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Environmental range of narrow endemic *Erodium paularense* Fern. Gonz. & Izco and its vulnerability to changing climatic conditions

Abstract

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Soil and climate properties, plant communities and population structure were studied at the two exclusive locations of the endemic *Erodium paularense*. It was concluded that the affinity for rare dolomite and andesite outcrops in siliceous landscape, the strict water requirements during the reproductive period and seedling establishment, and the need for shallow soils affected by freezing-thawing climatic perturbations make this species highly vulnerable to changing climatic conditions.

Introduction

Erodium paularense Fern. Gonz. & Izco is a perennial chamaephyte that presently occurs exclusively at two locations in Central Spain (Fernández-González & Izco 1989). Due to its reduced distribution, it is classified as vulnerable (V) (Gómez-Campo 1987) according to the IUCN categories. *E. paularense* is presently protected by a Madrid Regional law (BOCM 1989) and also formally listed in Annex II and Annex IV of the European Community Habitats and Species Directive (European Community 1992).

The original locality of this species is in Pinilla del Valle (Madrid), 90 km north of the city of Madrid at the Lozoya Valley on the south-western side of Sierra de Guadarrama. The second site is located about 160 Km away to the North East in Cañamares (Guadalajara) at a small valley between Sierra del Alto Rey and Sierra del Bulejo. Plants grow on small outcrops of dolomites in Lozoya and on andesites in Cañamares, surrounded in both cases by large extensions of siliceous rocks. The populations at both locations are experiencing a decline for which both human and natural processes are responsible (González-Benito & al. 1995). In order to assess the importance of natural processes on this decline and the vulnerability of the species to global change, the environmental range of the species was assessed through a comparative study of soil characteristics, climatic conditions, demographic structure and floristic composition, performed at both locations. This research is part of a long-term monitoring project on the biological performances of this rare and endangered plant (Iriondo & al. 1994, González-Benito & al. 1995).

Materials and Methods

Four soil samples, two from the Lozoya Valley and another two from Cañamares, were analysed. Twenty-year series of climate data were obtained from the nearest meteorological station to the Lozoya Valley (Rascafría) and to Cañamares (Atienza). To calculate the size structure of the *E. paularense* populations, twenty 6 × 3 m plots were randomly sampled in each one of the two locations. The maximum diameter of the rosette of rosettes that forms each individual was used to determine the size. Finally, the percentage cover of those perennial plants present in 1 × 1 m quadrats centered in randomly selected *E. paularense* plants were accounted. Thirty two plots (Fig. 3) were surveyed in each population. Perennial cover data were analysed by means of a Correspondence Analysis in order to detect the main floristic trends.

Results and Discussion

The physical properties of the soils at both locations were pretty similar: shallow soils, with a pH close to neutrality, low salinity and a fine sandy texture (Table 1). Soil samples from Cañamares had a much lower concentration of P, K and Na, whereas Ca values were pretty close to each other. In Cañamares II, where the soil is less developed, magnesium concentration is very high and organic matter contents much lower than in the rest of the samples. Cultivation assays performed in *E. paularense* have shown that it can be grown in a quite wide range of substrates. This fact supports the idea that in spite of having a distribution linked to the presence of dolomitic and andesitic outcrops, *E. paularense* does not strictly depend on these geological substrates; its distribution probably adjusts better to the model of refuge (Gankin & Major 1964). Thus, *E. paularense* populations are able to sur-

Table 1. Soil analysis of two samples taken at each location.

	Lozoya I	Lozoya II	Cañamares I	Cañamares II
Soil depth (cm)	5-20	5-20	5-10	5
Texture	Fine, sandy	Fine, sandy	Fine, sandy	Sandy
pH	7.4	7.0	6.0	6.5
Conductivity (µs/cm)	460	390	580	280
Organic matter (%)	8.04	9.10	9.11	4.69
Extractable P ppm	5	10	3	3
Extractable K ppm	120	120	11	9
Ca (meq/100 gr)	17	17	9.60	13.29
Mg (meq/100 gr)	3.3	3.3	4.03	8.64
Na (meq/100 gr)	0.87	0.87	0.06	0.03

