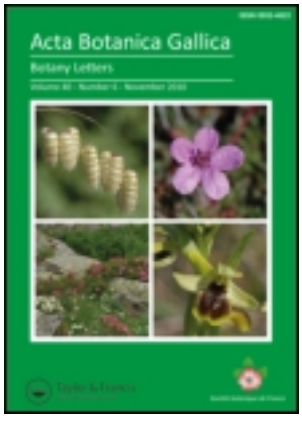

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Phytogeographic survey on the endemic vascular flora of the Hyblaean territory (SE Sicily, Italy)

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Phytogeographic survey on the endemic vascular flora of the Hyblaean territory (SE Sicily, Italy)

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Abstract.- A survey of the endemic flora of the Hyblaean territory, important centre of biodiversity and speciation in Sicily, is presented. The endemic flora of this area consists of 105 taxa. Among them, 39 are included in the IUCN Regional Red List and 32 in the National Red List, 17 Orchidaceae are protected by the CITES and 3 in the EU 92/43 Habitat Directive. The most represented families are Asteraceae and Orchidaceae (17%), Lamiaceae (10%). A large number of species are endemic to Sicily or central-southern Italy and Sicily. The endemic taxa exclusive to the Hyblaean territory are 20. Life form spectrum of the endemic flora indicates the predominance of geophytes (28.6%), chamaephytes (26.7%), hemicryptophytes (24.8%). The analysis of the habitat put in evidence that the endemics are widespread in garrigues, rocky walls and rocky coasts, dry grassland, woods and synantropic places. In this work, it's also provided an assessment of the conservation status of Hyblaean endemics and proposition for their protection.

Key words : endemic flora - life forms - habitat - conservation status - Hyblaean territory - Sicily.

Résumé.- Le territoire ibléen est un centre important pour la biodiversité et la spéciation en Sicile. Sa flore endémique représente 105 taxons. Beaucoup sont menacés par différentes activités humaines (agriculture intensive, urbanisation, pâturage, industrialisation). Parmi les taxons endémiques, 39 sont inclus dans la Liste rouge de l'UICN régionale et 32 dans la Liste rouge nationale, 17 Orchidaceae sont protégées par la CITES et 3 par la directive Habitat 92/43. Les familles les plus représentées sont: Asteraceae and Orchidaceae (17%), Lamiaceae (10%). Le spectre biologique de cette flore montre la dominance des géophytes (28,6%), chaméphytes (26,7%), hémicryptophytes (24,8%). L'analyse des habitats montre que les endémiques sont répandues dans les garrigues, parois rocheuses et côtes rocheuses, les prairies sèches, les bois et lieux anthropisés. Nous donnons une évaluation sur l'état de conservation des endémiques de ce territoire et des propositions pour leur protection.

Mots clés : flore endémique - formes de vie - habitat - état de conservation - territoire ibléen - Sicile.

I. INTRODUCTION

The importance of the Mediterranean region as a centre of plant biodiversity on a world scale is well known (Heywood, 1995; Médail & Quézel, 1999; Myers *et al*., 2000; Thompson *et al*., 2005; Médail & Diadema, 2009). The richness in biodiversity is not uniformly distributed, but rather strongly linked to the ecosystem diversity and to the historical determinants. Médail and Quézel (1997) consider Sicily as one of the most important hot-spots for biodiversity conservation in the Mediterranean basin. Within this region the Hyblaean territory represents an important centre of diversity and speciation. In particular, this areas coinciding with the SE Sicily, shows a flora rich in endemic species including, some paleoendemics, as testified by the long and complex paleogeographic history that has affected this area (La Greca, 1990; Brullo *et al*., 1995). Among these species *Urtica rupestris* and *Zelkova sicula* are undoubtedly the most important species of this territory (Bartolo *et al*., 1989; Di Pasquale *et al*., 1992; Garfì, 1996; Garfì *et al*., 2011). Blasi *et al*. (2009, 2010) identified six important plant areas (IPA) for the Hyblaean territory, essential for the conservation of plant biodiversity. These are "Torre Manfria (SIC 14)", "Valle F. Ippari e Punta Braccetto (SIC 15)", "Costa di Sampieri (SIC 16)", "Vendicari, Capo delle Correnti, Pantani della Sicilia meridionale (SIC 17)", "Monti Iblei (SIC 18)" and "Boschi di Niscemi e Costa di Gela (SIC19)".

During the last decade, numerous authors have examined the endemic vascular flora of different Mediterranean countries, in relation to their conservation and threats (Blanca *et al*., 1998; Melendo *et al*., 2003; Gimenez *et al*., 2004; Penas *et al*., 2005; Bacchetta & Pontecorvo, 2005; Bacchetta *et al*., 2005; Lorite *et al*., 2007; Stancic *et al*., 2008; Randelović *et al*., 2008; Yildiztugay *et al*., 2009; Fenu *et al*., 2010). This work provides a further contribution focused to increase the knowledge on this important but still little known Sicilian area. In this work an inventory of the endemic flora occurring in the Hyblaean territory is given and along with an assessment of the conservation status and priorities for species protection. It should be a starting point for further researches and conservation projects of Hyblaean flora.

II. MATERIAL AND METHODS

A. Study area

The study area, located in southern eastern Sicily (Fig. 1), is included by Brullo *et al*. (1995), in SE Sicilian subsector, which comprise the "Hyblaean" and "Camarino-Pachinense" districts. Most part of this subsector is represented by the Hyblaean plateau which belongs to the African plate. It consists of a crust of continental type different from that of the rest of Sicily (Ben Avraham & Grasso, 1990) while, from the geophysicist standpoint, it is characterized by a strong gravimetric and magnetic anomaly (Bouguer anomalies) chiefly due to its composition. The Hyblaean plateau extends south to the Maltese Islands from which it is separated by a continental shelf. Structurally, then the Hyblaean-Maltese Plateau is a single Crustal entity isostatically raised and well defined on its edges. Geologically, it is constituted by a large limestone plateau which reaches an altitude of 986 m in Monte Lauro, where a powerful series of Tertiary volcanic outcrops exists.

