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Salvatore Cambria & Francesco M. Raimondo

Ilex aquifolium (*Aquifoliaceae*) and the relics of Tertiary forest vegetation with Colchic affinity in Sicily (C-Mediterranean)

Abstract

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The role of *Ilex aquifolium* in the Mediterranean temperate vegetation is analysed with reference to the plant communities occurring in Sicily. In particular, the geobotanical literature following the reporting of the first extraordinary population of this species on the Madonie Mountains, in Sicily, is examined. From there the proposal to recognize not only for Sicily but also for the south of the Italian peninsula and the islands of Sardinia and Corsica, a belt of azonal vegetation, with a Colchic imprint, finding floristic, ecological and phytogeographic affinities with aspects of vegetation widely represented in Colchis, a Caucasian region spared from the devastating effects of the glacial phenomenon. In Sicily, the interest and the debate that arose stimulated further investigations, including phytosociological ones, in the same mountain system and subsequently in the rest of the island, in particular in the bordering territory of Nebrodi Mountains. The authors remind the plant communities of the island in which *Ilex aquifolium* still plays an appreciable role. In particular, in the Madonie and Nebrodi systems there are wide areas covered by mixed woods physiognomized by *I. aquifolium* (evergreen laurophyll element) and by deciduous oaks such as *Quercus. petraea* subsp. *austrotyrrhenica* and *Q. cerris* respectively. The authors, in preliminary presenting the problem for the entire Mediterranean region, despite the loss of interest, return to the subject for the purpose of the recovery, reconstitution and enhancement of the ancient Sicilian forest landscape, still represented within the two natural parks, among the most representative of the island.

Key words: Tertiary flora, evergreen laurophyll vegetation, Mediterranean region, Caucasus, Colchis.

Introduction

The presence in the Sicilian territory of relics of forest vegetation physiognomized by evergreen woody plants of the laurophyll type gave rise to a strong interest in Italy around their historical, phytogeographic and ecological interpretation, fueling a debate in the scientific community that lasted about ten years, between the years 70-80 of the last century. The author of this thought - in some ways revolutionary in Italy - was Sandro Pignatti who, after some contributions in which he anticipates the premises (Pignatti 1978), will end up proposing a scheme of

altitudinal distribution of Italian vegetation - in belts rather than in planes (Pignatti 1979) - placing in the two major islands of the Mediterranean (Sicily and Sardinia) and in the Mediterranean part of the Peninsula, a belt of azonal vegetation, with a prevalence of evergreen formations of the laurophyll type, interposed between the evergreen Mediterranean vegetation characterized by *Quercus ilex* - phytosociologically referred to *Quercetalia ilicis* - and the sub-Atlantic woods of *Fagus sylvatica*, within *Fagetalia sylvaticae*. This belt was defined as "colchica" more to introduce a strong reference to the type of tertiary vegetation with similar physiognomic and biological characteristics which has mainly been preserved to the east of the Mediterranean, precisely in the Colchis, a region of the Caucasus notoriously free from the devastating effects of the glacial period. Pignatti's interpretation was strongly opposed by other Italian geobotanists including Di Benedetto & al. (1983) and after Filibeck & al. (2004), probably because it was not understood conceptually. For one of the authors (Raimondo), who in this history had the role of bringing attention to these relics of forest vegetation (Di Martino & al. 1977; Raimondo 1984) making known meaningful strips of them in Sicily (Raimondo & Romano 1984), it is all too evident that it was a question of non-sharing based more on an ecological and phytocenotic approach rather than a historical-biogeographic approach to which Pignatti (1978, 1979) had referred instead. Convinced of the original interpretation of this author, and comforted by direct observations in nature - in Sicily, Sardinia, in various parts of the Mediterranean and then of the Georgian Colchis itself - we proposed to return to the topic, deepening the theme in the thesis of degree of one of the authors (Cambria 2014), relating the vegetation aspects of Sicily with those of Colchis, to the East, and the Atlantic region of Europe, to the West.

This contribution will be limited to further highlighting the Colchic affinities of the vegetation of Sicily, the island in the middle of the Mediterranean which, due to its biogeographical contacts, has played an important role in the natural history of the entire basin, acting as a bridge between East and West.

In this article, the representative element of the flora linking the Colchic type of Sicilian vegetation with that of the Southern Caucasus region will be preliminarily analyzed. The plant communities of this island, which recall aspects of the vegetation of the Colchis, will then be reviewed and commented on, in homage to the illustrious octogenarian professor emeritus George Nakhutsrishvili of the University of Tbilisi, author or co-author of important contributions for the knowledge of the vegetation of his country (Nakhutsrishvili 1999; Nakhutsrishvili & al. 2011).

The representative plant: *Ilex aquifolium*

Elements common to Mediterranean and Colchic vegetation (Fig. 1a, b) are almost non-existent in Mediterranean Europe, except for a few but significant examples, such as *Rhododendron ponticum* (Fig. 2f). Instead, *Prunus lusitanica* - present in France, Iberian Peninsula and Macaronesia - vicariate *P. laurocerasus,* a characteristic element of the colchic vegetation. In Sicily, among the few we remember *Ulmus glabra*, a Euro-Caucasian element significantly present in the temperate forest vegetation of Europe and in Colchis (Fig. 2c). Instead, there are frequent some related species that we can consider as western vicariants of Colchic plants. Among these are the evergreen laurophyll *Ilex aquifolium*, *Hedera helix* and *Daphne laureola* (Fig. 3b, c, d) vicariants of *Ilex colchica*, *Daphne pontica*, *Hedera colchica* (Fig. 2a, d, e).

Fig. 1. Forest landscapes in Georgian Colchis and in Sicily: a) forest expression in the Mtrala National Park (Chakvi municipality, Ajaria); b) forest expression in the Nebrodi Regional Park (NE-Sicily).

Among all, the woody species that plays a significant and sometimes physiognomically decisive role in the vegetation of Sicily (Fig. 3b; Fig. 4a-d; Fig. 5b, c, e; Fig. 6a) and the two other major islands in the Mediterranean (Sardinia and Corsica) is *Ilex aquifolium* (Fig. 6b).

Ilex L. (*Aquifoliaceae*) is a genus mainly distributed in the subtropical regions of the southern hemisphere. In Eurasia and North Africa it is basically represented by three species: *Ilex colchica* in the east, *I. canariensis* in the west and *I. aquifolium* in the middle of the two extremes, mainly in the Mediterranean area.

According to Rikli (1943), *Ilex aquifolium* together with *Arbutus, Buxus* and *Laurus* is to be considered a Tertiary relict - known for the Mediterranean area from fossil remains - of a family widely represented in the Tropics, although today it no longer exists in those regions.

