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Pasquale Marino[a]*, Giuseppe Castiglia[b], Giuseppe Bazan[c], Gianniantonio Domina[c] and Riccardo Guarino[a]

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Abstract:: Laurel woodlands in the Madonie mountains (Sicily) are characterized by the presence of *Laurus nobilis*, *Rhamnus lojaconoi* and *Vitis vinifera* subsp. *sylvestris*. The results of a phytosociological study are presented, and a new endemic association, *Rhamno lojaconoi–Lauretum nobilis*, is described. Present Mediterranean laurel communities are the result of an adaptive response by Tertiary laurel forest to the peculiar microclimatic conditions that characterize the refugia where they persist. These refugia have been recently considered as a priority habitat under the Directive 92/43/EEC, and their plant communities are very vulnerable. Protection measures of the studied laurel populations are necessary, with particular reference to the bulking up of *R. lojaconoi* through *in situ* and *ex situ* propagation. A multivariate analysis of 63 relevés from all the Sicilian laurel communities described so far and additional 65 relevés from all over southern Europe and the Mediterranean basin bears out the autonomy of the new association, showing at the same time some floristic affinities between Sicilian, southern Italian, Spanish and Iberian associations. Their syntaxonomic treatment is discussed.

Keywords: Mediterranean region; palaeotropical geoflora; phytosociology; relict vegetation; Sicily

Introduction

Evergreen laurel forests are important relict elements of Tertiary vegetation in Europe (Mai 1989), Colchis (Filibeck, Arrigoni and Blasi 2004), and Macaronesia (Fernández-Palacios et al. 2011). These evergreen woods include many remnants of the "palaeotropical geoflora" (Engler 1879–1882), most of which are rare or absent from present-day vegetation in Europe. The decline of a luxuriant humid subtropical vegetation in Europe is a consequence of the drastic climatic and palaeogeographical changes that took place during the Upper Miocene (Bocquet, Widler and Kiefer 1978; Rögl and Steininger 1983; Guarino, Giusso del Galdo and Pignatti 2006), resulting in the disintegration of the Eurasian laurel forest zone and in the nearly total extinction of the laurophyll elements all around the Mediterranean Basin. The climate deterioration began in the Eocene, increased after the Oligocene in the context of several complex global-scale tectonic events, and culminated in the Pleistocene glaciations with their devastating impact on the Holarctic (sub)tropical flora (Bertolani-Marchetti and Cita 1975; Mai 1991; Hofrichter et al. 2001).

Laurus nobilis is perhaps the most representative surviving element of this Palaeotropical geoflora. Its ability to withstand short periods of water deficit (Salleo, Trifilò and Lo Gullo 2006; Rodríguez-Sánchez and Arroyo 2008; Nardini et al. 2010) enabled the laurel to maintain a fairly broad distribution within the Mediterranean Basin, where several populations exist, ranging from the Pontic mountains in Anatolia to Morocco and Macaronesia (Komarov 1937; Meusel, Jäger and Weinert 1965; Jalas and Suominen 1991; Rodríguez-Sánchez et al. 2009).

In the last 30 years, several aspects of the vegetation with *L. nobilis* as a structural element have been mentioned in the Sicilian literature (Bonomo et al. 1977; Raimondo, Mazzolo and Castiglia 1980; Bartolo et al. 1990; Gianguzzi, Raimondo and Riggio 1995) and more recently, some phytosociological associations have been singled out, in which the laurel plays a key role. Apart from the recognition of *Hedero helicis–Lauretum nobilis* (Bueno Sánchez and Fernández Prieto 1991), the following associations have been described for Sicily: *Lauro–Quercetum virgilianae* from the Hyblaean Massif (Brullo, Costanzo and Tomaselli 2001) and *Acantho mollis–Lauretum nobilis* from the Sicani Mountains (Gianguzzi, D'Amico and Romano 2010). The *Lauro–Quercetum virgilianae lauretosum* was found, as well, in the Oreto Valley, near Palermo (Traina and Marcenò 2001), and considered a facies of *Lauro–Quercetum virgilianae* by Brullo et al. (2008).

In spite of the statements of Lojacono (1904), all recent authors considered *Laurus nobilis* as autochthonous in Sicily, highlighting its relictual character.

The aim of this paper is the study and characterization of the relict vegetation with *Laurus nobilis* in the Madonie Mountains (northern Sicily), through its phytosociological and statistical comparison with other occurrences described in extant publications.

