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Distribution of the genus *Ephedra* (Ephedraceae) in Calabria (S Italy)

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ABSTRACT: A chorological study on the distribution of the genus *Ephedra* L. in Calabria was carried out. *E. nebrodensis* subsp. *nebrodensis* was already known to occur in Pollino Massif (N Calabria). Field investigations have been done to find other stands in Calabria without results. *E. distachya* subsp. *distachya* occurs mainly on the sandy coasts, especially Ionian, occasionally inwards along sandy river banks and rarely in rocky habitats. This species shows a fragmented distribution, has disappeared from some coastal areas and is regressing because of human activities. *E. fragilis*, recently excluded from regional flora because of some wrong past records, has been found with a small population by the Tyrrhenian coast in the S. Ferdinando surroundings. All studied species need conservation measures against existing threats, especially *E. fragilis* because of its small population size, persisting human pressure and lack of protection.

Key words: Calabria, chorology, *Ephedra distachya* subsp. *distachya*, *Ephedra fragilis*, *Ephedra nebrodensis* subsp. *nebrodensis*, phytogeography

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INTRODUCTION

The genus *Ephedra* L. (*Ephedraceae*) includes about 60 species distributed in the Mediterranean region, central Asia, NW America, Mexico, southern Andes and Patagonia (do Amaral Franco 1986; Meusel *et al.* 1965). In Europe the genus, during glacial ages, implying xeric conditions, reached its maximum expansion (Elenga *et al.* 2000). In the European flora, *Ephedra* is represented by four species (Markgraf 1964), three of which are recorded for Calabria: *E. nebrodensis* Guss. subsp. *nebrodensis* (*E. major* Host subsp. *major*) (Bernardo 1995; Bernardo *et al.* 1995; Conti *et al.* 1997; Gargaglione 2001; Conti *et al.* 2005), *E. fragilis* Desf. (Porta 1879; Fiori 1923-25; Chiarugi 1956; Géhu *et al.* 1984; Zangheri 1976; Pignatti 1982), *E. distachya* L. subsp. *distachya* (De Candolle 1864; Micheletti 1895; Barbagallo & Furnari 1970; Bernardo *et al.* 1994; Biondi *et al.* 1994; Biondi *et al.* 1996; Brullo & Spampinato 1999; Brullo *et al.* 2001; Conti *et al.* 1997; Pasquale 1897; Pasquale 1904; Regione Calabria 2003; Schneider & Sutter 1982; Spampinato 2003; Conti *et al.* 2005; Maiorca *et al.* 2005).

E. nebrodensis subsp. *nebrodensis* is a Mediterranean mountain species, with fragmented distribution on xeric calcareous or gypseous rocky stands up to 1700 m a.s.l. in the Mediterranean, Macaronesia and W Asia (Orsomando 1969; do Amaral Franco 1986).

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In Italy it is a chasmophyte on calcareous dry places of Sicily, Sardinia, Umbria, Marche, Abruzzo, Apulia, Basilicata, and Emilia-Romagna (Orsomando 1969). In just one case (Vallone Silana - Regione Bidicolai, Sardinia) it occurs on schistose substrate (Desole 1964). In Calabria the species occurs in three stands on SE Pollino (Bernardo *et al.* 1995; Gargaglione 2001). According to Conti *et al.* (1997) the species is considered endangered for Calabria.

