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### The endemic vascular flora of Peloritani Mountains (NE Sicily): Plant functional traits and phytogeographical relationships in the most isolated and fragmentary micro-plate of the Alpine orogeny

S. Sciandrello<sup>a</sup>, R. Guarino<sup>b</sup>, P. Minissale<sup>a</sup> & G. Spampinato<sup>c</sup>

<sup>a</sup> Department of Biological, Geological and Environmental Sciences, University of Catania, Via A. Longo 19, I-95125 Catania, Italy

<sup>b</sup> Botanical Unit, Department of STEBICEF, University of Palermo, Via Archirafi 38, 90123 Palermo, Italy

<sup>c</sup> Department of STAFA, University of Reggio Calabria, Loc. Feo di Vito, I-89100 Reggio Calabria, Italy

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# The endemic vascular flora of Peloritani Mountains (NE Sicily): Plant functional traits and phytogeographical relationships in the most isolated and fragmentary micro-plate of the Alpine orogeny

S. SCIANDRELLO<sup>1</sup>, R. GUARINO<sup>2</sup>, P. MINISSALE<sup>1</sup>, & G. SPAMPINATO<sup>3</sup>

<sup>1</sup>Department of Biological, Geological and Environmental Sciences, University of Catania, Via A. Longo 19, I-95125 Catania, Italy; <sup>2</sup>Botanical Unit, Department of STEBICEF, University of Palermo, Via Archirafi 38, 90123 Palermo, Italy and <sup>3</sup>Department of STAFA, University of Reggio Calabria, Loc. Feo di Vito, I-89100 Reggio Calabria, Italy

## Abstract

This study is aimed at (1) producing a complete and updated inventory of the endemic vascular flora of Peloritani Mountains, (2) defining the geographical limits of Peloritani, regarded here as a biogeographical district and (3) highlighting possible paleogeographic connections with other Mediterranean lands. The heterogeneity analysis of the endemic flora was performed by means of contingency tables, through the  $\chi^2$  test. The endemic flora of this area consists of 129 specific and infraspecific *taxa*, of which 15 are restricted to the Peloritani Mountains. The analysis of habitats revealed that endemic *taxa* are most abundant on cliffs, rangelands, woods and garrigues. A large number of surveyed *taxa* are endemic to central-southern Italy and Sicily, while the number of endemic *taxa* in common with Calabria, Etna and Aeolian Islands turned out to be rather low, in spite of the geographical proximity. The endemic flora of Peloritani allows to emphasize palaeogeographical relationships not only with the neighbouring Mediterranean territories, but also with currently remote ones, such as southern Spain, Sardinia and Corsica. The phytogeographical framework substantiates the hypothesis that the Peloritani floristic district coincides with the limit given to Peloritani Mountains by structural geologists.

**Keywords:** Endemic flora, Calabrian-Peloritani Orogen, Mediterranean Region, *Erucastrum virgatum*, *Petagnaena gussonei*, paleogeography

## Introduction

Sicily is widely recognized as one of the main biodiversity hot-spots in the Mediterranean basin (Heywood 1995; Médail & Quézel 1997, 1999; Myers et al. 2000; Thompson et al. 2005; Médail & Diadema 2009; Raimondo & Spadaro 2012). In NE Sicily, the Peloritani Mountains represent an important, albeit neglected, centre of speciation and plants refuge. The rich flora of this territory includes rare and highly localized palaeo-endemites, such as *Colymbada tauromentana*, *Brassica raimondoi* and *Limonium sibthorpiantum*, testifying the long and complex paleogeographic history of this area (Arena et al. 1975; Gramuglio et al. 1985; Brullo et al. 1995; Spampinato et al. 2008; Sciandrello & D'Agostino 2014; Sciandrello et al. 2013a). Recently, for this reason, the area at issue has been identified by Blasi

et al. (2010) as one important plant area (IPA), essential for the conservation of plant biodiversity, indicated as “Monti Peloritani e Rupi di Taormina (SIC24)”. In recent times, many taxonomic investigations have been carried out in the Peloritani area (Brullo 1980; Brullo & Spampinato 1988; Brullo et al. 1997, 2009a; Cristaudo et al. 2009; Cataldo et al. 2012; Sciandrello et al. 2013a), but an update on the floristic knowledge of the whole area is still missing, being Nicotra (1878–1879) the last contributor who published a flora on such territory. In more recent years, accurate floristic lists were provided by Guarino (1997) and by Picone and Crisafulli (2006), although these contributions were not aimed at providing a complete check-list of the flora of Peloritani Mountains. Additional works including floristic contributions on smaller, but significant, areas of Peloritani were published

(Gramuglio et al. 1959, 1978; Minissale et al. 2007), while Picone et al. (2003) focused on the most endangered species of the area at issue.

This study aims at (1) producing a complete and updated inventory of the vascular endemic flora of the Peloritani Mountains, in the light of the most recent taxonomic novelties mentioned above; (2) comparing the endemic flora of Peloritani with that of Sicily and Hyblaean district; (3) better defining the geographical limits of Peloritani, regarded here as a biogeographical district and (4) highlighting possible paleogeographic connections with other Mediterranean lands. Besides, a complete and updated inventory of the endemic flora occurring in the Peloritani territory is provided, with the hope that this should be a starting point for further researches and conservation projects on the flora of Peloritani.

## Material and methods

### Study area

According to Brullo et al. (1995), the Peloritani district belongs to the NE Sicilian biogeographical subsector, together with Mt. Etna and the main elevations of the island, aligned along the so-called Sicilian Apennine, ranging along the NE-coast of Sicily, from the Strait of Messina up to the valley of the Torto River. In particular, Peloritani Mountains are divided from the Etnean district by the Alcantara

River and from the Nebrodi one by the two streams named Timeto and Roccella, the latter being a tributary of Alcantara (Picone et al. 2003). This phytogeographical delimitation of Peloritani Mountains is essentially based on geographical criteria, but it is here esteemed more appropriate to delimit the district on the basis of the geological units which are part of Calabria-Peloritani Orogen (Angi et al. 2010). This delimitation is notably supported by the occurrence and distribution pattern of some significant floristic elements that will be mentioned and commented later in the text. So, the area of the present study included the portion of Sicily located north of the tectonic line of Taormina, which from this locality stretches across the mountains up to the Tyrrhenian Sea just to the south of Capo d'Orlando (Figure 1). This setting agrees with the ecological classification of Italy ecoregions (Blasi & Frondoni 2011), where Peloritani Mountains are a section of the Calabria-Peloritani Arc Province, thereby recognizing a higher affinity of this territory to the Calabria rather than to the same Sicily.

The geological history of Peloritani Mountains dates back to the Alpine Orogen (Figure 2). In particular, together with the Aspromonte, Serre and Sila Massif (Calabria), they represent a patch of the Alpine orogeny located in the central part of the Mediterranean basin: the so-called Calabrian-Peloritani Arc (Cirrinicone et al. 2012). The Alpine range exposed in the western Mediterranean area was

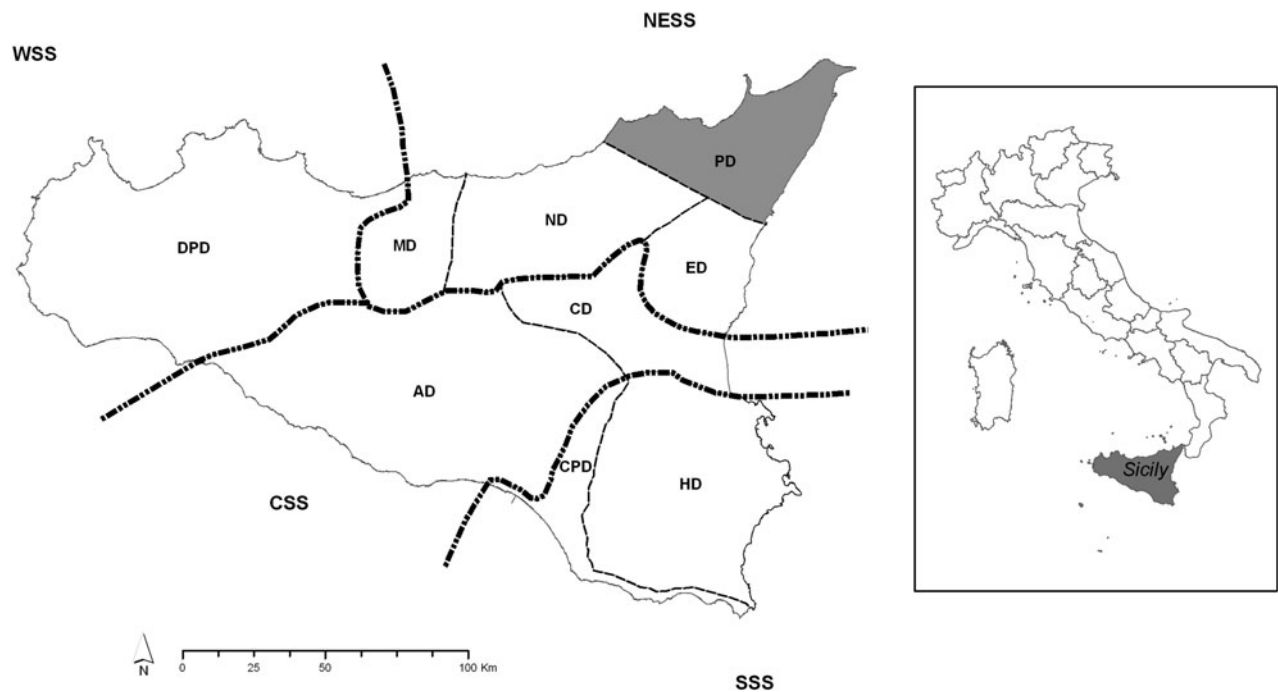


Figure 1. Phytogeographic subdivision of the Eusicilian sector according to Brullo et al. (1995, modified). The Peloritani territory is indicated in grey. CSS, central sub-sector; SSS, southern sub-sector; WSS, West sub-sector; NESS, north-east sub-sector; HD, Hyblaean district; CPD, Camarino-pachinense district; AD, Agrigento district; CD, Catania district; ED, Etna district; PD, Peloritani district; ND, Nebrodi district; MD, Madonie district; DPD, Drepano-Panormitano district.

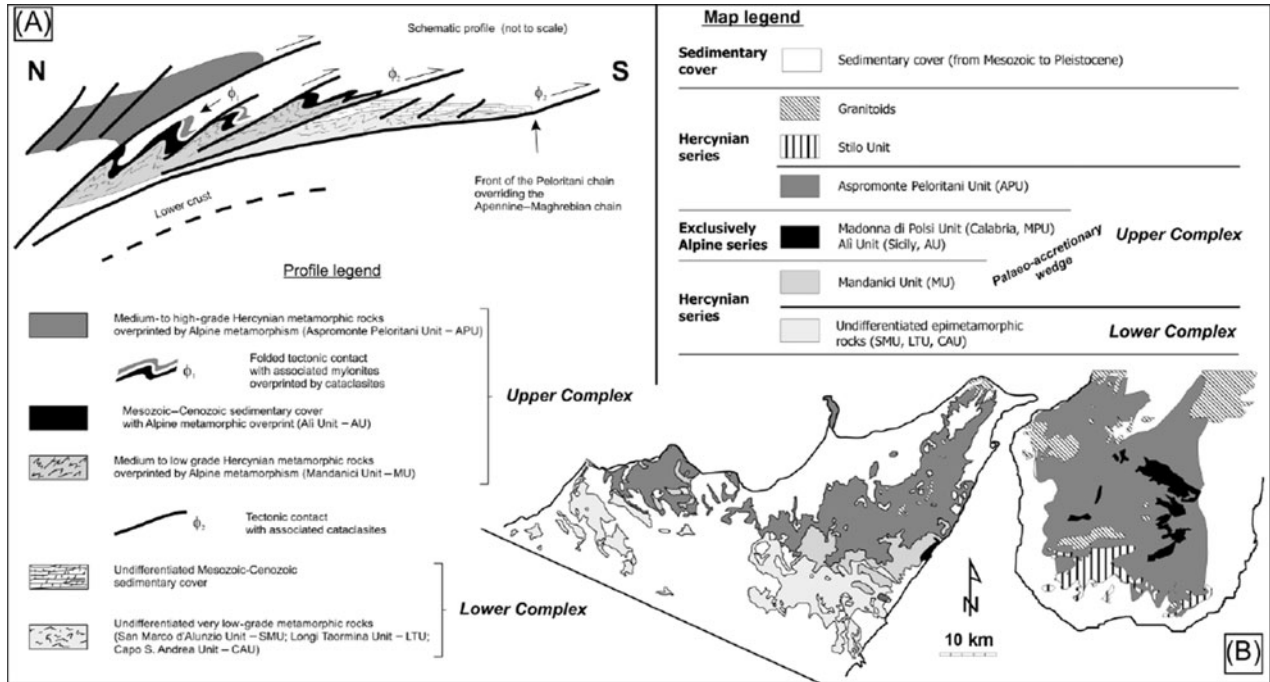


Figure 2. (A) Schematic profile of Peloritani Mountains. (B) Simplified geological map of Peloritani Mountains and Aspromonte Massif, where upper and lower complexes outcrop (from Cirrincione et al. 2012).

dismembered by subsequent tectonic movements and by the widening of the Tyrrhenian Basin, developed from Miocene to present times (Scandone 1980). The current structure of the Calabrian-Peloritani Orogen (CPO) consist of a nappe-pile edifice, involving distinct tectonic slices of metamorphic basement rocks characterized by different litho-types and distinct tectonic metamorphic evolutions, plus some Mesozoic-Coenozoic sedimentary sequences (Cirrincione et al. 1999; Appel et al. 2011; Fiannacca et al. 2013).

