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Towards an atlas of rare and threatened flora in the province of Cuenca (Spain): the case of *Erodium macrocalyx* (Geraniaceae) as a model species

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Abstract: Not only the geography but other environmental features of Cuenca province (Spain) makes it rich in plant species of very different origins, some of which have been attributed to different categories of protection. The purpose of this study was to select species that might help understand migratory or speciation processes, perhaps due to their scarcity and their unique distribution, and irrespective of whether they are included in any normative framework or not. As such, here we present the method used to elaborate an atlas of the relatively rare and threatened flora in this province, using *Erodium macrocalyx* (G. López) López Udias, Fabregat & Mateo as a model species.
Keywords: Threatened plants; protected plants; Chorology; Cuenca; Spain.

Metodología para la elaboración de un atlas de flora singular y amenazada de la provincia de Cuenca (España) utilizando como especie modelo *Erodium macrocalyx* (Geraniaceae).

Resumen. La ubicación geográfica de la provincia de Cuenca hace que sea rica en especies vegetales de muy distintos orígenes, algunas de ellas incluidas en diferentes categorías de protección. Este estudio pretende seleccionar especies valiosas que por su rareza, singularidad o distribución, estén o no incluidas en algún marco normativo, ayuden a entender los procesos migratorios o de especiación. En este artículo se presenta la metodología empleada para la elaboración de un atlas de la flora singular y amenazada de dicha provincia y se adjunta como ejemplo la ficha de *Erodium macrocalyx* (G. López) López Udias, Fabregat & Mateo.
Palabras clave: Flora amenazada; flora protegida; Corología; Cuenca; España.

Introduction

The province of Cuenca is located at the centre of the Iberian Peninsula, specifically in the most meridional foothills of the Iberian System, although it also includes part of the Manchego and Alcarreño territories. This geographical situation has historically made it a key site in the migration of vegetation, constituting a true floristic crossroads where vegetation of different origins coincide (Eurosiberian, Iranoturanian, Mediterranean, Atlantic, North African, etc., Figure 1). The orientation of the Iberian System has favoured the migration of plant species along latitudinal line as a result of past climatic changes. A true plant motorway that has contributed to the uniqueness and the wealth of flora in this study area. Conversely, the mountain systems that extend from east to west have acted as a barrier to migration (Central System, Pyrenees, Cantabrian Mountain range, etc.). In such "plant travels", some of the species that have passed through the province have taken refuge at favourable sites and they contribute to the floral wealth of this territory, the vegetative catalogue of which estimated to extend to 2300 species. As such, performing an in-depth study of the entire floristic catalogue of this province represents a quite monumental task. Indeed, since many of the species implicated provide little chorological and ecological information, there is a need to devise a method by which an atlas of the most valuable plant species present in the province of Cuenca can be developed. Accordingly, the approach adopted here represents a tool that might help in the management of the threatened species.

Selection of species

The selection of species was based on their representation in the territory, chorological value and their inclusion in listings of threatened species (Figure 2). The sources of information used were those providing basic information on plant species (Castroviejo & *al*., 1986-2015; Tutin & *al*., 1964-1980), periodic publications, information on herbs (MA, VAL, MAF, etc.), web applications (www.anthos.es; www.gbif.es; www.floragon.ipe.csic.es) and our own data obtained in the field. Having collected all this information for each species, we proceeded to

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filter the dataset based on taxonomic and chorological features.

A data sheet was prepared for each species, which included a header with the scientific name, its common name and the family to which it pertains. A representative photograph, and a map of the peninsular and of the province, on which the results of the field work and the information collected were displayed. A 10 x 10 km grid is superimposed on the map of the province, in which the shaded squares indicate where the presence of the species has been corroborated, those containing the letter 'E' are where it has become extinct and those with a 'P' are where it has been planted. Where doubts exist regarding its presence, the square contains a question mark "?".

Figure 1. Main migratory routes hypothesised to have contributed to the flora accumulated in the province of Cuenca.

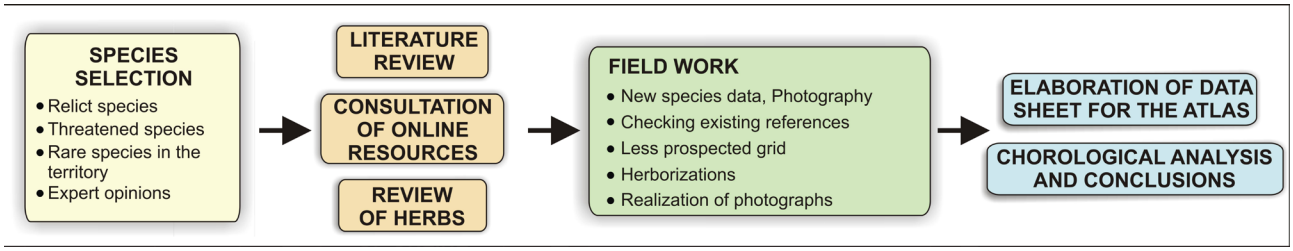


Figure 2. Methodological scheme.