E. distachya includes two subspecies [*E. distachya* subsp. *distachya* and *E. distachya* subsp. *helvetica* (C.A. Mey.) Asch. & Graebn. (Markgraf 1964)] also considered as species [*E. distachya* L. ed *E. helvetica* C.A. Mey. (Pignatti 1982)]. Such treatment is supported by DNA sequence data (Ickert-Bond & Wojciechowski 2004) although not so clearly morphologically based (Nouviant 1997; Parlatore 1867; Markgraf 1964). However, these *taxa* are ecologically well distinct: *E distachya* is a coastal psammophyte while *E. helvetica* occurs in mountain habitats, typical of very dry calcareous cliffs (Pignatti 1982). After Conti *et al.* (2005), in Calabria occurs only subsp. *distachya*, which is distributed in S Europe and WC Asia (do Amaral Franco 1986), even though doubts remain whether European populations and those from China and Kazakistan (Fu *et al.* 1999; Meusel *et al.* 1965; Ickert-Bond & Wojciechowski 2004) belong to the same *taxon*. In Italy *E. distachya* ssp. *distachya* occurs in the southern part and islands (Parlatore 1867; Pignatti 1982; Conti *et al.* 2005). This psammophyte occurs on inner dune slopes (Biondi *et al.* 1996), on back flat dune stands (Brullo *et al.* 2001; Spampinato 2002) or rarely inland on sandy substrates (Bernardo *et al.* 1994; Biondi *et al.* 1994; Desole 1944) and on marly-gypseous hills, calcareous and sandstone cliffs up to 1200 m a.s.l. (do Amaral Franco 1986). According to Conti *et al.* (1997) the species is considered low risk at the regional level.

E. fragilis occurs in the Mediterranean-Macaronesian western region (Parlatore 1867; do Amaral Franco 1986). In Italy it occurs in Sicily (Markgraf 1964), Sardinia and Calabria (Pignatti 1982 Greuter *et al.* 1984) on beaches, fields, cliffs or walls close to the sea (Arcangeli 1882; Fiori 1923-25; Zangheri 1976), in dry places on calcareous or gypseous substrata (do Amaral Franco 1986). This species is closely related to *E. foeminea* Forsk. [*E. fragilis* subsp. *campylopoda* (C.A. Mey.) Asch. & Graebn.] occurring in the eastern Mediterranean region, included Italy (Markgraf 1964; Conti *et al.* 2005) where it was found in two Apulian stands, Santa Cesarea Terme and Torre Minervino [Bianco *et al.* 1988; *Bernardo-Cesca*, 16.IV.1998 (CLU)] and in the Tuscan Archipelago in Pianosa (Baldini 2000). *E. fragilis* in Calabria was first recorded by Porta (1879) for the Ionian locality Gerace Marina, later by Chiarugi (1956) for a beach close to Roccella Ionica and by Géhu *et al.* (1984) for the sandy coast of Rocca Imperiale but the species has been recently excluded from Calabrian flora (Conti *et al.* 2005).

The present work provides comprehensive and updated information about the distribution of *Ephedra* in Calabria.