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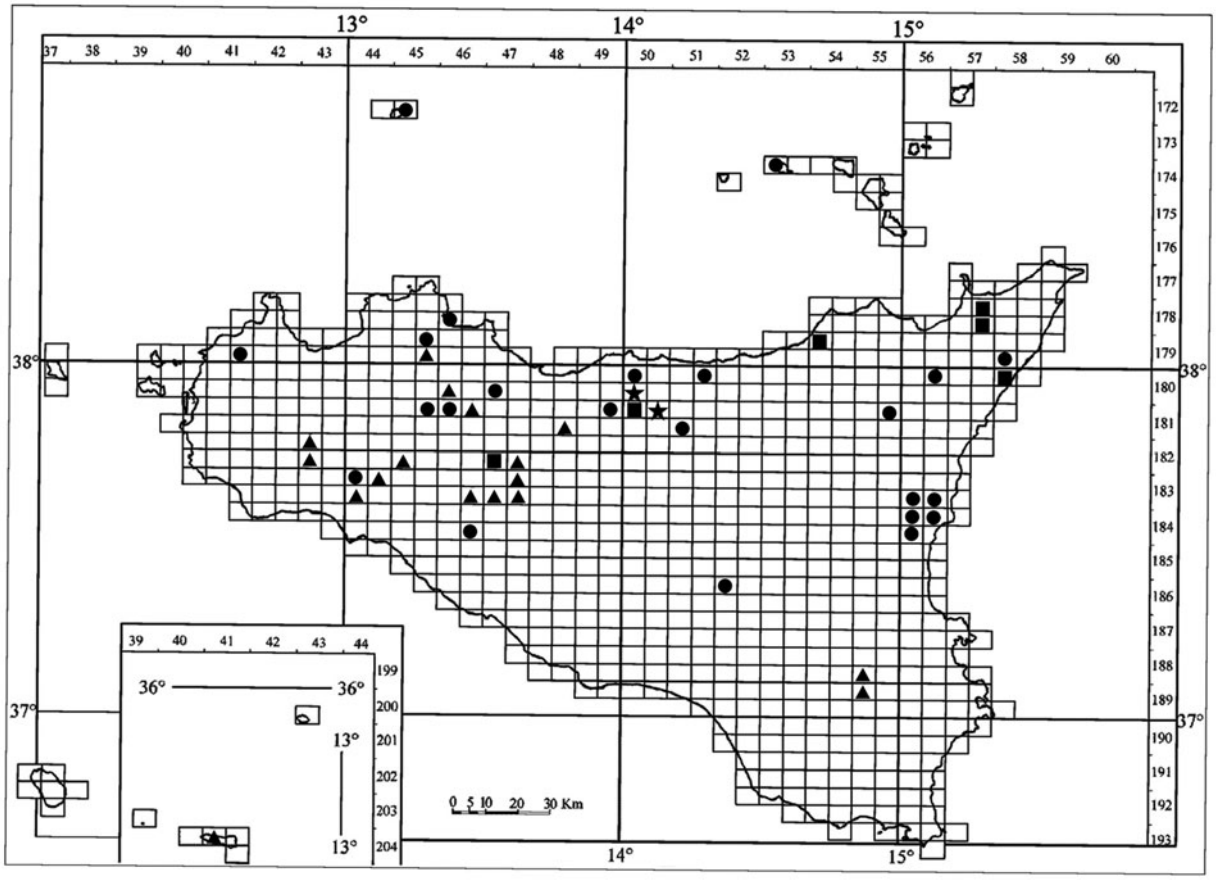