The complex geological and tectonic history is reflected by the rugged morphology of Peloritani, counting several mounts, hills and deep valleys, in spite of the relatively low altitudes. The main elevations are Montagna Grande (1374 m), Rocca Novara (1340 m), Pizzo di Vernà (1287 m), Monte Poverello (1279 m) and Monte Scuderi (1253 m).

According to the bioclimatic classification proposed by Rivas-Martínez (1993, 2004), Peloritani are characterized by a Mediterranean pluvio-seasonal oceanic bioclimate, with thermotypes ranging from the low thermomediterranean to the supra-Mediterranean and ombrotypes from the semiarid to the lower humid (Brullo et al. 1996; Bazan et al. 2006).

The physiognomic diversity determines a remarkable variety of habitat, with an extraordinary richness in flora and vegetation (Guarino 1997). However, strong anthropogenic alterations caused in the last century a continuous and unrestrained fragmentation of natural habitats and impoverishment of the

biodiversity (Guarino 1998; Sciandrello et al. 2013b).

#### Data sources and processing, nomenclature, abbreviations

This paper is based on literature data and herbarium investigation in Catania (CAT), Naples (NAP) and Palermo (PAL), integrated by several field observations carried out in the last two decades. As for the literature data, all reports dealing with the Peloritani district were considered (Nicotra 1878–1879; Brullo 1980; Brullo & Spampinato 1988; Brullo et al. 1997, 2009a; Guarino 1997; Brullo & Guarino 2001; De Leonardis et al. 2003; Foggi et al. 2007; Cristaudo et al. 2009; Cataldo et al. 2012; Sciandrello et al. 2013a), as well as the main floristic contributions regarding the whole island (Gussone 1843–1845; Lojacono Pojero 1888–1909; Lopriore 1900; Greuter et al. 1984–89; Giardina et al. 2007) or Italy (Fiori 1925–1929; Pignatti 1982; Conti et al. 2005).

Taxonomic nomenclature follows Giardina et al. (2007), Raimondo and Spadaro (2009) and recent monographic studies on critical genera, such as *Dianthus* (Bacchetta et al. 2010), *Limonium* (Brullo 1980), *Koeleria* (Brullo et al. 2009b) and *Ophrys* (Delforge 2005).

For each taxon, life form, chorology, habitat, current protection and IUCN status are reported in Table I. Life forms follow the Raunkiaer system, adopted by Pignatti (1982). For the chorological classification of the endemics, the following groups

Table I. List of the taxonomic units endemic of Peloritani territory.

Nr.	Taxonomic Units	Family	Dir. Habitat	CITES	IUCN national	IUCN regional	Chorology	Habitat	Life forms	Reproduction	Pollination	Dispersal
1	<i>Adenocarpus commutatus</i> Guss.	Fabaceae	-	-	LR	LR	PE	Scrubs	NP	H	B	Au
2	<i>Allium obtusiflorum</i> DC.	Amaryllidaceae	-	-	LR	LR	SE	Dry grassland	G	H	B	Sb
3	<i>Allium spaeocephalon</i> L. subsp. <i>laxiflorum</i> (Guss.) Giardina & Raimondo	Amaryllidaceae	-	-	-	-	SE	Dry grassland	G	H	B	Sb
4	<i>Anthemis arvensis</i> L. subsp. <i>sphaelata</i> (Presl) Fernandes	Asteraceae	-	-	-	-	CSISE	Pastures	H	H	B	Sb
5	<i>Anthemis cretica</i> L. subsp. <i>messanensis</i> (Brullo) Giardina & Raimondo	Asteraceae	-	-	-	-	PE	Cliffs	H	H	B	Sb
6	<i>Antyllus vulneraria</i> L. subsp. <i>busambarensis</i> (Lojac.) Pignatti	Fabaceae	-	-	LR	LR	SE	Cliffs	H	H	B	Sb
7	<i>Arabis colina</i> Ten. subsp. <i>rosea</i> (DC.) Minuto	Brassicaceae	-	-	LR	LR	SBE	Cliffs	H	H	B	Au
8	<i>Aristolochia clusii</i> Lojac.	Aristolochiaceae	-	-	LR	LR	SISE	Woods	G	H	B	Au
9	<i>Aristolochia sicula</i> Tineo	Aristolochiaceae	-	-	LR	LR	SE	Woods	G	H	B	Au
10	<i>Arrhenatherum nebrodense</i> Brullo, Minissale & Spampinato	Poaceae	-	-	-	-	SE	Woods	H	H	A	Ex
11	<i>Artemisia campestris</i> L. subsp. <i>variabilis</i> (Ten.) Greuter	Asteraceae	-	-	-	-	SBE	Gravels	Ch	H	A	Sb
12	<i>Asperula peloritana</i> Brullo C., Brullo, Giusso & Scuderi	Rubiaceae	-	-	-	-	PE	Cliffs	Ch	H	B	Sb
13	<i>Aubrieta deltoidea</i> (L.) DC. subsp. <i>sicula</i> (Strobl) Phitos	Brassicaceae	-	-	-	-	SE	Cliffs	Ch	H	B	My
14	<i>Barbarea sicula</i> C. Presl in J. & C. Presl	Brassicaceae	-	-	CR	CR	SBE	Temporary ponds	H	H	B	Sb
15	<i>Bellevaia dubia</i> (Guss.) Rchb. subsp. <i>dubia</i>	Asparagaceae	-	-	-	-	SE	Pastures	G	H	B	Sb
16	<i>Bellis margaritifolia</i> Huter	Asteraceae	-	-	-	-	SISE	Pastures	H	H	B	Ex
17	<i>Bellis perennis</i> L. var. <i>peloritana</i> Bég. & Mezzat.	Asteraceae	-	-	-	-	PE	Pastures	H	H	B	As
18	<i>Biscutella maritima</i> Ten.	Brassicaceae	-	-	-	-	SISSE	Synantropic	T	H	B	Aw
19	<i>Bonannia graeca</i> (L.) Halácsy	Apiaceae	-	-	-	-	SBE	Pastures	H	H	B	Aw
20	<i>Brassica incana</i> Ten.	Brassicaceae	-	-	LR	LR	CSISE	Cliffs	Ch	H	B	Sb
21	<i>Brassica raimondoi</i> Sciandr, Brullo C., Brullo, Giusso, Minissale & Salmeri	Brassicaceae	-	-	-	-	PE	Cliffs	Ch	H	B	Sb
22	<i>Brassica rupestris</i> Raf. subsp. <i>rupestris</i>	Brassicaceae	-	-	LR	LR	SE	Cliffs	Ch	H	B	Sb
23	<i>Bunium petraeum</i> Ten.	Apiaceae	-	-	-	-	CSISE	Pastures	G	H	B	Sb
24	<i>Cardamine dubia</i> Nicotra	Brassicaceae	-	-	-	-	SE	Temporary ponds	H	H	B	Au
25	<i>Carduus nutans</i> L. subsp. <i>siculus</i> (Franco) Greuter	Asteraceae	-	-	-	-	SE	Pastures	H	H	B	Ap
26	<i>Carlina hispanica</i> Lam. subsp. <i>globosa</i> (Arcang.) Meusel & Kästner	Asteraceae	-	-	-	-	SISE	Dry grassland	H	H	B	Ap
27	<i>Carlina nebrodensis</i> Guss. Ex DC.	Asteraceae	-	-	-	-	SISE	Pastures	H	H	B	Ap
28	<i>Carlina sicula</i> Ten. subsp. <i>sicula</i>	Asteraceae	-	-	-	-	SISE	Pastures	H	H	B	Ap
29	<i>Centaurea deusta</i> Ten. subsp. <i>divaricata</i> (Guss.) Matthäs & Pignatti in Pignatti	Asteraceae	-	-	-	EN	SISE	Coastal dunes	H	H	B	Ap
30	<i>Centaurea gussonei</i> Raimondo & Spadaro	Asteraceae	-	-	-	-	SE	Pastures	H	H	B	Ap
31	<i>Centaurea parlatoris</i> Heldr	Asteraceae	-	-	-	-	SE	Pastures	H	H	B	Ap
32	<i>Centaurea solstitialis</i> L. subsp. <i>schovii</i> (DC.) Gugler	Asteraceae	-	-	-	-	SCSE	Synantropic	H	H	B	Ap
33	<i>Centaurea todaroi</i> Lacaita subsp. <i>seguenzae</i> (Lacaita) Giardina & Raimondo	Asteraceae	-	-	-	-	PE	Cliffs	Ch	H	B	My