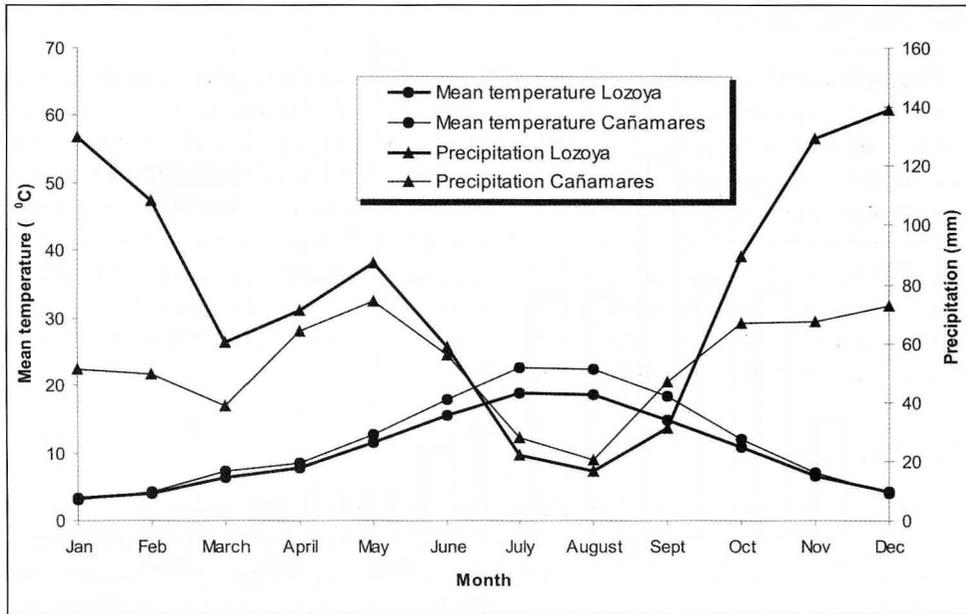


Fig. 1. Ombrothermic diagram (UNESCO-FAO).

vive in places with certain environmental restrictions, mainly edaphic, where competition with other taxa is less intense.

Climate data (Fig. 1) shows that *E. paularense* individuals grow within a wide range of temperatures. The temperature regime is more extreme in Cañamares, where throughout the annual seasons a temperature change of almost 34° C is observed, ranging between the 31.89° C maximum mean temperature in July and the -1.99° C minimum mean temperature in January. Annual rainfall in Lozoya Valley (943.06 mm) is over 40% higher than in Cañamares. However, the average precipitation in the months that coincide with the reproductive period (spring rainfall) of the species is pretty similar. This fact suggests spring rain is one of the key factors linking both populations.

The period of water deficit normally occurs right after fruit dispersal (Fig. 1). The length of the drought period is also similar at both locations and typically includes the months of July and August. Data from General Circulation Model (GCM) from the U.K. Hadley Centre unified model climate change experiment (HADCM2) (Butterfield & al. 1997) predict an increase of 2.5° C in annual mean temperature for the next 50 years in this area. This increase may not probably have a high direct effect on the survival of *E. paularense* adult plants due to their ability to survive in a wide range of temperatures. However, the reproductive success could be adversely affected through changes in the synchrony of the flowering process with the life cycle of their pollinators. Predicted changes in the rainfall regime might also directly interfere with the reproductive process and seedling germination and establishment. In 1995, the lack of precipitation (4% less than average) was the main factor responsible for the 20% decrease in the size of the populations of the Lozoya Valley.

Size structure is pretty similar at both locations (Fig. 2), although the populations at the

