

Conservation studies on threatened endemic plants of the Mediterranean area: a literature overview for Sardinia.

*G. Fenu, E. Mattana

Centro Conservazione Biodiversità, Dipartimento di Scienze della Vita e dell'Ambiente, Università degli Studi di Cagliari, V.le S. Ignazio da Laconi 13, 09123 Cagliari, Italy.

Abstract

Sardinia is the second-largest island in the Mediterranean Sea, situated in the West Mediterranean basin. Its isolation and high geological diversity have created a wide range of habitats, with high levels of endemism, especially on its mountain massifs. Despite the rich plant biodiversity of the Island and the threats to its endemic flora, few biological conservation studies have been conducted on Sardinian endemic plants.

A literature analysis highlighted that 19 papers were published, with the 68% of them being focused on threatened species. These data highlight the poor knowledge on the conservation status of the endemic flora of Sardinia. However, the increasing number of papers detected in the last three years represents a good signal that more attention will be devoted to threatened endemic species of the Island in the near future.

Key words: Biodiversity, Habitat Directive, Hot Spot, IUCN.

Riassunto

La Sardegna è la seconda isola per dimensioni del Mar Mediterraneo, situata nel bacino occidentale. Il lungo isolamento e l'elevata diversità geologica dell'Isola hanno determinato un'ampia diversificazione di habitat, con elevati livelli di specie endemiche, in particolar modo nei suoi massicci montuosi. Tuttavia, nonostante la ricca diversità vegetale dell'Isola e le minacce alla sua flora endemica, pochi studi di biologia della conservazione sono stati realizzati su piante endemiche della Sardegna.

L'analisi bibliografica ha evidenziato che sono stati pubblicati 19 articoli su specie endemiche, il 68% dei quali focalizzati su specie minacciate. Questi dati evidenziano l'attuale scarsa conoscenza sullo stato di conservazione della flora endemica della Sardegna. Tuttavia, il crescente numero di pubblicazioni osservato negli ultimi tre anni rappresenta un segnale positivo per il futuro, evidenziando una crescente attenzione per le specie endemiche minacciate dell'Isola.

Parole chiave: Biodiversità, Direttiva Habitat, Hot Spot, IUCN

Introduction

Biological diversity faces many threats throughout the world and, as a consequence, the loss of wild plant biodiversity is constantly increasing and taking place on a catastrophically short-time scale (Novacek & Cleland, 2001). Human actions are causing a biodiversity crisis, with species extinction rating up to 1000 times higher than background (Pimm *et al.*, 1995; Brooks *et al.*, 2006). Major threats to ecosystems and biodiversity are habitat loss and fragmentation, overexploitation, pollution, invasion of alien species, global climate change (IUCN, 2003) and disruption of community structures (Novacek & Cleland, 2001). For this reason the Convention on Biological Diversity (CBD) was signed in 1992 with the goal of ensuring the conservation, sustainable use, and the fair and equitable sharing of the benefits arising from the utilization of genetic resources (CBD, 1992).

During the last decade, nature conservation in Europe has been focused on the implementation of the Habitat Directive (DIR. 92/43/EEC) and the Natura 2000 network (Council of the European Communities, 1992). Natura 2000 is by far the most important conservation effort implemented in Europe

(Maiorano *et al.*, 2007) and it has been proposed as the main strategy to meet the target of halting (or at least significantly reducing) biodiversity loss by 2010 (Balmford *et al.*, 2005). Its main goal is either to maintain or restore a 'favorable' conservation status of species and habitat types of special importance.

Italy is still lacking in a comprehensive national legal framework for the protection of threatened plants and the current legal protection is mainly based on the Habitat Directive and, to attempt the obligations of the Directive, the Interpretation Manual of Italian Habitats was realized by Biondi *et al.* (2009). However, the annexes of the Directive fail to cover the actual diversity and peculiarity of the Italian Flora (Conti *et al.*, 2005a, 2007).