Table I – continued

Nr.	Taxonomic Units	Family	Dir. Habitat	CITES	IUCN national	IUCN regional	Chorology	Habitat	Life forms	Reproduction	Pollination	Dispersal
34	<i>Golybada tauromentiana</i> (Guss.) Holub	Asteraceae	-	-	LR	LR	PE	Cliffs	Ch	H	B	My
35	<i>Crepis vesicaria</i> L. subsp. <i>lyemalis</i> (Biv.) Babc.	Asteraceae	-	-	-	-	SSE	Synantropic	H	H	B	Ap
36	<i>Crocus longiflorus</i> Raf.	Iridaceae	-	-	-	-	CSISE	Pastures	G	H	B	My
37	<i>Crocus scitulus</i> Tineo in Guss.	Iridaceae	-	-	LR	LR	SE	Woods	G	H	B	My
38	<i>Gymbalaria pubescens</i> (C. Presl) Cufod.	Plantaginaceae	-	-	LR	LR	SE	Cliffs	H	H	B	Au
39	<i>Dianthus arrostii</i> C. Presl in J. & C. Presl	Caryophyllaceae	-	-	-	-	SCE	Cliffs	Ch	H	B	Sb
40	<i>Dianthus graminifolius</i> C. Presl.	Caryophyllaceae	-	-	-	-	SE	Dry grassland	H	H	B	Sb
41	<i>Dianthus rupicola</i> Biv. subsp. <i>aedictus</i> (Lojac.) Brullo & Minissale	Caryophyllaceae	-	-	-	-	PAE	Cliffs	Ch	H	B	Sb
42	<i>Dianthus rupicola</i> Biv. subsp. <i>rupicola</i>	Caryophyllaceae	X	-	VU	-	CSISE	Cliffs	Ch	H	B	Sb
43	<i>Dianthus scitulus</i> C. Presl	Caryophyllaceae	-	-	-	-	SE	Cliffs	H	H	B	Sb
44	<i>Echinops ritro</i> L. subsp. <i>scitulus</i> (Strobl) Greuter	Asteraceae	-	-	LR	LR	CSISE	Gravels	H	H	B	Ap
45	<i>Echium italicum</i> L. subsp. <i>scitulum</i> (Lacaita) Greuter & Burdet	Boraginaceae	-	-	-	-	SE	Synantropic	H	H	B	Sb
46	<i>Edraianthus graminifolius</i> (L.) DC. subsp. <i>scitulus</i> (Strobl) Lakusic	Campanulaceae	-	-	LR	LR	SISE	Cliffs	Ch	H	B	As
47	<i>Epipactis meridionalis</i> Baumann & R. Lorenz	Orchidaceae	-	X	-	-	SISE	Woods	G	H	B	As
48	<i>Ericastrum virgatum</i> C. Presl subsp. <i>virgatum</i>	Brassicaceae	-	-	-	-	SISE	Cliffs	H	H	B	Sb
49	<i>Erysimum bonamianum</i> C. Presl	Brassicaceae	-	-	-	-	SE	Cliffs	H	H	B	Aw
50	<i>Euphorbia ceratocarpa</i> Ten.	Euphorbiaceae	-	-	LR	LR	SISE	Synantropic	Ch	H	B	Au
51	<i>Euphorbia corallitoides</i> L.	Euphorbiaceae	-	-	LR	LR	CSISE	Woods	G	H	B	Au
52	<i>Euphorbia meuslii</i> Raimondo & Mazzola	Euphorbiaceae	-	-	-	-	SISSE	Woods	Ch	H	B	My
53	<i>Euphorbia gasparrinii</i> Boiss. subsp. <i>gasparrinii</i>	Euphorbiaceae	-	-	-	-	SE	Pastures	Ch	H	B	Au
54	<i>Festuca humifusa</i> Brullo & Guarino	Poaceae	-	EN	EN	EN	PE	Cliffs	H	H	A	As
55	<i>Festuca morisiana</i> Parl. subsp. <i>scitula</i> Cristaudo, Galesi, Maugeri & Foggi	Poaceae	-	-	-	-	PE	Cliffs	H	H	A	As
56	<i>Galium aeticum</i> Biv.	Rubiaceae	-	-	-	-	CSISE	Dry grassland	H	H	B	As
57	<i>Galium lucidum</i> All. subsp. <i>venustum</i> (Gord.) Arcang.	Rubiaceae	-	-	-	-	CSISE	Cliffs	H	H	B	As
58	<i>Gypsophila arrostii</i> Guss.	Caryophyllaceae	-	-	-	-	SISE	Dry grassland	Ch	H	B	Sb
59	<i>Helichrysum italicum</i> (Roth) G. Don subsp. <i>scitulum</i> (Gord. & Fourn.) Galbani	Asteraceae	-	-	-	-	SE	Gravels	Ch	H	B	Ap
60	<i>Heliotropium suaveolens</i> M. Bieb. subsp. <i>bocconei</i> (Guss.) Brummitt	Boraginaceae	-	-	LR	LR	SE	Synantropic	T	H	B	Sb
61	<i>Helleborus bocconei</i> Ten. subsp. <i>intermedius</i> (Guss.) Greuter & Burdet	Ranunculaceae	-	-	LR	LR	SISE	Woods	G	H	B	As
62	<i>Hyoseris taurina</i> (Pamp.) Martinoli	Asteraceae	-	VU	GR	GR	SCSE	Coastal cliffs	H	H	B	Ap
63	<i>Hypochoeris hispida</i> Willd.	Asteraceae	-	-	-	-	SISE	Pastures	H	H	B	Ap
64	<i>Koeleria splendens</i> C. Presl subsp. <i>splendens</i>	Poaceae	-	-	-	-	SE	Scrubs	H	H	A	Ap
65	<i>Lagurus ovatus</i> L. subsp. <i>nanus</i> (Guss.) Messeri	Poaceae	-	VU	VU	VU	SE	Coastal dunes	T	H	A	Ap
66	<i>Lamium pubescens</i> Sibth. ex Benth.	Lamiaceae	-	-	-	-	CSISE	Woods	H	H	B	Sb
67	<i>Lascepium siler</i> L. subsp. <i>scitulum</i> (Spreng.) Santangelo, Conti & Gubellini	Apiaceae	-	-	-	-	CSISE	Woods	H	H	B	Aw
68	<i>Lathyrus odoratus</i> L.	Fabaceae	-	-	-	-	CSISE	Synantropic	T	H	B	Au

Table 1 – continued

Nr.	Taxonomic Units	Family	Dir. Habitat	CITES	IUCN national	IUCN regional	Chorology	Habitat	Life forms	Reproduction	Pollination	Dispersal
69	<i>Leontodon scilulus</i> (Guss.) Nyman	Asteraceae	X	-	-	-	SE	Pastures	H	H	B	Ap
70	<i>Limonium jonicum</i> Brullo	Plumbaginaceae	-	-	EN	EN	PE	Coastal cliffs	H	H	B	Aw
71	<i>Limonium minutiflorum</i> (Guss.) Kuntze	Plumbaginaceae	-	-	LR	LR	PAE	Coastal cliffs	H	H	B	Aw
72	<i>Limonium sibirianum</i> (Guss.) Kuntze	Plumbaginaceae	-	-	CR	CR	PE	Coastal cliffs	H	H	B	Aw
73	<i>Limonium taurinense</i> Brullo	Plumbaginaceae	-	-	CR	CR	PE	Coastal cliffs	H	H	B	Aw
74	<i>Linaria multicaulis</i> (L.) Mill. subsp. <i>multicaulis</i> var. <i>multicaulis</i> var. <i>messanensis</i> Giardina & Zizza in De Leonardis & al.	Plantaginaceae	-	-	-	-	PCE	Coastal dunes	H	H	B	Aw
75	<i>Linaria purpurea</i> (L.) Miller	Plantaginaceae	-	-	-	-	CSISE	Gravels	H	H	B	Aw
76	<i>Linum punctatum</i> C. Presl in J. & C. Presl subsp. <i>punctatum</i>	Linaceae	-	-	LR	LR	SE	Cliffs	H	H	B	Sb
77	<i>Megathyrsus biconianus</i> (Brullo, P. Minissale, F. Scelsi & Spamp.) Verloove	Poaceae	-	-	-	-	SE	Dry grassland	H	H	A	As
78	<i>Micromeria graeca</i> L. subsp. <i>consentina</i> (Ten.) Arcangeli	Lamiaceae	-	-	-	-	SISE	Garigue	Ch	H	B	Sb
79	<i>Micromeria graeca</i> subsp. <i>tenuifolia</i> (Ten.) Nyman	Lamiaceae	-	-	-	-	CSISSE	Garigue	Ch	H	B	Sb
80	<i>Minuartia verna</i> (L.) Hiern subsp. <i>grandiflora</i> (Presl) Hayek	Caryophyllaceae	-	-	-	-	SSE	Gravels	Ch	H	B	Sb
81	<i>Myosotis sylvatica</i> Hoffm. subsp. <i>elongata</i> (Strobl) Grau	Boraginaceae	-	-	-	-	SISE	Woods	H	H	B	Ex
82	<i>Odonites bocconei</i> (Guss.) Walpers subsp. <i>bocconei</i>	Orobanchaceae	-	-	-	-	SE	Cliffs	Ch	H	B	Sb
83	<i>Odonites vulgaris</i> Moench subsp. <i>siculus</i> (Guss.) Bollinger	Orobanchaceae	-	-	-	-	SE	Pastures	T	H	B	Sb
84	<i>Oncostema sicula</i> (Tineo ex Guss.) Spera	Hyacinthaceae	-	-	EN	EN	SE	Dry grassland	G	H	B	Sb
85	<i>Onosma canescens</i> C. Presl	Boraginaceae	-	-	LR	LR	SE	Gravels	Ch	H	B	Sb
86	<i>Ophrys oxypetala</i> Tod.	Orchidaceae	-	X	-	LR	SE	Garigue	G	H	B	As
87	<i>Ophrys panormitana</i> (Tod.) Soò	Orchidaceae	-	X	LR	LR	SE	Garigue	G	H	B	As
88	<i>Orchis brancifortii</i> Biv.	Orchidaceae	-	X	-	-	SCSE	Garigue	G	H	B	As
89	<i>Petagnaea gussonei</i> (Spreng.) Rauschert	Apiaceae	X	-	EN	EN	SE	Riparian woods	H	H	B	Sb
90	<i>Pterorhagia saxifraga</i> (L.) Link subsp. <i>gasparrini</i> (Guss.) Greuter & Burdet	Caryophyllaceae	-	-	-	-	SISSE	Garigue	Ch	H	B	Sb
91	<i>Pimpinella anisoides</i> Briganti	Apiaceae	-	-	-	-	CSISE	Dry grassland	H	H	B	Sb
92	<i>Plantago peloritana</i> Lojac.	Plantaginaceae	-	-	EN	EN	PE	Pastures	H	H	A	Sb
93	<i>Plantago subulata</i> L. subsp. <i>humilis</i> (Jan x Guss.) Greuter & Burdet	Plantaginaceae	-	-	-	-	CSISE	Scrubs	Ch	H	A	Sb
94	<i>Polygala preslii</i> Sprengel	Polygalaceae	-	-	-	-	SCE	Pastures	H	H	B	My
95	<i>Quercus amplifolia</i> Guss.	Fagaceae	-	-	-	-	SISSE	Woods	P	M	A	Sb
96	<i>Quercus congesta</i> C. Presl in J. & C. Presl	Fagaceae	-	-	-	-	SCSE	Woods	P	M	A	Sb
97	<i>Ranunculus pratensis</i> C. Presl in J. & C. Presl	Ranunculaceae	-	-	-	-	SSE	Pastures	H	H	B	Ex
98	<i>Rumex glaucus</i> Jacq.	Polygonaceae	-	-	-	-	SSE	Gravels	H	H	B	Aw
99	<i>Salix gussonei</i> Brullo & Spampinato	Salicaceae	-	-	LR	LR	SE	Riparian woods	P	D	B	Ap
100	<i>Scorsonera villosa</i> Scop. subsp. <i>colturnae</i> (Guss.) Nyman	Asteraceae	-	-	-	-	SISE	Gravels	H	H	B	Ap
101	<i>Scutellaria columnae</i> All. subsp. <i>gussonei</i> (Ten.) Rech. fl.	Lamiaceae	-	-	-	-	CSISE	Woods	H	H	B	Sb
102	<i>Scutellaria rubicunda</i> Hornem. subsp. <i>limaeana</i> (Caruel) Rech.	Scrophulariaceae	-	-	-	-	SE	Woods	H	H	B	Sb