In the space between the photograph of the plant and the map of the peninsular, abbreviated information of the species is introduced that is related to its: biogeography, biology, the altitude interval in which it appears in the province, optimal bioclimatic unit, edaphic preference, size, phenology, degree of rarity, and the normative framework should it be under threat. Each of these features are explained in more detail below:

Biogeographic element: essentially refers to the general distribution of each species, for which the following abbreviations have been used (www.globalbioclimatics.org): Atl., Atlantic; Austral., Australian; Balear,Balearic Islands; Capense,Capense (South African); Centroas., Central Asia;Cosmop., Cosmopolitan; Chinojap., Chinese-Japanese; Euroas., Eurasian; Eurosib., Eurosiberian; Europ., European; Fr., France; Holart., Holarctic; Iberoatl., Ibero-Atlantic; Iberolev., East of the Iberian Peninsula; Iranot., Iranoturanian; Lateeurosib., Lateeurosiberian; Macar., Macaronesian; Medit., Mediterranean; Norteafr., North African; Norteam., North American; Neotrop., Neotropical (Central and South America); Paleotemp.,

Old World Temperate Regions; Paleosubtr., Subtropical regions of the Old World; Paleotrop., Tropical regions of the Old World; Pen. Iber., Iberian Peninsula; Plurirreg., Pluri-regional: Widely distributed throughout the world; Sahar., Saharo-Syndic; Subcosm., Subcosmopolitan; Subtrop., Subtropical. These abbreviations may be followed by acronyms that further specify the biogeographic element (C. central; CW. west-central; E. oriental; N. northern; NW. northwestern; S. southern; SW. southwest; W. western; CS. south-central)

Biological type: This feature tries to express the morphology and lifestyle of the species, using the following abbreviations (Font Quer, 1953): Bien., Biennial (lives two years); Bulb., Bulbous (with bulbs under-ground); Cam., Chamaephytes (perennial and low); Cesp., Turfing strongly (forming lawns); Epif., Epiphyte (rooted on another plant); Esc., Plant with a foliate stem; Escand., Climbing plant; Estol., Stoloniferous (emitter of stolons); Fan., Fanerophyte (with high buds); Frut., Woody plant; Geof., Geophyte (with underground buds); Hemic., Buds to ground floor; Hidr., Hydrophyte (lives in the water); Macrofan., Macrofanerophyte (High tree); Mesofan., Mesofanerophyte (High bush, low tree); Nanofan., Nanofanerophyte (low bush); Nat., Floating water plant; Par., Parasite (not a green plant); Pulv., Cushion plants; Rad., Plant rooted (hydrophytes and Geophytes with grounded roots); Rept., Crawling (Creeping); Riz., Rhizomatous (with subterranean rhizomes); Ros., Leaves in a basal rosette; Suc., Succulent plants; Sufr., Sufruticoso (slightly lignified at base); Ter., Annuals plants; Tub., Tuberous (with subterranean tubers).

Altitude interval: Altitude (in meters above sea level) at which the species can be found in the province of Cuenca. In the case of a single population, the altitude corresponds to the location in question.

Bioclimatic units: This feature adopts the criteria of recent publications (Rivas-Martínez & *al*., 2002, 2004; Martín Herrero & *al.*, 2003: 310). In the province of Cuenca the following bioclimatic units are relevant and used: Oro., Oromediterranean; Supra., Supramediterranean; Meso., Mesomediterranean; Suprasub., Suprasubmediterranean; Orosub., Orosubmediterranean.

Soil preference: This parameter provides information on the edaphic requirements of each species. As this may be complicated for many of them, only the categories "Calciphile", "Calcifuge plant", "Indifferent edaphic", "Gypsophile" or "Halophile" are considered. If multiple edaphic preferences are observed, the abbreviations may be shown in brackets next to the most commonly observed edaphic preference: (Ca), Calciphile; (Si), Calcifuge plant; (Gyps), Gypsophile; (Halóf), Halophile;

Size: Refers to the size of the plant based on bibliographic data, although this may be adjusted in the light of field observations. It indicates the minimum and maximum size measured in meters (m) or centimeters (cm). When atypically extreme sizes were observed they are indicated in parentheses.