In general, *I. aquifolium* is considered an element of the beech woods or at the limit between beech and deciduous oak woods. This seems to be the result of an approach starting from a wrong point of view: since middle Europe is incomparably better known than the vegetation of the Mediterranean mountains, there is a tendency to extrapolate for these what is already known about those. However, the mid-European vegetation represents an optimal area for beech; it follows that the whole problem is seen as a function of what is known for beech forests in the best ecological conditions of this species. On the contrary, it has been repeatedly stated that a type of vegetation should be studied where it is best developed. Since there is a competition between holly and beech it is quite clear that holly populations cannot be interpreted on the basis of the knowledge acquired where the beech lives in optimal conditions - therefore where the expansion power of the holly is minimal - but, on the contrary, the attention should be paid in the first place to the areas where the beech is missing (Balearics, Sardinia) or where the beech is at the limit of

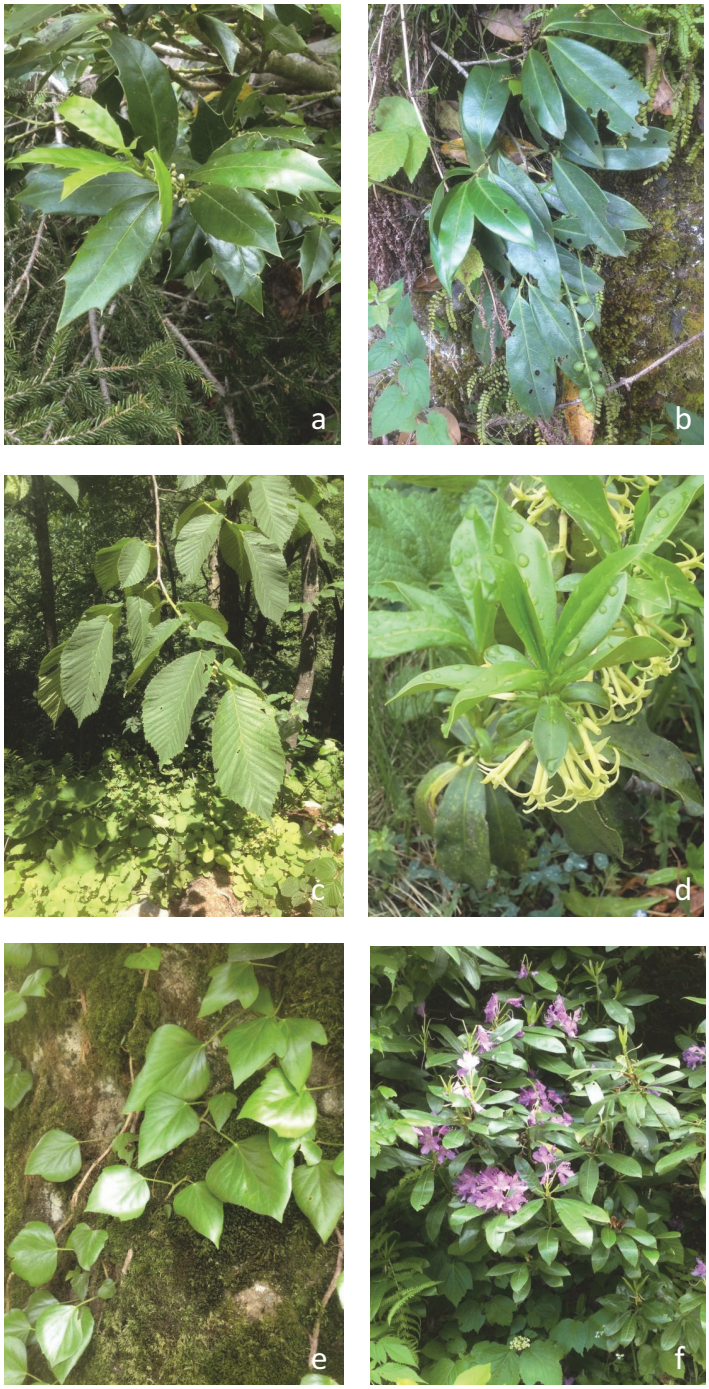

Fig. 2. Characteristic plants of Colchic vegetation in Georgia: a) *Ilex colchica*; b) *Prunus laurocerasus*; c) *Ulmus glabra*; d) *Daphne colchica*; e) *Hedera colchica*; f) *Rhododendron ponticum.*

the range, as happens in Sicily (e.g. Nebrodi and Madonie Mountains).

On the basis of these considerations Pignatti (1979) recognized a general belt of relict vegetation, sub-Mediterranean or Mediterranean-mountain, with ecological needs of an oceanic type, distributed over large areas of the Mediterranean (Iberian Peninsula, big islands, Northern Africa, Asia Minor and Caucasus). It is a coenose that had its maximum expansion in the Tertiary and that during the glaciations was progressively replaced by deciduous forests predominantly of *Quercus, Acer* and *Fagus*. Gamisans (1975) also reaches similar conclusions for the vegetational aspects of Corsica. In the Balearic Islands on the northern side of the highest mountains (over 1000 m a.s.l.) *Ilex aquifolium* occurs together with *Taxus baccata* and *Lonicera pyrenaica* (Knoche 1921). Also in the Balearics the beech is missing and *Ilex aquifolium* is found at 1200-1300 m (a.s.l.) associated with *Buxus balearica, Acer granatense, Amelanchier ovalis, Sorbus aria* [*Aria edulis*]*, Taxus baccata, Hedera helix, Juniperus oxycedrus*, etc. (Molinier & Bolos 1958).

In Sardinia, on the Gennargentu Mountain, between 1300-1500 m (a.s.l.), *Ilex aquifolium* is widely diffused together with *Taxus baccata* and *Alnus morisiana* (De Sole 1948; Camarda & Valsecchi 2008)