Table I – continued

Nr.	Taxonomic Units	Family	Dir. Habitat	CITES	IUCN national	IUCN regional	Chorology	Habitat	Life forms	Reproduction	Pollination	Dispersal
103	<i>Senecio ambiguus</i> (Biv.) DC. subsp. <i>gibbosus</i> (Guss.) Chater	Asteraceae	-	-	EN	EN	SCE	Coastal cliffs	Ch	H	B	Ap
104	<i>Senecio emeriaria</i> DC. subsp. <i>bicolor</i> (Willd.) Arcang.,	Asteraceae	-	-	LR	LR	CSISE	Coastal cliffs	Ch	H	B	Ap
105	<i>Senecio squaidus</i> L. subsp. <i>chrysanthemifolius</i> (Poir.) Greuter	Asteraceae	-	-	-	-	SCSE	Synantropic	Ch	H	B	Ap
106	<i>Serapias francavillae</i> Cristaudo, Galési & Lorenz	Orchidaceae	-	X	-	-	PE	Garigue	G	H	B	As
107	<i>Serapias nurrica</i> Corrias	Orchidaceae	-	X	-	-	SCSE	Garigue	G	H	B	As
108	<i>Seseli bocconi</i> Guss.	Apiaceae	-	-	-	-	SSE	Coastal cliffs	H	H	B	Sb
109	<i>Seseli tortuosum</i> L. subsp. <i>maritimum</i> (Guss.) Brullo C., Brullo, Giusso, Sciandrello	Apiaceae	-	-	-	-	CSISE	Coastal dunes	H	H	B	Sb
110	<i>Secleria nitida</i> subsp. <i>scula</i> Brullo & Giusso	Poaceae	-	-	-	-	SE	Pastures	H	H	A	As
111	* <i>Silene calycina</i> C. Presl	Caryophyllaceae	-	-	-	-	SE	Cliffs	H	H	B	Sb
112	<i>Silene italica</i> (L.) Pers. subsp. <i>scula</i> (Ucria) Jeanm.	Caryophyllaceae	-	-	-	-	SCE	Woods	H	H	B	Sb
113	* <i>Sisymbrella dentata</i> (L.) O. E. Schulz	Brassicaceae	-	-	EN	EN	SISE	Temporary ponds	T	H	B	Sb
114	<i>Stipa austroitalica</i> Martinovký subsp. <i>appendiculata</i> (Celak.) Moraldo	Poaceae	-	-	EN	EN	SISE	Dry grassland	H	H	A	Ap
115	<i>Stipa valdemoneensis</i> Cataldo, Giardina, Moraldo & Raimondo	Poaceae	X	-	-	-	SE	Dry grassland	H	H	A	Ap
116	<i>Symphytum gussonei</i> F.W.Schultz	Boraginaceae	-	-	LR	LR	SE	Woods	G	H	B	Sb
117	<i>Tanacetum siculum</i> (Guss.) Strobl	Asteraceae	-	-	LR	LR	SE	Synantropic	H	H	B	Sb
118	<i>Tenacrium siculum</i> (Raf.) Guss. subsp. <i>siculum</i>	Lamiaceae	-	-	LR	LR	CSISE	Woods	H	H	B	Ex
119	<i>Thalictrum calabricum</i> Sprengel	Ranunculaceae	-	-	-	-	SISE	Woods	H	H	A/B	Aw
120	<i>Thapsia garganica</i> L. subsp. <i>messanensis</i> (Guss.) Guglielmo, Pasta, Pavone & Salmeri	Apiaceae	-	-	-	-	PE	Dry grassland	H	H	B	Aw
121	<i>Thymus spinulosus</i> Ten.	Lamiaceae	-	-	-	-	CSISE	Garigue	Ch	H	B	As
122	<i>Tolpis quadristata</i> Biv.	Asteraceae	-	-	-	-	SE	Garigue	H	H	B	Ap
123	<i>Tolpis sexaristata</i> Biv.	Asteraceae	-	-	EN	EN	SE	Garigue	H	H	B	Ap
124	<i>Tolpis virgata</i> (Desf.) Bertol. subsp. <i>gussonei</i> (Fiori) Giardina & Raimondo	Asteraceae	-	-	-	-	SE	Garigue	H	H	B	Ap
125	<i>Tragopogon porrifolius</i> L. subsp. <i>cupanii</i> (DC.) I. Richardson	Asteraceae	-	-	-	-	SISE	Synantropic	H	H	B	Ap
126	<i>Trifolium biconvae</i> Guss.	Fabaceae	-	-	LR	LR	SE	Pastures	H	H	B	Sb
127	<i>Trifolium pratense</i> L. subsp. <i>semipurpureum</i> (Strobl) Pign.	Fabaceae	-	-	-	-	CSISE	Pastures	H	H	B	Sb
128	<i>Trifolium uniflorum</i> L. subsp. <i>scivianum</i> (Guss.) Nyman	Fabaceae	-	-	CR	CR	PCE	Pastures	H	H	B	Sb
129	<i>Viola aemensis</i> (DC.) Strobl subsp. <i>messanensis</i> (W. Beker) Merxm. & Lippert	Violaceae	-	-	LR	LR	SISE	Pastures	H	H	B	My

Notes: Abbreviations are explained in the paragraph "Material and methods". "\*" refers to locally extinct taxa.



and relative acronyms are adopted: “Endemic to Sicily” (SE), “Endemic to Peloritani” (PE), “Endemic to Sicily and Sardinia” (SSE), “Endemic to Sicily and Calabria” (SCE), “Endemic to Peloritani and Aeolian Islands” (PAE), “Endemic to Peloritani and Calabria” (PCE), “Endemic to Sicily, Calabria and Sardinia” (SCSE), “Endemic to Southern Italy and Sicily” (SISE), “Endemic to Southern Italy, Sicily and Sardinia” (SISSE), “Endemic to Central and Southern Italy and Sicily” (CSISE), “Endemic to Central and Southern Italy, Sicily and Sardinia” (CSISSE), “Sub-Endemic” (SBE).

The habitat of the considered species was defined on the basis of literature data and personal observations.

Pollination mode and seed dispersal strategy were determined as either biotic (B) or abiotic (A) on the basis of published reports (Heywood 1978; Faegri & Van der Pijl 1979; Van der Pijl 1982; Murray 1986) and unpublished databases for the flora of Italy (Pacini & Nepi, *in prep.*).

The following seed-dispersal strategies were considered (Vittoz & Engler 2007):

- exozoochory (Ex): dispersal of seeds by being carried on the body of animals;
- myrmecochory (My): seed dispersal by ants;
- autochory (Au): active dispersal, including ballistochory and blastochory;
- semachory/ombrochory/barochory (Sb): with no evident morphological adaptations for seed dispersal: seeds simply fall from the mother-plant or are dispersed by swaying movements of the infructescence (semachory) or by rain drops hitting the capsules (ombrochory);
- anemochory: seed dispersal by wind because of small diaspore size (As), by means of pappi/hairs (Ap), by means of wings (Aw).

As far as polichory is concerned, only the most evident adaptation for dispersal has been considered.

The reproductive mode was determined with the aid of floras (Pignatti 1982) and field observations. *Taxa* have been classified either as hermaphrodites (H), monoecious (M) and dioecious (D), omitting other categories such as gynodioecy, because the available information is incomplete.

The conservation status of threatened *taxa* was assessed according to IUCN criteria (Conti et al. 1992, 1997; Pignatti et al. 2001; IUCN 2005, 2008; Scoppola & Spampinato 2005). Protected *taxa* are quoted according to CITES (1973) and Habitat Directive 92/43 (EEC 1992).

The heterogeneity analysis was performed by means of contingency tables, through the chi-square tests. Data were processed with the Microsoft Excel Spreadsheet. Unless otherwise indicated, statistical

significance is assumed by *p*-values lower than 5%. Spearman rank correlation coefficients were used to show possible relationships between floristic richness and endemism. A *p*-value of <0.05 was taken as indicating a statistically significant difference or correlation.

## Results

The endemic flora of Peloritani consists of 129 specific and infraspecific *taxa*, including 71 species, 57 subspecies and 1 variety (Table I), ascribed to 28 families and 87 genera. The most represented families are *Asteraceae* (23%), *Brassicaceae* (9%), *Caryophyllaceae* (8%), *Apiaceae* and *Poaceae* (both 6%). The most represented genera are *Dianthus* (5 *taxa*), *Centaurea* (5 *taxa*) and *Limonium* (4 *taxa*). Of the surveyed endemic *taxa*, 42 are included in the IUCN Regional Red List (Conti et al. 1997), while 6 species of *Orchidaceae* are protected by the CITES and 4 by the EU 92/43 Habitat Directive.

The most represented life forms in the endemic flora of Peloritani are hemicytopytes (56%), chamaephytes (22%) and geophytes (14%), followed by therophytes (5%), phanerophytes (2%) and nanophanerophytes (1%) (Table II). Most of the surveyed *taxa* are found in natural or seminatural-habitats, mainly cliffs, rangelands, woods and garrigue. In total, 15 *taxa* (Figure 3) are exclusive to the Peloritani district, of which more than 50 per cent are hemicytopytes, mainly related to cliffs. Most *taxa* (44) are Sicilian endemics (SE), while a large number of *taxa* are CSISE (21) or SISE (also 21). Surprisingly low is the number of SCE (4), PCE (2) and PAE (2). The analysis of habitats (Figure 4) shows that the endemics predominantly occur in cliffs (24 *taxa*), pastures (also 24), woods (19), garigues (12) and dry grasslands (12).

The life form spectrum of the Peloritani endemic flora has been compared with that of the endemic flora of the Hyblean district, whose altitudinal range and surface area are most similar, in spite of the

Table II. Life forms of the Peloritani endemics and Hyblean endemic flora.

Life form	Hyblean endemics		Peloritani endemics		Sicilian flora (Rossello 2003)	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
G	30	28.6	18	14	72	15
Ch	28	26.7	28	22	126	27
H	25	23.8	73	56	163	35
T	17	16.2	6	5	67	14
P/NP	4	3.8	4	3	37	8
He/Hy	1	1.0	0	0	4	1
	105		129		469	

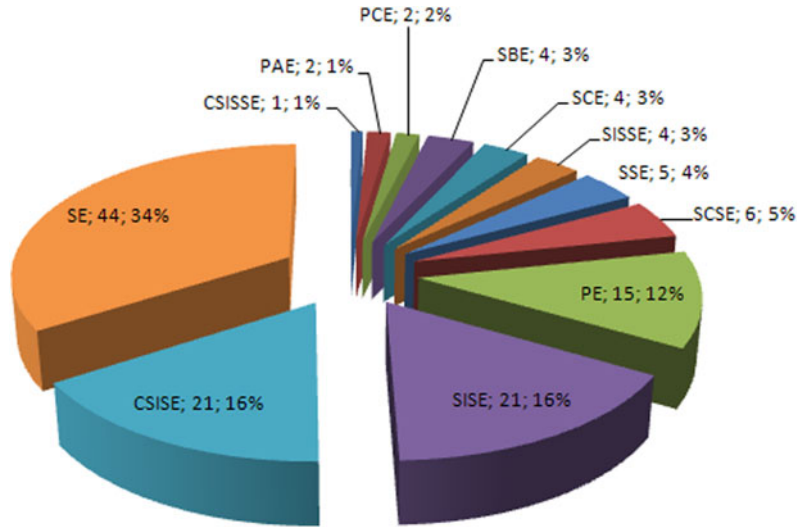


Figure 3. Chorologic spectrum of the endemic flora of the Peloritani territory (see text for acronyms).

profoundly different geomorphology (Brullo et al. 2011). The chi-square analysis reveals a significant difference between the two territories ( $\chi^2 = 30,63$ ), mainly due to the higher percentage of hemicryptophytes for Peloritani region (Table II). The comparison with the endemic species of the whole Sicily (Rossello 2003) shows, as well, significant differences ( $\chi^2 = 25.58$ ).

As concerns the seed dispersal strategy, short distance strategies (Au, Sb, My) are by far the largest group (54%). Accordingly, most of the endemic species do not present evident adaptations to promote seed dispersion. Although plants may take advantage of secondary mechanisms for this purpose (polichory), their disseminative potential tends to be limited. Nevertheless, the rate of wind-dispersed species is also considerable (42%), even if many of these adaptations are not very efficient: genera such as *Erysimum*, *Laserpitium*, *Linaria*, *Bonannia*, *Biscutella* have seeds/fruits with rudimentary wings. The

same holds true for the pappi of *Bellis*, *Tolpis* and of some *Centaurea* species. In any case, the significant incidence of anemochory might suggest that, in general, when explaining the richness in endemic species of Peloritani, habitat peculiarities are a much more important factor than the isolation of populations due to limited dispersal attitudes. This is particularly true for the species linked to rangelands, where anemochory tends to prevail. Indeed, along the ridge of Peloritani, where the endemic-rich rangelands occur, the rocky outcrops and, consequently, the edaphic conditions have no equals all over Sicily.

The biotic seed dispersal is mostly due to ants (6%). There are few exozoochore (4%) and no endozoochore. The lack of endozoochory is probably due to a common evolutionary trend in the Mediterranean Region towards the achievement of dry-fruited and dry-seeded dispersal strategy, as a response to the Mediterranean summer drought and to the common exigency of the Mediterranean plants

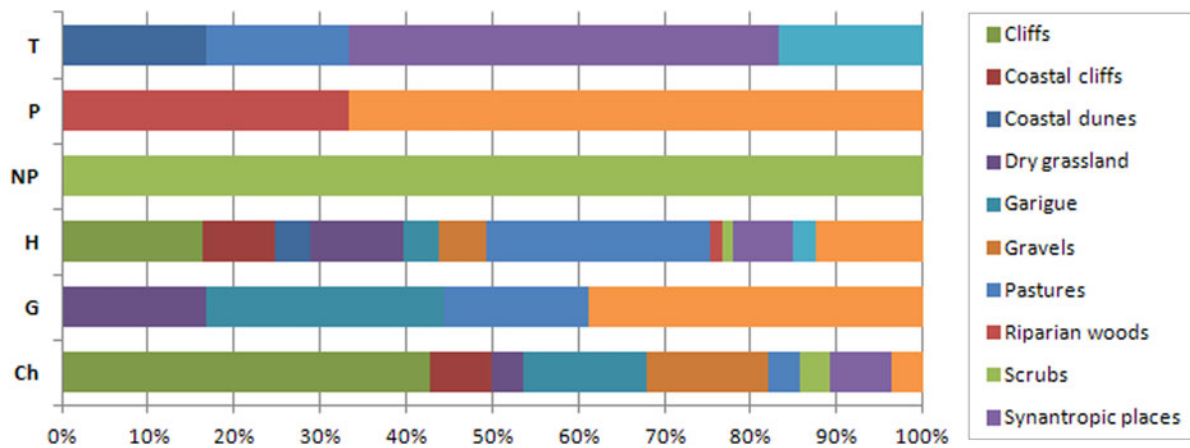


Figure 4. Ecological spectrum and habitat of the endemic flora of the Peloritani territory.

to form durable soil seed banks (Aronne & Wilcock 1994; Guarino et al. 2006).