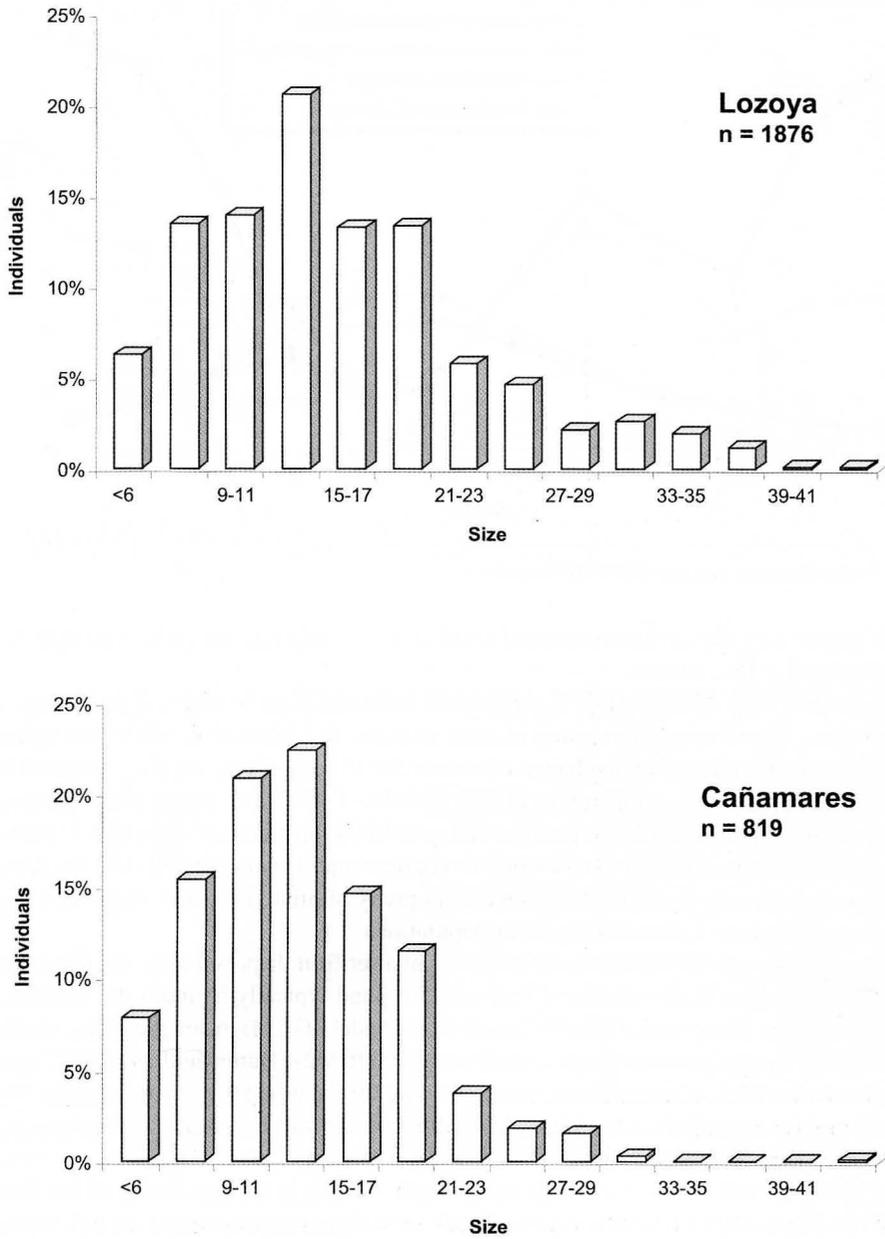


Fig. 2. Size structure of *Erodium paularense* populations at the Lozoya Valley and Cañamares in 1997.

