Floristic traits and biogeographic characterization of the Gennargentu massif (Sardinia)

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Abstract

BACCHETTA, G., G. FENU, R. GUARINO, G. MANDIS, E. MATTANA, G. NIEDDU & C. SCUDU (2013). Floristic traits and biogeographic characterization of the Gennargentu massif (Sardinia). *Candollea* 68: 209-220. In English, English and French abstracts.

A study on the vascular flora of the Gennargentu Massif (Central-Eastern Sardinia) is presented. According to our results, the flora consists of 948 taxa: 686 species, 249 subspecies, 10 varieties and 3 hybrids, belonging to 97 families and 427 genera. Three taxa are new findings for the flora of Italy and eight for that of Sardinia. Life form analysis revealed, in particular, dominance of 35.65% hemicryptophytes, 34.6% therophytes, 12.13% geophytes and 11.6% (nano)-phanerophytes. As concerns chorology, the Mediterranean element is largely prevailing (68.14%), mainly represented by circum-Medit. (29.1%) and Euro-Medit. (23.07%). Endemics are 14.87% of the whole flora (141 taxa), with a large prevalence of Sardo-Corsican (39.01%) and Sardinian taxa (35.46%), i.e. 74.47% of the total. Due to the high number of taxa (9) of Gennargentu exclusive endemics and the geologic and geomorphologic peculiarities, it is here proposed a biogeographic classification for these territories serving to the identification of an autonomous sector.

Key-words

Sardinia – Gennargentu – Floristics – Biogeography – Endemics – Mediterranean vascular flora

Résumé

BACCHETTA, G., G. FENU, R. GUARINO, G. MANDIS, E. MATTANA, G. NIEDDU & C. SCUDU (2013). Caractérisations floristiques et biogéographiques du massif du Gennargentu (Sardaigne). *Candollea* 68: 209-220. En anglais, résumés anglais et français.

L'étude de la flore vasculaire du massif du Gennargentu (Sardaigne centre-est) est présentée. Les investigations floristiques ont établi la présence de 948 taxa, dont 686 espèces, 249 sous-espèces, 10 variétés et 3 hybrides, appartenant a 97 familles et 427 genres. Trois nouveaux taxa sont signalés pour la flore d'Italie et huit pour la flore Sarde. L'analyse du spectre biologique établit, en particulier, la dominance d'hémicryptophytes (35,65%), de thérophytes (34,6%), de géophytes (12,13%) et de (nano-)phanérophytes (11,6%). L'analyse du spectre chorologique met en évidence la prédominance de composantes méditerranéennes (68,14%), principalement représentées par des taxa circum-méditerranéens (29,1%) et euro-méditerranéens (23,07%). Les entités endémiques représentent 14,87% (141 taxa) de la flore, avec une majorité d'éléments corsico-sardes (39,01%) et sardes (35,46%) formant ensemble 74,47% des endémiques. En raison du nombre élevé de taxa (9) d'espèces endémiques exclusives du Gennargentu et des particularités géologiques et géomorphologiques, une classification biogéographique est proposée pour ces territoires servant à l'identification d'un secteur autonome.

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Introduction

The Mediterranean basin has been recognised as one of the 34 most important biodiversity hotspots, also because of its high number of endemic plant species (Mittermeier & al., 2004). This area not only constitutes a refuge for many relic species, but the relatively short distance of many islands and peninsulas promotes floristic exchanges and active plant speciation. Médail & Diadema (2009) identified the Central-Northern Sardinia as one of the 52 putative floristic refugia within the Mediterranean, i.e. places facilitating the long-term persistence of a species (one or more glacial-interglacial cycles) or of one or more of its meta-populations in a well-defined geographical area (e.g. mountain range, gorge).

Sardinia, with its 24,090 km^2, is the second-largest island in the Mediterranean Sea. The prolonged isolation and high geological diversity created a wide range of habitats rich in endemic species, particularly on its mountain massifs, where the insularity is strengthened by the altitude and diversity of terrains (Médail & Quézel, 1997). The Sardinian flora consists of 2408 taxa including 2295 species (Conti & al., 2005) 168 of which are exclusive endemics (Bacchetta & al., 2012b).

According to the biogeographic classification of the Mediterranean region proposed by Rivas-Martínez & al. (2002), the Italo-Tyrrhenian province is composed by three subprovinces: the Sardinian, the Corsican and the Tuscano-Calabrian. Owing to the many similarities, not only in the floristic aspects, it is here preferred to recognize the rank of biogeographical province to Corsica and Sardinia, in the frame of an Italo-Tyrrhenian superprovince extended to all over the western coast of the Italian Peninsula, from Tuscany to Calabria, as formerly proposed by Ladero Alvarez & al. (1987). The Sardo-Corsican province, on the contrary, can be furtherly divided into a Sardinian and a Corsican subprovince, as stated by Bacchetta & Pontecorvo (2005). These authors, basing on their studies on the vascular endemic flora of Sulcis-Iglesiente, conferred the rank of biogeographic sector to these territories. Furthermore, a Sinisico subsector (included in the Campidano Sector) has been identified by Fenu & Bacchetta (2008) for the Sinis Peninsula (Central-Western Sardinia), while Fenu & al. (2010) proposed a new biogeographic sector for the Supramontes region (Central-Eastern Sardinia). Other parts of the island, including Gennargentu massif, still remain poorly investigated from a biogeographic viewpoint.

Gennargentu is the main mountain complex of Sardinia and since the beginning of the 18th century it became a popular destination for botanical investigations (Moris, 1827, 1837-1859; Barbey, 1885; Martelli, 1896-1904; Herzog, 1909; Schmid, 1933; Desole, 1948, 1966; Arrigoni, 1966, 1986; Brullo & al., 2001), that led to the description of several new taxa (Pignatti & Feoli, 1974; Pignatti & Pignatti, 1974; Arrigoni & al., 1977-1991; Pignatti & al., 1980; Bacchetta & Brullo, 2006; Bacchetta & al., 2000, 2006, 2010) and to the analysis of the conservation status of some threatened taxa (Fenu & al., 2011, 2012). In spite of the relevant information provided by the abundant literature, an organic review on the vascular flora of Gennargentu was still missing, as well as floristic checklists for the whole massif or single parts of it. Furthermore, relatively big portions of this territory were little known or even unexplored. For these reasons, up to now, a detailed biogeographic framework has never been proposed for the concerned area.

Aims of this work were a comprehensive checklist of the vascular flora of Gennargentu and the analysis of its endemic component, in order to set the area in the Sardinian biogeographic subprovince.