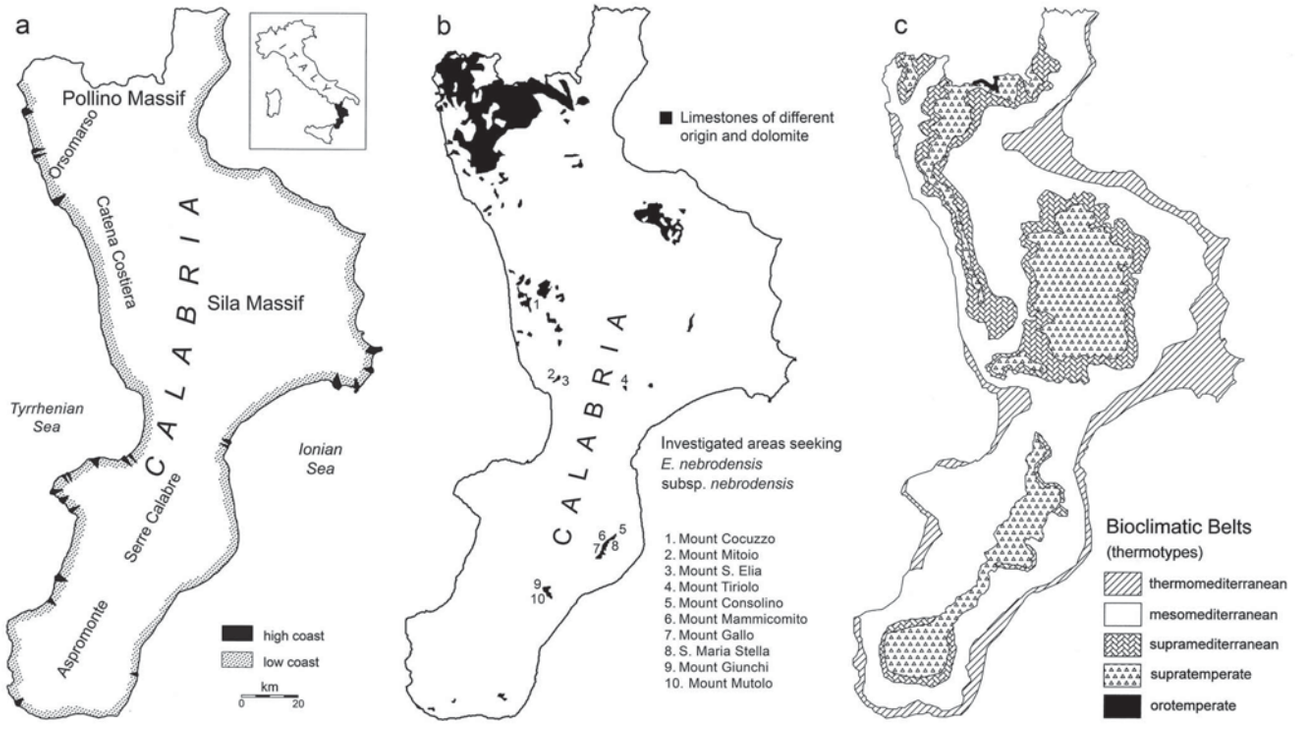

Fig.1. Main mountain ranges and coast type (high or low) of Calabria (Biondi et al. 1996 modified) (a); map of limestone and dolomite areas in Calabria (the investigated areas are listed and numbered) (b); bioclimatic map of Calabria: thermotype belts are reported (Spampinato 2003 modified) (c)

STUDY AREA

Calabria is the southernmost region of continental Italy, a peninsula surrounded by 740 km of coast, most of which (615 km) is sandy and the rest (125 km) rocky (Fig. 1a) (Regione Calabria 2001). The Tyrrhenian coast shows narrow beaches (except Gioia Tauro and Lamezia Terme plains) that don't evolve into stable dunes, while the Ionian coast has more developed dune systems. A short part of the Calabrian coast is characterized by high naturality, while the main part is environmentally modified (Biondi *et al.* 1996). Destabilization of the coast is a common and serious phenomenon in Calabria and erosion is partially due to anthropic actions (Regione Calabria 2001; Veltri *et al.* 2000; Niccoli & Procopio 1995). The inland is dominated by the following Apennine mountain ranges in the N-S direction: Pollino and Orsomarso (mainly calcareous basic rocks), Catena Costiera, Sila, Serre Calabre and Aspromonte (mainly acid rocks) (Fig.1a). On the cristalline section of the Calabrian Apennine some calcareous tectonic windows occur (Fig. 1b).

Bioclimate on the coastal areas is thermo-mediterranean and going up the Apennine range becomes gradually meso-mediterranean, supra-mediterranean and supra-temperate up to oro-temperate (Fig. 1c). Annual average rainfall goes from 500 mm recorded on the Ionian coast up to 2100 mm on Aspromonte Mt. The difference between annual average rainfall on the Tyrrhenian (600-1000 mm) and Ionian coasts (500-800) is marked. Annual average temperature is from 18°C on the Southern coast down to 5°C on the Pollino Massif (Ciancio 1971). The territory has a rich hydrographic net composed of small-medium streams, locally called «fiumare».

METHODS

This study is based on herbaria (CLU, FI, W), literature and field data. Field work (2000-2009) was based on verifying known stands (from literature and herbarium specimen labels) as well as looking for new stands. A preliminary GIS analysis based on geology, geomorphology and bioclimate was carried out to delineate areas, later verified in the field, with ecological features suitable to the needs of different species. GIS analysis addressed field work towards sandy coasts, the central or terminal parts of rivers and limestone mounts. All data have been organized as a database, used to produce regional maps of species distribution, using ArcView 9.3. The stands have been numbered in a clockwise direction starting from the northern Ionian coast. For *specimina* determination Flora d'Italia (Pignatti 1982) and Flora Europaea (Markgraf 1964) have been used. The nomenclature used follows Conti *et al.* (2005).