According to Rikli (1943), *Ilex aquifolium* is one of the most characteristic components of the beech forest undergrowth. It has a range similar to that of beech; however characterized by greater oceanicity. It is not a coincidence that it abounds in England, Ireland and Norway, where it goes up to Trondheim; here the beech is almost absent. In the west it is widespread up to the southern parts of the Iberian Peninsula, to the Atlas; in the east it occurs as far as the Peloponnese and Asia Minor, where *Fagus sylvatica* is missing. On the Maroccan Rif it lives on limestone, granite and basalt at 1500-2300 m, in humid and foggy areas. In the Moroccan Atlas it is found up to 1800 m (a.s.l.), together with *Quercus lusitanica* (deciduous species) and *Quercus ballota*; On the Moroccan Middle Atlas (Azru, Ifrane province) - at about 1800 m - *Ilex aquifolium* occurs together with *Crataegus monogyna, Sorbus torminalis* [*Torminalis glaberrima*]*, Rosa canina, Daphne laureola, Tamus communis, Hedera helix, Vitis vinifera.* In Algeria it occurs on the Djurdjura range, where it comes into contact with *Cedrus atlantica* or *Pinus nigra* subsp. *mauritanica* woods, while in the Babor massif (West Algeria), it is found at 1800-2000 m (a.s.l.) with *Abies numidica* or with *Cedrus atlantica, Taxus baccata* and the deciduous trees *Quercus mirbeckii, Q. afares* and *Acer obtusatum*. In Portugal, in the Serra de Monchique (Algarve), the holly is found in the most humid and protected areas together with *Quercus humilis, Myrica faya, Ruscus aculeatus* and - very significant case - together with *Rhododendron ponticum*. Similarly, in southern Spain holly is present in some humid valleys near Cadiz within deciduous oak forests together with other evergreen species such as *Laurus nobilis*, *Rhododendron ponticum* and *Viburnum tinus* (Mejías & al. 2006). In the Balkan Peninsula it often occurs together with beech, but sometimes also in relict stands with *Aesculus hippocastanum*, *Castanea sativa* and *Fraxinus ornus* (Peçi & al. 2012), or in the pseudomaquis with thorny, deciduous woody species. In the Caucasus it occurs in the plain woods with *Fagus orientalis, Quercus petraea, Ulmus glabra*, *Prunus laurocerasus* and species of *Acer, Carpinus,* and in undergrowth *Buxus, Rhododendron,* etc.

Fig. 3. Characteristic plants of vegetation of Colchic type in Sicily: a) old tree of *Quercus petraea* subsp. *austrotyrrhenica* (a); particular of *Ilex aquifolium* (b), *Hedera helix* (c), *Daphne laureola* (d), *Euonymus europaeus* (e) and *Crataeus laciniata* (f).

Fig. 4. Expressions of vegetation with Colchic affinity in the Madonie Regional Park (NC-Sicily): a) monumental group of *Ilex aquifolium* trees in Piano Pomo; b) autumn landscape of the mixed forest with *Quercus petraea* subsp. *austrotyrrhenica* and *Ilex aquifolium* in Pomieri locality; c) structure of *Ilici-Quercetum austrotyrrhenicae*; d) grazed aspect of *Anemono-Fagetum sylvaticae.*

The oak and holly forest of Madonie (CN-Sicily)

Madonie are a small mountain system extending in the north-western part of the island, representing the westernmost portion of the Sicilian Apennines, the mountain range that runs parallel to the north coast of Sicily starting from the Strait of Messina and of which they include the highest peak (Monte Carbonara, 1979 m a.s.l). From the geological point of view, limestone, carbonate or dolomitic rocks prevail. In particular, the basal complex is made up of an alternation of carbonates and dolomites from the Triassic period, however, especially in the eastern sector, siliceous substrates with fairly extensive formations of clays and sandstones are well represented (Grasso & al. 1978). Madonie represent an area of extraordinary floristic and vegetational richness thanks to the remarkable environmental variety that includes Mediterranean forest formations, mesophilic, rocky environments, peat bogs, riparian vegetation, Mediterranean maquis, garrigues, pastures, etc. Overall in the Madonie area there are about 1500 taxa representing about 50% of the entire Sicilian flora. The endemism consists of more than 170 making this area the richest in endemic plants on the island (Raimondo & al. 2004): one genus of *Apiaceae* is endemic.

The basal area, which falls within the thermo-Mediterranean bioclimatic belt, is very anthropized and has a vegetation of maquis and garrigue generally of secondary significance, as a result of the degradation of the evergreen forest of *Quercus suber* on siliceous substrates and *Quercus ilex* on limestone ones. However, these forest types have a greater extension above 500 m, in the Mesomediterranean belt, in more mesophilic aspects. In the wetter and deeper soils, the deciduous oak wood prevails with *Quercus virgiliana*. In this belt the residual formations of *Laurus nobilis* and *Rhamnus lojaconoi* are found in a fragmentary way. Above 1000 m, in the supramediterranean belt, a remarkable variety of forest formations can be found with holm oaks reaching 1800 m a.s.l. in the warmest limestone slopes, while in the wetter valleys, that has a higher degree of humidity, the wood of oak and holly settles, which generally at about 1500 meters above sea level comes into contact with *Fagus sylvatica* which at higher altitudes becomes the dominant forest species. In the higher areas most unsuitable for forest vegetation, the climax vegetation is represented by the orophilous cushion-like vegetation of *Astragalus nebrodensis*, which however have a considerable diffusion thanks to the degradation of the forest, therefore very often assuming a secondary meaning. Focusing the attention on the oak and holly forest, it can be seen that it is part of a rather extensive altitudinal belt, placed between the mesomediterranean area in the most favorable edaphic conditions and the supramediterranean area up to 1500 m a.s.l. (Fig. 7a, b). However, these are residual formations of limited extension, if we exclude the approximately 1000 hectares of Bosco Pomieri, very threatened by anthropic activity which has already largely reduced their diffusion (Raimondo 1984). As well as in the locality of Pomieri and its immediate vicinity (Stretto Canna, Piano Farina, Portella di Maurigi. Contrada Marcato, Zotta Massaro, northern slope of Pizzo di Fao) other more or less extensive formations are known in locality Scorzone and mostly between Cozzo Luminario and Pizzo Stefano, where in Piano Pomo there are some impressive populations of *Ilex aquifolium* (Fig. 4a; Fig. 6a) which probably in the past had a much higher diffusion as testified by the shepherds of the area who brought their livestock in these dense populations of hollies to protect it from storms and adverse weather conditions (Raimondo 1984). Finally, it should be noted the presence in these formations of impressive oak trees which is represented here by a sub-endemic subspecies (distributed in Sicily, Basilicata, Calabria and Puglia), *Quercus petraea* subsp. *austrotyrrhenica*,(Fig. 3: a) in Sicily known only on Madonie and on Nebrodi, where however only a few sporadic individuals occur (Brullo 1984). Among the most impressive oaks known on Madonie there are: the oak of Cozzo Pomeri, the oak of contrada Pomeri (Fig. 3a) and the oak of Sempria (Castelbuono) which have maximum circumferences of the trunk of 6.90, 7.60, 8.90 meters respectively (Schicchi & Raimondo 1999).