Study Area

Gennargentu (Fig. 1) is located in the central-eastern part of Sardinia and borders the "Barbagia di Ollolai" to the North, the "Mandrolisai" to the North-West and West, the "Sarcidano" and "Barbagia di Belvì" to the South, the "Ogliastra" to the East, the "Supramontes of Urzulei and Orgosolo" to the North-East. The study area has a surface of 50,000 ha and consists of a system of summits and windy ridges at 1400-1500 m, with four culminations at more than 1800 m: Punta La Marmora (1834 m), Bruncu Spina (1828 m), Su Sciusciu (1823 m) and Punta Florisa (1822 m). Other important landmarks are Punta Paolinu (1792 m), Monte Spada (1596 m) and Mont'Arbu (1568 m). The heights of Tonneri de Sa Irgini and Arcu Correboi have also been included in the study area (Fig. 1).

Metamorphic rocks are by far the most represented outcrops. They include Carboniferous metasiltstones and metasandstones, regularly superimposed to schists, limestones and dating, respectively, to Devonian-Silurian and Ordovician (Carmignani & al., 2001). As by-products of the late Hercinic orogeny, intrusions of granites and porphyrites are also frequent (Carmignani & al., 2001). In the area of Arcu Correboi, thick Ordovician quartzitic and foliated silicates are interstratified, with Devonian-Silurian black schists and limestones. The study area covers the whole layered structure that identifies the Gennargentu lithostratigraphic unit (Carmignani & al., 2001).

According to the Rivas-Martínez's bioclimatic classification, most of the Gennargentu massif has a temperate-submediterranean climate, with thermotypes ranging from the lower supratemperate to the lower orotemperate, and ombrotypes from the upper subhumid to the upper humid. The Mediterranean climate is only found on the eastern and southern slopes of the massif, with a lower supramediterranean thermotype and ombrotype ranging from the upper subhumid to the lower humid (Bacchetta & al., 2009a).

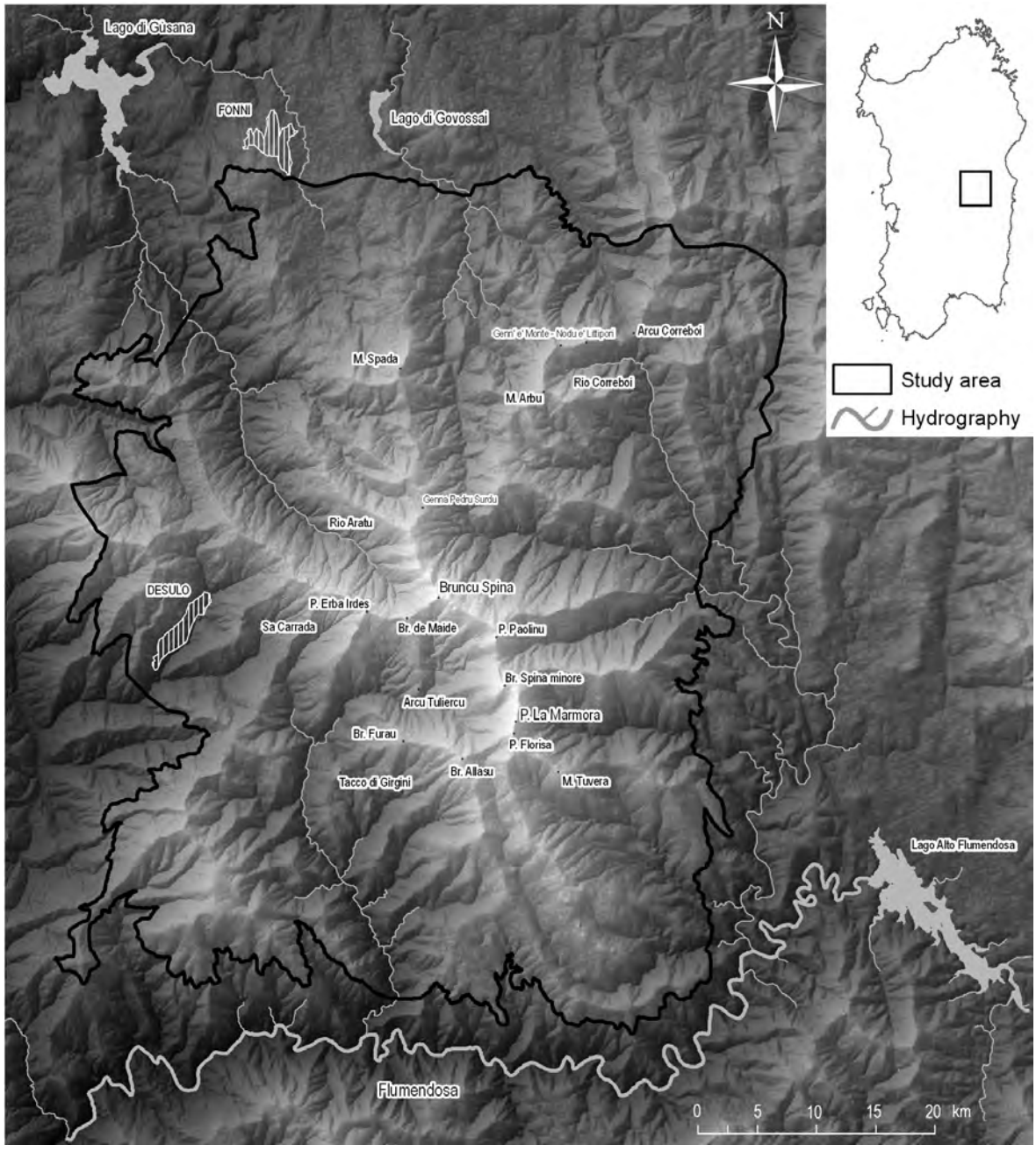

Fig. 1. – Study area in Sardinia.

Methods

Years of floristic researches have been carried out between 2004 and 2011; field trips were effectuated from February to November. Specimens and seeds collected in the field are stored in CAG and in the Sardinian Germplasm Bank (BG-SAR), respectively. Bibliographic and herbariological researches have been fulfilled in BOLO, CAG, CAT, FI, NAP, PAL, RO, SASSA, SS, TO, W, Z.

Collected specimens have been identified using Pignatti (1982), Tutin & al. (1964-80; 1993), Arrigoni & al. (1977-1991), Jeanmonod & Gamisans (2007), Bolòs & Vigo (1984-2001) and Castroviejo & al. (1986-2011).

The delimitation of the plant families listed in our checklist followed the APG III proposal (APG III, 2009; Chase & Reveal, 2009; Peruzzi, 2010). Taxonomic nomenclature followed mainly Conti & al. (2005, 2007) and Greuter & al. (1984-2008), Jalas & Suominen (1972-1994), Jalas & al. (1996-1999) and Kurtto & al. (2004).