In 2002, with the Global Strategy for Plant Conservation (GSPC; Decision VI/9), the Conference of the Parties of the CBD provided a framework for actions at regional, national and global level. This led the Council of Europe and Planta Europa to develop in 2002 the European Strategy for Plant Conservation to halt the loss of wild plant diversity (Planta Europa, 2008). Understanding, documenting and developing conservation strategies are key issues that need to be urgently addressed as national responsibilities (GSPC,

2008; Sharrock & Jones, 2009). Among others, in the Global Strategy for Plant Conservation, that includes 16 targets to be achieved by 2010, target 2 urges “a preliminary assessment of the conservation status of all known plant species at national, regional and international levels” (GSPC, 2008).

IUCN RED LISTs of Threatened Species have increasingly been adopted as the gold standard for information on the conservation status of species (e.g. Grammont de & Cuarón, 2006; Rodrigues *et al.*, 2006; Hoffman *et al.*, 2008). The first Italian red data book, including vascular plants, bryophytes and lichens, was published in 1992 (Conti *et al.*, 1992), successively followed by revisions for vascular plants and bryophytes, at national and regional level (Conti *et al.*, 1997). During the last years, the Italian Botanical Society promoted a new and comprehensive Red List of the Italian Flora, based on the more recent IUCN criteria and categories (Rossi & Gentili, 2008).

Demographic monitoring and understanding the natural history of rare plants are then crucial for both population management, conservation (e.g. Adams *et al.*, 2005; Lehtilä *et al.*, 2006) and reproduction, recruitment and survival are particularly important when attempting to interpret plant rarity (e.g. Evans *et al.*, 2003; Ellis *et al.*, 2007). Rare species conservation is closely related to understanding the key factors determining their distribution and abundance. Knowledge of their life-cycle and reproductive traits is essential in identifying limits to population growth and persistence (Bevill & Louda, 1999). Information on survival strategies of threatened species is critical for optimizing and determining the success of *in situ* and *ex situ* conservation efforts. Knowledge of their germination behaviour, in particular, is vital in promoting *ex situ* conservation measures (e.g. Cerabolini *et al.*, 2004; Perez-Garcia *et al.*, 2005).

Conservation studies represent a crucial issue in the Mediterranean biome because this area, which represents only 2% of the world's surface, houses 20% of the world's total floristic richness (Medail & Quezel, 1999). The Mediterranean basin, with 11.8 endemic plants per 100 km², has been recognized as one of the priority regions for conservation in Europe and identified as one of the 25 most important “biodiversity hotspots” on the planet (Myers *et al.*, 2000). Sardinia is the second-largest island in the Mediterranean Sea (after Sicily) situated in the West Mediterranean basin and its flora consists of 2,408 *taxa* including 2,295 species (Conti *et al.*, 2005b) and 347 of these are endemics (e.g. narrow endemics, Sardinian endemics, Corso-Sardinian endemics, Corso-Sardinian-Balearic

endemics) with 45.8% being exclusive Sardinian endemics (Bacchetta *et al.*, 2005). About a hundred of species endemic to Sardinia have been recognized as threatened (Conti *et al.*, 1992, 1997; Scoppola & Spampinato, 2005) and five exclusive endemics to the island [*Aquilegia barbaricina* Arrigoni *et E. Nardi*, *A. nuragica* Arrigoni *et E. Nardi*, *Lamyropsis microcephala* (Moris) Dittrich *et* Greuter, *Polygala sinisica* Arrigoni and *Ribes sardoum* Martelli] have been included by the IUCN/SSC in the “Top 50 Mediterranean Island Plants” to be urgently conserved (Montmollin de & Strahm, 2005).

Despite this rich biodiversity and the threats to these species, while the vegetation series (including the threatened habitats), of the Island were characterized (Bacchetta *et al.*, 2009) few biological conservation studies have been carried out on threatened endemic species of Sardinia. Consequently, the aim of this study was to verify the degree of scientific knowledge on the most threatened endemic plant species of the Island.