Other deciduous oakwoods with *Ilex aquifolium* in Sicily

The forest types similar to the colchic vegetation due to the presence of a deciduous tree layer and a dense and intricate shrub layer of holly in Sicily do not end in the oak and holly

Fig. 5. Expressions of vegetation with Colchic affinity in the Nebrodi Regional Park (NE-Sicily): a) old tree of *Quercus cerris* at the edge of the wood; b) structure of *Ilici-Quercetum cerridis*; c) structure of the beech forest with *Ilex aquifolium* (*Anemono apenninae-Fagetum*); d) different expression of forest with *Quercus cerris*, *Ilex aquifolium* and *Ostrya carpinifolia*; e) late-autumn expression of the mixed forest with *Fagus sylvatica* and *Ilex aquifolium*; f) twig in fruit of *Taxus baccata*, rare element of the thermophilic oak and beech woods of Sicily, in the island occurring exclusively in the Nebrodi Mountains.

Fig. 6. Unusual aspects of *Ilex aquifolium* trees in Sicily (Madonie) (a) and Sardinia (Gennargentu) (b).

wood of Madonie, but it has more or less extensive manifestations also in some forest formations spread on the Madonie itself or in other parts of the island. On the Madonie, a very characteristic formation, only recently classified from a phytosociological point of view (Maniscalco & Raimondo 2009), is given by a form of deciduous oakwood dominated by species belonging to the *Quercus pubescens* cycle with a dense undergrowth of *Ilex aquifolium*. This coenosis is referred to the association *Ilici aquifolii-Quercetum leptobalani* Maniscalco & Raimondo, of the *Pino-Quercion congestae* (cl. *Querco-Fagetea*) alliance and it is considered as exclusive of the area comprised between Pizzo di Corcò and Vicaretto (Geraci Siculo) at an altitude of 1000-1200, with an isolated station in the Gonato valley (Castelbuono) where it develops below 1000 m a.s.l. The substrates are represented by quartzarenites, belonging to the Numidian Flysch series and have a slightly acidic pH (5-6). From a climatic point of view, in absence of representative meteorological stations for the area, it is possible to hypothesize conditions similar to those observed for the oak and holly forest, with respect to which the coenosis itself can probably be interpreted as a more thermophilic formation that nevertheless takes place in the same conditions of oceanicity as mentioned above. The bioclimate is a mesomediterranean type with a superior subhumid ombrotype. From the structural point of view, the coenosis is characterized by a tree layer consisting of *Quercus congesta* to which *Quercus leptobalanos, Quercus dalechampii* are associated and more sporadically *Fraxinus ornus, Acer campestre* and *Quercus ile*x that on the calcareous slopes of this altitudinal belt forms large forest expres-

sions, referred to the association *Geranio versicoloris-Quercetum ilicis.* The tree layer also frequently includes tree specimens of *Ilex aquifolium*, as observed in the sites with less slope where it characterizes a peculiar facies, but mostly it occurs as a bush in the shrub layer of which it constitutes the clearly dominant species.

The herbaceous layer includes several nemoral entities belonging to the contingent of the order *Fagetalia sylvaticae* and of the *Quercetalia pubescenti-petraeae*, while the typical species of the *Querceta ilicis* class are less represented. Furthermore, within this formation, as also observed for the oak and holly woods, it is not uncommon to find small humid environments, often in correspondence with groups of tree hollies, and in particular the so-called "Margi filiciari" rich in pteridophytes such as *Osmunda regalis, Blechnum spicant* and *Athyrium filix-foemina* but also *Hypericum androsaemum* and other infrequent entities. From a dynamic point of view, the degradation of the forest led to shrubs of the *Rhamno-Prunetea* class, in which members of the Rosaceae family prevail, but *Ilex aquifolium* is often very frequent. The last stage of forest degradation is instead given by the mesophilic grassland, referred to the *Cynosuro-Leontodontetum siculi* association. Among the species occurring in this coenosis we can mention *Anthemis arvensis* subsp. *sphacelata, Anthoxanthum odoratum, Arrhenatherum elatius, Briza maxima, Cynosurus cristatus, C. echinatus, Dactylis glomerata* subsp. *hispanica, Hypochaeris radicata,* etc. In the environments more subject to grazing, *Eryngium campestre, Scolymus grandiflorus, Carlina sicula* and *Asphodelus ramosus* become prevalent, while *Pteridium aquilinum* plays an important role in the progression of the series because, forming a dense cover, it prevents the growth of herbaceous species, fostering the tree species instead (Maniscalco & Raimondo 2009).

Another example of deciduous oakwood with holly in which the tree layer is formed by entities from the *Quercus pubescens* cycle is known on the Peloritani Mountains, however, settling in relatively different pedological and bioclimatic conditions compared to those exposed for Madonie. In fact, the coenosis develops on substrates consisting of metamorphic rocks of various types, at an altitude of 1000-1150 m a.s.l. in correspondence with the wetter slopes of an area between Pizzo Croce (1,214 m), Pizzo Acqua Bianca (1,210 m) and Monte Cavallo (1,216 m) (Maniscalco & Raimondo 2009). The coenosis investigated is referred to *Conopodio capillifolii Quercetum congestae*, association framed in the all. *Pino-Quercion congestae* (*Quercetalia pubescenti-petraeae, Querco-Fagetea*). The tree layer is physiognomized by the presence of *Quercus congesta,* to which *Quercus ilex* and *Castanea sativa* associate; *Ilex aquifolium* is sometimes abundant but generally does not constitute the dense undergrowth observed in the Madonie coenosis. A discrete contingent of characteristic species of the order *Quercetalia pubescent-petraea* is represented such as *Asperula laevigata, Clinopodium vulgare* subsp. *orientale, Crepis leontodontoides, Drymochloa drymeia, Fraxinus ornus, Luzula forsteri, Ostrya carpinifolia, Poa sylvicola, Tamus communis, Teucrium siculum* and *Viola alba* subsp. *dehnhardtii.* While *Acer obtusatum, Allium pendulinum, Aquilegia sicula, Aremonia agrimonoides, Doronicum orientale, Geranium versicolor, Galium rotundifolium, Euphorbia meuselii, Lamium flexuosum, Luzula sylvatica* subsp. *sicula, Polygonatum gussonei* and *Ilex aquifolium* are typical of the order *Fagetalia sylvaticae*. Even some species of the class *Quercetea ilicis* are represented, such as *Cyclamen repandum, Dryopteris pallida, Erica arborea, Lonicera etrusca, Quercus ilex* and *Thalictrum calabricum.*