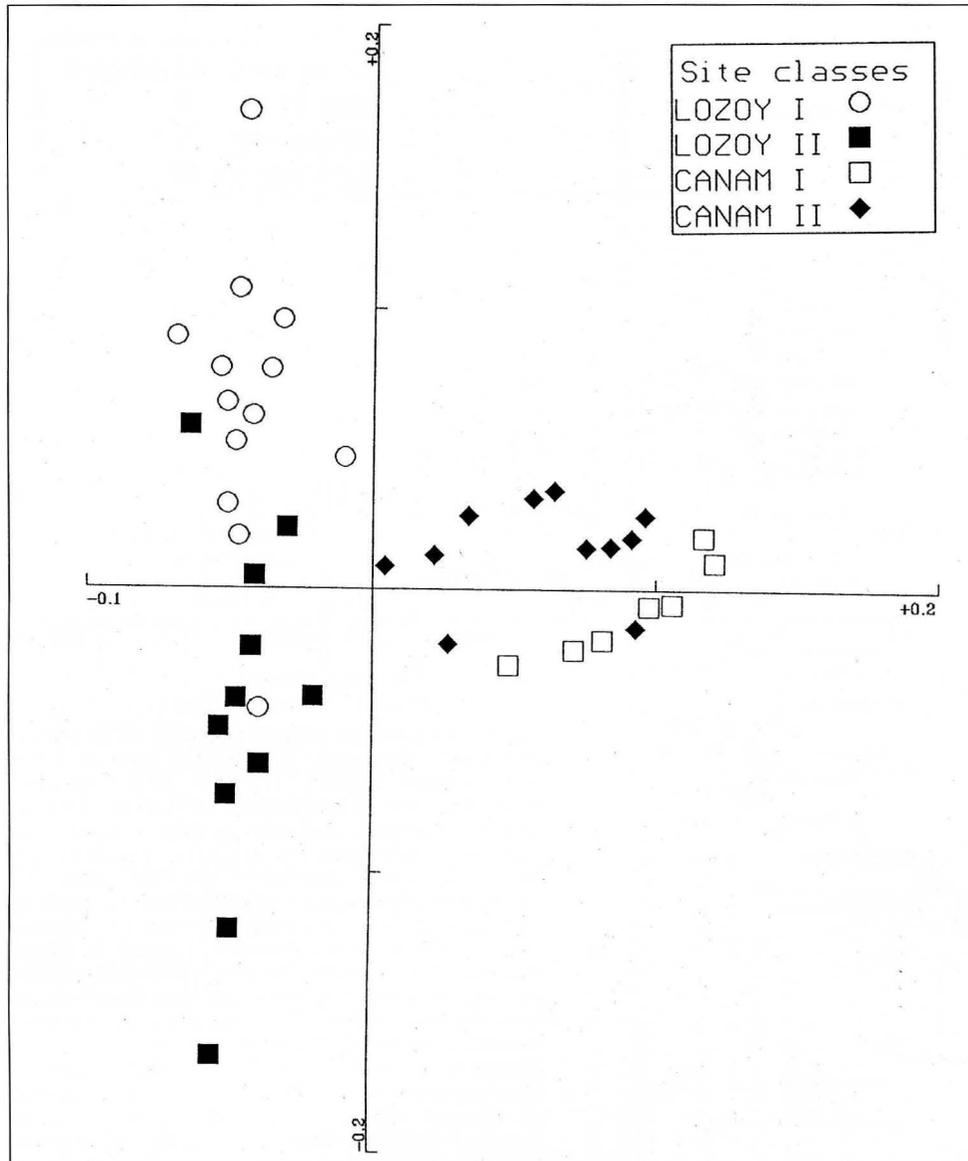


Fig. 3. Correspondence Analysis Ordination of the plots. Axes 1 and 2. Plots are classified at population and microhabitat level (lithosol: bold, rock: white).

Lozoya Valley are able to produce larger individuals. A pyramid truncated at its base shape denotes problems of reproduction and recruitment in this species. Reproduction and seedling establishment are the main limiting processes in the viability of *E. paulare* populations. It is at these stages where the vulnerability to changes in environmental conditions is also greater.