Growth and life forms have been determined in the field, following the classification of Raunkiaer (1934), and expressed with the abbreviations proposed by Pignatti (1982).

In addition to the consulted floras, chorotypes refer to the classification proposed by Brullo & al. (1996). For the chorological classification of the endemics, the nomenclature proposed by Arrigoni & Tommaso (1991) and modified by Bacchetta & Pontecorvo (2005) is followed.

For the non-native species, the place of origin is reported, as well as the abbreviations on the "status" proposed by Richardson & al. (2000) and modified by Pyšek & al. (2004): "Cas = casual", "Nat = naturalized", "Inv = invasive".

Taxa known from literature but not found during our field investigations have not been considered in the floristic analysis.

For the biogeographic analysis of the investigated area, the methodological framework proposed by Rivas-Martínez (2007) has been followed. The same has been recently applied for several areas of Sardinia by Bacchetta & Pontecorvo (2005), Fenu & Bacchetta (2008), Angius & Bacchetta (2009), Bacchetta & al. (2009a) and Fenu & al. (2010).

Results

The vascular flora of Gennargentu consists of 948 taxa, of which 686 are species, 249 subspecies, 10 varieties and 3 hybrids, belonging to 97 families and 427 genera. Among the Angiosperms, dicots (incl. Laurales and Piperales) prevail, with 707 taxa (74.58% of the whole flora); monocots count for 199 taxa (20.99%). Pteridophytes and Gymnosperms include 28 (2.95%) and 14 (1.48%) taxa, respectively.

The most represented families are *Asteraceae* (118 taxa), followed by *Poaceae* (99) and *Fabaceae* (79); significant are also *Caryophyllaceae* (55), *Lamiaceae* (34), *Rosaceae* (31), *Apiaceae* (30), *Brassicaceae* (28) and *Orchidaceae* (26).

The richest genera are *Trifolium* L. (22 *taxa*), *Ranunculus* L. (18), *Sedum* L., *Vicia* L. and *Carex* L. (13), *Poa* L. (12), *Silene* L. (11), *Euphorbia* L., *Galium* L., *Orchis* L. and *Rumex* L. (10), *Allium* L., *Filago* L., *Quercus* L., *Juncus* L. and *Orobanche* L. (8), *Geranium* L., *Epilobium* L., *Veronica* L., *Vulpia* C. C. Gmel., *Cerastium* L., *Hieracium* L. and *Medicago* L. (7).

The following taxa are new records for the Sardinian and the Italian flora: *Anarrhinum corsicum* Jord. & Fourr., *Hypericum corsicum* Steud. and *Sagina procumbens* subsp. *muscosa* (Jord.) Nyman; the following ones are new for the flora of the Island: *Asplenium adiantum-nigrum* L. subsp. *adiantum-nigrum*, *A. trichomanes* subsp. *pachyrachis* (Christ) Lovis & Reichst., *Carex depauperata* Curtis & With., *C. flava* L., *Rubus caesius* L., *Rumex aquaticus* L., *Senecio erucifolius* L., and *Tragopogon dubius* Scop.

Life form analysis (Fig. 2) highlighted a clear prevalence of hemicryptophytes (35.65%), followed by therophytes (34.6%), geophytes (12.13%) and (nano-)phanerophytes (11.6%).

As concerns chorology (Fig. 3), the flora of Gennargentu is mostly constituted by Mediterranean taxa (68.14%); the only other significant chorotype is the palaeotemperate (9.07%), the rest ranging between 0.21 and 7.28%. In the Mediterranean quota, the circum-Mediterranean elements prevail (188 taxa, 29.1%), followed by the Euro-Medit. (149 taxa,

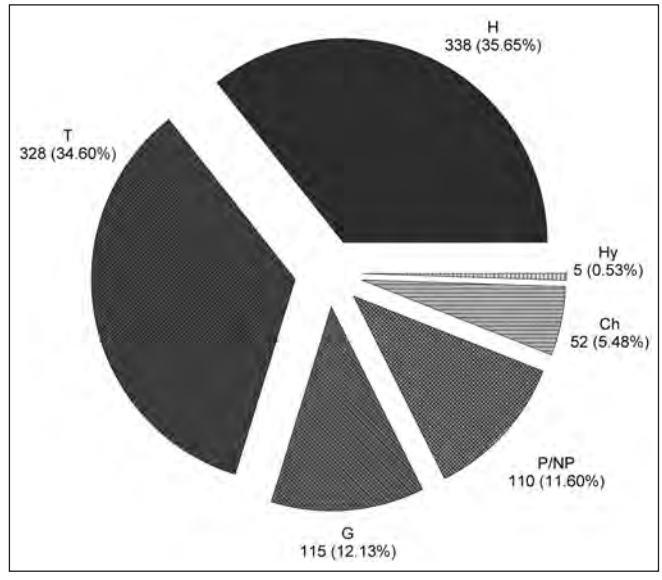

Fig. 2. – Life forms percentages, referred to the whole flora. H = hemicryptophytes; C = chamaephytes; G = geophytes; NP = nanophanerophytes; P = phanerophytes; T = therophytes; Hy = hydrophytes.

Table 1. – List of endemic taxa.

