Habitat, occurrence and conservation of Saharo-Arabian-Turanian element *Forsskaolea tenacissima* L. in the Iberian Peninsula

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The aim of this study is to assess the Iberian populations of *Forsskaolea tenacissima* L. according to its biogeographical interest, habitat, geographical range and conservation status. Results point out that they are restricted to gravel wadis of Tabernas Desert (SE Spain), are scarcely included in protected areas and represent historically isolated populations with relict behaviour. We also describe a new association, *Senecioni-Forsskaoleetum tenacissimae*. Conservation status of species is cause for concern and two conservation actions must be carried out. Firstly, protected areas should house *Forsskaolea* populations and secondly, phytosociological characterization of a community allows inventorying its habitat and directing conservation efforts to community level.

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**Keywords:** biodiversity; flora; phytosociology; protected areas; reduced geographical range; relict populations; semi-arid ecosystems; Tabernas Desert

Introduction

The origin of the steppe areas in the Iberian Peninsula along the Pleistocene is an old classic controversial issue. The so-called ‘Steppe Theory’ (Del Villar, 1915) considered the vegetation of these ecosystems as the result of the destruction of primitive sclerophilous forests. For this reason the flora and vegetation of these ecosystems have been undervalued for conservation priorities. However, the most recent trend is to consider the possibility of persistence of non-forested areas across the Pleistocene in the Iberian Peninsula (e.g. Terradas, 1986; González-Bernáldez, 1989; Suárez Cardona *et al.*, 1992; Blondel & Vigne, 1993; Suc *et al.*, 1995; Willis, 1996; Ribera & Blasco-Zumeta, 1998).

This debate is important because as Gómez-Campo (1985) pointed out, the origin of Mediterranean flora has deep implications with regard to conservation attitudes. In SE Spain, steppe areas are semi-arid ecosystems that support a notable richness in...
species, with a large number of endemisms and Mesogeian elements (Peinado et al., 1992; Cabello, 1997). One of the latest is the Saharo-Arabian–Turanian element *Forsskaoea tenacissima* L. (Danin & Orshan, 1999) extending into the Mediterranean region (Fig. 1). This plant has a disperse geographical distribution along Palestine (Zohary, 1966; Evenari et al., 1971), Egypt (Ayyard & Ghabbour, 1986), North Africa and Sahara Desert (Ozenda, 1983; Le Houérou, 1986, 1995) and SE Spain (Sagredo, 1987; Paiva, 1993).

Literature (Sagredo, 1987; Paiva, 1993; Lorite et al., 1998), suggests that the geographical range in Europe of this species is restricted to a few localities in SE Iberian Peninsula, where the regional climate is notably semi-arid both due to the rainfall shadow effect of the main Betic ranges and its proximity to northern Africa (Geiger, 1973).

Regarding the biogeographical and ecological interest of this species in a European biodiversity scenario, the aim of this study is to assess the populations of *F. tenacissima* L. in the Iberian Peninsula according to its habitat, geographical range and conservation status. Taking into account that conservation becomes more logical when directed to syntaxa or to ecosystems than to a single species (Gómez-Campo, 1985), we studied the habitat of the species to enhance its role as a conservation target.

### Material and methods

The study was based on collections, literature and fieldwork carried out during 1999–2000. To assess the habitat of the species we studied biotope, community and bioclimatic traits. At the community level we studied the phytosociological behaviour of the species according to the Zurich–Montpellier school methods (Braun-Blanquet, 1979; Gehú & Rivas-Martínez, 1981). Taxa nomenclature first follows Castroviejo et al. (1986–2001) and Tutin et al. (1964–1980) for those taxa non-cited in the former reference. The syntaxonomical scheme follows Rivas-Martínez et al. (2001). For the description of this new association we used International Code of Phytosociological Nomenclature (Weber et al., 2000). For bioclimatic characterization of the populations, we considered bioclimatic It index proposed by Rivas-Martínez & Loidi (1999). Conservation status was studied to assess the occurrence of populations in protected areas (Fig. 2).