The rate of dioecious, monoecious, hermaphroditic species varies dramatically from one flora to another (see, for instance, Bawa 1980; Kay & Stevens 1986; Oliveira 1996). It strongly depends on the floristic lineages and is relatively independent from local selective pressure (Renner & Ricklefs 1995). Hermaphroditism is the general reproductive mode in the Peloritani endemics, since only two of them (*Quercus*) are monoecious and only one (*Salix*) is dioecious. Such small numbers do not allow to draft any general conclusion on this issue.

## Discussion

### Degree of endemism

According to Guarino (1997), the flora of Peloritani consists of 1220 specific and infra-specific *taxa*. In the current survey, 129 of this *taxa* are considered endemic, corresponding to 10.5% of whole flora. In the Sicilian flora, the endemic *taxa* (including neighbouring islets) amount to 414, upon the whole of 3235 *taxa* (Giardina et al. 2007; Raimondo & Spadaro 2009), with a percentage corresponding to 12.8%. The percentage of endemic *taxa* in Peloritani flora is therefore comparable to that of the Sicilian flora and of other Mediterranean districts, where the percentage of endemism is around 10–12% (Table III). The percentage of endemics confirms the floristic originality of the Mediterranean lands, where the isolation, a complex geological history and a remarkable habitat diversity play a major role in the speciation processes and, at the same time, act as biogeographical refugia (Médail & Verlaque 1997).

The statistical analysis of Table III, using the Spearman correlation coefficient, allows to highlight other peculiarities of Mediterranean insular floras *sensu lato*. This is especially the correlation between species richness of a territory and its endemic species ( $r = 0.85$ ;  $p < 0.05$ ). There is also a highly significant correlation between the species richness and exclusive endemism ( $r = 0.92$ ;  $p < 0.05$ ) (Figure 5). Previously, also Kallimanis et al. (2010), examining the flora of more than 200 islands, have highlighted for Aegean archipelago that the number of endemic species is highly correlated with the floristic richness. Probably a large pool of species facilitates the emergence of endemics more, or in the same way, than habitat diversity or territorial extension. As it can be seen from Table III, Peloritani Mountains have a fair number of exclusive endemic species. They are: *Adenocarpus commutatus*, *Anthemis cretica* subsp. *messanensis*, *Asperula peloritana*, *Bellis perennis* var. *peloritana*, *Brassica raimondoi*, *Centaurea todaroi* subsp. *seguenzae*, *Colymbada tauromenitana*, *Festuca humifusa*, *Festuca morisiana* subsp. *sicula*, *Limonium jonicum*, *Limonium sibthorpiatum*, *Limonium tauromenitanum*, *Plantago peloritana*, *Serapias francavillae*, *Thapsia garganica* subsp. *messanensis*. Most of them are found in rocky habitat and often closely linked to a specific stratigraphic unit. This is the case of *Colymbada tauromenitana*, *Brassica raimondoi* and *Limonium jonicum*, living on the limestones of the Longi unit, outcropping in the area of Taormina; *Adenocarpus commutatus*, *Anthemis cretica* subsp. *messanensis*, *Centaurea todaroi* subsp. *seguenzae* linked to the metamorphic rocks of the Aspromonte-Peloritani Unit; *Limonium sibthorpiatum* on sedimentary rocks of Ali Unit.

Table III. Endemic *taxa* in some Mediterranean lands.

Region	Plant species	No. of endemics	Endemism (%)	No. of restricted endemics	Restricted endemics (%)	Surface (km <sup>2</sup> )	Altitudinal range	Authors
Andalusia	3680	553	15.2	178	4.9	87598	0–3482	Melendo et al. (2003)
Balearic Islands	1500	180	12	144	9.6	4992	0–1432	Médail and Verlaque (1997)
Sardinia	2522	282	11.1	151	6.0	24090	0–1834	Bocchieri (1995) and Conti et al. (2005)
Sulcis (SW Sardinia)	1235	93	7.5	18	1.4	2130	0–1113	Bacchetta (2006)
Aspromonte	1295*	121	9.7	28	2.2	1650	0–1956	Brullo et al. (2001)
Sicily	3235*	414	12.8	294	9.1	25700	0–3323	Giardina et al. (2007), Raimondo and Spadaro (2009)
Hyblaean district	1527*	105	6.9	20	1.3	4730	0–986	Brullo et al. (1998), Giardina et al. (2007), and Brullo et al. (2011)
Peloritani district	1220*	129	10.5	15	1.5	1827	0–1350	Guarino (1997) and (this study)
N Cyrenaica	1406*	159	11.3	74	5.3	37350	0–865	Brullo and Guglielmo (2001)
Maltese Islands	1000*	23	2.3	13	1.3	312	0–258	Weber and Kendzior (2006) and Lanfranco (1995)
Cyprus	1620	171	10.6	158	9.8	9251	0–1952	Alziar (1995)

Note: \*subspecies included.

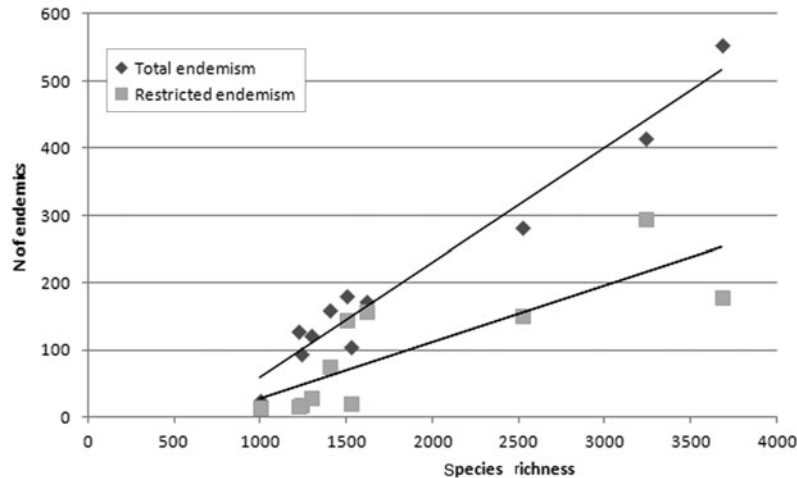


Figure 5. Correlation between species richness, total endemism and restricted endemism.

Two *taxa* are “Peloritani and Calabria Endemic”: *Linaria multicaulis* subsp. *messanensis* and *Trifolium uniflorum* subsp. *savianum*, to these could be added *Erucastrum virgatum* and *Viola aethnensis* subsp. *messanensis* whose distribution extends only with few locations also in Basilicata. Among the endemics with limited distribution, there are also *Dianthus rupicola* subsp. *aeolicus* and *Limonium minutiflorum*, both widely distributed in the Aeolian Islands, with a single outpost in the Peloritani flora, at Capo Milazzo.

The dominance of Asteraceae and Brassicaceae in the Peloritani district agrees with the results of Pérez-García (2012) regarding Mediterranean flora, particularly the endemic flora growing in the Rif and the Betic Ranges.

The commonest life form in the Peloritani endemics are hemicryptophytes, mostly found not only on cliffs, but also in seminatural habitat, such as rangelands, originated by slight anthropic disturbance, while the richness of chamaephytes is related to the abundance of cliffs. The low percentage of nanophanerophytes and phanerophytes can be related to the slow speciation rate of such life forms, due to their longevity and to the limited elevation of Peloritani that does not favour speciation processes (Brullo et al. 2011). The low incidence of endemic therophytes is in accordance with their very effective dispersal strategies (Pignatti, 1979). Moreover, the incidence of therophytes tends to be lower in highly selective habitats and at higher elevations, where endemic taxa are most frequent.

#### Comparing endemic flora

The flora of Peloritani is characterized by the highest number of endemic hemicryptophytes, while endemic therophytes and phanerophytes are better represented in the rest of Sicily. This fact could be

explained by the prevalence, in the Peloritani district, of metamorphic and schistose substrata, that, due to their high friability and instability, create suitable conditions for the hemicryptophytic life form.

As already noticed, most of the Peloritani endemics (hemicryptophytes and chamaephytes) are found in rangelands and rocky habitats. These stressing habitats favour both speciation that the conservation of endemic species, as already observed for other Mediterranean areas (Gómez-Campo 1985; Médail & Verlaque 1997; Soriano et al. 2012). Also Georghiou and Delipetrou (2010) highlight the predominance of chamaephytes and hemicryptophytes in endemic flora of Greece, arguing that these life forms are connected to their habitat, adaptive strategies and related speciation processes. Moreover, the dominance of hemicryptophytes was also confirmed in the endemic flora of Corsica (Verlaque et al. 2001).

Another peculiarity of the endemic flora of Peloritani is the insect pollination, regarding 88% of taxa. Many pollinators are quite precise in their flower-visiting habits (Mitchell et al. 2009) and it is likely that a certain percentage of the endemic flora is the result of species-specific pollination strategy that progressively segregated new characters. This process is well known for the genus *Ophrys* (Paulus & Gack 1990), but it might be true for some other genera such as *Anthyllis* sect. *vulneraria*, *Dianthus*, *Galium*, *Micromeria* and others.

All over the Mediterranean region, human activities played an important role in the spreading of plant species, endemics included, mainly those living in semi-natural habitats such as pastures, garrigues, dry grasslands and synanthropic places. The spreading of these habitats in Sicily in the last millennia is well supported by palinological data (Sadori & Narcisi 2001; Noti et al. 2009).



### Geographical limits

The endemic flora largely contributes to define the extent and significance of the Peloritani District, highlighting the connection between geology and palaeogeography. In particular, the distribution range of some endemic species reveals, at the same time, the extent of the Peloritani District and of the structural unit of the Calabrian Peloritani Arc. This is particularly true for *Viola aethnensis* subsp. *messanensis*, *Hyoseris taurina* and *Erucastrum virgatum*. Especially, the last species is a good marker of the geological and phytogeographical limit westwards, which, along the coast, is found well beyond Capo d'Orlando, and, in inland areas, stretches up to the villages of Mirto and Roccella Valdemone, right along the structural edge of the Calabrian-Peloritani Arc (Giardina et al. 2007).