Outcropping successions in the Hyblaean plateau consist mostly of carbonate and carbonate-marly sediments ranging from Lower Cretaceous to Pleistocene, where basic vol-

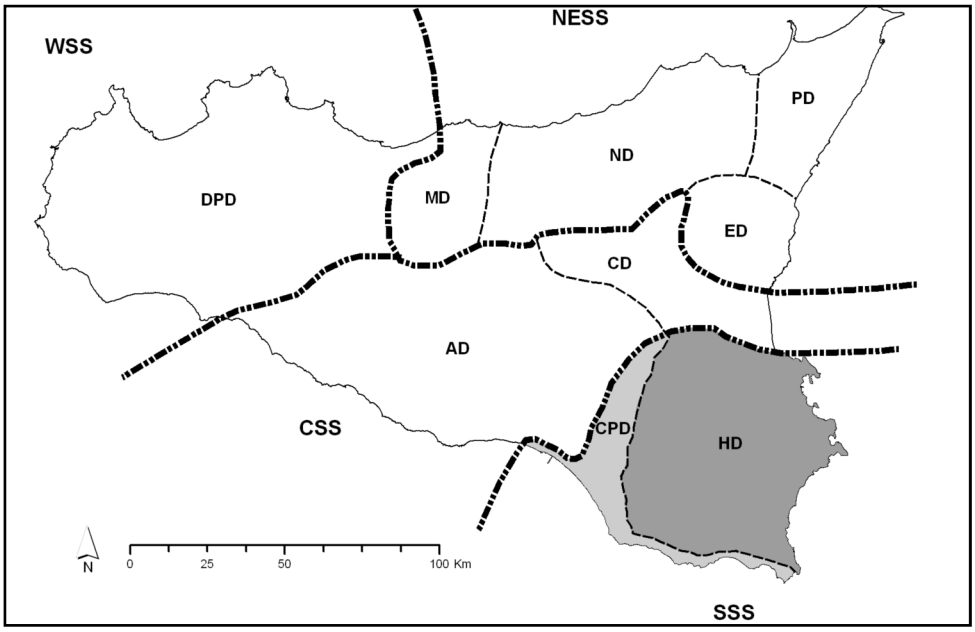

Fig. 1.- Phytogeographic subdivision of the Eusicilian sector according to Brullo *et al.* (1995, modified). In grey the Hyblaean territory. CSS, Central sub-sector; SSS, Southern sub-sector; WSS, West sub-sector; NESS, North East sub-sector; HD, Hyblaean district; CPD, Camarino-pachinese district; AD, Agrigento district; CD, Catania district; ED, Etna district; PD, Peloritani district; ND, Nebrodi district; MD, Madonie district; DPD, Drepano-Panormitano district.

Fig 1.- Subdivision phytogéographique du secteur Eusicilian selon Brullo *et al.* (1995, modifié).

canics of considerable power (Bianchi *et al*., 1989) are intercalated. The coastal area of the Hyblaean territory is characterized by Pleistocene substrates, such as calcarenites and sand deposits that extend often up to the inland.

According to the bioclimatic classification proposed by Rivas-Martínez (1993, 2004) the area under study is referred to the Mediterranean pluviseasonal oceanic bioclimate, with thermotypes ranging from the low thermomediterranean to the supramediterranean and ombrotypes from the semiarid to lower humid (Brullo *et al*., 1996; Scelsi & Spampinato, 1998).

One of the most typical landscapes of the Hyblaean area are the "Cave", which are valleys of fluvial-tectonic origin having a cross-section very similar to a V with steep slopes. Water courses flowing in the “Cave”, usually have temporary arrangements or a permanent regime (Brullo *et al*., 1993; Brullo & Spampinato, 1990; Minissale *et al*., 2007). Other environment of particular interest are the coastal salt marshes, characterized by a highly specialized flora. These wetlands are of extreme importance for migratory birds that can stop during migration routes finding suitable habitats. Two of those, Biviere di Gela and Vendicari are wetlands of international importance included in the Ramsar List. Another very important habitat are the sandy dunes, where one can find the relict patches of edaphoclimacic vegetation characterized by *Juniperus macrocarpa* and *Ephedra fragilis*

(Bartolo *et al*., 1982), and the rocky coasts, where numerous endemic and rare plants grow (Brullo, 1972, 1980, 1988; Brullo & Pavone, 1985; Bartolo & Brullo, 1993).

Overall the Hyblaean area is quite varied and articulated in terms of geological, geomorphological and bioclimatic features. These physiographic diversities determine a great variety of habitat with an extraordinary richness in flora and vegetation (Brullo *et al*., 1998). However, strong anthropogenic alterations in the last century caused a continuous and unrestrained fragmentation of natural habitats and impoverishment of the biodiversity (Minissale, 2007).