No.	Taxon	Family	Biological form	Chorology	Biogeographic unit
1	*Allium parciflorum* Viv.	*Amaryllidaceae*	G	SA-CO	Sardo-Cors. Prov.
2	*Allium roseum* var. *insulare* Gennari	*Amaryllidaceae*	G	SA-CO	Sardo-Cors. Prov.
3	*Anarrhinum corsicum* Jord. & Fourr.	*Plantaginaceae*	H	SA-CO	Sardo-Cors. Prov.
4	*Aquilegia barbaricina* Arrigoni & E. Nardi	*Ranunculaceae*	G	SA	Sard. Subprov.
5	*Aquilegia nugorensis* Arrigoni & E. Nardi	*Ranunculaceae*	G	SA	Sard. Subprov.
6	*Arenaria balearica* L.	*Caryophyllaceae*	Ch	SA-CO-AT-BL	W-Medit. Subregion
7	*Aristolochia rotunda* subsp. *insularis* E. Nardi & Arrigoni	*Aristolochiaceae*	G	SA-CO-AT	Ital.-Tyrr. Superprov.
8	*Aristolochia tyrrhena* E. Nardi & Arrigoni	*Aristolochiaceae*	G	SA-CO-AT	Ital.-Tyrr. Superprov.
9	*Armeria morisii* Boiss.	*Plumbaginaceae*	H	SA	Sard. Subprov.
10	*Armeria sardoa* subsp. *genargentea* Arrigoni	*Plumbaginaceae*	H	SA	Gennargentu Sector
11	*Armeria sardoa* Spreng. subsp. *sardoa*	*Plumbaginaceae*	H	SA	Sard. Subprov.
12	*Arum pictum* L. f. subsp. *pictum*	*Araceae*	G	SA-CO	Sardo-Cors. Prov.
13	*Astragalus genargenteus* Moris	*Fabaceae*	Ch	SA	Sard. Subprov.
14	*Barbarea rupicola* Moris	*Brassicaceae*	Ch	SA-CO	Sardo-Cors. Prov.
15	*Bellium bellidioides* L.	*Asteraceae*	H	SA-CO-BL	W-Medit. Subregion
16	*Berberis vulgaris* subsp. *aetnensis* (C. Presl) Rouy & Foucaud	*Berberidaceae*	NP	SA-CO-SI-ITM	Ital.-Tyrr. Superprov.
17	*Bituminaria morisiana* (Pignatti & Metlesics) Greuter	*Fabaceae*	Ch	SA-TN (La Galite)	W-Medit. Subregion
18	*Borago pygmaea* (DC.) Chater & Greuter	*Boraginaceae*	H	SA-CO-AT	Ital.-Tyrr. Superprov.
19	*Brimeura fastigiata* (Viv.) Chouard	*Asparagaceae*	G	SA-CO-BL	W-Medit. Subregion
20	*Bunium corydalinum* DC. subsp. *corydalinum*	*Apiaceae*	G	SA-CO	Sardo-Cors. Prov.
21	*Campanula forsythii* (Arcang.) Bég.	*Campanulaceae*	H	SA	Sard. Subprov.
22	*Carduus sardous* DC.	*Asteraceae*	H	SA-CO-AT-ITC	Ital.-Tyrr. Superprov.
23	*Carex caryophyllea* subsp. *insularis* (Barbey) Arrigoni	*Cyperaceae*	H	SA-CO-(SI)	Ital.-Tyrr. Superprov.
24	*Carex microcarpa* Moris	*Cyperaceae*	G	SA-CO-AT	Ital.-Tyrr. Superprov.
25	*Carlina macrocephala* Moris subsp. *macrocephala*	*Asteraceae*	H	SA-CO	Sardo-Cors. Prov.
26	*Centaurea magistrorum* Arrigoni & Camarda	*Asteraceae*	Ch	SA	Gennargentu Sector
27	*Cephalaria mediterranea* (Viv.) Szabó	*Caprifoliaceae*	Ch	SA	Sard. Subprov.
28	*Cerastium palustre* Moris	*Caryophyllaceae*	T	SA	Sard. Subprov.
29	*Cistus creticus* subsp. *corsicus* (Loisel.) Greuter	*Cistaceae*	NP	SA-CO	Sardo-Cors. Prov.
30	*Clinopodium sardoum* (Asch. & Levier) Peruzzi & F. Conti	*Lamiaceae*	Ch	SA	Sard. Subprov.
31	*Clypeola jonthlaspi* subsp. *microcarpa* (Moris) Arcang.	*Brassicaceae*	T	SA-CO-SI	Ital.-Tyrr. Superprov.
32	*Colchicum alpinum* subsp. *parvulum* (Ten.) Nyman	*Colchicaceae*	G	SA-CO-SI-ITC	Ital.-Tyrr. Superprov.
33	*Colchicum gonarei* Camarda	*Colchicaceae*	G	SA	Sard. Subprov.
34	*Crepis vesicaria* subsp. *hyemalis* (Biv.) Babc.	*Asteraceae*	H	SA-SI	Ital.-Tyrr. Superprov.
35	*Crocus minimus* DC.	*Iridaceae*	G	SA-CO-AT	Ital.-Tyrr. Superprov.
36	*Cuscuta epithymum* subsp. *corsicana* (Yunck.) Lambinon	*Convolvulaceae*	T	SA-CO	Sardo-Cors. Prov.
37	*Cymbalaria aequitriloba* (Viv.) A. Chev. subsp. *aequitriloba*	*Plantaginaceae*	Ch	SA-CO-AT-BL	W-Medit. Subregion
38	*Cymbalaria muelleri* (Moris) A. Chev.	*Plantaginaceae*	Ch	SA	Sard. Subprov.
39	*Cynoglossum barbaricinum* Arrigoni & Selvi	*Boraginaceae*	G	SA	Gennargentu Sector
40	*Delphinium pictum* Willd. subsp. *pictum*	*Ranunculaceae*	H	SA-CO-BL-H	W-Medit. Subregion
41	*Dianthus genargenteus* Bacch., Brullo, Casti & Giusso	*Caryophyllaceae*	H	SA	Gennargentu Sector
42	*Dianthus oliastrae* Bacch., Brullo, Casti & Giusso	*Caryophyllaceae*	H	SA	Sard. Subprov.
43	*Dianthus sardous* Bacch., Brullo, Casti & Giusso	*Caryophyllaceae*	H	SA	Sard. Subprov.
44	*Digitalis purpurea* var. *gyspergerae* (Rouy) Fiori	*Plantaginaceae*	H	SA-CO	Sardo-Cors. Prov.
45	*Dipsacus ferox* Loisel.	*Caprifoliaceae*	H	SA-CO	Sardo-Cors. Prov.
46	*Echium anchusoides* Bacch., Brullo & Selvi	*Boraginaceae*	H	SA	Sard. Subprov.
47	*Euphorbia amygdaloides* subsp. *semiperfoliata* (Viv.) Radcl.-Sm.	*Euphorbiaceae*	H	SA-CO	Sardo-Cors. Prov.
48	*Euphorbia gayi* Salis	*Euphorbiaceae*	G	SA-CO-BL	W-Medit. Subregion
49	*Euphorbia hyberna* subsp. *insularis* (Boiss.) Briq.	*Euphorbiaceae*	G	SA-CO-ITC (Liguria e Toscana)	Ital.-Tyrr. Superprov.

Cont.