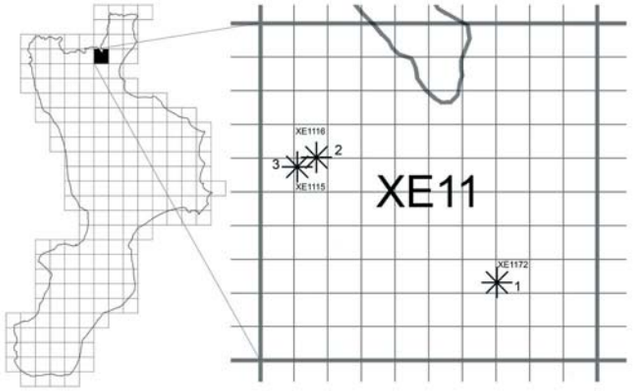

Fig.2. Distribution of E. nebrodensis subsp. nebrodensis in Calabria referred to UTM WGS 1984 33N 10 km MGRS (left) and WGS 1984 UTM Zone 33N 1 km MGRS (right).

RESULTS

E. nebrodensis* subsp. *nebrodensis. The species occurs in a few localities, as listed in Tab. 1 (Fig. 2), located inside Pollino National Park on rocky slopes between 900 and 1200 m a.s.l. Each known stand has a small number of individuals and is under persistent grazing impact. To find new occurrences of the species southwards, based on preliminary GIS analysis, investigations on calcareous mountain ranges were carried out. Cocuzzo (Catena Costiera), Mitoio (Sila), S. Elia (Sila), Tiriolo (Sila), Consolino (Serre), Mammicomito (Serre), Gallo (Serre), S. Maria Stella (Serre), Giunchi (Aspromonte) and Mutolo (Aspromonte) were investigated (Fig. 1b) without a positive outcome. The occurrence of species on Pollino Massif could be considered relictual. Although not considered threatened at the national level (Conti *et al.* 1997), the lack of ability to colonise and the persisting human pressure justify the inclusion of the species in the Red Data Book at the regional level.

E. distachya* subsp. *distachya. Recorded for southern Italy with no reference to Calabria (Zangheri 1976; Pignatti 1982), despite already being recorded for regional territory on the basis of Tenore and Pasquale (De Candolle 1864), Fiori (1923-1925) and Micheletti (1895), the species is quite common on the Ionian Calabrian coast and rare on the Tyrrhenian (Fig. 3a; Tab. 2). Of the 43 stands that have been found (22 previously known, 21 recorded here for the first time), 39 are located on the coast (41 Ionian, 2 Tyrrhenian), 3 are inland (Torrente Colognati, Fiumara Trionto, Fiume Nicà), and 2 on a rocky promontory (Copanello). All local populations are, at different levels, threatened. 18 of them are included in Sites of Community Importance (SCI - NATURA 2000); the rest are outside protected areas (Tab. 2). Of the 30 previously-known

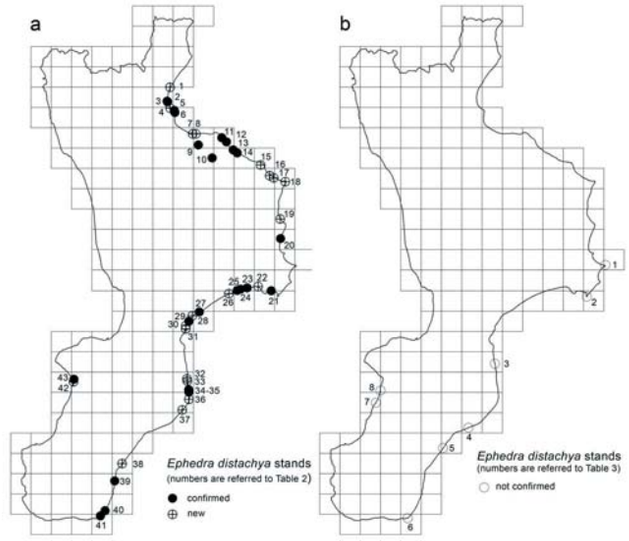

Fig.3. Distribution of E. distachya subsp. distachya in Calabria (UTM WGS 1984 33N 10 km MGRS): confirmed, new (numbers are referred to Table 2) (a) and not confirmed stands (numbers are referred to Table 3) (b).

