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The Sicilian phanerophytes: still a noteworthy patrimony, soon a lost resource?

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Abstract
This paper is focused on the Sicilian phanerophytes. The rather high species-richness of this group depends not only on the central position of the island within the Mediterranean area and its probable key-role as a refuge-area during Pleistocene glaciations, but also on its wide latitudinal/altitudinal range, its high topographic and substrate heterogeneity and the high frequency and intensity of disturbance in the last 10,000 years. The present paper contains either an up-to-date check-list of Sicilian native phanerophytes or a critique reference list, which together shall be considered as "first-aid tools" for a better knowledge of this topic. Furthermore, this work aims to put in evidence the present lack of information on the biology, the demography and the population genetic structure of most part of the Sicilian phanerophytes. Future researches should 1) clarify the dispersal paths of Sicilian phanerophytes during the Pleistocene glaciations, 2) the role played by habitat and landscape fragmentation on the present species-richness and peculiarity of Sicilian forest flora and 3) quantify the risk-level connected with the low genetic flux between (and the low variability within) Sicilian phanerophyte populations.

Key-words: Sicily, phanerophytes, intra-specific diversity, genetics, conservation

Introduction
The Mediterranean Basin is one of the most important plant biodiversity hot-spots of the World Médail and Quézel, 1997; Heywood, 1998; Myers et al., 2000). Due to its peculiar position (Figure 1), Sicily played and still plays a major role for plant dispersal, survival and evolution within this region. On the island (ca. 25,000 Km^2) live about 2,700 native vascular plants, many of which are endemic, rare and/or threatened taxa (Di Martino e Raimondo, 1979; Raimondo et al., 1994; Brullo et al., 1995). The same occurs if we consider only phanerophytes, represented by nearly 100 infrageneric taxa (S. Pasta, *pers. data*).
The phytogeographic relevance of the Sicilian forest flora was already put in evidence by Quézel (1995) and Barbero et al. (2001). The supra- and the oro-mediterranean belts (Brullo et al., 1996b) of the island give hospitality to some trees endemic to Sicily (*Abies nebrodensis* and *Betula aetnensis*) or to Southern Italy (*Pinus laricio* subsp. *calabrica*, *Quercus petraea* subsp. *austrotyrrhenica* and *Sorbus aucuparia* subsp. *praemorsa*) and clearly deriving from more widespread Mid-European or Oromediterranean taxa, but also to many other woody species typical of the mid-european deciduous woodland and shrubland, such as *Acer* spp., *Fraxinus excelsior*, *Malus sylvestris*, *Salix cinerea*, *Sorbus aria* s.l., *Sorbus torminalis*, *Taxus baccata*, *Tilia platyphyllos*, *Ulmus glabra*, etc.
Many other deciduous trees and shrubs live in the meso- (and even in the thermo-) mediterranean belt (Brullo et al., 1996b). Among them we find many noteworthy endemics - such as *Salix*

gussonei (closely related to *Salix pedicellata*), *Zelkova sicula*, *Quercus gussonei* and *Q. leptobalanos* (closely related to *Q. cerris* and to *Q. congesta*, respectively: cfr. Brullo and Marcenò, 1985) – many species belonging to the Eastern Mediterranean floristic element, such as *Platanus orientalis*, *Carpinus orientalis*, *Ostrya carpinifolia*, *Celtis tournefortii* s.l., *Quercus cerris* and *Q. congesta*, *Crataegus orientalis* subsp. *presliana*, etc., and some lauriphyllous evergreen trees such as *Ilex aquifolium* and *Laurus nobilis*.

Among the thermophilous woody species which dominate the Mediterranean sclerophyllous evergreen maquis (*Arbutus unedo*, *Ceratonia siliqua*, *Chamaerops humilis*, *Erica arborea*, *Myrtus communis*, *Olea europaea* var. *sylvestris*, *Phillyrea angustifolia* and *P. latifolia*, *Pistacia lentiscus*, evergreen *Quercus*, *Rhamnus alaternus* and *R. lycioides* subsp. *oleoides*, *Viburnum tinus*, etc.) - many of which belong to tropical families and/or genera - some are endemic to Sicily, like *Rhamnus lojaconoi* (closely related to *R. alaternus*: cfr. Raimondo, 1979) and *Cytisus aeolicus*, or to the Central Mediterranean area, as *Genista thyrrena* and *G. aetnensis*.