Table 1. – *Cont.*

No.	Taxon	Family	Biological form	Chorology	Biogeographic unit
50	*Euphorbia meuselii* Geltman	*Euphorbiaceae*	Ch	SA-SI-ITM (Calabria)	Ital.-Tyrr. Superprov.
51	*Euphrasia nana* Rouy	*Orobanchaceae*	T	SA-CO	Sardo-Cors. Prov.
52	*Festuca morisiana* Parl.	*Poaceae*	H	SA	Sard. Subprov.
53	*Galium corsicum* Spreng.	*Rubiaceae*	H	SA-CO	Sardo-Cors. Prov.
54	*Galium schmidii* Arrigoni	*Rubiaceae*	Ch	SA	Sard. Subprov.
55	*Genista aetnensis* (Biv.) DC.	*Fabaceae*	P	SA-CO-SI	Ital.-Tyrr. Superprov.
56	*Genista corsica* (Loisel.) DC.	*Fabaceae*	NP	SA-CO	Sardo-Cors. Prov.
57	*Genista desoleana* Vals.	*Fabaceae*	NP	SA-CO-ITC (Liguria e Toscana)	Ital.-Tyrr. Superprov.
58	*Genista pichisermolliana* Vals.	*Fabaceae*	NP	SA	Gennargentu Sector
59	*Glechoma sardoa* (Bég.) Bég.	*Lamiaceae*	H	SA	Sard. Subprov.
60	*Helichrysum microphyllum* subsp. *tyrrhenicum* Bacch., Brullo & Giusso	*Asteraceae*	Ch	SA-CO-BL	W-Medit. Subregion
61	*Helichrysum saxatile* Moris subsp. *saxatile*	*Asteraceae*	Ch	SA	Sard. Subprov.
62	*Helleborus lividus* subsp. *corsicus* (Briq.) P. F. Yeo	*Ranunculaceae*	G	SA-CO	Sardo-Cors. Prov.
63	*Herniaria litardierei* (Gamisans) Greuter & Burdet	*Caryophyllaceae*	H	SA-CO	Sardo-Cors. Prov.
64	*Hieracium iolai* Arrigoni	*Asteraceae*	H	SA	Sard. Subprov.
65	*Hieracium soleirolianum* Arv.-Touv. & Briq.	*Asteraceae*	H	SA-CO	Sardo-Cors. Prov.
66	*Hieracium zizianum* subsp. *sardonium* Zahn	*Asteraceae*	H	SA-CO	Sardo-Cors. Prov.
67	*Hypericum annulatum* Moris	*Hypericaceae*	H	SA	Sard. Subprov.
68	*Hypericum corsicum* Steud.	*Hypericaceae*	H	SA-CO	Sardo-Cors. Prov.
69	*Hypericum hircinum* L. subsp. *hircinum*	*Hypericaceae*	NP	SA-CO-AT	Ital.-Tyrr. Superprov.
70	*Hypochaeris sardoa* Bacch., Brullo & Terrasi	*Asteraceae*	H	SA-CO	Sardo-Cors. Prov.
71	*Iberis integerrima* Moris	*Brassicaceae*	Ch	SA	Sard. Subprov.
72	*Juniperus communis* var. *corsicana* Lebreton, Mossa & Gallet	*Cupressaceae*	NP	SA-CO	Sardo-Cors. Prov.
73	*Lamium garganicum* subsp. *corsicum* (Gren. & Godr.) Mennema	*Lamiaceae*	H	SA-CO	Sardo-Cors. Prov.
74	*Lamyropsis microcephala* (Moris) Dittrich & Greuter	*Asteraceae*	G	SA	Gennargentu Sector
75	*Limonium morisianum* Arrigoni	*Plumbaginaceae*	Ch	SA	Sard. Subprov.
76	*Lonicera cyrenaica* Viv.	*Caprifoliaceae*	NP	SA-LI	W-Medit. Subregion
77	*Luzula spicata* subsp. *italica* (Parl.) Arcang.	*Juncaceae*	H	SA-CO	Sardo-Cors. Prov.
78	*Mentha requienii* Benth. subsp. *requienii*	*Lamiaceae*	H	SA-CO	Sardo-Cors. Prov.
79	*Mentha suaveolens* subsp. *insularis* (Req.) Greuter	*Lamiaceae*	H	SA-CO-AT-BL	W-Medit. Subregion
80	*Mercurialis corsica* Coss. & Kralik	*Urticaceae*	Ch	SA-CO	Sardo-Cors. Prov.
81	*Micromeria filiformis* subsp. *cordata* (Bertol.) Pignatti	*Lamiaceae*	Ch	SA	Sard. Subprov.
82	*Morisia monanthos* (Viv.) Asch.	*Brassicaceae*	H	SA-CO	Sardo-Cors. Prov.
83	*Myosotis soleirolii* Godr.	*Boraginaceae*	H	SA-CO	Sardo-Cors. Prov.
84	*Noccaea brevistyla* (DC.) Steud.	*Brassicaceae*	H	SA-CO	Sardo-Cors. Prov.
85	*Odontites corsicus* (Loisel.) G. Don	*Orobanchaceae*	T	SA-CO	Sardo-Cors. Prov.
86	*Oenanthe lisae* Moris	*Apiaceae*	H	SA	Sard. Subprov.
87	*Orchis mascula* subsp. *ichnusae* Corrias	*Orchidaceae*	G	SA-CO	Sardo-Cors. Prov.
88	*Ornithogalum corsicum* Jord. & Fourr.	*Asparagaceae*	G	SA-CO	Sardo-Cors. Prov.
89	*Orobanche denudata* Moris	*Orobanchaceae*	G	SA	Gennargentu Sector
90	*Orobanche rapum-genistae* subsp. *rigens* (Loisel.) Arcang.	*Orobanchaceae*	G	SA-CO	Sardo-Cors. Prov.
91	*Paeonia corsica* Tausch	*Paeoniaceae*	G	SA-CO	Sardo-Cors. Prov.
92	*Pancratium illyricum* L.	*Amaryllidaceae*	G	SA-CO-AT	Ital.-Tyrr. Superprov.
93	*Petrorhagia saxifraga* subsp. *bicolor* (Jord. & Fourr.) Gamisans	*Caryophyllaceae*	H	SA-CO	Sardo-Cors. Prov.
94	*Phalaroides arundinacea* subsp. *rotgesii* (Husn.) Valdés & H. Scholz	*Poaceae*	H	SA-CO	Sardo-Cors. Prov.
95	*Plantago subulata* subsp. *insularis* (Gren. & Godr.) Nyman	*Plantaginaceae*	Ch	SA-CO	Sardo-Cors. Prov.
96	*Poa balbisii* Parl.	*Poaceae*	H	SA-CO	Sardo-Cors. Prov.
97	*Polygala sardoa* Chodat	*Polygalaceae*	H	SA	Sard. Subprov.
98	*Potentilla caulescens* subsp. *nebrodensis* (Zimm.) Arrigoni	*Rosaceae*	Ch	SA-SI	Ital.-Tyrr. Superprov.

Cont.