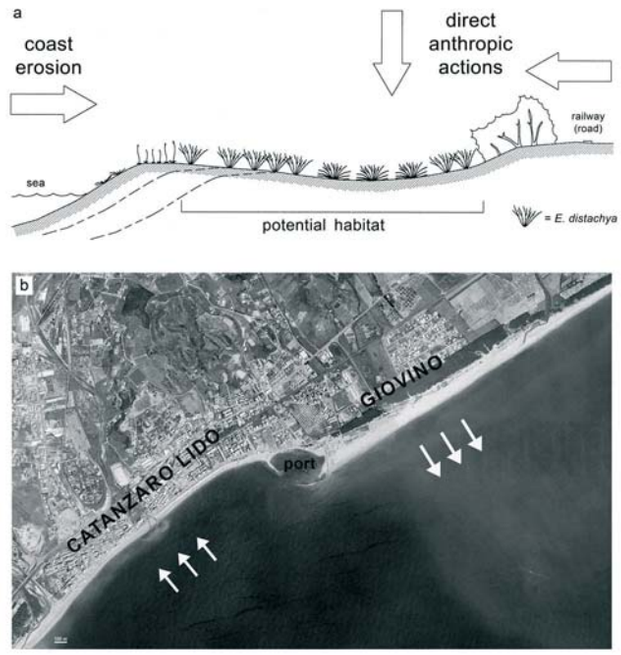

Fig.4. Transcect of potential habitat of E. distachya subsp. distachya on Ionian coast (a) and coastline dynamics due to Catanzaro Lido port construction. The arrows show regression (Catanzaro Lido) and expansion of beaches (Giovino) (b).

stands (22 confirmed, Tab. 2), 8 could not be confirmed by the present study, 4 were mistakenly recorded (different species or location confusion) and 4 are probably extinct (Fig. 3b; Tab. 3).

The varying climatic patterns and the geomorphological features as well as human pressure seem to be the main factors explaining the present distribution of the species in the studied area. *E. distachya* dunal stands are vulnerable because of direct human activities (tourism, infrastructure, grazing, agriculture, fire, exotic weeds, exotic woody species plantation, garbage abandonment, etc.) impacting natural vegetation from the inner side of dunes towards the sea line. Because of these activities, complete series of dune vegetation are very rare, as proved by the rarity of coastal associations belonging to *Pistacio-Rhamnetalia alaterni* Rivas-Martínez 1975. This implies a direct loss of *E. distachya* habitat, emphasised by coastal erosion that modifies the sea side of the dune (Fig. 4a) (Regione Calabria 2001; Veltri *et al.* 2000; Niccoli & Procopio 1995). As a result of direct human activities the local population has become more fragmented into its potential habitat, determining isolation of small groups of individuals. This could be observed in some Ionian villages (Lido S. Angelo, S. Caterina, Guardavalle) where *E. distachya* was found on dunes just outside the urbanised area.

Although Calabrian dune systems are considered mainly regressing, in particular conditions they can also grow. This is the case of Giovino (NE Catanzaro Lido, Catanzaro municipality) where the sandy beach is increasing because the building of the port in 1968 changed the shore stream dynamics determining a strong erosion SW of the harbour (in front of Catanzaro Lido) and an increase of the NE beach, at Giovino (Niccoli & Procopio 1995) (Fig. 4b). In this place until 1999, *E. distachya* was quite common, despite being threatened by roads, reforestation (*Pinus pinea* L., *Eucalyptus camaldulensis* Dehnh., *Acacia cyanophilla* Lindley), tourism, etc. In this case, in spite of the increased potential habitat for the species in this area, during the last ten years the surface occupied by *E. distachya* has drastically decreased. At the moment the species is very rare inside Catanzaro municipality, its potential environment is damaged and the risk of species extinction is real, as has already happened with *Pancratium maritimum* L. a few years ago.