Materials and methods

Scientific works on the endemic species of Sardinia were selected by querying on July 2010 the “ISI Web of KnowledgeSM” (<http://apps.isiknowledge.com>) and “ScopusTM” (<http://www.scopus.com>) websites, using the following keywords and query operators: “Conservation AND Sardinia AND Endemic”. The threatened endemic species of Sardinia were identified on the basis of their presence in “The 2009 IUCN Red List of Threatened SpeciesTM” (<http://www.iucnredlist.org>) under the Critically Endangered category (CR) or in the Annex II of the DIR. 92/43/EEC “Habitat”.

Results and discussion

The literature analysis on endemic species of Sardinia, highlighted that 19 papers, which matched the searching criteria, have been, at date, published (Table 1). Except 3 works in the period 2000 – 2004 on *Anchusa crispa* Viv. (Quilichini & Debussche, 2000; Quilichini, 2001; Quilichini *et al.*, 2004) and the study of the endemic vascular flora by Bacchetta & Pontecorvo (2005), the great majority (15) of the works were published in the last three years (Fig. 1). The low number of papers reported for the 2010 is determined by the date of the query (July 2010).

These data highlight the poor knowledge on the

N	Study	Target
1	Quilichini, 2000	<i>Anchusa crispa</i> Viv. s.l.
2	Quilichini & Debussche, 2000	<i>Anchusa crispa</i> Viv. s.l.
3	Quilichini <i>et al.</i> , 2004	<i>Anchusa crispa</i> Viv. s.l.
4	Bacchetta <i>et al.</i> , 2008e	<i>Anchusa</i> sp.
5	Coppi <i>et al.</i> , 2008	<i>Anchusa</i> sp.
6	Mattana <i>et al.</i> , 2008	<i>Astragalus maritimus</i> Moris and <i>Astragalus verrucosus</i> Moris
7	Bacchetta & Pontecorvo, 2005	Endemic flora of Iglesiente (SE Sardinia)
8	Mansion <i>et al.</i> , 2009	Boraginales
9	Mameli <i>et al.</i> , 2008	<i>Centaurea horrida</i> Badarò
10	Farris <i>et al.</i> , 2009	<i>Centaurea horrida</i> Badarò
11	Pisanu <i>et al.</i> , 2009	<i>Centaurea horrida</i> Badarò
12	Bacchetta <i>et al.</i> , 2008a	<i>Cephalaria bigazzii</i> Bacch., Brullo & Giusso
13	Roselló <i>et al.</i> , 2009	<i>Cephalaria squamiflora</i> (Sieber) Greuter
14	Falchi <i>et al.</i> , 2009	<i>Cistus creticus</i> L. s.l.
15	Paolini <i>et al.</i> , 2009	<i>Cistus creticus</i> L. s.l.
16	Orellana <i>et al.</i> , 2009	<i>Delphinium pictum</i> Willd. subsp. <i>pictum</i>
17	Mattana <i>et al.</i> , 2009b	<i>Lamyropsis microcephala</i> (Moris) Dittrich <i>et</i> Greuter
18	Mattana <i>et al.</i> , 2010	<i>Polygala sinisica</i> Arrigoni
19	Mattana <i>et al.</i> , 2009a	<i>Rhamnus persicifolia</i> Moris

Tab. 1 – List of papers on endemic species of Sardinia, published in journals indexed by ISI or Scopus (data updated at July 2010).

biology, ecology and conservation status of the endemic component of the Sardinian flora. However, it should be taken into account that other conservation studies have been published in journals not indexed by ISI or Scopus (e.g. Bacchetta *et al.*, 2007, 2008b, c, e, f, g; Bocchieri & Iiriti, 2007; Farris & Filigheddu, 2008; Pisanu & Filigheddu, 2008; Fenu & Bacchetta, 2008a, b).