### Paleogeographic connections

From the phytogeographical viewpoint, the Peloritani endemic flora allows to emphasize palaeogeographical relationships not only with neighbouring Mediterranean territories, but also with currently remote ones. Once again, the case of *Erucastrum virgatum* is of particular importance. Most species of this genus have a west Mediterranean or central south-west European distribution and many of them are steno-endemics (Gómez-Campo 1982, 1983, 1984), confined to the territories belonging to the Alpine orogeny as outlined by Von Raumer et al. (2003) and Cirriuncione et al. (2012) (Figure 6). For example, *Erucastrum rivanum* (Emberger & Maire) Gómez-Campo is from Morocco in the Rif; *E. palustre* (Pirone) Vis is a narrow endemics of NE Italy. In the case of *E. virgatum*, there is a wide and surprising disjunction with *E. virgatum* subsp. *virgatum*, endemic to Peloritani and Calabria, and the other

subspecies: in fact, *E. virgatum* subsp. *baeticum*, *E. virgatum* subsp. *pseudosinapis* and *E. virgatum* subsp. *brachycarpum* are endemic to south and east Spain, mainly in the Betic Mountains (Gómez-Campo 1983). To explain such disjunction, Gómez-Campo (1983) postulates a possible effect of the Quaternary glaciations that would have reduced a wider distribution area. But if we consider the common geological history of the Betic Cordillera and Calabrian Peloritani Arc, both belonging to Alpine orogeny, it might be possible that the current distribution of *Erucastrum virgatum* still reflects the movement of microplates. In particular, from 35 to 16 Ma, the Iberian margin rifted and the Corsica–Sardinia–Calabro–Peloritani block migrated counterclockwise with the Apenninic section of the trench consuming ocean floor and leaving in its wake the newly formed Liguro–Provencal Basin (Gueguen et al. 1998; Faccenna et al. 2001; Goes et al. 2004). By 15 Ma, subduction and trench migration had stalled along the whole margin, as the western end of the trench collided with Africa's margin. In this second phase of roll-back, the Calabrian–Peloritani block rifted from the Corsica–Sardinian block and migrated rapidly, at a rate of up to 6–8 cm per year, to its present position between Sicily and Apulia (Speranza et al. 2002, 2003), while the Tyrrhenian basin opened in the back-arc (Faccenna et al. 2004). All these movements have occurred in an epoch when the genus *Erucastrum* could already be differentiated with a single areal of *E. virgatum*. This hypothesis is supported by recent research on the age of the *Brassicaceae*. Based on phylogenetic trees derived from molecular investigations, calibrated on four well-dated fossils, Beilstein et al. (2010) says the majority of *Brassicaceae* radiated in the mid- to late Eocene from 43.4 to 33.3 Mya. For the tribe of *Brassicaceae* to which the genus *Erucastrum* belongs (Bailey et al. 2006), Beilstein et al. (2010) estimate an age of about 22.5 million years.

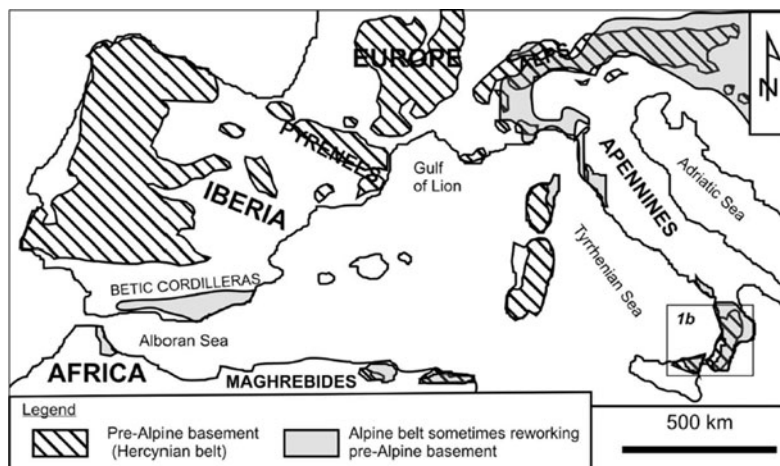


Figure 6. Geological sketch map of Alpine and pre-Alpine ranges in the West-Mediterranean area (after Von Raumer et al. 2003, from Cirriuncione et al. 2012).



The case of *Festuca morisiana* is also relevant: the nominal subsp. is endemic to Gennargentu Massif (Central-Eastern Sardinia), while the subsp. *scicula* is exclusively found in the Peloritani Mountains. They are schizoendemics originated in two areas nowadays remarkably isolated, but with ancient tectonic connections as above said.

The paleo-geographical links of Peloritani and in particular their detachment from the Sardinian-Corsican plate, described above, are highlighted also by some non-endemic species, whose current distribution retains somehow a paleogeographic memory. Particularly relevant is the case of two *Cistaceae*, a family, like the *Brassicaceae*, of ancient origin (Guzman & Vargas 2009), having fruits and seeds with little chance for long-distance dispersion. They are *Cistus crispus* L. and *Tuberaria lignosa* (Sweet) Samp. The first is currently distributed (Greuter et al. 1984) in Algeria, south of France, Iberian peninsula, Morocco, Tunisia, doubtly in Corsica and, in Sicily, exclusively in the Peloritani Mountains; the second occurs in Algeria, Morocco, Tunisia Balearic Islands, Corsica, Sardinia Southern France, Iberian peninsula, Italian peninsula but only in Liguria, Tuscany, Calabria and south of Apulia; in Sicily, again, only in the Peloritani Mountains. In both cases, the discontinuity in the distribution along the Italian peninsula underlines the origin of the Calabrian-Peloritani Arc in the Mediterranean context. The distribution of *Woodwardia radicans* is also interesting: this relic fern of the Mediterranean Tertiary flora is currently occurring in Macaronesia, Portugal, Spain, Algeria, Corsica, Crete, Sicily only in Peloritani, Italian Peninsula only in Calabria and Campania (Pichi Sermolli 1979; Pignatti 1982; Greuter et al. 1984). This is one more case where it is possible to recognize the western phytogeographical connection of the Calabrian-Peloritani arc and Sardinia-Corsica microplate. Similarly, the Peloritani Mountains and W-Sardinia are the only two places in Italy where autochthonous populations of *Pinus pinea* can be found. In particular, the northern end of Peloritani Mountains is the most eastern outpost of the distribution range of such species, whose native status is testified by Pliocene fossil cones (Zodda 1902). The same holds true for *Cytisus scoparius* (L.) Link, a West-Mediterranean-Atlantic species that in Italy is native along the Tyrrhenian coasts of the Peninsula, Sardinia and Peloritani.

In spite of the western Mediterranean gravitation of some ancient elements of the Peloritani flora, many other species testify connections with the eastern Mediterranean, because of the current position of this area, right in the centre of the Mediterranean basin. For instance, the following *taxa* are, in Sicily, limited to the Peloritani district, whereas their distribution range stretches north-

wards and eastwards into the mainland, along the Italian and, in some cases, the Balkanic peninsula: *Anthemis chia* L., *Anthemis tomentosa* L., *Arctium nemorosum* Lej. et Court., *Aristolochia lutea* Desf., *Artemisia variabilis* Ten., *Bellis margaritifolia* Huter., *Cardamine chelidonia* L., *Carduus cephalanthus* Viv., *Coeloglossum viride* (L.) Hartm., *Conringia orientalis* (L.) Dumort., *Echinops spinosissimus* Turra, *Epilobium dodonaei* Vill., *Fritillaria messanensis* Rafin., *Galanthus reginae-olgae* Orphanides subsp. *corcyrensis* (G. Beck) Kamari, *Hypochoeris pinnatifida* (Ten.) Cyr., *Senecio gibbosus* (Guss.) DC., *Silene tenuiflora* Guss., *Tilia platyphyllos* Scop., *Tolpis grandiflora* Ten.

As for the endemic *taxa*, the Eastern connections are testified by *Trifolium uniflorum* subsp. *savianum*, vicariant of *Trifolium uniflorum* subsp. *uniflorum* of Greece, Crete and the Aegean Islands (Brullo et al. 2000); *Anthemis peregrina* subsp. *peregrina*, vicariant of *Anthemis peregrina* subsp. *heracleotica* (Boiss. & Heldr.) Georgiou from Greece (Georgiou 1997). It must be noted that the land connections with Calabria were interrupted with the opening of the Strait of Messina, started just 0.5 Mya (Monaco & Tortorici 2000; Catalano and De Guidi 2003; Goes et al. 2004) and never re-established, not even during the glaciations (Lambeck et al. 2004).

Last but not least, the vicariance between endemic *taxa* of Peloritani and the rest of Sicily are a further proof of the peculiarity of such district that, forming the long and narrow northern end of the island, may act as bottleneck, reducing the inter-population gene flow. This can explain the origin of *Centaurea todaroi* subsp. *seguenzae*; *Thapsia garganica* subsp. *messanensis*; *Linaria multicaulis* var. *messanensis*; *Bellis perennis* var. *peloritana*, etc.

The phytogeographical framework so far developed substantiates the hypothesis that the Peloritani floristic district coincides with the Peloritani Mountains as defined by structural geologists (Lentini et al. 1994) rather than in the common geographical sense, therefore including some areas and endemic species which were traditionally ascribed to the Nebrodi Mountains. This is the case of *Petagnaea gussonei* (Spreng.) Rauschert: a palaeoendemic relic of the Tertiary flora, so far considered endemic to the Nebrodi Mountains, which is actually straddling the boundary between the two mountain ranges. This species borders mountain streams or rivulets that do not dry out in summer, in the shade of beechwoods (Gianguzzi et al. 2004). It is a perennial, rhizomatous plant, usually reproducing asexually, through stolons. At present, the species is distributed in a restricted area of Northern Sicily, on both sides of the contact between the “Calabrid” and the “Maghrebid” geostratigraphic units, respectively, forming the Peloritani and Nebrodi Mountains. All known populations are distributed within a radius of

a few tens of kilometres (De Castro et al. 2009, 2013). The largest number of locations is actually found right along the structural edge of Peloritani (Figure 7, suppl.).

Molecular calibration performed by Kadereit et al. (2008) demonstrated that the tribe of *Saniculoideae*, to which *P. gussonei* belongs, is the most ancient of *Apiaceae*, existing by more than 50 Mya. The node of *P. gussonei* can be dated to 23.4–15.1 Mya. Due to its ancient origin, this species might have its origin on one of the two previously mentioned geostratigraphic units and, when these units come into contact along with the displacement of the Calabrian Peloritani Arc, some populations might have been able to reach suitable sites on the other unit.

Different circumstances led to hypothesize that *P. gussonei* might have in the Peloritani District its primary locations: (1) in the old world, most of the genera of the tribe of *Saniculoideae* have a Central European distribution (Kadereit et al. 2008), therefore, it is likely that *P. gussonei* has greater “phylogeographic affinity” for the Calabrid, rather than for the Maghreb Unit; (2) the Calabrid Unit hosts, as well, another archaic *Apiaceae*: *Lereschia thomasi* (Ten.) Boiss., whose ecological behaviour is quite similar to that of *P. gussonei*, even if the two species belong to different tribes; (3) nearly all the known populations of *P. gussonei* are found on, or in close proximity to, the metamorphic outcrops of the San Marco d’Alunzio Unit, a part of the Hercynian basement which is forming the western boundary of the Calabrian Peloritani Arc (Lentini et al. 2000; Catalano 2010). This might be the reason why the species has such a limited and relict distribution range, even if habitats suitable for its ecological requirements can be found all along the beechwoods of Northern Sicily, up to the metaquartzitic outcrops of Madonie Mountains.

## Conclusions

The inventory of the vascular endemic flora of the Peloritani Mountains commented in this paper highlighted the floristic interest of this area and its unique role in the phytogeographic context of Sicily. The distribution range of some palaeoendemics suggest that the limit of the Peloritani Mountains, regarded here as a biogeographical district, should be extended westward, in order to include some parts traditionally ascribed to the Nebrodi Mountains. The proposed limits, based on floristic evidences, strengthen the new insights on the structural limits of the Calabria-Peloritani Orogen provided by Angi et al. (2010).

The endemic flora of Peloritani Mountains has a remarkable floristic autonomy that supports the geologic foreignness of this area from the rest of Sicily and highlights paleogeographic connections with

other Mediterranean lands. Further research is worth to be done on the molecular phylogeny of the species mentioned earlier, in order to obtain a more precise and focused phylogeographic reconstruction of the Peloritani flora.

We hope that our findings will convince administrators and stakeholders to adopt suitable conservation measures to ensure the survival of the flora of Peloritani that, like many other Sicilian areas and vegetation units (Guarino et al. 2008; Brullo et al. 2013; Minissale & Sciandrello 2013), suffers of ever-increasing anthropic assaults in the name of profitability, that often is prioritized even in the management of the many newly established protected areas all over the Italian territory (Guarino & Pignatti 2010; Guarino et al. 2011).

