed) and "maximum number of flowers" (both arctan transformed), and subsequently used in the analysis of data. Significant interactions between "population" and "microhabitat" ($p<0.05$ or $p<0.01$) were found when three-way analyses of variance were performed on the dependent variables to assess the effect of population, microhabitat and plant size. Thus, the dependent variables were studied separately for each population.

Time variables.- Flowering started in mid-February in PI and at the beginning of April in PII, and concluded at the beginning of June and mid-May, respectively (Fig. 1). Similarly, the maximum flowering period (>50% of the plants with open flowers), was also longer in PI. These differences seem to depend on the specific microclimatic factors that operate in each location. Within each population, no significant differences in the length of the flowering period were found between microhabitats or between size classes (Table 1), indicating that factors affecting the length of the flowering period were relatively constant within each population.

Flowering overlapping between plants in PII was, in average, higher than that found in PI (0.56 vs. 0.38), whereas the mean synchrony between populations was low (0.18). The latter indicates that a plant in PI can exchange genes with just 18% of the individuals of PII and viceversa. The chances of genetic exchange between the two populations are further restricted by the distance (1150 m) that lies between them, large enough to isolate the populations (EHRLICH & RAVEN, 1969). The results obtained for flowering duration and synchrony allow *E. paularense* to be placed among typical

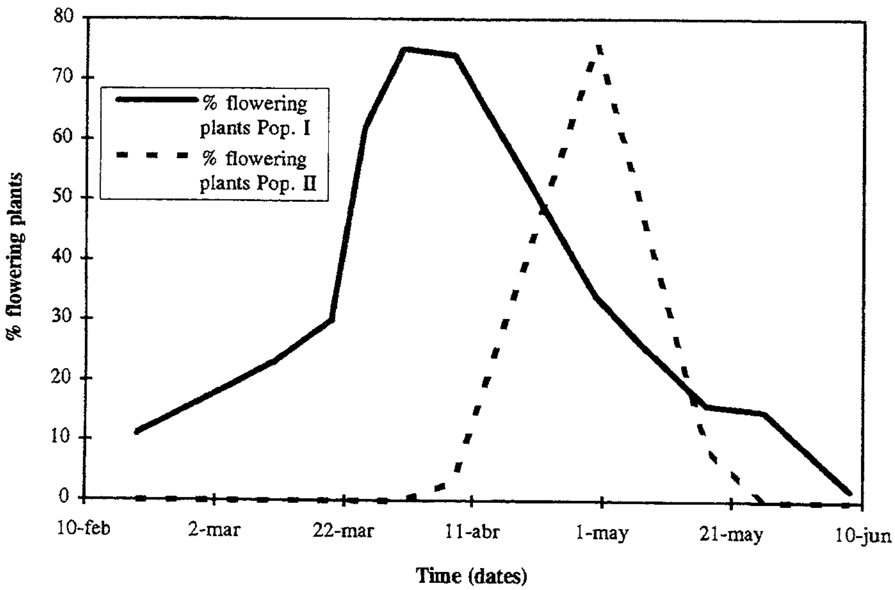

Fig. 1. Percentage of flowering plants of *E. paularense* in the 1995 season (Population I, n=61; Population II, n=31).

	Population I			Population II		
	Microhabitat	Size	M x S	Microhabitat	Size	M x S
Flowering period	0.57	1.40	0.67	1.76	0.77	0.62
Max. no. of flowers	0.03	2.36	0.68	3.65*	0.64	0.72
Total no. of flowers	0.15	1.82	0.61	3.11	0.51	0.83
Max. no. of fruits	0.98	0.60	0.99	4.89$^{\gamma}$	0.00	2.25
Total no. of seeds	0.88	2.61	4.06$^{\gamma}$	0.61	0.61	2.16

Table 1. Effects of microhabitat and plant size on time and reproductive variables of *E. paularense* (F-values of two-way ANOVAs; $^{\gamma}$ $p<0.08$; * $p<0.05$).

insect-pollinated species characterised by a small but constant flower production over a long period of time (RATHCKE & LACEY, 1985).

Fruit ripening synchrony was 0.45 ± 0.13 in PI and 0.54 ± 0.04 in PII, whereas the synchrony of seed deposition (not measured) was probably much lower. This is due to the high number of fruits without seeds that remained in the parent plant for a much longer time than the seed-bearing fruits and thereby increased the values of fruit ripening synchrony. Low levels of synchrony of seed deposition might be advantageous in seed dispersal to reduce the loss of seeds by predation.

Reproductive variables.- No significant differences were found in the reproductive variables for plant size and microhabitat in PI (Table 1). Nevertheless, the type of microhabitat affected the maximum number of flowers (rock: 6.71 ± 5.80; lithosol: 3.47 ± 5.08) and also the maximum number of fruits per plant in PII (rock: 25.36 ± 22.65; lithosol: 8.79 ± 10.73). Significant correlations were found between the maximum number of flowers and the total number of flowers per plant, and between the maximum number of fruits per plant and the maximum number of flowers per plant, in both populations (Table 2). The correlations between the maximum number of flowers, the total number of flowers and the maximum number of fruits, and the total number of seeds were only sginificant in PI (Table 2). The low total number of seeds per plant obtained (PI: 1.70 ± 3.03; PII: 0.18 ± 0.63) ratifies the results of previous studies (IRIONDO & al., 1994).

The significant effect of plant size upon the total number of seeds per plant found in other angiosperms (JORDANO, 1988) was only observed in lithosol in PI (class 1: 0.33 ± 0.82; class 2: 2.07 ± 2.58; class 3: 3.33 ± 1.33; $F_{2,30}=6.01$, $p<0.01$), when a separate analysis was performed for each microhabitat due to the microhabitat x plant size interactions detected (Table 1).

A flowering period in high synchrony with the population seems to be determinant for the reproductive success of an individual (GUITIÁN & SÁNCHEZ, 1992). However, in *E. paularense* (PII), a negative correlation was found between flowering synchrony and the total number of seeds ($r=-0.41$, $N=26$, $p<0.05$). Further data is needed to evaluate this situation.

Conclusions on conservation.- Data collection in coming years is needed to ratify or rectify the interpretations made from the results of the 1995 season. Nevertheless,

	Population I	Population II
Max. no. of flowers x Total no. of flowers	0.97** (n=61)	0.93** (n= 33)
Max. no. of flowers x Max. no. of fruits	0.83** (n=61)	0.88** (n=33)
Max. no. of flowers x Total no. of seeds	0.44** (n=61)	0.09 (n=33)
Max. no. of fruits x Total no. of seeds	0.48** (n=61)	0.21 (n=33)
Total no. of flowers x Total no. of seeds	0.45** (n=61)	0.21 (n=33)

Table 2. Spearman correlation coefficients (* $p<0.05$; ** $p<0.01$).

from a conservation perspective, the present data suggest that: 1. there is effective genetic isolation between the two populations of Valle del Paular and thus a higher vulnerability to catastrophic events, and 2. there is a bottleneck in the reproductive process at the stage of fertilisation and seed formation that limits the reproductive potential of the species.

Acknowledgements

This work has been partially funded by Project CICYT: AMB 93-0092, and by Project No. 086/92, Plan Regional de Investigación, Comunidad de Madrid. We thank Dr. A. Escudero, R. Alonso, A. Báez, D. Pereira, N. Sánchez and L. De Hond for their assistance in various fields.

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