Many drought-resistant plants which live in the harshest areas of Sicily belong to the Tethydic or to the SE-Mediterranean element (*sensu* Takhtajan, 1984) and are needle-leaved (*Pinus halepensis*, *P. pinaster* subsp. *hamiltonii* and *P. pinea*, *Juniperus oxycedrus* subsp. *macrocarpa* and *J. turbinata*) or show an ephedroid habit (e.g. *Tamarix* spp., etc.); other ones behave as summer (semi)deciduous and often belong to tropical families and/or genera, like *Euphorbia dendroides*, *Rhus pentaphylla* and *R. tripartita*, etc.

The rather high species-richness of Sicilian woody flora and the overwhelming variability of its landscape depends also on 1) its wide latitudinal (35° to 39° N) and altitudinal (up to 3,300 m a.s.l. on Mount Etna) ranges; 2) its high topographic and substrate (both soil and rock types) heterogeneity; 3) the high frequency and intensity of both natural (volcanic eruptions, earthquakes, wildfires) and anthropic disturbance in the last 10,000 years. Besides, during Pleistocene glaciations, together with - and perhaps more than - the Italian Peninsula (Bennett et al., 1991; Hewitt, 1996; Taberlet et al., 1998; Trewick et al., 2002), Sicily seems to have played a role of refuge-area for many mesophilous deciduous trees (e.g. *Fagus sylvatica*, *Populus tremula* and *Juniperus communis* s.l.), some of which spred again from the island to recover the neighbouring areas of Mid- and Northern Europe during the warmer (in Europe) and wetter (on Mediterranean mountains) periods.

The present work aims to provide an up-to-date list of Sicilian native phanerophytes and to put in evidence the enormous threats (either at species or at population level) these plants undergo due to human activities. Infact, more than 9 millennia of more or less continuous human impact (Malone and Stoddart, 2000) induced a strong reduction, fragmentation and transformation of the Sicilian natural landscape. The most affected vegetation units were forest and pre-forest communities. During the last century, a steep increase of anthropic pressure (urbanization, especially along the coasts; afforestation practices using allochthonous germplasm probably inducing genetic contamination of local races; change of agricultural techniques, etc.) determined a further reduction of species-richness and caused an even more severe fragmentation and degradation of the remnant semi-natural and sub-natural communities (i. e. woodlands, shrublands, garrigues, grasslands and coastal vegetation), so that many woody species disappeared or still survive with very small and scattered populations. Nevertheless, residual patches of the forest and pre-forest communities still survive in the most unsuitable areas, and in some areas it is still possible to record not only rather high values of wilderness and species-richness but also very peculiar synecological (Brullo and Marcenò, 1985; Brullo et al., 1996a, 1999) and structural-typological (La Mantia et al., 2000, 2001) features.

Materials and methods

In the following paragraph we provide a list of all the Sicilian native phanerophytes linked to forest and pre-forest habitats (even those whose origin is still uncertain); neither introduced subspontaneous species, nor hybrids, nor doubtful species (e.g. *Quercus sicula* Borzì) have been taken in account. This list takes origin from the most recent biosystematic and genetic literature concerning these plants; among the papers concerning the ecophysiology and/or the productivity of Sicilian phanerophytes, just the few ones which provide some comparison between different Sicilian and/or Italian populations have been considered.

Results

The taxomomic and nomenclatural treatment of the taxa listed in table 1 follows Pignatti (1982) and several recent monographs.

Table 1 - Checklist of all the (certainly or doubtfully) native Sicilian phanerophytes living in forest and pre-forest habitats. In bold: endemic taxa; (D): taxa whose origin is still unclear (i.e. probably introduced by men in the past centuries); cv.-rns: the available references, concerning some autochthonous cultivars, are not shown; ER = extremely rare (<50 individuals growing in the wild); VR = very rare (<500 individuals growing in the wild); R= (<5,000 individuals growing in the wild); L = localised (quite common but showing a somewhat narrow geographic, ecological or dynamic amplitude); C = common (5,000-500,000 individuals growing in the wild); VC = very common (>500,000 individuals growing in the wild); U = unknown; I = increasing; S = steady; D = decreasing (during the last 50 years); A: available (for the numbers cfr. literature); NA = not available.