### Results

#### Geographical range

Iberian populations are restricted to gravel banks of some wadis of Tabernas Desert (Fig. 2): Rambla de Espinaza (Losa & Rivas Goday, 1968), Rambla de San Indalecio, Rambla de Gérgal (Kunkel, 1987), Rambla de Tabernas (Kunkel, 1987; Sagredo, 1987), Rambla de los Yesos (Lorite et al., 1998). As a result of fieldwork we confirmed all citations, and we added new localities: Rambla de San Telmo (Herbario de la Universidad de Almería, 1317) y Rambla de Los Alhamillos-Gérgal (Herbario de la Universidad de Almería, 1318).

#### Habitat

Iberian populations inhabit on gravel banks. This biotope emerges naturally in wadis, and in man-made terraces in flood plains of Tabernas Desert. Considering
Figure 1. Geographical range of *Forsskaolea tenacissima* L. in the Mediterranean Basin and bioclimatic features of its area.
the species composition recorded in the relevés, the community of *F. tenacissima* (Table 1) belongs to *Glaucion flavi* Alliance (*Andryaletalia ragusinae* Order, *Thlaspietea rotundifolii* Class), which represent the vegetation of gravel and pebbles of riverbanks in the Mediterranean Region. The community always appears in the early stages of succession, and when the substratum becomes steadier, perennial communities of Pegano-Salsoletea Class displace it. Due to this, on the bank of the wadis, where the disturbances more frequently occur in a natural way, the community is more constant.

*Forsskaolea tenacissima* populations appear from 100 to 500 m of altitude. The aridity of its distribution area is obvious since the annual rainfall average is lower than 300 mm, and recent studies of Tabernas Desert reveal that 34% of the months it is lower than 10 mm (Lázaro *et al.*, 2001). According to the bioclimatological indices from Rivas-Martínez & Loidi (1999), the geographical range falls in the Mediterranean desertic–oceanic bioclimate, thermo-Mediterranean arid and semi-arid belts (Table 2).

### Conservation status

The area of occupancy is extremely reduced, since we only found seven main populations (Table 2), which are scarcely included in protected areas. Only the Rambla de Tabernas population is partially embraced by the Tabernas Desert Natural Park.
Park and the Rambla de Los Yesos population is included in the Sierra Nevada Natural Park. The rest of them are outside any protected area (Fig. 2).

Discussion

The ecological behaviour described above for Iberian populations of *F. tenacissima* agree with other world areas. Gravel banks of Tabernas wadis represent the same edaphic conditions described for other areas like the Negev Desert (Evenari *et al.*, 1971) or the Sahara Desert (Maire, 1952–1977). The Tabernas Desert with Mediterranean hyperdesertic and Mediterranean desertic–oceanic bioclimes (according to Rivas-Martínez & Loidi, 1999), is the only European area with similar bioclimatic conditions to semi-arid areas of North Africa and West Asia (Fig. 1).
Table 2. Location, bioclimatic traits and presence in protected areas of Iberian populations of Forsskaolea tenacissima L.

<table>
<thead>
<tr>
<th>Localities</th>
<th>Population</th>
<th>Geographic coordinates (UTM)</th>
<th>Bioclimatic traits</th>
<th>Protected area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alt* (m)</td>
<td>It†</td>
</tr>
<tr>
<td>Rambla de Los Yesos</td>
<td>1</td>
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<td>30SWF4576</td>
<td>100</td>
<td>275</td>
</tr>
</tbody>
</table>

*Altitude.
†It: Thermicity index: Sum, multiplied by 10, of the annual mean temperatures (T), mean maximum temperature of the coldest month (M) and mean minimum temperatures of the coldest month (m), It = 10(T+M+m) (Rivas-Martinez & Loidi, 1999).
‡Precipitation.
Iberian *F. tenacissima* communities present biogeographical and floristic traits that allow us to propose a new association. Thermo- and meso-Mediterranean shrublands of stony areas and dry rivers distributed throughout the East Iberian Peninsula and Balearic Islands belongs to *Andryaletum ragusinae* association (*G. flavi* Alliance), led by *Andryala ragusina* L. and *Mercurialis tomentosa* L. (Bolós, 1967). However, the community of the Tabernas Desert wadis is led by both *F. tenacissima* and *Senecio flavus* (Decne.) Sch. Bip. The first one is a Saharo-Arabian–Turanian element and the second one is a West Mediterranean element with restricted distribution in the Iberian Peninsula. From a biogeographical standpoint and at regional scale, both elements are differential taxa from the Occidental-Almerian District with regard to the rest of the Almerian Sector—Murcian–Almerian Province (Peinado *et al*., 1992; Mota *et al*., 1997).