Table 1. – *Cont.*

No.	Taxon	Family	Biological form	Chorology	Biogeographic unit
99	*Potentilla crassinervia* Viv.	*Rosaceae*	Ch	SA-CO	Sardo-Cors. Prov.
100	*Potentilla rupestris* subsp. *corsica* (Lehm.) Rouy & E. G. Camus	*Rosaceae*	H	SA-CO	Sardo-Cors. Prov.
101	*Prospero autumnale* var. *corsicana* (Boullu) Briq.	*Asparagaceae*	G	SA-CO	Sardo-Cors. Prov.
102	*Ptilostemon casabonae* (L.) Greuter	*Asteraceae*	H	SA-CO-H-AT	W-Medit. Subregion
103	*Ptychotis sardoa* Pignatti & Metlesics	*Apiaceae*	H	SA	Sard. Subprov.
104	*Pulicaria vulgaris* var. *sardoa* Fiori	*Asteraceae*	T	SA	Sard. Subprov.
105	*Quercus ichnusae* Mossa, Bacch. & Brullo	*Fagaceae*	P	SA	Sard. Subprov.
106	*Ranunculus cordiger* Viv. subsp. *cordiger*	*Ranunculaceae*	H	SA-CO	Sard. Subprov.
107	*Ranunculus cymbalarifolius* Moris	*Ranunculaceae*	H	SA	Sard. Subprov.
108	*Rhamnus persicifolia* Moris	*Rhamnaceae*	P	SA	Sard. Subprov.
109	*Ribes multiflorum* subsp. *sandalioticum* Arrigoni	*Grossulariaceae*	NP	SA	Sard. Subprov.
110	*Romulea requienii* Parl.	*Iridaceae*	G	SA-CO	Sardo-Cors. Prov.
111	*Rumex pulcher* subsp. *suffocatus* (Bertol.) Nyman	*Polygonaceae*	H	SA	Sard. Subprov.
112	*Rumex scutatus* subsp. *glaucescens* (Guss.) Brullo, Scelsi & Spamp.	*Polygonaceae*	H	SA-SI-ITM (Calabria)	Ital.-Tyrr. Superprov.
113	*Ruta lamarmorae* Bacch., Brullo & Giusso	*Rutaceae*	Ch	SA	Gennargentu Sector
114	*Sagina pilifera* (DC.) Fenzl	*Caryophyllaceae*	H	SA	Sardo-Cors. Prov.
115	*Salix arrigonii* Brullo	*Salicaceae*	P	SA	Sard. Subprov.
116	*Salix purpurea* subsp. *eburnea* (Borzí) Cif. & Giacom.	*Salicaceae*	P	SA	Sard. Subprov.
117	*Santolina insularis* (Fiori) Arrigoni	*Asteraceae*	NP	SA	Sard. Subprov.
118	*Saponaria ocymoides* subsp. *alsinoides* (Viv.) Arcang.	*Caryophyllaceae*	H	SA-CO	Sardo-Cors. Prov.
119	*Saxifraga corsica* Gren. & Godr. subsp. *corsica*	*Saxifragaceae*	H	SA-CO	Sardo-Cors. Prov.
120	*Saxifraga pedemontana* subsp. *cervicornis* (Viv.) Engl.	*Saxifragaceae*	Ch	SA-CO	Sardo-Cors. Prov.
121	*Scorzonera callosa* Moris	*Asteraceae*	H	SA	Sard. Subprov.
122	*Scrophularia oblongifolia* Loisel. subsp. *oblongifolia*	*Scrophulariaceae*	H	SA-CO	Sardo-Cors. Prov.
123	*Scrophularia trifoliata* L.	*Scrophulariaceae*	H	SA-CO-AT	Ital.-Tyrr. Superprov.
124	*Sedum villosum* subsp. *glandulosum* Moris	*Crassulaceae*	T	SA	Gennargentu Sector
125	*Sesleria insularis* subsp. *barbaricina* Arrigoni	*Poaceae*	H	SA	Sard. Subprov.
126	*Silene nodulosa* Viv.	*Caryophyllaceae*	H	SA-CO	Sardo-Cors. Prov.
127	*Silene requienii* Otth	*Caryophyllaceae*	Ch	SA-CO	Sardo-Cors. Prov.
128	*Sorbus aucuparia* subsp. *praemorsa* (Guss.) Nyman	*Rosaceae*	P	SA-CO-SI-ITM	Ital.-Tyrr. Superprov.
129	*Stachys corsica* Pers.	*Lamiaceae*	H	SA-CO	Ital.-Tyrr. Superprov.
130	*Stachys glutinosa* L.	*Lamiaceae*	Ch	SA-CO-AT	Ital.-Tyrr. Superprov.
131	*Tanacetum audibertii* (Req.) DC.	*Asteraceae*	H	SA-CO	Sardo-Cors. Prov.
132	*Taraxacum garbarianum* Peruzzi, Aquaro, Caparelli & Raimondo	*Asteraceae*	H	SA-SI	Ital.-Tyrr. Superprov.
133	*Teucrium marum* L.	*Lamiaceae*	Ch	SA-CO-BL-AT-H	W-Medit. Subregion
134	*Thesium italicum* A. DC.	*Santalaceae*	H	SA	Sard. Subprov.
135	*Thymus herba-barona* Loisel. subsp. *herba-barona*	*Lamiaceae*	Ch	SA-CO	Sardo-Cors. Prov.
136	*Trisetum gracile* (Moris) Boiss.	*Poaceae*	H	SA-CO	Sardo-Cors. Prov.
137	*Urtica atrovirens* Loisel.	*Urticaceae*	H	SA-CO-AT	Ital.-Tyrr. Superprov.
138	*Verbascum conocarpum* Moris subsp. *conocarpum*	*Scrophulariaceae*	H	SA-CO-AT	Ital.-Tyrr. Superprov.
139	*Veronica verna* subsp. *brevistyla* (Moris) Rouy	*Plantaginaceae*	T	SA-CO	Sardo-Cors. Prov.
140	*Vinca difformis* subsp. *sardoa* Stearn	*Apocynaceae*	Ch	SA	Sard. Subprov.
141	*Viola corsica* subsp. *limbarae* Merxm. & W. Lippert	*Violaceae*	H	SA	Sard. Subprov.

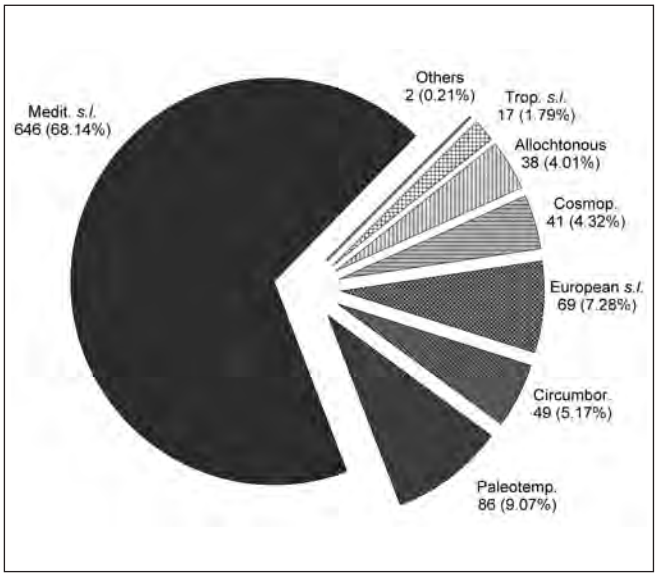

Fig. 3. – Percentages of the chorologic units, referred to the whole flora.