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## Supplemental data

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## References

- Alzari G. 1995. La flore de Chypre. *Ecol Medit* 21: 47–52.
- Angi G, Cirrincione R, Fazio E, Fiannacca P, Ortolano G, Pezzino A. 2010. Metamorphic evolution of preserved Hercynian crustal section in the Serre Massif (Calabria-Peloritani Orogen, southern Italy). *Lithos* 115: 237–262.
- Appel P, Cirrincione R, Fiannacca P, Pezzino A. 2011. Age constraints on Late Paleozoic evolution of continental crust from electron microprobe dating of monazite in the Peloritani Mountains (southern Italy): Another example of resetting of monazite ages in high-grade rocks. *Int J Earth Sci* 100: 107–123.
- Arena M, Gramuglio G, Willari R. 1975. Anatomical and ecological observations on *Centaurea tauromenitana* Guss. *Atti Soc Peloritana Sci Fis Mat Nat* 21: 99–104.
- Aronne G, Wilcock CC. 1994. Reproductive characteristics and breeding system of shrubs of the Mediterranean region. *Funct Ecol* 8: 69–76.
- Bacchetta G. 2006. Flora vascolare del Sulcis (Sardegna Sud-Occidentale, Italia). *Guineana* 12: 1–350.
- Bacchetta G, Brullo S, Casti M, Giusso del Galdo G. 2010. Taxonomic revision of the *Dianthus sylvestris* group (Caryophyllaceae) in central southern Italy, Sicily and Sardinia. *Nord J Bot* 28: 137–173.
- Bailey CD, Koch MA, Mayer M, Mummenhoff K, O’Kane W, JrSL, Warwick SI, Windham MD, Al-Shehbaz IA. 2006. Toward a Global Phylogeny of the *Brassicaceae*. *Mol Bio Evol* 23: 2142–2160.

- Bawa KS. 1980. Evolution of dioecy in flowering plants. *Ann Rev Ecol Syst* 11: 15–39.
- Bazan G, Marino P, Schicchi R, Surano N. 2006. Analisi geostatistica integrata come metodo per la conoscenza del bioclima della Sicilia. 10a Conferenza nazionale ASITA, Bolzano, 1: 253–258.
- Beilstein MA, Nagalingum NS, Clements MD, Manchester SR, Mathews S. 2010. Dated molecular phylogenies indicate a Miocene origin for *Arabidopsis thaliana*. *Proc Nat Acad Sci* 107: 18724–18728.
- Blasi C, Frondoni R. 2011. Modern perspectives for plant sociology: The case of ecological land classification and the ecoregions of Italy. *Plant Biosyst* 145(suppl.): 30–37.
- Blasi C, Marignani M, Copiz R, Fipaldini M, Bonacquisti S, Del Vico E, Rosati L, Zavattero L. 2010. Important Plant Areas in Italy: From data to mapping. *Biol Conser* 144: 220–226.
- Bocchieri E. 1995. La connaissance et l'état de conservation de la flore da Sardaigne. *Ecol Medit* 21: 71–81.
- Brullo C, Brullo S, Giusso del Galdo GP. 2009a. Taxonomical notes on the Sicilian populations of *Asperula gussonei* (Rubiaceae): *A. peloritana* sp. nov. *Anales Jard Bot Madrid* 66: 85–92.
- Brullo C, Minissale P, Sciandrello S, Spampinato G. 2011. Evaluation of the endemic vascular flora of Hyblaean territory (SE Sicily-Italy). *Acta Bot Gallica* 158: 617–631.
- Brullo S. 1980. Taxonomic and nomenclatural notes on the genus *Limonium* in Sicily. *Bot Not* 133: 281–293.
- Brullo S, Giusso Del Galdo GP, Guarino R, Minissale P, Sciandrello S, Spampinato G. 2013. Syntaxonomic survey of the class Pegano-Salsoletea in Italy. *Plant Biosyst* 147(2): 472–492. doi:10.1080/11263504.2012.717544
- Brullo S, Giusso Del Galdo GP, Minissale P. 2009b. Taxonomic revision of the *Koeleria splendens* C. Presl group (*Poaceae*) in Italy based on morphological characters. *Plant Biosyst* 143: 140–161.
- Brullo S, Grillo M, Guglielmo A. 1998. Considerazioni fitogeografiche sulla flora iblea. *Boll Acc Sci Nat* 29: 45–111.
- Brullo S, Guarino R. 2001. *Festuca humifusa* (*Gramineae*), a new species from Sicily. *Bocconea* 13: 409–412.
- Brullo S, Guarino R, Minissale P. 2000. Taxonomical and phytogeographical remarks on *Trifolium savianum* Guss. a misappreciated species of the Italian flora. *Botanische Jahrbücher Syst* 122: 469–480.
- Brullo S, Guglielmo A. 2001. Considérations phytogeographiques sur la Cyrénaïque septentrionale. *Bocconea* 13: 209–221.
- Brullo S, Minissale P, Siracusa G, Spampinato G. 1997. Taxonomic and phytogeographical considerations on *Hyoseris taurina* (*Compositae*), a S. Tyrrhenian element. *Bocconea* 5: 707–716.
- Brullo S, Minissale P, Spampinato G. 1995. Considerazioni fitogeografiche sulla flora della Sicilia. *Ecol Medit* 21: 99–117.
- Brullo S, Minissale P, Spampinato G. 1997. *Arrhenatherum nebrodense*, a new species from Sicily. *Lagascalia* 19: 903–910.
- Brullo S, Scelsi F, Siracusa G, Spampinato G. 1996. Caratteristiche bioclimatiche della Sicilia. *Giorn Bot Ital* 130: 177–185.
- Brullo S, Scelsi F, Spampinato G. 2001. La vegetazione dell'Aspromonte. Reggio Calabria: Laruffa.
- Brullo S, Spampinato G. 1988. *Salix gussonei* (*Salicaceae*) a new species from Sicily and its relationships with *S. pedicellata*. *Willdenowia* 7: 5–10.
- Catalano S. 2010. Note illustrative della Carta Geologica d'Italia alla scala 1:50.000. foglio 613 Taormina. Firenze: Ispra S.E.L. Ca.
- Catalano S, De Guidi G. 2003. Late Quaternary uplift of northeastern Sicily: Relation with active normal faulting. *J Geodyn* 36: 445–467.
- Cataldo D, Giardina SA, Moraldo B, Raimondo FM. 2012. *Stipa valdemonensis* (*Poaceae*), a new species from Sicily. *Plant Biosyst* 146: 658–663.
- Cirrinzione R, Atzori P, Pezzino A. 1999. Sub-greenschist facies assemblages of metabasites in South-Eastern sector of Peloritani range. *Miner Petrol* 67: 193–212.
- Cirrinzione R, Fazio E, Ortolano G, Pezzino A, Punturo R. 2012. Fault-related rocks: Deciphering the structural–metamorphic evolution of an accretionary wedge in a collisional belt, NE Sicily. *Int Geol Rev* 54: 940–956. doi:10.1080/00206814.2011.623022
- CITES. 1973. Convention on international trade in endangered species of wild fauna and flora. Australia: CITES.
- Conti F, Manzi A, Pedrotti F, editors. 1992. Libro rosso delle piante d'Italia. Roma: Associazione Italiana per il World Wildlife Fund.
- Conti F, Manzi A, Pedrotti F, editors. 1997. Liste rosse Regionali delle Piante d'Italia. Camerino: WWF–SBI.
- Conti F, Abbate G, Alessandrini A, Blasi C, editors. 2005. An annotated checklist of the Italian vascular flora. Roma: Palombi Editori.
- Cristaudo A, Galesi R, Lorenz R. 2009. Über zwei stabilisierte Hybrid populationen aus der Gattung *Serapias* auf Sizilien. *J Eur Orch* 41: 587–610.
- De Castro O, Cennamo P, De Luca P. 2009. Analysis of the genus *Petagnaea* Caruel (*Apiaceae*), using new molecular and literature data. *Plant Syst Evol* 278: 239–249.
- De Castro O, Sepe F, Di Maio A, Cennamo P, De Luca P, Gianguzzi L, Menale B. 2013. Genetic structure in the paleoendemic and endangered *Petagnaea gussonei* (Spreng.) Rauschert (*Saniculoideae*, *Apiaceae*) and implications for its conservation. *Plant Syst Evol* 299: 209–223.
- De Leonardis W, De Santis C, Fichera G, Giardina G, Zizza A. 2003. *Linaria multicaulis* (*Scrophulariaceae*) in Sicily: An investigation within its subspecific and varietal ranks. *Bocconea* 16: 585–595.
- Delforge P. 2005. Guide des Orchidées d'Europe, d'Afrique du Nord et du Proche-Orient. 3rd ed. Paris: Delachaux et Niestlé.
- EEC 1992. Council Directive 92/43 EEC of 22.7.92. *Off J Eur Commun. L* 206/7.
- Faccenna C, Becker TW, Lucente FP, Jolivet L, Rossetti F. 2001. History of subduction and back-arc extension in the Central Mediterranean. *Geophys J Int* 145: 809–820.
- Faccenna C, Funicello F, Piromallo C, Rossetti F, Giardini D, Funicello R. 2004. Subduction and back-arc extension in the Tyrrhenian Sea. *Memorie descrittive della Carta Geologica d'Italia* 54: 165–184.
- Faegri K, Van der Pijl L. 1979. The principles of pollination ecology. 3rd ed, Oxford: Pergamon Press.
- Fiannacca P, Williams IS, Cirrinzione R, Pezzino A. 2013. The augen gneisses of the Peloritani Mountains (NE Sicily): Granitoid magma production during rapid evolution of the northern Gondwana margin at the end of the Precambrian. *Gondwana Res* 23: 782–796.
- Fiori A. 1925–1929. Nuova flora analitica d'Italia. Ricci: Firenze.
- Foggi B, Galesi R, Maugeri G. 2007. *Festuca morisiana* subsp. *sicula* (*Poaceae*) taxon nuovo della flora della Sicilia. *Parlatorea* 9: 95–99.
- Georgiou O. 1997. Taxonomic notes on *Anthemis peregrina* (*Asteraceae*). *Flora Medit* 7: 101–106.
- Georghiou K, Delipetrou P. 2010. Patterns and traits of the endemic plants of Greece. *Bot J Linn Soc* 162: 130–422.
- Gianguzzi L, La Mantia A, Lo Presti RM. 2004. Distribuzione, ecologia e status conservativo di *Petagnaea gussonei* (Sprengel) Rauschert (*Apiaceae*). *Nat Sicil* 19: 205–242.
- Giardina G, Raimondo FM, Spadaro V. 2007. A catalogue of plants growing in Sicily. *Bocconea* 20: 5–582.