Taxon	Presence/distribution, demographic trend and major threats	Reference(s)
***Abies nebrodensis* (Lojac.) Mattei**	ER; S; out-breeding difficulties([1]), genetic pollution hazard with *Abies alba* (not confirmed), low fitness	Ducci et al. 1999; Gramuglio 1967; Michelozzi 1997; Parducci et al. 1999, 2001a-b; Raimondo et al. 1990; Schicchi et al. 2000; Schicchi et al. 2003; Vendramin et al. 1995a-b; Vicario et al. 1995
Acer campestre L.	C; S: habitat disturbance	NA
Acer monspessulanum L.	L; S: habitat disturbance	NA
Acer obtusatum Waldst. et Kit.	L; S: habitat disturbance	NA
Acer opalus Miller	L; S: habitat disturbance	NA
Acer platanoides L.	R; S: habitat disturbance	NA
Acer pseudoplatanus L.	R; S; habitat disturbance; genetic pollution hazard (not confirmed)	NA
Alnus glutinosa (L.) Gaertner	L; D: habitat disturbance	NA
Arbutus unedo L.	C; D; habitat disturbance, genetic pollution hazard, low fitness	NA
***Betula aetnensis* Rafin.**	L; S: global warming	Biondi and Baldoni 1984
Carpinus orientalis Miller	R; U: habitat disturbance	NA
Celtis australis L. (D)	VC; I (but D in rural areas)	NA
Celtis tournefortii Lam. s.l.	L; S: habitat disturbance, out-breeding difficulties([1])	Troìa 1997
Chamaerops humilis L.	C; D: land-use change	NA
Crataegus laevigata (Poiret) DC. (= "*C. oxyacantha*" Auct.)	L; U: habitat disturbance, land-use change	NA

Crataegus monogyna Jacq.	VC; S: land-use change (local cultivars are disappearing)	NA
Crataegus orientalis M. Bieb. subsp. *presliana* K.I. Chr. (= *C. laciniata* Ucria)	L; U: habitat disturbance, land-use change	NA
***Cytisus aeolicus* Guss.**	VR; D; out-breeding difficulties(1), low fitness	Conte et al. 1998
Erica arborea L.	C; D: land-use change	NA
Fagus sylvatica L.	L; D: global warming, habitat disturbance	Comps et al. 1991; Demesure et al. 1996; Denk et al. 2002; Giannini 2003; Giannini and Borghetti 2001; Leonardi and Menozzi 1995, 1996; Rossi et al. 1996; Vettori et al. 2004; Paffetti et al., in press
Ficus carica L.(D)	VC; U: land-use change (local cultivars are disappearing)	A (cv.-rns)
Fontanesia phillyraeoides Labill.	ER; U: habitat disturbance, low fitness	NA
Fraxinus angustifolia Vahl subsp. *angustifolia*	C; D: land-use change, habitat disturbance (local cultivars are disappearing)	Crescimanno et al. 1993; Ilardi and Raimondo 1999
Fraxinus excelsior L.	ER; U: global warming, habitat disturbance, out-breeding difficulties(1)	Ilardi and Raimondo 1999
Fraxinus ornus L.	C; S (D in rural areas, where local cultivars are disappearing)	Crescimanno et al. 1993; Ilardi and Raimondo 1999
Genista aetnensis Rafin.	L; I (often used for afforestation purposes outside its natural range)	NA
Genista thyrrena Valsecchi	L; S: land-use change	De Castro et al. 2002; De Marco et al. 1987
Ilex aquifolium L.	L; S: global warming, habitat disturbance, out-breeding difficulties(1)	NA
Juniperus communis L. s.l.	L; S: global warming, habitat disturbance	Adams and Pandey 2003
Juniperus oxycedrus L. subsp. *macrocarpa* (Sm.) Ball	L; D: habitat disturbance	NA
Juniperus turbinata Guss.	L; D: habitat disturbance, out-breeding difficulties(1)	NA
Laurus nobilis L. (D)	L; S	NA
Ligustrum vulgare L.	VR; U: habitat disturbance	NA
Malus sylvestris (L.) Miller	L; U: habitat disturbance (D in rural areas, where local cultivars are disappearing)	NA
Mespilus germanica L.	L; D: habitat disturbance, out-breeding difficulties(1)	NA
Myrtus communis L.	C; D: habitat disturbance	NA