From a dynamic point of view, the replacement vegetation is represented by shrubs with an oceanic character in which *Erica arborea* and *Cytisus scoparius* dominate and by herbaceous formations in which *Pteridium aquilinum* assumes a preponderant role. A more characteristic formation similar to the oak and holly wood of the Madonie is represented by a particular form of woods of *Quercus cerris* (Fig. 5a) with limited diffusion to the Nebrodi Mountains. It is *Ilici-Quercetum cerridis* (Fig. 5b, f), which can be considered as a vicarian coenosis of *Ilici-Quercetum austrotyrrhenicae* on Nebrodi (Raimondo & al. 2009). Although the coenosis in question differs from the latter for aspects of a geological-pedological type, preferring substrates with a meaningful clayey component, it develops in a fragmentary manner in the same micro-limestone conditions characterized by an accentuated oceanic character that occurs only in the north-facing slopes. which benefit from a high amount of precipitation and an additional supply of humidity due to frequent fogs. These characteristics are thus represented on the northern side of the Nebrodi system, subjected to the action of the humid currents coming from the Tyrrhenian Sea and among the most significant examples we can mention the area of Pizzo Luminaria and the basin of the Torrente Inganno in an area between Poggio della Cattiva, north of the Lake Maulazzo, and the localities Pileci, Faitella, Laceroni and Cidara. A second, smaller nucleus is located on the northern side of Monte Sambughetti (Bosco della Giumenta) at the southwestern edges of the geographical area of Nebrodi Mountains. This last nucleus differs significantly from the other woods of *Q. cerris* of the Nebrodi, since these normally extend up to 5 km from the coast line, while the wood of *Q. cerris* of Monte Sambughetti is placed to 20 km from the coast. In this case, the positioning in the upper part of the valley of the River Tusa which acts as a corridor for the humid currents coming from the Tyrrhenian Sea, allow the development of a coenosis with marked oceanic characters in apparently inadequate conditions (Raimondo & al. 2009). On the Nebrodi Mountains, however, *Q. cerris* has a much wider distribution forming more or less extensive forest formations in the belt between the evergreen Mediterranean woods and the beech woods, between 900 and 1600 m a.s.l. The coenosis investigated, on the other hand, is limited to a narrower altitudinal range between 800 and 1300 m, where it develops in the presence of a bioclimate with an upper-supra-Mediterranean upper-Mediterranean thermotype with a humid-sub-humid shadow type. The substrates consist of graded quartzarenites, with intercalations of argillites and siltstones (Numidian Flysh) from the Upper Langhian-Oligocene period. The main structural feature distinguishing these formations from the other woods of Turkey oaks of the Nebrodi (referred to the association *Arrhenathero nebrodensis-Quercetum cerridis*) is the abundant presence of *I. aquifolium,* completely absent or rare in the other woods of *Q. cerris.* In this case, on the other hand, the holly, sporadically present also with tree individuals, forms a dense shrub layer that refers to what has been described for the oak and holly wood of Madonie. However, *Quercus petraea* subsp. *austrotyrrhenica* is completely missing from the Nebrodi formation, whose dominant role in the tree layer is instead assumed by *Q. cerris*, which is more sporadically accompanied by *Acer campestre, Quercus dalechampii, Sorbus torminalis* (*Torminalis glaberrima*) and *I. aquifolium.* The shrub layer, which is often remarkably developed in height, is physiognomized not only by *I. aquifolium* but also by *Euonymus europaeus, Malus sylvestris, Crataegus monogyna* and in the margins *Pyrus vallis-demonis, Pyrus spinosa* and *Pyrus* sp. too. Among the small shrubs *Ruscus aculeatus, Rubus* sp. and *Daphne laureola* are abundant, while among the lianas we remember

Hedera helix and *Tamus communis.* The herbaceous layer, although with low coverage indexes, includes several mesophilic nemoral entities such as *Anthriscus nemorosa, Aremonia agrimonoides, Geranium versicolor, Lamium flexuosum, Lathyrus venetus, Melica uniflora, Mercurialis perennis, Viola reichenbachiana, Asperula laevigata, Clinopodium vulgare, Luzula sylvatica* subsp. *sicula, Melittis melissophyllum* subsp. *albida, Oenanthe pimpinelloides,* etc. In the more shady and humid stretches there are often dense populations of the pteridophyte *Polystichum setiferum.* Among the species considered differential for the association there are *Scutellaria rubicunda* subsp. *linneana*, endemic of Sicily, *Euphorbia meuselii* and *Euonymus europaeus.* The *Ilici aquifolii-Quercetum cerridis* is dynamically linked with a pre-forest mantle of *Pruno-Rubion ulmifolii* with *Pyrus vallis-demonis* and in the sectors not occupied by woody vegetation, with mesophilic grasslands referable to *Plantaginion cupanii* (Raimondo & al. 2009).

Beechwoods and other forest formations in which *Ilex aquifolium* occurs in Sicily

In the formations referable to the colchic-type belt examined up to now, a common element is the presence of *I. aquifolium* in the tree layer and above all in the shrub layer. However, the mere presence of holly is not sufficient to include in the Colchic belt some formations that show structural and ecological characters different from those seen so far. Therefore, in Sicily *I. aquifolium* is locally frequent in the orophilous holm oaks referred to the association *Geranio versicoloris-Quercetum ilicis* which settles on acid substrates of the eastern side of Madonie Mountains (Maniscalco & Raimondo 2003) and also on the Nebrodi and the Peloritani. It is an evergreen mesophilic formation widespread between 900 and 1200 m, which settles on acid and humus-rich substrates, connected to the Numidian Flysch series, in the presence of a lower humid supramediterranean bioclimate. The tree layer is dominated by *Quercus ilex* and *I. aquifolium,* which however is well represented also in the shrub layer. Among the herbaceous plants *Silene sicula, Thalictrum calabricum. Aremonia agrimonioides* and *Mellitis albida* are considered typical. Although there is a dense evergreen shrub layer of holly, contrary to the formations previously illustrated, the tree layer is dominated by evergreen species, making this coenosis structurally very different from the Colchic forest. In addition, although several mesophilic entities are represented so to include the association in the *Querco-Fagetea* class, there is a rich contingent of thermophilic species coming from the lower vegetation belt. Moreover, the bioclimatic conditions are also slightly different with a more marked drought period and consequently a lower oceanic character. The same observations can also be valid for holm oaks with holly spread on the calcareous substrates of North-Western Sicily, especially on the mountains of Palermo where, however, the forest vegetation is reduced to small strips and sometimes only a few isolated individuals of holly or in strongly threatened small populations. The aspects of basophil holm oak with *Ilex aquifolium* are referred to *Aceri campestris Quercetum ilicis* subass. *helleboretosum bocconei.* Another woodland expression in which *Ilex aquifolium* is quite common is the beech wood, a deciduous mesophilic coenosis dominated by *Fagus sylvatica.* The beech shows a wide geographical diffusion in central-western and northern Europe, while it tends to fade towards forms similar to *Fagus orientalis* on the Balkan Peninsula and to disappear completely in Mediterranean Europe.