Phenology: Period in which it the plant is usually found in flower (sporangia in ferns) in the province of Cuenca, indicating the months in Roman numerals (I, II, III, IV, V, VI, VII, VIII, IX, X, XI and XII). This data is based on field observations and on information in the literature (Castroviejo & *al*., 1986-2015). When the month is placed in brackets it refers to abnormal floral periods observed in the field.

Level of rarity: Gives an approximate idea of the rarity or frequency of the species in the territory to according to the following scale (Presence in grids 10x10 km). The squares of the grid in which the population has been planted, it is extinct or its presence is doubtful are not included: CC, Very abundant (>30); C, Abundant (>20–≤30); M, Frequent but not abundant (>10–≤20); R, Rare (>5–≤10); RR, Very rare (≤5).

Normative framework of threat: Established at the regional level according to the Regional Catalogue of Threatened Species of Castilla-La Mancha (Anon., 1998b; Anon., 2001) as follows: PEXT, Danger of extinction; VUL, Vulnerable; IE, Special Interest; OTR, Other Species of Interest not included in the Catalogue.

At the national level, the 2008 Red List of Spanish vascular flora was used (Moreno, 2008) and its subsequent update from 2010 (Moreno, 2011), establishing the following categories: LREX, Extinct; LREW, Extinct in the wild; LRRE, Extinct at the regional level; LRCR, Critically endangered; LREN, In danger; LRVU, Vulnerable; LRNT, Almost threatened; LRLC, Minor concern; LRDD, Insufficient data; LRNE, Not rated. This parameter also takes into account the Royal Decree 139/2011 (Anon., 2011), which creates the Spanish Catalogue of Threatened Species according the following categories: RD139PE, Danger of extinction; RD139VU, Vulnerable; RD139SC, Unclassified.

There are basic guidelines for the conservation of flora at the European level. The first is Council Directive 92/43/CEE, 21st May 1992, on the conservation of natural habitats and of wild fauna and flora (Anon., 1981, 1992, 1997). This directive is associated with a series of relevant annexes: Annex II (Animal and plant species of Community interest for which conservation is necessary to designate special areas of conservation); Annex IV (Animal and plant species of Community interest requiring strict protection); and Annex V (Species animals and plants of Community interest whose collection and exploitation of which may be the subject of management measures). The abbreviations adopted in this case are: DHAII, Habitats Directive Annex II; DHAIV, Habitats Directive Annex IV; DHAV, Habitats Directive Annex V; *, Priority taxes.

The other European standard to be taken into account is Council Decision 82/72/CEE, 3rd December 1981, on the conclusion of the Convention on the conservation of European wildlife and natural habitats (Berne Convention), and Council Decision 98/746/CE, 21st December 1998, on the approval, on behalf of the Community, of amendments to Annexes II and III of the Berne Convention for the conservation of life wild fauna and flora of the European Union adopted during the 17th meeting of the Standing Committee of the Convention (Anon., 1998a).

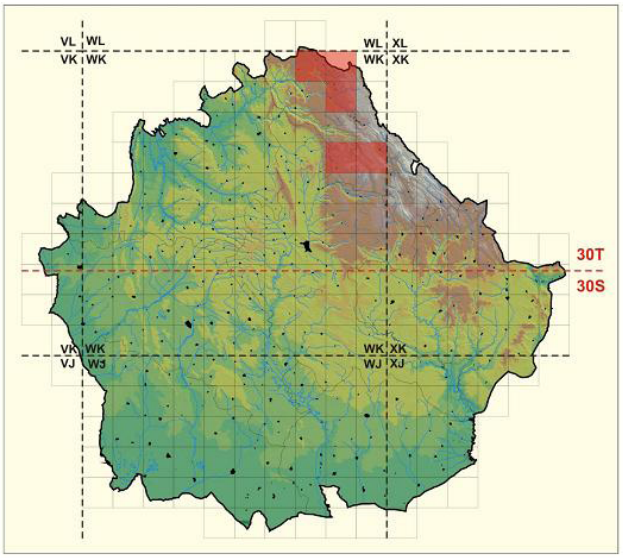
Further information that is related to other parameters is included in an unabbreviated form for each species.

Erodium macrocalyx (G. López) López Udías, Fabregat & Mateo in Flora Montiberica 8: 75 (1998)

GERANIACEAE

(Big calyx geranium)

Iberolev.
Cam.-Pulv.
5.2-12.5 cm.
Calcicola
Orosub.
1380-1750 m.
IV-IX
RR
IE, LRVU



Synonyms: *Erodium daucoides* Boiss. subsp. *macrocalyx* G. López in Anales Jard. Bot. Madrid 37(1): 96 (1980).