	(local cultivars are disappearing)	
Ostrya carpinifolia Scop.	L; S: global warming, habitat disturbance	NA
Phillyrea angustifolia L.	L; U: habitat disturbance	NA
Phillyrea latifolia L.	C; S	NA
Pinus halepensis Miller	L; D (native populations) and I (planted stands and disturbed areas): genetic pollution hazard	NA
Pinus laricio Loudon subsp. *calabrica* Cesca et Peruzzi	L; D: habitat disturbance, sylvicultural practices change, genetic pollution hazard with *Pinus nigra* s.l.	Rafii et al. 1996; Cesca and Peruzzi 2002; Paci and Ricciardi 1988
Pinus pinaster Solander subsp. *hamiltonii* (Ten.) Huguet del Villar	L; U: land-use change, habitat disturbance	Anzidei et al. 2000; Catalano 2004; Destremau et al. 1976; ElAlami et al. 1996; Falleri 1994; Idrissi-Hassani and Lebreton 1992; Vendramin et al. 1998
Pinus pinea L.	L; U (native populations) and I (planted stands): land-use change, genetic pollution hazard	
Pistacia lentiscus L.	VC; I: genetic pollution hazard	NA
Pistacia terebinthus L.	C; S (but D in rural areas)	NA
Platanus orientalis L. (D)	L; D: habitat disturbance, genetic pollution hazard, parasitic attacks	NA
Populus alba L.	C; S: habitat disturbance	NA
Populus nigra L.	VC; S: habitat disturbance, genetic pollution hazard	NA
Populus tremula L.	R; U: global warming	NA
Pyrus communis L. (incl. *Pyrus pyraster*)	L; U: land-use change (local cultivars are disappearing)	A (cv.-rns)
Pyrus spinosa Forsskaal (incl. *Pyrus amygdaliformis*)	VC; I: land-use change	A (cv.-rns)
Quercus amplifolia Guss.	C; D: habitat disturbance, out-breeding difficulties([1]), genetic pollution hazard, oak decline syndrome	Arena 1958; Brullo et al. 1999; Di Noto et al. 1995, 1998; Dumoulin-Lapègue et al. 1997; Fineschi et al. 1995a-b-c; Fineschi et al. 1998; Petit et al. 2002a-b; Ronsisvalle et al. 1984([2])
Quercus cerris L.	L; D: global warming, habitat disturbance, parasitic attacks, out-breeding difficulties([1])	Brullo et al. 1999
Quercus coccifera L. s.l. (incl. *Quercus calliprinos* Webb)	R; D: land-use change, out-breeding difficulties([1])	La Mantia 1998
Quercus congesta C. Presl	L; U: habitat disturbance, genetic pollution hazard, oak decline syndrome	([2])

Quercus dalechampii Ten.	C; U: habitat disturbance, genetic pollution hazard, oak decline syndrome	([2])
***Quercus gussonei* (Borzì) Brullo**	C; U: habitat disturbance, oak decline syndrome	Brullo et al. 1999
Quercus ilex L.	VC; D: genetic pollution hazard	Burgarella et al. 2003; Fineschi et al. in press; Gramuglio et al. 1973; La Mantia 1999; La Mantia et al. 2003; Lumaret et al. 2002; Michaud et al. 1995; Toumi and Lumaret 2001
***Quercus leptobalanos* Guss.**	L; U: habitat disturbance, genetic pollution hazard, oak decline syndrome	([2])
Quercus petraea (Mattuschka) Liebl. subsp. *austrotyrrhenica* Brullo, Guarino et Siracusa	L; U: global warming, habitat disturbance, genetic pollution hazard	Brullo et al. 1999; Bruschi et al. 2003; Dumoulin-Lapègue et al. 1997; Fineschi et al. 1995a-b
Quercus suber L. s.l.	C; D: habitat disturbance, genetic pollution hazard, oak decline syndrome	Jiménez Sancho 2001; Toumi and Lumaret 1998
Quercus virgiliana (Ten.) Ten.	C; S: habitat disturbance, genetic pollution hazard, oak decline syndrome	([2])
Rhamnus alaternus L.	VC; U: habitat disturbance	NA
Rhamnus cathartica L.	L; U: habitat disturbance	NA
***Rhamnus lojaconoi* Raimondo**	ER: habitat disturbance	Raimondo 1979
Rhamnus lycioides L. subsp. *oleoides* (L.) Jahandiez et Maire	L; U: habitat disturbance	NA
Rhamnus saxatilis Jacq. subsp. *infectoria* (L.) P. Fourn.	R; U: habitat disturbance	NA
Rhus pentaphylla (Jacq.) Desf.	L; U: habitat disturbance	NA
Rhus tripartita (Ucria) Grande	L; U: habitat disturbance	NA
Salix alba L. s.l.	VC; D: habitat disturbance	NA
Salix apennina A. Skvortsov	L; U: habitat disturbance	NA
Salix caprea L.	L; U: habitat disturbance	NA
Salix cinerea L.	L; U: habitat disturbance	NA
Salix fragilis L.	L; U: habitat disturbance	NA
Salix gussonei Brullo et Spampinato	L; U: habitat disturbance	Brullo and Spampinato 1988
Salix pedicellata Desf.	C; D: habitat disturbance	NA
Salix purpurea L.	C; D: habitat disturbance	NA
Sorbus aria (L.) Crantz s.l.	R; U: global warming, habitat disturbance	NA
Sorbus aucuparia L.	R; U: habitat disturbance	NA