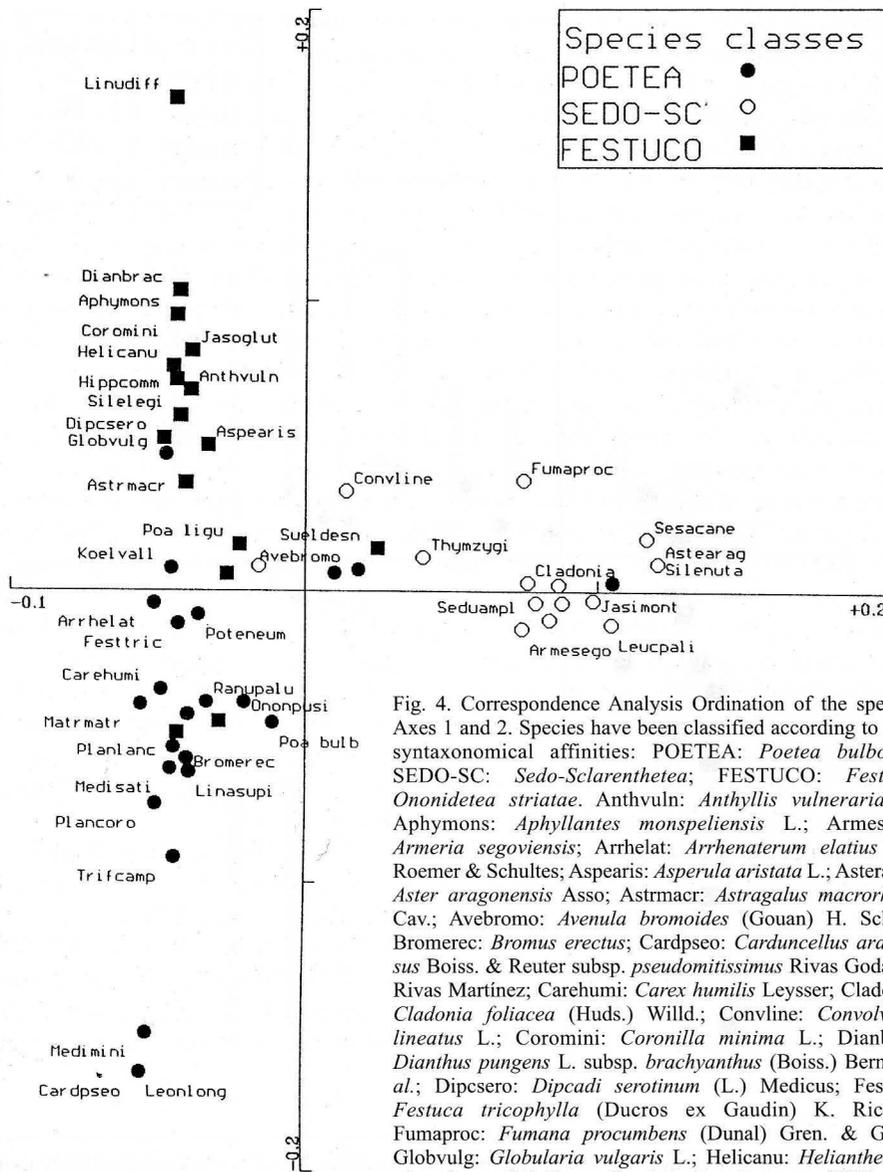


Fig. 4. Correspondence Analysis Ordination of the species. Axes 1 and 2. Species have been classified according to their syntaxonomical affinities: POETEA: *Poetea bulbosae*; SEDO-SC: *Sedo-Sclarenthetea*; FESTUCO: *Festuco-Ononidetea striatae*. Anthvuln: *Anthyllis vulneraria* L.; Aphymons: *Aphyllantes monspeliensis* L.; Armesego: *Armeria segoviensis*; Arrhelat: *Arrhenaterum elatius* (L.) Roemer & Schultes; Aspearis: *Asperula aristata* L.; Asterarag: *Aster aragonensis* Asso; Astrmacr: *Astragalus macrorrhizus* Cav.; Avebromo: *Avenula bromoides* (Gouan) H. Scholz; Bromerrec: *Bromus erectus*; Cardpseo: *Carduncellus araneosus* Boiss. & Reuter subsp. *pseudomitissimus* Rivas Goday & Rivas Martínez; Carehumi: *Carex humilis* Leysser; Cladonia: *Cladonia foliacea* (Huds.) Willd.; Convline: *Convolvulus lineatus* L.; Coromini: *Coronilla minima* L.; Dianbrac: *Dianthus pungens* L. subsp. *brachyanthus* (Boiss.) Bernal *et al.*; Dipcsero: *Dipcadi serotinum* (L.) Medicus; Festtric: *Festuca tricophylla* (Ducros ex Gaudin) K. Richter; Fumaproc: *Fumana procumbens* (Dunal) Gren. & Godr.; Globvulg: *Globularia vulgaris* L.; Helicanu: *Helianthemum oleandicum* (L.) Dum. Cours. subsp. *incanum* (Willk.) G.