- Gómez-Campo C. 1982. Studies on Cruciferae: IX. *Erucastrum rifaunum* (Emberger & Maire) Gómez-Campo, comb. nov. *Anales Jard Bot Madrid* 38: 353–356.
- Gómez-Campo C. 1983. Studies on Cruciferae: X. Concerning some west species of *Erucastrum*. *Anales Jard Bot Madrid* 40: 63–72.
- Gómez-Campo C. 1984. Studies on Cruciferae: XI. *Erucastrum ifniense* Gómez-Campo, sp. nov., and its allies. *Anales Jard Bot Madrid* 41: 83–85.
- Gómez-Campo C. 1985. The conservation of Mediterranean plants: Principles and problems. In: Gómez-Campo C, editor. *Plant Conservation in the Mediterranean area*. Dordrecht: Dr. W. Junk. pp. 3–8.
- Goes S, Giardini D, Jennya S, Hollenstein C, Kahleb HG, Geiger A. 2004. A recent tectonic reorganization in the south-central Mediterranean. *EPSL* 226: 335–345.
- Gramuglio G, Arena M, Rosso R. 1959. La vegetazione del Capo S. Alessio, con osservazioni sul problema dei piani di vegetazione in Sicilia. *Webbia* 15: 249–309.
- Gramuglio G, Rossitto M, Arena M, Villari R. 1978. Nuova stazione di *Woodwardia radicans* (L.) Sm in Sicilia. *Nat Sicil* 2: 127–134.
- Gramuglio G, Triscari C, Arena M. 1985. Ancora una nuova stazione di *Centaurea tauromentana* Guss., endemica dei Monti Peloritani (Sicilia Nord-Orientale). *Inform Bot Ital* 15: 163–167.
- Greuter W, Burdet HM, Long G. 1984–89. *Med-checklist*, 1-3-4. Conservatoire et Jardin botaniques de la Ville de Genève. Genève.
- Guarino R. 1997. La vegetazione dei Monti Peloritani (Sicilia Nord-Orientale). Doctoral Thesis, Unpublished, University of Catania.
- Guarino R. 1998. Biodiversità e stenocoria all'interno delle diverse classi di vegetazione dei monti Peloritani: l'effetto dell'azione umana sugli spettri biologici e corologici ponderati. *Atti del 93° Congresso della Società Botanica Italiana*: 131.
- Guarino R, Bazan G, Marino P. 2011. La sindrome delle aree protette. In: Pignatti S, editor. *Aree Protette e Ricerca Scientifica*. Pisa: ETS. pp. 143–158.
- Guarino R, Giusso del Galdo G, Pignatti S. 2006. The Mediterranean dwarf shrubs: Origin and adaptive radiation. *Ann Bot (Roma)* 5: 93–101.
- Guarino R, Guglielmo A, Ronsisvalle F, Sciandrello S. 2008. Italian case study II: The NATURA 2000 site “Torre Manfreda ITA 050011”. In: Ivanov E, Manakos I, Zdruli P, editors. *Coastal habitat conservation strategies: Towards harmonization and integration in the Mediterranean*. Bari: Ideaprint. pp. 114–151.
- Guarino R, Pignatti S. 2010. Diversitas and biodiversity: The roots of a 21st century myth. *Rend Linc* 20(4): 351–357. doi:10.1007/s12210-010-0104-2
- Gueguen E, Doglioni C, Fernandez M. 1998. On the post-25 Ma geodynamic evolution of the western Mediterranean. *Tectonophysics* 298: 259–269.
- Gussone J. 1843. *Florae Siculae Synopsis* 1. Neapoli.
- Gussone J. 1844. *Florae Siculae Synopsis* 2(1). Neapoli.
- Gussone J. 1845. *Florae Siculae Synopsis* 2(2). Neapoli.
- Guzman B, Vargas P. 2009. Historical biogeography and character evolution of *Cistaceae* (Malvales) based on analysis of plastid *trnL* and *trnL-trnF* sequences. *Org Divers Evol* 9: 83–99.
- Heywood V. 1978. *Flowering plants of the world*. Oxford: Oxford University Press.
- Heywood V. 1995. The Mediterranean flora in the context of world biodiversity. *Ecol Medit* 21: 11–18.
- IUCN. 2005. Guidelines for using the IUCN red list, categories and criteria. IUCN Standards and Petitions Subcommittee Gland, Cambridge: IUCN.
- IUCN. 2008. IUCN red list of threatened species. Gland, Switzerland: IUCN.
- Kadereit JW, Reppinger M, Schmalz N, Uhlir CH, Wörz A. 2008. The phylogeny and biogeography of Apiaceae subfamily Saniculoideae tribe Saniculeae: From south to north and south again. *Taxon* 57: 365–382.
- Kay QON, Stevens DP. 1986. The frequency, distribution and reproductive biology of dioecious species in the native flora of Britain and Ireland. *Bot J Linn Soc* 92: 39–64.
- Kallimanis AS, Bergmeier E, Panitsa M, Georghiou K, Delipetrou P, Dimopoulos P. 2010. Biogeographical determinants for total and endemic species richness in a continental archipelago. *Biodivers Conserv* 19: 1225–1235.
- Lambeck K, Antonioli F, Purcell A, Silenzi S. 2004. Sea-level change along the Italian coast for the past 10,000 yr. *Quat Sci Rev* 23: 1567–1598.
- Lanfranco E. 1995. The Maltese flora and conservation. *Ecol Medit* 21: 165–168.
- Lentini F, Carbone S, Catalano S. 1994. Main structural domains of the central Mediterranean region and their tectonic evolution. *Boll Geof Teor Appl* 36: 103–125.
- Lentini F, Catalano S, Carbone S. 2000. Carta Geologica della Provincia di Messina. Scala 1:50.000 Firenze: SELCA.
- Lojacono Pojero M. 1888–1909. *Flora sicula, o descrizione delle Piante vascolari spontanee o indigenate in Sicilia*. 3 voll. Palermo.
- Lopriore C. 1900. *Studi comparativi sulla flora lacustre della Sicilia*. Catania.
- Médail F, Diadema K. 2009. Glacial refugia influence plant diversity patterns in the Mediterranean Basin. *J Biogeogr* 36: 1333–1345.
- Médail F, Quézel P. 1997. Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. *Ann Miss Bot Gard* 84: 112–127.
- Médail F, Quézel P. 1999. Biodiversity Hotspots in the Mediterranean Basin: Setting global conservation priorities. *Conserv Bio* 13: 1510–1513.
- Médail F, Verlaque R. 1997. Ecological characteristics and rarity of endemic plants from Southeast France and Corsica: Implications for biodiversity conservation. *Bio Conserv* 80: 269–281.
- Melendo M, Giménez E, Cano E, Gómez-Mercado F, Valle F. 2003. The endemic flora in the south of the Iberian Peninsula: Taxonomic composition, biological spectrum, pollination, reproductive mode and dispersal. *Flora* 198: 260–276.
- Minissale P, Sciandrello S. 2013. A relict wood of *Juniperus turbinata* Guss. (Cupressaceae) in Sicily. Ecological features and conservation perspectives. *Plant Biosyst* 147: 145–157.
- Minissale P, Sciandrello S, Spampinato G. 2007. Analisi della biodiversità vegetale e relativa cartografia della Riserva Naturale Orientata “Pantalica, Valle dell’Anapo e Torrente Cava Grande” (Sicilia sudorientale). *Quad Bot Amb Appl* 18: 241–303.
- Mitchell RJ, Irwin RE, Flanagan RJ, Karron JD. 2009. Ecology and evolution of plant–pollinator interactions. *Ann Bot* 103 (9): 1355–1363. doi:10.1093/aob/mcp122
- Monaco C, Tortorici L. 2000. Active faulting in the Calabrian arc and eastern Sicily. *J Geodyn* 29: 407–424.
- Murray DR, editor. 1986. *Seed dispersal*. San Diego, CA: Academic Press.
- Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GAB, Kents J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.
- Nicotra L. 1878. *Prodromus flora messanensis*. Messanae.
- Nicotra L. 1879. Ulteriori osservazioni sulla flora di Messina. *Giorn Bot Ital* 1 II: 211–214.
- Noti R, van Leeuwen JFN, Colombaroli D, Vescovi E, Pasta S, La Mantia T, Tinner W. 2009. Mid- and late-Holocene vegetation

- and fire history at Biviere di Gela, a coastal lake in southern Sicily, Italy. *Veget Hist Archaeobot* 18: 371–387.
- Oliveira PE. 1996. Dioecy in the Cerrado vegetation of central Brazil. *Flora* 191: 235–243.
- Pacini E, Nepi M. Data-base on pollination and dispersal strategies. In: Guarino R, La Rosa M, Pignatti S. editors. *Flora Italiana Digitale*. Bologna: Edagricole in preparation.
- Paulus HF, Gack C. 1990. Pollinators as pre-pollinating isolation factors: Evolution and speciation in *Ophrys* (*Orchidaceae*). *Israel J Bot* 39: 43–79.
- Pérez-García FJ. 2012. Iberian Baetic endemic flora and the implications for a conservation policy. *Annales Botanici Fennici* 49: 43–54.
- Pichi Sermolli REG. 1979. A survey of pteridological flora of Mediterranean Region. *Webbia* 34: 175–242.
- Picone RM, Crisafulli A. 2006. La Flora dei Peloritani. In: Botanical Department of the University of Messina, editor, DVD-Rom.
- Picone RM, Crisafulli A, Zaccone S, Damino R. 2003. The flora of Peloritani District (Sicily): Contribution to the knowledge of endangered entities distribution. *Bocconea* 16: 831–838.
- Pignatti S. 1979. Plant geographical and morphological evidences in the evolution of the mediterranean flora (with particular reference to the Italian representatives). *Webbia* 34: 243–255.
- Pignatti S. 1982. *Flora d'Italia*. 1–3. Bologna, Italy: Edagricole.
- Pignatti S, Menegoni P, Giacanelli V. 2001. Liste rosse e blu della flora italiana. Agenzia Nazionale per la Protezione dell'Ambiente.
- Raimondo FM, Spadaro V. 2009. Addenda et emendanda to the "A catalogue of plants growing in Sicily". *Flora Medit* 19: 303–312.
- Raimondo FM, Spadaro V. 2012. Caratteri biogeografici della flora vascolare della Sicilia. *Biogeographia* 30: 113–139.
- Renner SS, Ricklefs RE. 1995. Dioecy and its correlates in the flowering plants. *Am J Bot* 82: 596–606.
- Rivas-Martínez S. 1993. Bases para una nueva clasificación bioclimática de la tierra. *Folia Bot Matritensis* 10: 1–23.
- Rivas-Martínez S, Penas A, Diaz TE. 2004. Biogeographic map of Europe. Cartographic Service, University of León.
- Rossello F. 2003. Analisi fitogeografica della flora fanerogamica della Sicilia. PhD Thesis. Department of Botany. University of Catania. Italy. 1–160.
- Sadori L, Narcisi B. 2001. The Postglacial record of environmental history from Lago di Pergusa, Sicily. *The Holocene* 11: 655–670.
- Scandone P. 1980. Origin of the Tyrrhenian Sea and Calabrian Arc. *Boll Soc Geol Ital* 98: 27–34.
- Sciandrello S, Brullo C, Brullo S, Giusso del Galdo G, Minissale P, Salmeri C. 2013a. A new species of *Brassica* sect. *Brassica* (*Brassicaceae*) from Sicily. *Plant Biosyst* 147: 812–820.
- Sciandrello S, D'Agostino S. 2014. Distribution patterns and floristic analysis of the *Colymbada tauromenitana* (Guss.) Holub populations in Sicily (Italy). *Acta Bot Croatica* 73. doi:10.2478/botcro-2014-0006.
- Sciandrello S, D'Agostino S, Minissale P. 2013b. Vegetation analysis of the Taormina Region in Sicily: a plant landscape characterized by geomorphology variability and both ancient and recent anthropogenic influences. *Lazaroa* 34: 151–190.
- Scoppola A, Spampinato G. 2005. Atlante delle specie a rischio di estinzione (CD-Rom). Min. Amb. D.P.N. Soc. Bot. Ital., Univ. Della Tuscia, Univ. Roma La Sapienza. Palombi editore.
- Soriano P, Estrelles E, Bianchelli M, Galiè M, Biondi E. 2012. Conservation aspects for chasmophytic species: Phenological behavior and seed strategies of the Central Apennine threatened endemism *Moehringia papulosa* Bertol. *Plants Biosyst* 146: 143–152.
- Spampinato G, Cameriere P, Crisafulli A, Gangale C, Picone R, Santangelo A, Uzunov D. 2008. *Woodwardia radicans* (L.) Sm. *Inform Bot Ital* 40(suppl.1): 132–134.
- Speranza F, Maniscalco R, Grasso M. 2003. Pattern of orogenic rotations in central-eastern Sicily: Implications for the timing of spreading in the Tyrrhenian Sea. *J Geol Soc London* 160: 183–195.
- Speranza F, Villa IM, Sagnotti L, Florindo F, Cosentino D, Cipollari P, Mattei M. 2002. Age of the Corsica–Sardinia rotation and Liguro–Provençal Basin spreading: New paleomagnetic and Ar/Ar evidence. *Tectonophysics* 347: 231–251.
- Thompson JD, Lavergne S, Affre L, Gaudeul M, Debussche M. 2005. Ecological differentiation of Mediterranean endemic plants. *Taxon* 54: 967–976.
- Van der Pijl L. 1982. Principles of dispersal in higher plants. 3rd ed, Berlin: Springer.
- Verlaque R, Médail F, Aboucaya A. 2001. Valeur prédictive des types biologiques pour la conservation de la flore méditerranéenne. *Comptes-Rendus de l'Académie des Sciences, Sciences de la Vie / Life Sciences* 324: 1157–1165.
- Vittoz P, Engler R. 2007. Seed dispersal distances: A typology based on dispersal modes and plant traits. *Bot Helv* 117: 109–124.
- Von Raumer J, Stampfli GM, Bussy F. 2003. Gondwana derived microcontinents. The constituents of the Variscan and Alpine collisional orogens. *Tectonophysics* 365: 7–22.
- Weber HC, Kendzior B. 2006. Flora of the Maltese islands. Weikersheim: Margraf Publishers.
- Zodda G. 1902. Il *Pinus pinea* L. nel Pontico di Messina. *Malpighia* 17: 488–491.