Differentiating characteristics: Plant of the *Erodium daucoides* Boiss. group, which also includes *E. astragaloides* Boiss & Reut., *E. aguilellae* López Udias, Fabregat & Mateo and *E. daucoides* Boiss. It is noted for the robustness of all its elements: sepals of 9-11.7 mm before flowering and 12.5-15.2 mm in fructification, with a mean of 8-10(11) mm. Its fruit is the largest of the group, mericarps 9-10 mm and rostro 40-45 mm. A characteristic of this group is that their glands are located at the base of the superior petals, which assemble small drops of water that possibly attract insects. Other features to be taken into account are its oblong leaves up to 15 cm long, which are ovate to lanceolate, pinnatified and with non-divided foliols, as in *E. celtibericum* Pau and *E. glandulosum* (Cav.) Willd.

Habitat: Lives in limestone roquets and lithosols some of which are nitrified. Such nitrification is favoured and maintained by the presence of sheep, which tend to concentrate in high areas, and that rest and pass the night there in summer. It is curious that all the populations are located on limestone from the superior cretaceous period, on ephemeral sandy soils formed by decalcification, or on crags and rocks.

List of localities: WK79: (García Cardo & Sánchez Melgar, 2007: 109). **WK86:** (García Cardo, 2010: 30). **WK88:** (Roselló *et al*., 2004: 74); (García Cardo & Sánchez Melgar, 2005: 109); (García Cardo, 2016: 49). **WK89:** (García Cardo, 2016: 50). **WK96:** (López González, 1980: 96); (Roselló *et al*., 2004: 74); (García Cardo & Sánchez Melgar, 2005: 109).

Observations: Endemic to the Iberian peninsula, with a distribution limited to the Southern Iberian System. It was believed to be exclusive to the province of Cuenca but it has recently been located on the Alto Tajo region of the province of Guadalajara (Ferrero & Medina, 2011), near Serrezuela de Valsalobre.

Pressures and threats: Climatic change, excess and lack of extensive livestock pressure.

Proposed measures: Census and monitoring of known populations, propsecting of potential areas, management of livestock use.

Figure 3. Example sheet of an endangered species (Roselló & *al*., 2004; García Cardo, 2016).

Synonyms: The most important synonym for the name of the species in the most common floral works (Bolòs & Vigo, 1984-2001; Castroviejo & *al*., 1986-2015).

Differentiating characteristics: These features are not intended to provide an extensive or detailed description of each species but rather, they aim to highlight the main differentiating characteristics with respect to other species that may be found in the province. Hence, the species identification can be corroborated in different states by focusing on just some aspects of this species.

Habitat: Lists the main environments in which the species can be found in the province of Cuenca, which may help differentiate the species and facilitate its location. If possible, the habitat is indicated in accordance with the latest publications (Rivas-Martínez & *al*., 2001; Rivas-Martínez & *al*., 2002).

List of localities: A list of localities where each species has been recorded, collected or seen. These are sorted by UTM grids and chronological order, corresponding to the shaded regions shown on the provincial map. Reference will be made to any relevant publication (e.g., García Cardo, 2015: 3), whereas for unpublished herbarium sheets, the collector and identifier will be followed by the sheet code (e.g., *J. Fernández Casas* (MA 248419)). These new citations will include the following data: UTM, municipality, place name, altitude, habitat, date (day-month-year), collector, identifier or observer (in italics). The corresponding code may be enclosed in brackets and the following abbreviations may be used after the UTM coordinate: E, extinct; P, planted; ?, doubtful presence.

Observations: This section deals with aspects that include: biogeographic issues (global, national, regional and provincial distribution); issues related to known populations of each species; specific problems; taxonomic issues; and some other curiosities and peculiarities.

Pressures and threats: The main problems and real threats to each of the species in the province of Cuenca are listed and discussed. This will help to establish a line of practical, simple and feasible measures for conservation, and for the possible recovery of species.

Proposed measures: Considering the above, a series of measures are proposed with a view to improving or maintaining the conservation of each species. Some of the actions may already have been undertaken and their possible effectiveness can be indicated.

Using all of these criteria some 850 species were selected, which represents 37% of the total flora in the territory (García Cardo & Sánchez Melgar, 2005, 2007; García Cardo, 2010; Figure 3).

Conclusions

This work constitutes a basic tool for the management of threatened species, and for updating catalogues and red lists. It provides a protocol to obtain complete and detailed information, which will allow new areas of conservation to be proposed or existing ones to be modified. In addition, the chorological analysis of taxa will provide an outline of the possible migratory routes followed in response to the different climatic changes over the ages.

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