The majority of these 19 papers (68%) were focused on threatened species, with 42% of the total on species listed in the Annex II of the DIR. 92/43/EEC, 5% in the 2009 IUCN Red List under CR, and 21% in both of them (Fig. 2).

In Table 2 the 18 endemic species of Sardinia listed in the Annex II of the DIR. 92/43/EEC, with 13 of them being “Priority” species and the 8 critically endangered (CR) for the IUCN are reported.

Only 6 of these species (*Anchusa crispa*, *Centaurea horrida* Badarò, *Astragalus maritimus* Moris and *A. verrucosus* Moris, *Lamyropsis microcephala* and

Polygala sinisica) have been investigated in some aspects of their morphology, biology, ecology or population and conservation biology, while other four species [*Brassica insularis* Moris, *Linaria flava* (Poir.) Desf. subsp. *sardoa* (Sommier) Arrigoni, *Linum muelleri* Moris and *Rouya polygama* (Desf.) Coincy] are listed in the floristic work of Bacchetta & Pontecorvo (2005). Figure 3 highlights as half of the endemic species listed in the Annex II of the DIR. 92/43/EEC were investigated, while only 3 (*Anchusa crispa*, *Lamyropsis microcephala* and *Polygala sinisica*) of the 8 species classified as critically endangered by IUCN were analysed. *Anchusa crispa* was the species with the major number of studies (4); in particular, germination ecology, dispersal patterns, population biology and geographic differentiation with conservation implication of this species have been investigated by Quilichini and collaborators (Quilichini & Debussche, 2000; Quilichini, 2001; Quilichini *et al.*, 2004) and more recently by Bacchetta *et al.* (2008d).

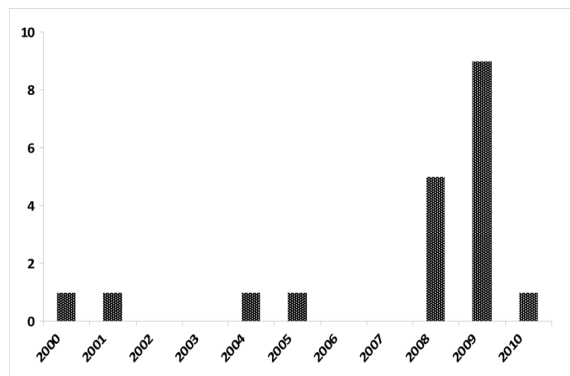


Fig. 1- Number of papers per year on endemic species of Sardinia, published in journals indexed by ISI and/or Scopus (data updated at July 2010).

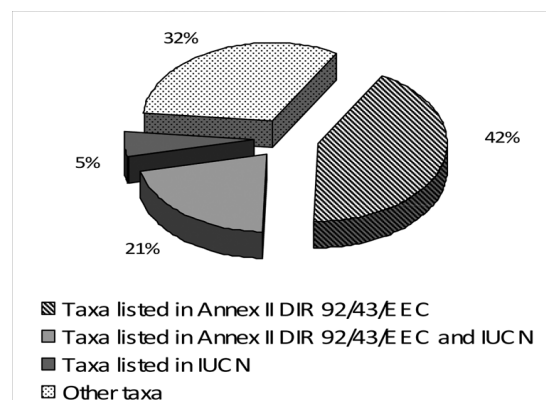


Fig. 2 - Percentages of papers related to the *taxa* listed in Annex II Directive 92/43/EEC and in the IUCN Red List 2009 under CR category.