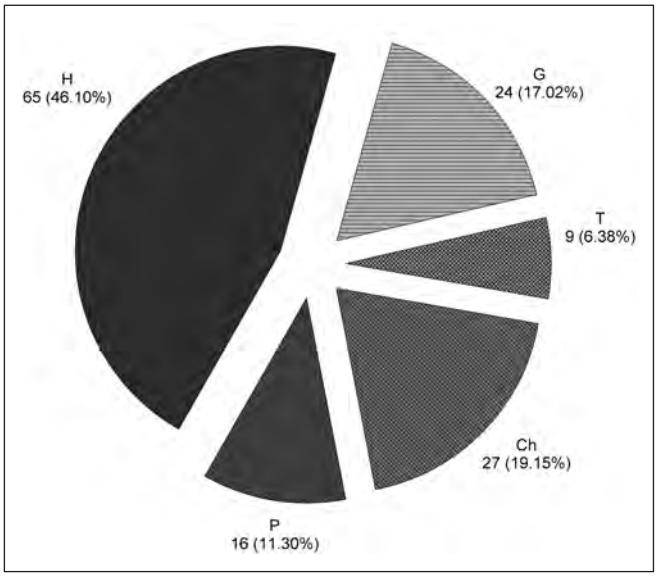

Fig. 4. – Life forms percentages of the endemic flora of Gennargentu. H = hemicryptophytes; C = chamaephytes; G = geophytes; NP = nanophanerophytes; P = phanerophytes; T = therophytes.

23.07%) and the endemic (141 taxa, 21.83%). The West-Medit. (56 taxa, 8.67%), together with the Medit.-Atlantic (29 taxa, 4.49%) count for 13.16% of the whole flora.

In our census, only 38 non-native taxa have been found, i.e. 4.01% of the whole flora: 1 of them is considered invasive (*Xanthium spinosum* L.), 19 casual and 18 naturalized.

The endemic component (Table 1) includes 141 taxa: 84 species, 51 subspecies and 6 varieties, belonging to 46 families and 108 genera. The most represented families are *Asteraceae* (18 taxa), *Caryophyllaceae* (11), *Lamiaceae* (10) *Ranunculaceae*, *Plantaginaceae* and *Fabaceae* (6). The genera richest in endemic taxa are: *Genista* L. and *Euphorbia* L. (4), *Armeria* Willd., *Dianthus* L., *Hieracium* L., *Hypericum* L., *Potentilla* L. (3), followed by 17 genera with 2 taxa each, such as for example *Aquilegia* L., *Ranunculus* L., *Saxifraga* L., *Carex* L. and *Scrophularia* L.

Nearly the half of the endemics (Fig. 4) are hemicryptophytes (46.1%), the rest are chamaephytes (19.15%), geophytes (17.02 %) and (nano-)phanerophytes (11.35 %).

The Sardo-Corsican elements (Fig. 5) prevail (39.01%), followed by the Sardinian ones (35.46%) and by the Italo-Tyrrhenian (18.44%). The last group includes taxa in common with the Tuscan Archipelago (7.8%) and some others ranging up to limited portions of the western coast of the Italian peninsula and Sicily (10.64%).

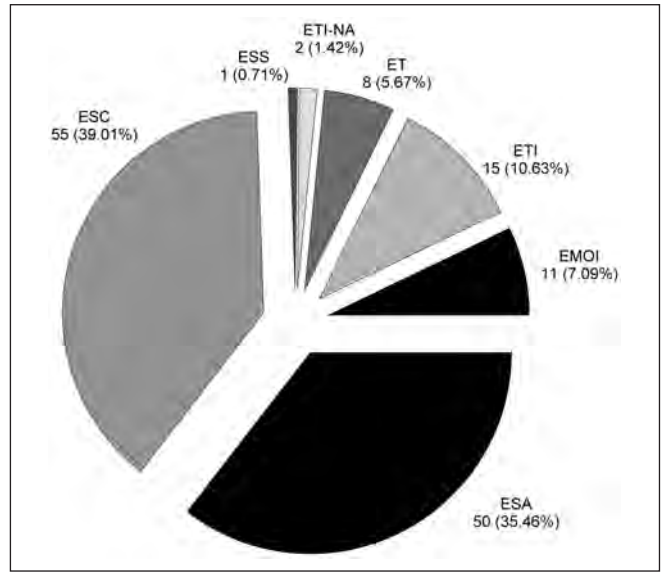

Fig. 5. – Percentages of the chorologic units of the endemic flora of Gennargentu. EMOI = W-Mediterranean insular endemics; ETI = Tyrrhenian insular endemics; ET = Tyrrhenian endemics; ETI-NA = Tyrrhenian insular and N-Africa endemics; ESS = Sardinia and Sicily endemics; ESC = Sardo-Corsican endemics; ESA = Sardinian endemics.

Discussion

In the area of Gennargentu, corresponding roughly to 1% of Sardinia, more than 30% of the regional flora is occurring. Although the available floristic data do not allow to estimate species-area relationships, this high number of taxa, combined with more general considerations on the uniqueness of Gennargentu in terms of largeness and altitude highlight the floristic importance of this area.

The floristic richness of Gennargentu can be explained hypothesizing that along the Quaternary age, the less drastic climate changes on large Mediterranean islands favoured the local persistence of high plant richness and the co-existence of distinct genetic lineages (Valiente Banuet & al., 2006; Medail & Diadema, 2009), confirming the identification of this area as one of the Mediterranean putative refugia. The observed pattern in plant family distribution, which is only partially correlated with the pattern of endemic species, may testify that Gennargentu acted as a "climatic island" during the Quaternary climatic variations. Floristic changes were more severe and drastic in the lowlands and re-colonisation was particularly important for shaping the modern floras at lower altitudes. Not all taxa were able to recolonise and the empty niches were filled by new adaptive radiation of migrating taxa, with a strong tendency towards the annual life strategy (Guarino, 2006). The result is that families are generally larger, but with fewer endemic species in the lowlands than in the summit areas of Gennargentu, where the elevation facilitated the survival or, eventually, an independent adaptive radiation of locally surviving taxa. For example, a high potential for adaptive radiation of the *Ranunculaceae* may be seen in the fact that this family has a significant number of endemic species on Gennargentu, even if it does not account for the most representative families in that area, nor in the whole Sardinian flora. Likewise, the *Asteraceae* seem to have a strong potential for both migrations and local adaptive radiation, whereas the *Poaceae* are remarkable for a high migration potential but may have a low potential for local, independent adaptive radiation. Families like *Fabaceae, Asteraceae* and *Euphorbiaceae* were likely to be able to diversify on the Gennargentu summits not only in the Pleistocene, but also in the Post-Messinian phase.