Sicily represents the southern limit in the range of the species which in fact manages to develop only in the coolest and humid areas above 1000 m a.s.l., up to almost 2000 mainly on the Nebrodi and Madonie Mountains, but with small formations also on the Peloritani and on Etna. Beechwoods of Sicily have some peculiarities that allow them to be distinguished from those of the Apennines. Contrary to these last ones, in fact, they develop in climatic conditions apparently hostile for a mesophilic species such as the climate. Therefore, it is above all the edaphic and meso-microclimatic factors that guarantee its survival and in particular the exposure to the humid northern currents, the occult precipitations, the snow, the cloud cover represent aspects of primary importance. For example, for the beech a remarkable problem is given by transpiration which is particularly significant during the spring period when the young leaves develop. However, in that period the mountains of northern Sicily are subject to frequent fogs and rather humid northern currents which allow to reduce transpiration. Comparing the Sicilian formations with those of the Apennines, a certain floristic impoverishment is noted, so for example *Abies alba* is completely missing, still relatively frequent on the reliefs of southern Calabria, even if it is possible that in the past it was present as some pollens found in the peat bogs of the Madonie, where however *Abies nebrodensis* is still present, although with very few individuals, for which a wide distribution can be hypothesized before the arrival of man. A point in common between the Sicilian beech woods (except the formations of Etna) and those of the southern Apennines is the frequent presence of *Ilex aquifolium* as a shrub in the undergrowth. However, contrary to the thermophilic formations of the Gargano or Calabria which show a dense undergrowth of *I. aquifolium* and *Taxus baccata*, the Sicilian beechwood generally has a shrubby layer with low levels of coverage even though the presence of holly is relatively frequent, while the yew is known only on the Nebrodi where however it is very rare. The holly in Sicily seems to find its ecological optimum in deciduous oak woods rather than in beech woods. The ideal bioclimatic belt for *I. aquifolium* is in fact placed between the meso-Mediterranean and the lower supra-Mediterranean ones (Maniscalco & Raimondo 2003), at altitudes between 1000 and 1500 m coinciding with the belt occupied by mesophilic deciduous oakwoods and the lower limit of the beechwood belt, while higher up, where the beechwood is predominant, i.e. between 1500 and 1900 m, holly tends to progressively rarefy and disappear completely above 1500 m (although isolated individuals are known up to 1850 m on the southern slope of Madonie) probably due to the low winter temperatures. Therefore, contrary to what some authors have proposed, which include all aspects of beechwoods in southern Italy and Sicily in the "Colchic belt", in our opinion it would be more appropriate to refer to the latter only the more thermophilic beechwood formations that actually show a shrub layer of holly with high levels of coverage, such as the well-known formations on the Gargano in Puglia that develop in a wide altitude range almost from sea level to 1000 m, but also the more thermophilic aspects of the Calabrian beech forests that reach up to 500-600 m of altitude. From a phytosociological point of view, the Sicilian formations refer to various coenoses, the most widespread of which is the *Anemono apenninae-Fagetum*, among whose differential species *I. aquifolium* (Fig. 1b; Fig. 5c, e) is included, although in fact the species is common only in the lower part of the beech belt. However, all the Nebrodi, Madonie and Peloritani beech forests which settle on siliceous substrates from 900 m to 1800 m are generally referred to this association.

The other coenoses described for Sicily show an even more scarce presence of the holly, as in the aspects of basophil beechwoods of the Madonie referred to *Luzulo siculae-Fagetum* and the formations of Etna framed in *Epipactido meridionalis-Fagetum* and in *Rubo aetnici-Fagetum* in which *I. aquifolium* is totally absent. Other forest formations including an abundant presence of holly are some aspects of chestnut wood on Etna and above all the forest of yew and holly of the Nebrodi Mountains. This last coenosis, partly referable to the similar formations of Sardinia, is particularly significant due to the abundance of tertiary species. It is a dense forest formation with a tree layer without a clearly dominant entity, which instead sees more or less equally represented *Fagus sylvatica, Taxus baccata* and *I. aquifolium*, while other taxa such as *Acer pseudoplatanus, Ulmus glabra* and *Fraxinus excelsior* subsp. *siciliensis* are much more sporadic.

I. aquifolium and *T. baccata* are once again well represented in the shrub layer (Fig. 5e, f). This wood expression is framed in *Ilici aquifolii-Taxetum baccatae*, pertaining to the alliance *Geranio versicoloris-Fagion sylvaticae*, and in Sicily it is considered exclusive of the northern side of Nebrodi and in particular of the Bosco Tassita in the territory of Caronia, but it is also known for southern Calabria. On the Nebrodi Mountains, the yew and holly forest is located in the beechwood belt at about 1400 m a.s.l. in the most sheltered sites with siliceous substrates (schists, granites, gneisses) which enjoy a particularly humid microclimate and oceanic characteristics thanks to the frequent fogs. This formation, very demanding from the ecological point of view, therefore shows meaningful floristic and structural affinities with the Colchic formations seen previously, even if the occurrence of *T. baccata* gives it an original physiognomy.

Discussion and conclusion

Within the Mediterranean region, the Tertiary vegetation, Miocenic and Pliocenic, was almost entirely destroyed, remodeled or replaced due to the geo-climatic events of the Quaternary. The glacial phenomenon of Pleistocene, with its well-known thermal fluctuations, contributed significantly to cancel the subtropical appearance and the character of climacic forest, also interesting the Middle-European and Eurasian regions, represented by luxuriant expressions of evergreen forest, of the laurophyll (Miocene) and sclerophyll type (Pliocene), respectively. This last type, floristically impoverished, survived in large areas of the Mediterranean basin and makes up the bottom of the current climacic woods (*Quercetea ilicis*) (Fenaroli & Giacomini 1958).

As evidence of the humid tropical, Miocene climate vegetation, forest expressions whose woody constituents have close affinity with the Colchic flora still survive today on the most ancient geological systems of the Mediterranean. Mostly in the Caucasus region of the Colchis and in the Macaronesian area, the particular geographical position and the persistence of oceanic climatic conditions allowed the maintenance of that vegetation that in the Miocene (Gomez Campo 1974; Pignatti 1978, 1979) and probably in the humid interglacials connected the eastern and western Mediterranean area in a single biome (Fenaroli & Giacomini 1958).

This type of vegetation has been well-preserved at the extremes of the Mediterranean area, in particular in the Atlantic Islands (Canary Islands). Also in the west, eloquent remains have been preserved in the Iberian Peninsula and in the Balearic Islands (Bolòs & Molinier 1958;

Pignatti 1978), while to the east in the Balkans, Amanos Mountains (Turkey) and in the Euxinian region, near the Black Sea (Zohary 1973). For the "laurisilva" of the Canaries, Ciferri (1962) establishes floristic affinities with neotropical situations.