subsp. *praermosa* (Guss.) Nyman		
Sorbus domestica L.(D)	C; S: land-use change (local cultivars are disappearing)	A (cv.-rns)
Sorbus torminalis (L.) Crantz	L; U: global warming, habitat disturbance	NA
Tamarix africana Poiret	VC; I: habitat disturbance	NA
Tamarix dalmatica Baum	L; U: habitat disturbance	NA
Tamarix parviflora DC.	L; U: habitat disturbance	NA
Tamarix gallica L.	C; U: habitat disturbance	NA
Taxus baccata L.	ER; S: global warming, habitat disturbance	NA
Tilia platyphyllos Scop.	ER; U: global warming, habitat disturbance	NA
Ulmus canescens Melville	L; D: habitat disturbance, parasitic attacks	Scialabba et al. 1997
Ulmus glabra Hudson	R; D: global warming, habitat disturbance, parasitic attacks	Scialabba et al. 1997
Ulmus minor Miller	C; D: habitat disturbance, parasitic attacks	Scialabba et al. 1997
Zelkova sicula **Di Pasquale, Garfì et Quézel**	ER; D: global warming, habitat disturbance, low fitness	Fineschi et al. 2002; Nakagawa et al. 1998; Yu-Feil et al. 2001

[1] Very often represented by scattered and/or small-sized populations.
[2] Owing to the present disagreement upon the taxonomic treatment of the deciduous Sicilian taxa of the genus *Quercus*, it is actually unclear if all of them have been studied. For the references concerning the whole see *Q. amplifolia*.

Discussions and Conclusions

At present the most interesting relic Sicilian forest and pre-forest areas are protected, as they fall into the Etna, Alcantara, Nebrodi and Madonie parks or within the 80 nature preserves. Nevertheless, the knowledge on the biology, the demography and the population genetic structure of most part of the Sicilian phanerophytes is still unsatisfactory. As a matter of fact, the only well studied taxa are *Abies nebrodensis*, *Cytisus aeolicus*, *Q*. cfr. *petraea* and *Zelkova sicula*, while there is no recent literature about more than 2/3 of the considered taxa (cfr. table 1). Besides, the studies on the Sicilian *Fagus sylvatica*, *Quercus ilex* and *Q*. gr. *pubescens* populations do not cover the whole range of these species within the island.

Many phanerophytes are experiencing a demographic crisis, which seems to be mainly linked to habitat distruction and discontinuity. Thus, future researches on Sicilian phanerophytes, in some cases common at the need of research in Europe (Scarascia Mugnozza et al., 2003), must pay a particular attention on three topics: 1) the dispersal and genetic differentiation paths of Sicilian populations (to, out from and within the island) during the Pleistocene glaciations; 2) the role played by habitat fragmentation and landscape heterogeneity on the present diversity, rarity and peculiarity of Sicilian forest flora; 3) the risk level connected with the low genetic flux between (and the low variability within) Sicilian populations.

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