B. Flora analysis

This paper is based on literature data and herbarium investigation, integrated by several field observations carried out in different seasons. As concerns the literature we used all reports dealing with the flora of the Hyblaean territory (Bianca, 1839-1857; Zodda, 1928; Albo, 1961; Gentile, 1962; Brullo & Furnari, 1970; Brullo, 1972, 1980, 1988; Brullo & Marcenò, 1973; Brullo *et al*., 1976, 1998, 2000, 2007, 2009; Bartolo *et al*., 1976, 1989, 1998, 2009; Bartolo & Pulvirenti, 1993, 1997; Brullo & Pavone, 1985; Giardina, 1988; Di Pasquale *et al*., 1992; Galesi, 1992, 1993, 1995; Maugeri & Cristaudo, 1995; Galesi *et al*., 2006; Arrigoni, 2006; Guarino *et al*., 2008; Minissale *et al*., 2007; Galesi & Lorenz, 2010), 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). Raimondo *et al.* (2005), examining the state of knowledge of Hyblaean flora, define as "well known" the Hyblaean plateau and the eastern coastal strip, and "fairly well known" the rest of the territory.

The herbarium investigations have been carried out mainly on the Botanical Museum of Catania (CAT) and Palermo (PAL).

For the nomenclatural and taxonomical aspect we have followed Giardina *et al*. (2007), Raimondo & Spadaro (2009) and various monographic studies and taxonomic contributions regarding same critically genus or specie complex, as *Gagea* (Peruzzi *et al*., 2009), *Dianthus* (Bacchetta *et al*., 2010) and *Ophrys* (Delforge, 2005).

For each taxon, life form, chorological element, habitat, current protection and IUCN status are reported. The life form follows Raunkiaer system as proposed by Pignatti (1982). The classification of taxa takes into account of the bibliographic data and our field researches.

For the chorological classification of the endemics, the following groups and relative acronyms, are adopted: “Sicilian Endemic” (SE), “Hyblaean Endemic” (HE), “Hyblaean-Maltese Endemic” (HME), “Camarino-Pachinense Endemic” (CPE), “Sicilian-Maltese Endemic” (SME), “Sicily and Sardinia Endemic” (SSE), “Southern Italy and Sicily Endemic” (SISE), “Southern Italy, Sicily and Sardinia Endemic” (SISSE), “Central and Southern Italy and Sicily Endemic” (CSISE), “Central and Southern Italy, Sicily and Sardinia Endemic” (CSISSE), “Sub-Endemic” (SBE) (circumscribed to Italy and neighbouring countries). The phytogeographic subdivision of Sicily follows Brullo *et al*. (1995).

For the definition of the habitat of endemic species have been considered ecological characteristics of each species on the basis of data from literature and personal observations.

Conservation status assessment of threatened taxa are quoted according to IUCN criteria (IUCN, 2005, 2008; Conti *et al*., 1992, 1997; Pignatti *et al*., 2001; Scoppola & Spampinato, 2005). Considering the results of field investigation, it is here proposed to

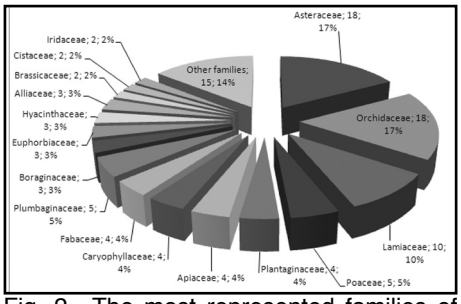

Fig. 2.- The most represented families of the endemic flora of the Hyblaean territory. Species number and percentage are indicated.

Fig. 2.- Familles les plus représentées de la flore endémique du territoire ibléen.

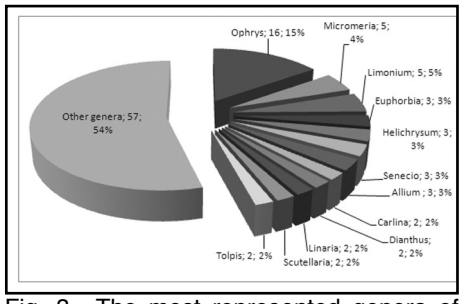

Fig. 3.- The most represented genera of the endemic flora of the Hyblaean territory.

Fig. 3.- Genres les plus représentés de la flore endémique du territoire ibléen.

change the risk class of some surveyed taxa, according to the IUCN guidelines (IUCN, 2008).

Protected taxa are quoted according to CITES (1973), Habitat Directive 92/43 (EEC, 1992) too. Sicily has not a regional law on protected flora so far.

III. RESULTS

A. Taxonomic composition

The endemic flora of the Hyblaean territory counts 105 specific and infraspecific taxa of which 79 species, 23 subspecies and 3 varieties (Table I), belonging to 30 families and 69 genera. Families counting the highest number of endemic are Asteraceae and Orchidaceae (18 taxa), Lamiaceae (10 taxa), Poaceae (5 taxa) and Plantaginaceae (4 taxa) (Fig. 2). The most represented genera are *Ophrys* (16 taxa), *Micromeria* (5 taxa) and *Limonium* (5 taxa) (Fig. 3).

B. Life form

Life form spectrum of the endemic flora indicate the predominance of geophytes (28,6%), chamaephytes (26.7%), hemicryptophytes (24.8%), followed by therophytes (15.2%), nanophanerophytes (1.9%), phanerophytes (1.9%), helophytes (1%). The high number of geophytes can be related to the wide spread of natural habitats, mainly garrigue. Hemicryptophytes are related to seminatural habitat such as dry grassland, originated by anthropic disturbance, and uncultivated lands. The richness of chamaephytes is related to the abundance of rocky wall and 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 Hyblaean plateau, does not offer favourable conditions for the speciation (Bacchetta & Pontecorvo, 2005). The low incidence of endemic therophytes is in accord with their frequent capacity of high dispersal in wide territories (Pignatti, 1979). The only endemic helophyte is *Cyperus papyrus* L., which in Sicily is represented by subsp. *papyrus* endemic of the island (Tournay, 1950).