Less expressive remains, but nevertheless meaningful, are still scattered across large stretches of the Mediterranean: in particular in the three major islands (Sicily, Sardinia and Corsica). They result in frequent mosaics within the deciduous broadleaf formations, extending over the Mediterranean mountains during the Pleistocene. In some cases, they are continuous, non-subordinate expressions, or real belts of extrazonal vegetation, as in Sicily on the Madonie and Nebrodi Mountains (Di Martino & al. 1977; Pignatti 1978, 1979; Raimondo 1984; Raimondo & al. 2009). They therefore take on a remarkable phytogeographic and landscape interest and could lead to the recognition of a current belt of relict vegetation (Mediterranean-Miocene) sub-Mediterranean or Mediterranean-mountain, with ecological needs of an oceanic type (Fig. 7a, b). It is therefore a possible coenosis which had its maximum expansion in the Tertiary period and which was gradually replaced by deciduous forests of the Middle European type (Di Martino & al. 1977). Its present distribution would affect the Iberian Peninsula, North Africa, the south of Italy, the large Islands, Asia Minor and the Caucasus. The remains mentioned above allow to reconstruct the hypothesized belt, whose continuity is now vastly interrupted both for the current climatic characteristics and for the anthropic impact.

The expressions of Colchic vegetation still present in the geographical areas listed above, represent a precious relict whose scientific interest alone would be enough to justify an urgent integral protection and, where possible, its reconstitution.

Among the evergreen tertiary elements laurophyill, still present in the Mediterranean vegetation of a temperate climate, *Ilex aquifolium* plays an incisive role. This role is particularly appreciated in Sicily where there are remains of forest vegetation that occupy extensive areas on the northern mountain systems, mainly the Nebrodi and Madonie. These are areas subject to frequent stagnation of fog in winter and summer, a factor that mitigates thermal extremes and dampens summer dryness. On the island, *I. aquifolium* is associated with other ecologically similar evergreen elements: These include *Hedera helix, Daphne laureola,* and *Taxus baccata* (Fig. 3c, d; Fig. 5f) the latter vicariates to the east by species of the same genus endemic to Colchis where the genus *Ilex* is instead represented by *I. colchica*. It is therefore elements connected to the Euro-Caucasian flora and of probable miocenic relics. In Sicily, *I. aquifolium* participates in various plant associations. Among these, however, only two of them take on an extensive character, defining very expressive forest landscapes that affect the strip between the evergreen oak woods (*Quercetalia ilicis*) and the deciduous beech woods (*Fagetalia sylvaticae*). On the basis of the elements and studies referred to, it is still possible to recognize, at least in Sicily, an altitudinal distribution of natural vegetation that includes a belt of azonal vegetation strongly characterized by the presence of *Ilex aquifolium*, which is is predominantly related to two forms of mixed forest, respectively differentiated by *Quercus petraea* subsp. *austrotyrrhenica* in the Madonie mountains (*Ilici-Quercetum austrotyrrhenicae*) and *Q. cerris* in the Nebrodi range (*Ilici-Quercetum cerridis*). (Fig. 7a-b). Eloquent expressions of this vegetation with a rich dendrological flora - few frequent in Europe and in the Mediterranean area - can steel be found in some localities of the Nebrodi natural Park, in the territory of Militello Rosmarino municipality. These have been proposed to the visitors of the protected area by creating a suggestive naturalistic path inside it called "Sentiero agrifoglio" (holly pathway).

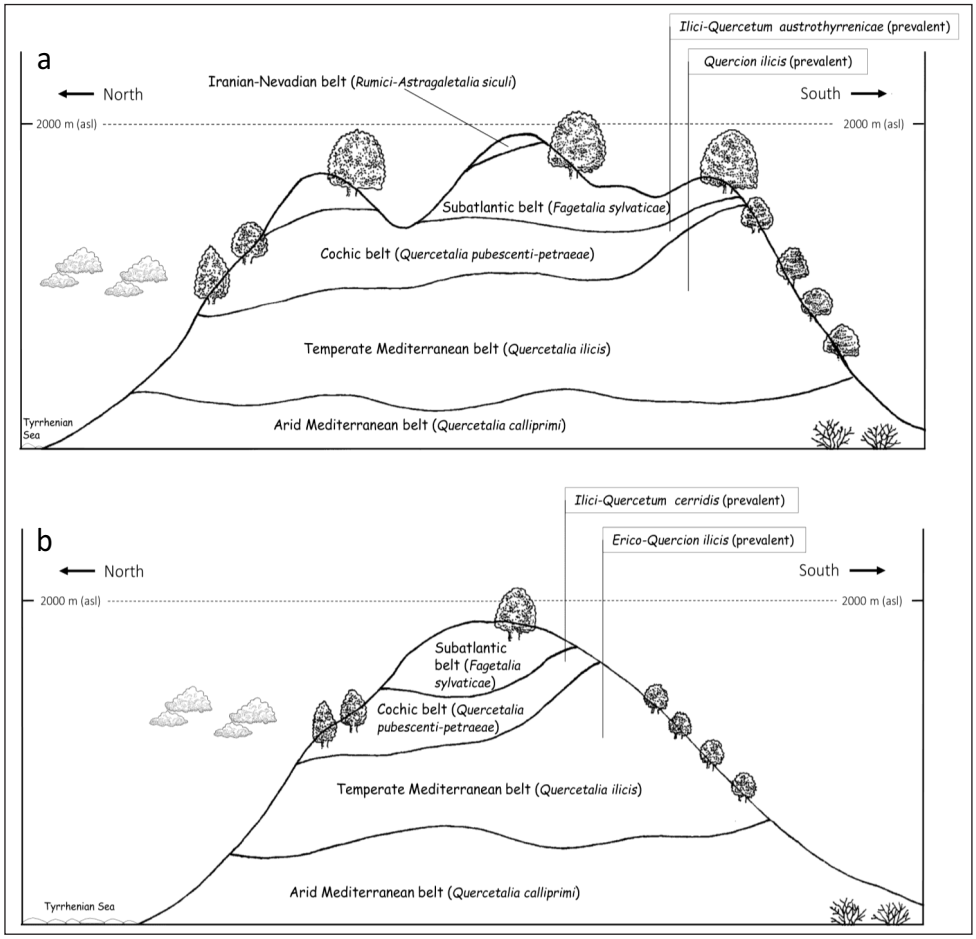

Fig. 7. Transects of the altimetric distribution of the potential vegetation in the Madonie (a) and Nebrodi (b) Mountains, according to the belts defined by Pignatti (1979).

Even more expressive from a landscape point of view on the Madonie are the aspects of degradation of these formations, in the past subject to cutting and intensive grazing (Fig. 8 a-f). These are expression of secondary and anthropogenic vegetation, poor floristically but of great landscape impact, deserving to be valued also as a cultural heritage.