E. fragilis. The occurrence of *E. fragilis* on Calabrian territory recorded by Italian Floras (Fiori 1923-25; Zangheri 1976; Pignatti 1982) was based on two erroneous records. The first one was reported by "Viaggio botanico in Calabria (1877)" (Porta 1879) for Gerace Marina, today Locri (Cortese 1894). The second was published on the social excursion report of the Italian Botanical Society in Calabria (Chiarugi 1956), for the coast between Monasterace Marina and Roccella Ionica. Specimens of both records, stored in Herbarium Centrale Italicum (FI), belong to *E. distachya*. Field investigation on the coast from Monasterace Marina to Locri did not reveal the occurrence of *E. fragilis*, neither in Rocca Imperiale

Fig.5. Distribution of Ephedra fragilis in Calabria (UTM WGS 1984 33N 10 km MGRS): new and not confirmed stands (numbers are referred to Table 4) (a). Location of the population of E. fragilis in Calabria (b).

territory, where the species was recorded by Géhu *et al.* (1984). Plants still living close to Monasterace belong to *E. distachya*, while the Locri stand is extinct. *E. fragilis*, according to Conti *et al.* (2005) has been excluded from the Calabrian flora. Field investigation led to the discovery of a previously unknown population of this species, north of San Ferdinando village on the southern Tyrrhenian coast of Calabria (Fig. 5a, Tab. 4) (Caruso *et al.* 2010). The small population [totalling 17 individuals, 6 actively reproducing (2 males, 4 females) and 11 vegetative], occurring along a coast sector about 500 m long, between S. Ferdinando and Villaggio Praia, is very important from the phytogeographical and floristic points of view. It represents, at the moment, the only known stand of *E. fragilis* on continental Italy, extending the species distribution northwards. Unfortunately the newly-discovered population is settled in a dune area where many threat factors occur: coastal erosion, infrastructures, tourism, fire, alien invasive plants, etc. Considering that the area is not under any environmental protection status, it is urgent to elaborate and apply conservation measures.

CONCLUSION

In Calabria the distribution of genus *Ephedra* can be summarized as follows: *E. nebrodensis* subsp. *nebrodensis* occurs in the stands already known on the eastern slope of Pollino Massif. The population of this relict species is regressing because of anthropic activities (mainly grazing) even though protected under the authority of Pollino National Park. *E. distachya* subsp. *distachya* is still rather common on Ionian Calabrian coasts and inland on sandy river banks and rarely on rocky habitats. The regional population of this species is fragmented due to anthropic pressure and needs urgent conservation measures. *E. fragilis*, found in S. Ferdinando municipality, shows a very small population living in a territory with no protection, many persisting threats and extremely high risk of extinction.

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Botanica SERBICA

REZIME

Rasprostranjenje roda *Ephedra* (Ephedraceae) u Kalabriji (Južna Italija)

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U radu su prikazani rezultati rasprostranjenja roda *Ephedra* L. u Kalabriji. *E. nebrodensis* subsp. *nebrodensis* je poznata sa masiva Pollino (Severna Kalabrija). Uprkos terenskim istraživanjima druga nalazišta ove vrste nisu konstatovana. *E. distachya* subsp. *distachya* se javlja na peščanim obalama, naročito Jonskog mora, ali i unuar kopna duž peščanih retko i kamenitih rečnih obala. Ova vrsta pokazuje fragmetisanu distribuciju, nestala je sa nekih priobalnih staništa i povlači se usled ljudskih aktivnosti. *E. fragilis*, koje je isključena iz regionalnih flora zbog pogrešnog nalaza iz prošlosti, ponovo je pronadjena u okolini S. Ferdinando (obala Tirenskog mora) u maloj populaciji. Svim izučavanim vratama potrebne su hitne mere konzervacije, ali naročito *E. fragilis* zbog male veličine populacije pod ljudskim uticajem i nedostatkom bilo kakave zaštite.

Ključne reči: Kalabrija, horologija, *Ephedra distachya* subsp. *distachya*, *Ephedra fragilis*, *Ephedra nebrodensis* subsp. *nebrodensis*, fitogeografija