The role of Gennargentu as a "climatic island" was also confirmed by the life form analysis where the ratio between hemicryptophytes and therophytes is much higher than in the rest of Sardinia (28.1% and 39.9% for H and T, respectively; Bocchieri, 1995). Even the number of nano-phanerophytes is well above the average value for Sardinia (8.8%; Bocchieri, 1995) The percentage of geophytes is also pretty high; this is probably linked to the pastoral land-use of the whole area, frequently affected by periodical fires as for the whole Island (12.1%; Bocchieri, 1995). Chamaephytes display values slightly under the average value for Sardinia (8.1%; Bocchieri, 1995) and the few hydrophytes testify the lack of backwater on Gennargentu.

In the chorologic analysis, the relatively high percentage of palaeotemperate elements outlines the temperate-submediterranean bioclimate in the summit areas of the massif, as well as on its northern slopes. The low percentage of non-native taxa denotes the high naturalistic value of the inspected area and suggests that the mountain flora of Sardinia is probably less prone to competition by allochtonous taxa (Bacchetta & al., 2009b).

Sardinia is well known for its richness in endemic taxa, due to the isolation and high topographic diversity (Médail & Quézel, 1997). The Gennargentu massif, even if its elevation is not comparable with that of the Corsican mountains and has never been affected by glacial perturbation, hosts several distinctive ecological niches as highlighted in the case of *Lamyropsis microcephala* (Moris) Dittrich & Greuter by Mattana & al. (2009). The ecologic and bioclimatic isolation, added to the geographic insularity of Sardinia lets to identify the Gennargentu massif as one of the main "micro hotspot" of Sardinia sensu Fenu & al. (2010).

Moreover, like the Supramontes region (Fenu & al., 2010), Gennargentu represents a southern European "refugium" (sensu Tzedakis & al., 2002) for some temperate tree species (e.g. *Acer monspessulanum* L. subsp. *monspessulanum*, *Ilex aquifolium* L., *Ostrya carpinifolia* Scop., *Quercus congesta* C. Presl, *Rhamnus alpina* L. subsp. *alpina*, *Sambucus nigra* L., *Sorbus aria* (L.) Crantz subsp. *aria*, *S. aucuparia* subsp. *praemorsa* (Guss.) Nyman, *S. torminalis* Crantz, *Taxus baccata* L.). Therefore, it represents an area of special value for the long-term persistence of biodiversity (Taberlet & Cheddadi, 2002), as further testified by the occurrence of several relict endemic taxa, like *Astragalus genargenteus* Moris, *Lamyropsis microcephala*, *Rhamnus persicifolia* Moris, *Ribes multiflorum* subsp. *sandalioticum* Arrigoni, *Ruta lamarmorae* Bacch., Brullo & Giusso, *Tanacetum audibertii* (Req.) DC.

In particular, rocky habitats and windy summit areas, in spite of their limited extension, form a very important reservoir for the local biodiversity (Médail & Quézel, 1997). The high percentage of Sardinian endemics (35.46%) and, within these, of the taxa exclusively growing on Gennargentu (6.38%) testifies the floristic autonomy of the massif. The relatively high percentage of Sardo-Corsican endemics (39.01%), as well as of endemic taxa in common with the Tuscan Archipelago (7.8%) turns out to be so high because of the prevalence of siliceous rocks, that enhances the floristic affinity of Gennargentu with the Corsican and the Ilvensian territories (Bacchetta & Pontecorvo, 2005). On the other hand, in the Sardinian areas where limestones and carbonatic rocks in general prevail, and particularly in the so-called

"carbonate-metalliferous ring" (i.e. S-W Sardinia), or in the Supramontes area (i.e. C-E Sardinia, just around Gennargentu), the number of Sardinian exclusive endemics tends to be higher than in Gennargentu (BACCHETTA & PONTECORVO, 2005; FENU & al., 2010).

The nine endemic taxa in common with the Balearic Islands, added to the 8.51% of West-Mediterranean elements, confirmed the biogeographical affiliation of Sardinia to the so-called "W-Mediterranean subregion" (BACCHETTA & PONTECORVO, 2005). The 11 taxa in common with Corsica and the Tuscan Archipelago justify the biogeographical identity of an Italo-Tyrrhenian Superprovince, as proposed by LADERO ALVAREZ & al. (1987) and followed by BACCHETTA & al. (2012a).

Due to the relatively high number of exclusive endemics of Gennargentu massif, and the geologic and geomorphologic peculiarities, it is here proposed a biogeographic classification for these territories with the identification of an autonomous sector named "Gennargentu". According to RÍOS RUIZ & al. (2003), the floristic autonomy of this sector is highlighted not only by the presence of nine exclusive taxa (*Armeria sardoa* subsp. *genargentea* Arrigoni, *Centaurea magistrorum* Arrigoni & Camarda, *Cynoglossum barbaricinum* Arrigoni & Selvi, *Dianthus genargenteus* Bacch., Brullo, Casti & Giusso, *Genista pichisermolliana* Vals., *Lamyropsis microcephala*, *Orobanche denudata* Moris, *Sedum villosum* subsp. *glandulosum* Moris, *Ruta lamarmorae*) but also by several differential taxa, with a wider distribution range and limited in Sardinia to the study area, such as *Anarrhinum corsicum*, *Euphorbia hyberna* subsp. *insularis* (Boiss.) Briq., *Euphrasia nana* Rouy, *Herniaria litardierei* (Gamisans) Greuter & Burdet, *Hypericum corsicum*, *Gentiana lutea* L. s.l., *Myosotis soleirolii* Godr., *Noccaea brevistyla* (DC.) Steud., *Sorbus aucuparia* subsp. *praemorsa* (Guss.) Nyman, *Tanacetum audibertii*, *Trisetum gracile* (Moris) Boiss. In addition, the Gennargentu massif shares with the surrounding sector of Supramontes some relictual endemic calcifugous taxa like *Genista aetnensis* (Biv.) DC., *Morisia monanthos* (Viv.) Asch., *Cerastium palustre* Moris, *Astragalus genargenteus*, *Juniperus nana* var. *corsicana* Lebreton, Mossa & Gallet and *Carex microcarpa* Moris (FENU & al., 2010).

In conclusion, the overall floristic richness of Gennargentu massif, determined by its ecological insularity and the richness of its endemic flora, highlighted the peculiarity of this territory and its identification as one of the Mediterranean putative "refugia", as stated by MEDAIL & DIADEMA (2009), justifying the set up of an autonomous biogeographic sector.

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