N.	Taxon	Annex II DIR 92/43/EEC	IUCN Red List 2009
1	<i>Anchusa crispa</i> Viv.	NP	CR
2	<i>Aquilegia barbaricina</i> Arrigoni et E. Nardi		CR
3	<i>Aquilegia nuragica</i> Arrigoni et E. Nardi		CR
4	<i>Astragalus maritimus</i> Moris	P	
5	<i>Astragalus verrucosus</i> Moris	P	
6	<i>Brassica insularis</i> Moris	NP	
7	<i>Carex panormitana</i> Guss.	P	
8	<i>Centaurea horrida</i> Badarò	P	
9	<i>Centranthus amazonum</i> Fridl. et A. Raynal	NP	CR
10	<i>Euphrasia genargentea</i> (Feoli) Diana Corrias	P	
11	<i>Herniaria latifolia</i> Lapeyr. subsp. <i>litardierei</i> Gamisans	P	
12	<i>Lamyropsis microcephala</i> (Moris) Dittrich et Greuter	P	CR
13	<i>Limonium insulare</i> (Bég. et Landi) Arrigoni et Diana	P	
14	<i>Limonium pseudolaetum</i> Arrigoni et Diana	P	
15	<i>Limonium strictissimum</i> (Salzmann) Arrigoni	P	CR
16	<i>Linaria flava</i> (Poiret) Desf. subsp. <i>sardoa</i> (Sommier) Arrigoni	NP	
17	<i>Linum muelleri</i> Moris	P	
18	<i>Polygala sinisica</i> Arrigoni		CR
19	<i>Ribes sardoum</i> Martelli	P	CR
20	<i>Rouya polygama</i> (Desf.) Coincy	NP	
21	<i>Silene velutina</i> Pourret et Loisel	P	

Tab. 2 - Checklist of endemic *taxa* of Sardinia listed in Annex II Directive 92/43/EEC and in the IUCN Red List 2009 under critically endangered category (CR).

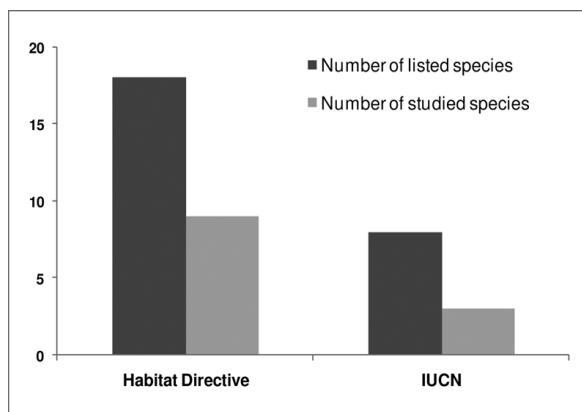


Fig. 3 - Comparison between *taxa* listed in Annex II Directive 92/43/EEC or in the IUCN Red List 2009 and investigated *taxa*.

Centaurea horrida was the second species mostly investigated, with three different works on population genetics (Mameli *et al.*, 2008), conservation status (Pisanu *et al.*, 2009) and the effect of site management

on this species (Farris *et al.*, 2009). The fruit and seed morphology of *Astragalus maritimus* and *A. verrucosus* were analyzed by Mattana *et al.* (2008) as well as seed dormancy and germination ecology of *Lamyropsis microcephala* (Mattana *et al.*, 2009b) and ecological and morphological seed traits of *Polygala sinisica* (Mattana *et al.*, 2010).

This literature overview showed a poor knowledge on conservation of threatened endemic species of Sardinia, considering the few amount of studies carried out on them and that only one of them was focused on the assessment of the conservation status of a species (Pisanu *et al.*, 2009). The great majority of the papers analyse some particular aspects of their biology and ecology, such as the phylogeny of *Boraginiales* (Mansion *et al.*, 2009) for *Anchusa crispa*, or their implications for species conservation as in Quilichini *et al.* (2004) and Bacchetta *et al.* (2008d) for the same species. However, the increasing number of papers detected in the last three years represents a good signal that more attention will be devoted to threatened endemic species in the near future.

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*Corresponding author:

Fenu Giuseppe

Centro Conservazione Biodiversità, Dipartimento di Scienze della Vita e dell'Ambiente, Università degli Studi di Cagliari, V.le S. Ignazio da Laconi 13, 09123 Cagliari, Italy. Tel: 0039-0706753508 Fax: 0039-0706753509 e-mail: gfenu@unica.it