Table I.- List of the taxonomic units endemic of Hyblaean territory.
Tabelau I.- Liste des taxons endémiques du territoire ibléen.

Taxonomic unit	Family	Dir. Habitat	CITES	IUCN national	IUCN regional	Chorology	Habitat	Life form
Allium lehmannii Lojac.	Amaryllidaceae	-	-	LR	LR	SE	Therophytic community	G
Allium obtusiflorum DC.	Amaryllidaceae	-	-	LR	LR	SE	Therophytic community	G
Allium sphaerocephalon L. subsp. *laxiflorum* (Guss.) Giardina & Raimondo	Amaryllidaceae	-	-	-	-	SE	Dry grassland	G
Anthemis gussonei (Cesati, Passer. & Gibelli) C. Brullo & Brullo	Asteraceae	-	-	EX	EX	CPE	Psammophilous community	T
Antirrhinum siculum Mill.	Plantaginaceae	-	-	-	-	SBE	Rocky walls	Ch
Aristolochia clusii Lojac.	Aristolochiaceae	-	-	-	LR	CSISE	Woods	G
Arrhenatherum nebrodense Brullo, Minissale & Spampinato	Poaceae	-	-	-	-	SE	Dry grassland	H
Astragalus huetii Bunge	Fabaceae	-	-	LR	LR	SE	Dry grassland	H
Bellevalia dubia (Guss.) Rchb.	Asparagaceae	-	-	-	-	SE	Synantropic places	G
Brassica incana Ten.	Brassicaceae	-	-	-	LR	CSISE	Rocky walls	Ch
Calendula suffruticosa Vahl subsp. *gussonei* Lanza	Asteraceae	-	-	-	LR	HME	Synantropic places	Ch
Carduus corymbosus Ten.	Asteraceae	-	-	-	-	CSISSE	Synantropic places	T
Carlina hispanica subsp. *globosa* (Arcang.) Meusel & Kästner	Asteraceae	-	-	-	-	SISE	Dry grassland	H
Carlina sicula Ten. subsp. *sicula*	Asteraceae	-	-	-	-	SISE	Dry grassland	H
Crepis hyemalis (Biv.) Cesati, Pass. & Gibelli	Asteraceae	-	-	-	-	SE	Synantropic places	H
Cymbalaria pubescens (C. Presl) Cufod.	Plantaginaceae	-	-	LR	LR	SE	Rocky walls	H
Cyperus papyrus L. subsp. *papyrus*	Cyperaceae	-	-	VU	VU	SE	Water courses	He
Desmazeria pignattii Brullo & Pavone	Poaceae	-	-	VU	VU	HME	Rocky coast	T
Dianthus graminifolius C. Presl	Caryophyllaceae	-	-	-	-	SE	Dry grassland	H
Dianthus rupicola Biv. subsp. *rupicola*	Caryophyllaceae	1468	-	VU	-	CSISE	Rocky walls	Ch
Diplotaxis crassifolia Raflin.	Brassicaceae	-	-	-	-	SE	Rocky walls	Ch
Echinaria todaroana Ces.	Poaceae	-	-	-	VU	SE	Therophytic community	T
Echium italicum L. subsp *siculum* (Lacaita) Greuter & Burdet	Boraginaceae	-	-	-	-	SE	Synantropic places	H
Erica multiflora L. subsp. *hyblaea* Domina & Raimondo	Ericaceae	-	-	-	-	HE	Garrigue	Ch
Eryngium bocconei Lam.	Apiaceae	-	-	-	-	SE	Dry grassland	H
Euphorbia ceratocarpa Ten.	Euphorbiaceae	-	-	-	-	SISE	Synantropic places	Ch
Euphorbia meuselii Mazzola & Raimondo	Euphorbiaceae	-	-	-	-	SISSE	Woods	Ch
Euphorbia pycnophylla (Kramer & Westra) C. Brullo	Euphorbiaceae	-	-	-	VU	SME	Therophytic community	T
Gagea sicula Lojac.	Liliaceae	-	-	-	-	SISE	Dry grassland	G
Helianthemum sicanorum Brullo, Giusso & Sciandrello	Cistaceae	-	-	-	-	CPE	Garrigue	Ch
Helichrysum hyblaeum Brullo	Asteraceae	-	-	VU	VU	HE	Dry grassland	Ch
Helichrysum italicum (Roth) G. Don. Fil. subsp. *siculum* (Jordan & Fourr.) Glabany L. Saez & Benedi	Asteraceae	-	-	-	-	SE	Garrigue	Ch
Helichrysum scandens Guss.	Asteraceae	-	-	-	-	HE	Rocky walls	Ch
Hypochoeris hispida Willd.	Asteraceae	-	-	-	-	SISE*	Synantropic places	H
Iris pseudopumila Tineo	Iridaceae	-	-	-	-	SBE	Garrigue	G