López; Hippcomm: *Hippocrepis commutata* Pau; Koelvall: *Koeleria vallesiana* (Honckeny) Gaudin; Jasimont: *Jasione montana* L.; Jasoglut: *Jasonia glutinosa* (L.) DC.; Leonlong: *Leontodon longirostris* (Finch & P.D. Sell) Talavera; Leucpali: *Leucanthemopsis pallida* (Mill.) Heywood; Linasupi: *Linaria supina* (L.) Chazelles; Linudiff: *Linum differens* Pau; Matrmatr: *Matricaria matricarioides* (Less.) Porter; Medimini: *Medicago minima* (L.) Bartal.; Medisati: *Medicago sativa* L.; Ononpusi: *Ononis pusilla* L.; Poabulb: *Poa bulbosa* L.; Plancoro: *Plantago coronopus* L.; Planlanc: *Plantago lanceolata* L.; Poaligu: *Poa ligulata* Boiss.; Poteneum: *Potentilla neumanniana* Reichenb.; Ranupalu: *Ranunculus paludosus* Poiret; Seduampi: *Sedum amplexicaule* DC. subsp. *amplexicaule*; Sesacane: *Sesamoides canescens* (L.) O. Kuntze subsp. *canescens*; Silelegi: *Silene legionensis* Lag.; Silenuta: *Silene nutans* L.; Trifcamp: *Trifolium pratense* L.; Thymzygi: *Thymus zygis* L..

In spite of its narrow distribution, *E. paularense* occurs in very different floristic communities. The first extracted axis clearly separates communities from andesites in its positive half from communities on the dolomitic outcrops of Lozoya; however, the second axis leads the separation of the chasmophytic communities of the Lozoya population from the pasture communities which appear in the bottom half of the scatterplots (Fig. 3-4). Richness is notoriously higher on the Lozoya Valley population (mean 13.60 ± 26.93) and it is specially poor on the shallowest andesite soils of Cañamares (mean 8.09 ± 3.75). *Erodium paularense* seems to be confined to communities related to the shallower and cryo-disturbed soils close to the bare rock outcrops. These plant communities can be ascribed to the creeping chamephyte-rich and endemic *Minuartio-Poion ligulatae* Bolos 1962 (*Festuco-Ononidetea striatae* Rivas Martínez & al. 1991) communities on the Lozoya Valley and to its vicariant on acid soils, *Hieracio castellani-Plantaginion radicatae* Rivas Martínez & Cantó 1987 (*Sedo-Scleranthetea* Br.-Bl. 1955 em. Muller 1961) on the Cañamares andesites. Due to the lithological nature of the andesites, these acidophilous communities are floristically impoverished and even some generalist calcicolous plants appear. In any case, the presence of these communities seems to be interactively controlled by the existence of a daily freezing-thawing process, at least during spring, and poor soil development. Within each population two different floristic trends can be derived from this optimum. The first related to cliff-rock biotopes, with communities belonging to *Asplenio-Saxifragion cuneatae* Rivas Martínez in Loidi & Fernández Prieto 1986 (*Asplenieta trichomanis* (Br.-Bl. in Meier & Br.-Bl. 1934) Oberdorfer 1977) in the Lozoya Valley, which has been provisionally described as *Erodietum paularense* (Fernández-González 1988), and to the acidophilous *Rumici-Dianthion lusitani* Rivas Martínez, Izco & Costa ex Fuente 1986 (*Phagnalo-Rumicetea indurati* (Rivas Goday & Esteve 1972) Rivas Martínez & al. 1973) in Cañamares. The second trend is related to those sites with deeper soils, becoming close to the *Poa bulbosa*-dominated pastures, so-called 'majadales' in Spanish (*Poetea bulbosae* Rivas Goday & Rivas Martínez in Rivas Martínez 1978).

We conclude that vulnerability of *Erodium paularense* to a global change is high, because of its present narrow distribution and the needed coincidence of a complex set of conditions such as, the affinity for rare dolomite and andesite outcrops in a very homogeneous siliceous landscape, the existence of a minimum threshold limit of water during reproductive period and seedling establishment, and the necessity of freezing-thawing driven climatic perturbations on very shallow soils. An additional limiting factor is the dispersal strategy of *Erodium paularense*, which is severely constrained in time and space.

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