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Fig. 8. Suggestive expressions of the degraded forest with *Fagus sylvatica* or *Quercus petraea austrotyrrhenica* and *Ilex aquifolium* modeled by the bite of reared cattle (a-f).

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ANNEXES

a) List of the taxa cited in the text.

Abies alba Mill.
Abies nebrodensis (Lojac.) Mattei
Abies numidica De Lannoy ex Carrière
Acer L.
Acer campestre L.
Acer granatense Boiss.
Acer obtusatum Waldst. & Kit. ex Willd.
Alnus morisiana Bertol.
Allium pendulinum Ten.
Amelanchier ovalis Medik.
Anthemis arvensis subsp. *sphacelata* (C. Presl) R. Fern.
Anthoxanthum odoratum L.
Anthriscus nemorosa (M. Bieb.) Spreng.
Aremonia agrimonoides (L.) DC.
Aria edulis (Willd.) M. Roem.
Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C. Presl
Asperula laevigata L.
Asphodelus ramosus L.
Aquilegia sicula (Strobl) E. Nardi
Briza maxima L.
Buxus L.
Buxus balearica Lam.
Carlina sicula Ten.
Carpinus L.
Castanea sativa Mill.
Cedrus atlantica (Endl.) G. Manetti ex Carrière
Clinopodium vulgare L.
Clinopodium vulgare subsp. *orientale* Bothmer
Crataegus laciniata Ucria
Crataegus monogyna Jacq.
Crepis leontodontoides All.
Cyclamen repandum Sm.
Cynosurus echinatus L.
Cynosurus cristatus L.
Cytisus scoparius (L.) Link
Dactylis glomerata subsp. *hispanica* (Roth) Nyman
Daphne pontica L.
Daphne laureola L.
Doronicum orientale Rchb.
Drymochloa drymeia (Mertens & W.D.J. Koch) Holub
Dryopteris pallida (Bory) C, Chr. ex Maire & Petitm.
Erica arborea L.
Eryngium campestre L.
Euphorbia meuselii Geltman
Euonymus europaeus L.

Fagus orientalis Lipsky
Fagus sylvatica L.
Fraxinus ornus L.
Galium rotundifolium L.
Genista cupanii Guss.
Genista aristata C. Presl
Geranium versicolor L.
Juniperus oxycedrus L.
Hedera colchica (K. Koch) K. Koch
Hedera helix L.
Hypochaeris radicata L.
Ilex aquifolium L.
Ilex colchica Pojark.
Ilex canariensis Poir.
Lamium flexuosum Ten.
Lathyrus venetus (Mill.) Wohlf.
Lonicera etrusca Santi
Lonicera pyrenaica L.
Luzula forsteri (Sm.) DC.
Luzula sylvatica subsp. *sicula* (Parl.) K. Richt.
Malus crescimannoi Raimondo
Malus sylvestris Mill.
Melica uniflora Retz.
Melittis albida Guss.
Mercurialis perennis L.
Myrica faya Aiton
Oenanthe pimpinelloides L.
Ostrya carpinifolia Scop.
Poa sylvicola Guss.
Polygonatum gussonei Parl.
Polystichum setiferum (Forssk.) T. Moore ex Woynar
Prunus laurocerasus L.
Pteridium aquilinum (L.) Kuhn
Pyrus spinosa Forssk.
Pyrus vallis-demonis Raimondo & Schicchi
Quercus afares Pomel
Quercus ballota Desf.
Quercus congesta C. Presl
Quercus dalechampii Ten.
Quercus ilex L.
Quercus humilis Walter
Quercus lusitanica Lam.
Quercus mirbeckii Durieu
Quercus petraea (Matt.) Liebl.
Quercus petraea subsp. *austrotyrrhenica* Brullo, Guarino & Siracusa
Rhododendron L.
Rhododendron ponticum L.
Rosa canina L.
Ruscus aculeatus L.

Silene sicula Ker Gawl. ex Rohrb.
Sorbus aria (L.) Crantz
Sorbus torminalis (L.) Crantz
Scolymus grandiflorus Desf.
Scutellaria rubicunda subsp. *linneana* (Caruel) Rech. fil.
Taxus baccata L.
Teucrium scorodonia subsp. *crenatifolium* (Guss.) Arc.
Tamus communis L.
Taxus baccata L.
Thalictrum calabricum Spreng.
Torminalis glaberrima (Gand.) Sennikov & Kurtto
Ulmus glabra Huds.
Viola alba subsp. *dehnhardtii* (Ten.) Becker
Viola reichenbachiana Jord. ex Boreau
Vitis vinifera L.

b) List of the syntaxa cited in the text.

Aceri campestris- Quercetum ilicis Brullo & Marcenò 1984 subass. *helleboretosum bocconei* Marcenò & Colombo 1987
Anemono apenninae-Fagetum (Gentile 1969) Brullo 1984
Arrhenathero nebrodensis-Quercetum cerridis Brullo, Minissale, Signorello & Spampinato 1996
Conopodio capillifolii Quercetum congestae Maniscalco & Raimondo 2003
Ilici aquifolii-Quercetum cerridis Raimondo, Schicchi & Bazan 2009
Ilici-Quercetum austrotyrrhenicae Brullo & Marcenò 1984
Galio scabri-Quercetum ilicis Gamisans (1977) 1986,
Geranio versicoloris-Quercetum ilicis Maniscalco & Raimondo 2003
Geranio versicoloris-Fagion sylvaticae Gentile 1968
Epipactido meridionalis-Fagetum Brullo, Minissale, Signorello & Spampinato 1999
Fagetalia sylvaticae Scamoni et Passarge 1959
Ilici aquifolii-Taxetum baccatae Brullo, Minissale, Signorello & Spampinato 1999
Pino-Quercion congestae Brullo, Minissale, Signorello & Spampinato 1999
Pruno-Rubion ulmifolii Brullo, Minissale, Signorello & Spampinato 1999
Querco-Fagetea sylvaticae Br.-Bl. et Viegler 1937
Quercetalia ilicis Br.-Bl. ex Molinier 1934
Quercetalia pubescenti-petraeae Klika 1933
Rubo aetnici-Fagetum Brullo, Minissale, Signorello & Spampinato 1996
Plantaginion cupanii Brullo & Grillo 1980

Addresses of the authors:
Salvatore Cambria[1] & Francesco Maria Raimondo[2],
[1]Department of Environmental, Biology and Geological Sciences, University of Catania, Via Antonino Longo, 95100 Catania, Italy.
[2]*PLANTA*/Center for Research, Documentation and Training, Via Serraglio Vecchio 28, 90123 Palermo, Italy.