Jacobaea lycopifolia (Poir.) Greuter & E. Nord.	Asteraceae	-	-	-	-	SISE	Dry grassland	H
Lamium pubescens Bentham	Labiatae	-	-	-	-	SISE	Woods	H
Leopoldia gussonei Parl.	Asparagaceae	1830	-	EN	EN	CPE	Psammophilous community	G
Limonium gussonei (Tineo ex Lojac.) Giardina & Raimondo	Plumbaginaceae	-	-	-	-	HE	Rocky coast	Ch
Limonium hyblaeum Brullo	Plumbaginaceae	-	-	LR	LR	SE	Rocky coast	Ch
Limonium pachinense Brullo	Plumbaginaceae	-	-	CR	CR	HE	Salt marshes	Ch
Limonium pavonianum Brullo	Plumbaginaceae	-	-	EN	EN	HE	Rocky coast	Ch
Limonium syracusanum Brullo	Plumbaginaceae	-	-	LR	LR	HE	Rocky coast	Ch
Linaria multicaulis (L.) Mill. subsp. *humilis* (Guss.) De Leonardis, Giardina & Zizza	Plantaginaceae	-	-	-	-	CPE	Psammophilous community	T
Linaria purpurea (L) Miller	Plantaginaceae	-	-	-	-	CSISE	Garrigue	H
Linum bienne Mill. var. *siculum* (C. Presl) Giardina & Raimondo	Linaceae	-	-	-	-	SE	Therophytic community	H
Malope malacoides L. var. *pedunculata* (Raf.) Fiori	Malvaceae	-	-	-	-	SE	Synantropic places	T
Micromeria canescens (Guss.) Benth.	Labiatae	-	-	-	-	CSISE	Garrigue	Ch
Micromeria graeca (L.) Benth. ex Rchb. subsp. *consentina* (Ten.) Guinea	Labiatae	-	-	-	-	SISE	Garrigue	Ch
Micromeria graeca (L.) Benth. ex Rchb. subsp. *longiflora* (C. Presl) Nyman	Labiatae	-	-	-	-	CSISE	Garrigue	Ch
Micromeria graeca (L.) Benth. ex Rchb. subsp. *tenuifolia* (Ten.) Nyman	Labiatae	-	-	-	-	CSISSE	Garrigue	Ch
Micromeria microphylla (Dum.-Urville) Bentham	Labiatae	-	-	VU	LR	CSISE	Rocky walls	Ch
Myosotis tinei Brullo C. & Brullo	Boraginaceae	-	-	-	-	HE	Temporary ponds	H
Odontites bocconei (Guss.) Walpers subsp. *angustifolia* (Lojac.) Giardina & Raimondo	Orobanchaceae	-	-	-	-	HE	Rocky walls	Ch
Oncostema sicula (Tineo ex Guss.) Speta	Asparagaceae	-	-	EN	EN	SME	Dry grassland	G
Ononis olygophylla Ten.	Fabaceae	-	-	-	-	CSISE	Dry grassland	T
Ophrys archimedea P. Delforge & M. Walravens	Orchidaceae	-	X	-	-	SE	Garrigue	G
Ophrys biancae (Tod.) Macch.	Orchidaceae	-	X	EN	EN	SE	Garrigue	G
Ophrys caesiella P. Delforge	Orchidaceae	-	X	-	-	HME	Garrigue	G
Ophrys calliantha Bartolo & Pulvirenti	Orchidaceae	-	X	-	-	SE	Garrigue	G
Ophrys exaltata Ten.	Orchidaceae	-	X	-	-	CSISE	Garrigue	G
Ophrys explanata (Lojac.) P. Delforge	Orchidaceae	-	X	-	-	SE	Garrigue	G
Ophrys flammeola P. Delforge	Orchidaceae	-	X	-	-	SE	Garrigue	G
Ophrys grandiflora Ten.	Orchidaceae	-	X	-	-	SISE	Garrigue	G
Ophrys lacaitae Lojac.	Orchidaceae	-	X	-	VU	CSISE	Garrigue	G
Ophrys laurensis Melki & Geniez	Orchidaceae	-	X	-	-	HE	Garrigue	G
Ophrys lunulata Parl.	Orchidaceae	1905	X	LR	LR	SE	Garrigue	G
Ophrys mirabilis Geniez & Melki	Orchidaceae	-	X	-	-	SE	Garrigue	G
Ophrys numida J. Devillers-Terschuren	Orchidaceae	-	X	-	-	SBE	Garrigue	G
Ophrys oxyrrhynchos Tod.	Orchidaceae	-	X	-	LR	SE	Garrigue	G
Ophrys panormitana (Tod.) Soò	Orchidaceae	-	X	LR	LR	SE	Garrigue	G
Ophrys passionis Sennen var. *garganica* (E. Nelson ex O. Danesch & E. Danesch) P. Delforge	Orchidaceae	-	X	-	-	SISE	Garrigue	G
*Orchis branciforti*Biv.	Orchidaceae	-	X	-	-	SSE	Garrigue	G
Paeonia morisii Cesca, Bernardo & Passalacqua	Paeoniaceae	-	-	-	-	SSE	Woods	G