Because of this floristic feature and the frequent presence in the relevés of *Ononis talaverae*, another restricted Iberian–North-African element (Devesa, 2000), we described a new endemic association for the Occidental-Almerian District (Almerian Sector, Murcian–Almerian Province) (Table 1, syntypus rel. 4). The presence in the relevés of *Salsolo-Peganion* elements as accompanying species is due to the pioneer perennial vegetation which is the spatial and successional contiguous vegetation.

Preservation of isolated populations and capturing the geographic range of species is widely demanded in Conservation Biology (Rojas, 1992; Sutherland, 2000; Scott *et al*., 2001). Reasons for this are the possible effects on biodiversity elements caused by global and regional climate changes (Peters & Lovejoy, 1992), the need to maintain genetic diversity (Jones *et al*., 2001), and the fact that stochastic events may threaten resources restricted to just one area (Pressey *et al*., 1993, 1994). Moreover, Lesica & Allendorf (1995) suggest that populations on the periphery of their ranges may be the most genetically variable and thus evolutionarily valuable if they are confronted with contracting ranges, and so may be less vulnerable to anthropogenic or natural changes.

The main objective of this work was to assess *F. tenacissima* as a conservation flora priority in the European context. Taking into account that the last connection between Africa and Europe was 3 millions years ago (Sanz de Galdeano, 1997), the Tabernas Desert populations represent historically (at geological-evolut-ionary time scale) isolated populations from the rest of African, Arabian and Turanian populations, and hence, as we showed above, they are interesting from biodiversity point of view. In addition, its occurrence in the SE Iberian Peninsula has a great importance from a biogeographical approach. This is due to two facts: on the one hand, it reflects both the floristic interchange between SE Iberian Peninsula and northern Africa and western Asia during the Messinian desiccation of the Mediterranean Sea (Suárez *et al*., 1992), and, on the other one, it stresses the hypothesis of considering the presence of steppe habitats along the Pleistocene in the Iberian peninsula. Some authors suggest that those areas, less affected by glaciers, constituted refuges for xerophytic elements during the Quaternary Period (Bolós, 1951; Blanca, 1991; Cabello, 1997).

Whereas in other areas such as Israel, it is a common taxon (The Hebrew University Herbarium, 2000) in the Iberian area it is rare. Predictive distribution based on bioclimatic and ecological conditions suggest that the species should appear in most of the Murcian–Almerian Province. However, as a result of the fieldwork, even within the Tabernas Desert, we have observed just a few populations. Two reasons for such a restricted area of occupancy might be either a low dispersal capacity of *F. tenacissima* or the fact that Tabernas basin materials are mainly Tortonian marine marls, and hence many wadis have high salinity conditions. In addition, peripheral populations of a given species tend to be smaller and more isolated than core populations. In any case, the relict behaviour of Iberian populations is clearly stressed by their reduced geographical range.
According to the last Red List of Spanish Vascular Flora (VV.AA., 2000), *F. tenacissimae*, with the IUCN threatened category VU D2, is facing a high risk of extinction in the wild in the medium-term future. We believe that it is a cause for concern that Iberian populations are scarcely included in protected areas. Categorization of species according to their vulnerability to extinction in red lists does not represent an effective measure to preserve biodiversity. Two conservation actions could be carried out. At a local scale, present protected areas in SE Iberian Peninsula must be reviewed, embracing *Forsskaolea* populations as conservation targets. At a regional scale, the phytosociological characterization of this new described community allows the inventory and incorporation of this biotope in the European Communities CORINE information and Mapping System (EUR 12587, 1991), to be subsequently included in the EU Habitats Directive 92/43/EEC.

**Syntaxonomic scheme**


**References**