Petrorhagia saxifraga (L.) Link subsp. *gasparrini* (Guss.) Greuter & Burdet	Caryophyllaceae	-	-	-	-	SISSE**	Garrigue	Ch
Pimpinella anisoides Briganti	Apiaceae	-	-	-	-	CSISE	Dry grassland	H
Poa bivonae Parl. ex Guss.	Poaceae	-	-	-	-	SBE	Rocky walls	H
Quercus amplifolia Guss.	Fagaceae	-	-	-	-	SISSE	Woods	P
Retama raetam (Forsskål) Webb subsp. *gussonei* (Webb) Greuter	Fabaceae	-	-	CR	EN	SISE	Psammophilous community	NP
Romulea melitensis Bég.	Iridaceae	-	-	-	-	HME	Rocky coast	G
Salsola agrigentina Guss.	Amaranthaceae	-	-	VU	VU	SE	Scrubs	NP
Scorzonera villosa Scop subsp. *columnae* (Guss.) Nyman	Asteraceae	-	-	-	-	CSISE	Dry grassland	H
Scutellaria columnae All. subsp. *gussonei* (Ten.) Rech. fil.	Labiatae	-	-	-	-	CSISE	Woods	H
Scutellaria rubicunda Hornem.	Labiatae	-	-	LR	LR	SE	Woods	H
Senecio glaucus L. subsp. *hyblaeus* Brullo	Asteraceae	-	-	-	-	CPE	Psammophilous community	T
Senecio pygmeaus DC.	Asteraceae	-	-	EN	EN	SME	Rocky coast	T
Senecio squalidus L. subsp. *squalidus*	Asteraceae	-	-	-	-	SE	Synantropic places	T
Serapias orientalis (Greuter) H. Baumann & Kunkele subsp. *siciliensis* Bartolo & Pulvirenti	Orchidaceae	-	X	CR	CR	SE	Garrigue	G
Silene sicula Ucria	Caryophyllaceae	-	-	-	-	SISE	Woods	H
Stachys germanica L. subsp. *dasyanthes* (Raf.) Arcang.	Labiatae	-	-	-	-	SE	Dry grassland	Ch
Stipa gussonei Moraldo	Poaceae	-	-	VU	VU	SISE	Psammophilous community	H
Symphytum gussonei F.W.Schultz	Boraginaceae	-	-	LR	LR	SE	Woods	G
Taraxacum caramanicae Lojac.	Asteraceae	-	-	CR	CR	SSE	Synantropic places	H
Thalictrum calabricum Sprengel	Ranunculaceae	-	-	-	-	CSISE	Woods	H
Thymus spinulosus Ten.	Labiatae	-	-	-	-	CSISE	Garrigue	Ch
Tillaea basaltica (Brullo & Siracusa) Brullo, Giusso & Siracusa	Crassulaceae	-	-	-	-	SE	Therophytic community	T
Tolpis quadriaristata Biv.	Asteraceae	-	-	-	-	SE	Dry grassland	H
Tolpis sexaristata Biv.	Asteraceae	-	-	EN	EN	SE	Dry grassland	H
Torilis nemoralis (Brullo) Brullo & Giusso	Apiaceae	-	-	-	VU	HE	Psammophilous community	T
Trachelium lanceolatum Guss.	Campanulaceae	-	-	LR	LR	HE	Rocky walls	Ch
Trifolium macropodum (C.Prel) Guss.	Fabaceae	-	-	-	-	SE	Synantropic places	T
Tuberaria villosissima (Pomel) Grosser subsp. *sicula* (Grosser) Bartolo, Pulvirenti & Salmeri	Cistaceae	-	-	EN	EN	CPE	Psammophilous community	T
Urtica rupestris Guss.	Urticaceae	-	-	LR	LR	HE	Rocky walls	Ch
Visnaga crinita (Guss.) Giardina & Raimondo	Apiaceae	-	-	-	-	SISE	Synantropic places	T
Zelkova sicula Di Pasquale, Garfì & Quezel	Ulmaceae	-	-	CR	CR	HE	Woods	P

* also in Maltese Islands
** also in Corsica

Table II.- Life forms of the Hyblaean endemics and Sicilian flora.

Tabelau II.- Types biologiques des endémiques de la flore ibléenne et sicilienne.

	Hyblaean endemics		Sicilian flora (Di Martino & Raimondo, 1979)		Sicilian flora (Rossello, 2003)	
Life form	N.	%	N.	%	N.	%
G	30	28,6	351	13,3	486	15,8
Ch	28	26,7	223	8,5	276	8,9
H	25	23,8	755	28,7	812	26,3
T	17	16,2	985	37,4	1116	36,2
P	4	3,8	255	9,7	314	10,2
He/Hy	1	1,0	62	2,4	81	2,6
	105	100	2631	100	3085	100

The life form spectrum of the Hyblaean endemic flora can be compared with the flora of Sicily for which the data are well known (Di Martino & Raimondo, 1979; Rossello, 2003). The differences are very significant (Table II) as confirmed by statistical analysis of the chi-square test (χ^2= 60.67, $p < 0.001$). In particular most of the endemic species are geophytes, chamaephytes and hemicryptophytes which together constitute the 80% of the flora. Otherwise the Sicilian flora has a very high percentage of therophytes (36.2%), but this pattern is similar to other mediterranean regions (Melendo *et al*., 2003); also phanerophytes show a higher percentage (10.2%) than the endemic flora. Accordingly, geophytes and chamaephytes have much lower rate (15.8% and 8.9% respectively) than the endemic flora. Hemicryptophytes have about the same percentage (26.3%). It is of some interest the fact that the endemic chamaephytes are about three times, in percentage, the same life form in the Sicilian flora. The most part of Hyblaean endemics chamaephytes grow in the rocky habitat (Table I). So it seems to be possible recognize a tendency of concentration of endemic in this life form. This observation is in agreement with Pignatti (1979) who pointed out that the evolution of Mediterranean flora follows a pattern of reduction of the vegetative apparatus associated with an expansion of the geographic distribution. 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 and adaptive strategy and related to speciation processes.

C. Chorological features

Fourteen endemic taxa (Fig. 4; Table I) are exclusive to the Hyblaean district (HE) and six species are endemic to the Camarino-Pachinense district (CPE). There are also 4 endemics of the Hyblaean-Maltese area (HME). Most taxa (37) are exclusive Sicilian endemics (SE). A large number of species (30) are endemic to central-southern Italy and Sicily (CSISE, SISE), testifying ancient paleogeographic links between Sicily and southern sector of the Italian Peninsula. Few taxa are: Sicilian-Maltese endemics (3), southern Italy-Sicily-Sardinia endemics (3), southern Italy-Sicily-Sardinia-Corsica endemics (1), centre-southern Italy-Sicily-Sardinia endemics (2).

According to literature data, some other Sicilian endemics occur in the Hyblaean territory, such as *Calendula maritima* Guss., *Trifolium congestum* Guss., *Carduus nutans* L. subsp. *siculus* (Franco) Greuter. These records are probably a mistake not being supported by herbarium specimens and also our field researches don't confirm the presence of these species.

D. Ecological features

The analysis of the habitat (Fig. 5) characteristic of endemic taxa shows that the endemics predominantly occur in garrigues (29 taxa), rocky walls and rocky coasts (18), dry grassland (17 taxa), woods (11), synanthropic places (12 taxa). Among the taxa localized

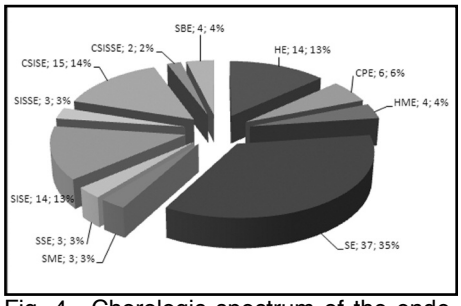

Fig. 4.- Chorologic spectrum of the endemic flora of the Hyblaean territory (see text for acronyms).

Fig. 4.- Spectre chorologique de la flore endémique du territoire ibléen.

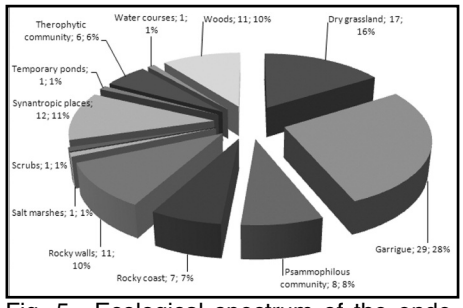

Fig. 5.- Ecological spectrum of the endemic flora of the Hyblaean territory.

Fig. 5.- Spectre écologique de la flore endémique du territoire ibléen.

in primary habitats, poorly affected by man, a lot of endemics occur in the rocky walls, and rocky coasts. Besides, other ones characterize woodlands, psammophilous communities. Also the salt marshes provide the habitat of a very rare endemic (*Limonium pachynense*). Several representative taxa are members of garrigues and dry grasslands. It is quite relevant the occurrence of many endemic species linked to habitats strongly affected by man.

Human activities have played an important role in the spread of plants, endemics included, mainly those ones occurring in secondary semi-natural habitats such as garrigues, dry grasslands and synanthropic places. The spreading of these habitats in Sicily is after the last Glacial Period and especially in the last millennia is supported by palinological data (Sadori & Narcisi, 2001; Noti *et al*., 2009).

E. Conservation status

As regards the conservation status (Fig. 6) for the Hyblaean district, 39 taxa are included in the regional Italian red list (Conti *et al*., 1997), 17 of them are considered at low risk (LR), 9 vulnerable (VU), 8 endangered (EN), 4 critically endangered (CR) and 1 (*Anthemis gussonei*) extinct (EX). Besides, 32 of these taxa are also included in the national red list (Conti *et al*., 1997). Three endemics are included in the annex IIb of Directive EEC 92/43: *Dianthus rupicola, Leopoldia gussonei* and *Ophrys lunulata*; the late two are considered as priority species, while the CITES Convention includes in the annex 2 all the endemic Orchidaceae occurring in the Hyblaean territory.

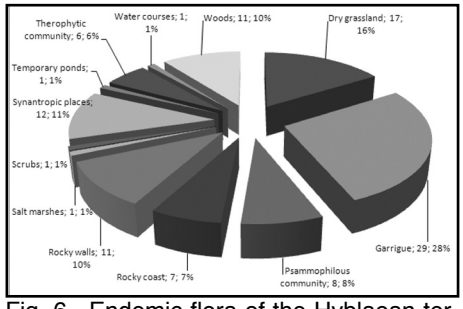

Fig. 6.- Endemic flora of the Hyblaean territory included in the CITES, Dir. 92/43 EEC, and Italian Red List.

Fig. 6.- Flore endémique du territoire ibléen inclus dans la CITES, Dir. 92/43 CEE, et dans la Liste rouge Italienne.

Basing on our field surveys carried out on the Hyblaean endemic flora, the IUCN status of 9 taxa is readjusted (Table III). As concerns *Helichrysum scandens* and *Myosotis tinei*, their inclusion in the Italian red list is proposed, while for *Desmazeria pignattii, Limonium pachynense, L. pavoneanum, Ophrys*

Table III.- Proposed changes of the IUCN ranks for the Hyblaean endemic taxa.
Tabelau III.- Modifications proposées des rangs de l'UICN pour les espèces menacées ou endémiques ibléennes.

Nr.	Taxonomic unit	Current IUCN status (Conti *et al*., 1997)	Proposed IUCN status	No. of detected populations	No. of populations falling in protected areas (natural reseve (NR), SCI or SPA
1	*Helichrysum scandens*	-	VU B1ab(i,ii,iii) + B2ab(i,ii,iii)	9	9 SCI, 2 NR
2	*Myosotis tinei*	-	EN B1ab(ii,iii,v) + B2ab(i,ii,iii,v)	1	1 SCI
3	*Trachelium lanceolatum*	LR	EN B2ab(i,ii,iii)	3	3 SCI, 2 NR
4	*Ophrys laurensis*	-	EN B2ab(i,ii,iii) + C1	3	1 SCI
5	*Limonium pachinense*	CR	CR A4 + B2ab(i,ii,iii,v)	1	1 SCI/SPA
6	*Limonium pavoneanum*	EN	EN B2ab(i, ii,iii,iv) + C1	2	-
7	*Zelkova sicula*	CR	EN A3c + C1	2	1 SCI
8	*Urtica rupestris*	LR	VU A2 + B2ab(i,ii,iii,iv)	6	3 SCI, 2RN
9	*Desmazeria pignattii*	VU	VU B1ab(i,ii) + B2ab(i,ii,iii)	2	1 SCI/SPA, 1 NR

laurensis, Trachelium lanceolatum, Urtica rupestris and *Zelkova sicula* the IUCN risk category is evaluated and sometimes changed.

VI. DISCUSSION

According to Brullo *et al.* (1998), and considering the latest revision (Giardina *et al*., 2007; Raimondo & Spadaro, 2009) the flora of Hyblaean territory is estimated at 1527 specific and infraspecific taxa. From this list the endemics are 105 corresponding to 6,9% of whole flora (Table IV). For the Sicilian flora, the endemic taxa occurring in the island and 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 %; therefore somewhat higher than that of the Hyblaean territory. The percentage of endemics of Hyblaean flora is also lower than that of other Mediterranean territories (Médail & Verlaque, 1997) where the percentage of endemism is around 10-12%.

This may be attributed to the fact that the Hyblaean area lacks a purely mountain belt where there is usually a high degree of endemism (Médail & Verlaque, 1997), and not for the limited surface of this territory nor for its wide geographical connection with the rest of Sicily.

Table IV.- Endemic taxa of some central Mediterranean countries.
Tableau IV.- Taxons endémiques de certains pays de la Méditerranée centrale.

Region	Plant species*	N. of endemics	Endemism (%)	N. of strictly endemics	Strictly endemics (%)	Surface (km^2)	Altitudinal range	Authors
Sicily	3235	414	12,8	294	9,1	25700	0-3323	Giardina *et al*., 2007; Raimondo & Spadaro, 2009
Hyblaean territory	1527	105	6,9	20	1,3	4730	0-986	Brullo *et al*., 1998; Giardina *et al*. 2007, new data
Apulia	2286	98	4,5	20	0,9	19346	0-1151	Conti *et al*., 2005
N Cyrenaica	1406	159	11,3	74	5,3	37350	0-865	Brullo & Guglielmo, 2001
Maltese Islands	1000	23	2,3	13	1,3	312	0-258	Weber & Kendzior, 2006; Lanfranco, 1995

In agreement with Thompson (2005) most of the Hyblaean endemics can be considered neo-endemics, as taxa of more recent origin, having closely related species in other territories. Some of these must be considered as schizo-endemics, *e.g*. *Leopoldia gussonei*, related to *L. maritima* with a North African distribution, *Retama raetam* subsp. *gussonei* vicaried by the subsp. *raetam* in North Africa (Maire, 1952-1977) and *Helianthemum sicanorum* showing remarkable relations with *Helianthemum kairicum* Delile occurring in the southern Mediterranean territories (Brullo *et al*., 2007). It is interesting to note the high number (16) of neoendemics belonging to genus *Ophrys*. For this genus, closely related to the habitat of garrigue, changes in floral odour and associated pollinator switches are considered the main cause of speciation (Schiestl & Ayasse, 2002). Also the combined effects of chromosomal rearrangements and labellum inversion may contribute to speciation in sympatry in some species (Cortis *et al*., 2009). The spread of garrigue caused by humans activities might also be considered as evolutionary pressure in speciation of genus *Ophrys* in the Hyblaean territory.

Important however is the presence of some endemics of Tertiary origin, which can be considered paleo-endemics, such as *Urtica rupestris* showing some affinities with *Urtica morifolia* Poir. of the Canary Islands (Bartolo *et al*., 1998), *Zelkova sicula* related to *Z. abelicea* (Lam.) Boiss. from Crete (Di Pasquale *et al*., 1992) and *Trachelium lanceolatum* taxonomically quite isolated, which seems to be the ancestor of *T. caeruleum* L. widely distributed in W Mediterranean area.

Based on the phytogeographycal aspect of the Hyblaean flora and on the endemic vicariance is possible to emphasize close paleogeographical correlation among the Hyblaean plateau and other neighbouring Mediterranean territories, particularly Apulia, Maltese Islands and Northern Cyrenaica. In fact, the substrata of these territories show the same geological origin being constituted mainly by Oligo-Miocenic marls and limestones (Catalano *et al*., 1996; Yellin Dror *et al*., 1997; Rosenbaum *et al*., 2004).

These paleogeographical links are supported by the common occurrence of some rare or very peculiar species. This the case of *Gagea trinervia*, endemic to Cyrenaica and the Hyblaean area (Peruzzi *et al*., 2009) and *Crucianella rupestris*, distributed in the Central Mediteranean, as Libya, Egypt, Lampedusa and Maltese Islands (Brullo & Marcenò, 1973). Some endemics have a hyblaean-maltese distribution as *Calendula suffruticosa* subsp. *gussonei, Desmazeria pignattii, Senecio pygmeaus* and *Romulea melitensis* or an apulian-sicilian distribution as *Carlina sicula* subsp. *sicula* which is vicaried in Cyrenaica by the subsp. *mareotica* (Asch. & Schweinf.) Greuter. These paleo-geographical links are pointed out also by distribution of some non-endemic species, *e.g. Sarcopoterium spinosum, Salvia fruticosa* (Gargano *et al*., 2008). *Phlomis fruticosa*, east Mediterranean species occurring in Sicily, Malta and Apulia; *Cichorium spinosum*, east Mediterranean species present in the Hyblaean territory, Maltese Islands and Cyrenaica; *Cistus clusii* species with a west Mediterranean distribution occurring only in Hyblaean and Apulian region.

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