Figure 1. Distribution map of laurel vegetation in Sicily and minor islands (circles indicate records from Herbarium specimens in PAL and CAT, triangles refer to sites known both from herbarium and bibliography; squares indicate bibliographic records with no herbarium specimens, stars indicate the field locations of the present work. Records from Herbarium specimens: PALERMO – Monti del Parco, maggio, s.coll. (PAL!). – Ficuzza, s.d., Todaro (PAL!). – *sine loco*, s.d., s.coll., Minà Palumbo? (PAL!). – Palermo *in sylvaticis, martio*, Todaro (PAL!). – Lercara, s.d., Tornabene (CAT). – Gonato, *martio*, s.coll. (Herb. Minà, Castelbuono!). – Madonie ai Monticelli, m 650, una ceppaia addossata alla roccia e varie plantule, 20-3-1971, Raimondo e Mazzola (Herb. Minà, Castelbuono!). – Gonato, m 730, in una strettoia del torrente Vicaretto, 2-11-1973, Raimondo e Mazzola (Herb. Minà, Castelbuono!). – Canalicchio, sulla rupe sovrastante Passo Scuro, m 650, agosto I977, Raimondo e Mazzola (PAL!). – Vicaretto, m 500, "Addavararu di l'Acqua fitienti", vasta stazione con popolamenti discontinui presso una sorgentella sulfurea, 12-9-1977, Raimondo e Mazzola (PAL!). – Vallone "di l'Addavaru", fra Geraci e Gangi, m 500, ottobre 1977, Raimondo, Mazzola e Scialabba (PAL!). – Al Passo del Bambino sotto il bosco di Granzi tra Alia e Montemaggiore, 500 m circa, settembre 1978, Romano (PAL!). – Castronovo di Sicilia a Retrosciacca, 500 m circa, rigoglioso e spontaneo lungo un vallone umido, maggio 1979, Raimondo e Romano (PAL!). – Vallone Annunziata, m 650, vari esemplari lungo un rigagnolo che scende dal Piano Triemula, 16-9-1979, Raimondo, Mazzola e Castiglia (PAL!). Ficuzza, 15-6-1985, S. Brullo (CAT). Baucina, 8-4-1980, Bartolo-Brullo (CAT!). Madonie: Gibilmanna, 18-6-1990. Raimondo (PAL!). Palermo: Fiumelato di Meccini, 29/05/1990, Raimondo, Gianguzzi and Ilardi (PAL!). TRAPANI Boschetto di Erice, culta?, m 700, Novembre 1978, Raimondo e Dia (PAL!). AGRIGENTO – Bivona: C.da S. Margherita, 20/04/1965, Catanzaro (PAL). Contrada Salaci nell'agro di Cammarata, ai margini del boschetto igrofilo a Populus, 16-6-1978, Bonomo e Raimondo (PAL!). CATANIA – Sicilia, *sine loco*, gennaio marzo, s. coll. (CAT!). MESSINA – Capo S. Alessio (Messina), 5-5-1956, Arena, Rosso e Gramuglio (MS). – Vallone Lacino, m 600 circa, S.Lucia del Mela, maggio 1972, Gramuglio (MS). – Stazione *Woodwardia* ValI. Mandrazza, S. Lucia del Mela, m 560 circa, luglio 1975, Gramuglio e Rossitto (MS). – Stazione *Woodwardia* Vall. – Mandrazza S. Lucia del Mela, 10-11-1977, Gramuglio e Rossitto (MS). – S. Fratello in contrada Mascarino, m 450, giugno 1979, Raimondo e Mazzola (PAL!). – Fiumedinisi Vallone Santissima, 29/5/1987, Bartolo, Brullo, Minissale e Spampinato (CAT). USTICA – Ustica, 1854, s. Coll. (PAL!). FILICUDI – Filicudi, 30-4-1980, Brullo (CAT!). Records from literature: PALERMO – Gonato (Minà Palumbo 1844; Strobl 1878); Lercara, *in humidis et ad sepes, januario martio* (Tornabene 1887), Bonagia (Ponzo 1900); M. di Palermo: Rocca dell'Aquila (Marcenò and Ottonello, 1991); M. di Palermo: M. Saraceno, Fiume S. Elia a Valle di Pioppo, Pizzo Valle Fico (Pasta and Troia 1994); TRAPANI – Castello della Pietra o Riserva Zangara, Castelvetrano, (Pasta et al., 2008). AGRIGENTO – S. Magherita (Senni 1992; Pavari 1932; Giacobbe 1939); Cammarata in contrada Salaci (Bonomo et al. 1977); Bivona (Catanzaro 1970); Sambuca di Sicilia, SW side of Lago Arancio (unpublished observation). CATANIA – Randazzo (Strobl 1880); Battiati, S. Giovanni La Punta, Valverde, Aci S. Antonio, Viagrande, Mascalucia, Pedara (Tornabene 1891). MESSINA – S. Fratello (Strobl 1880); Vallone Lacino, Vallone Mandrazza (Gramuglio et al. 1978); Capo S. Alessio (Gramuglio et al. 1959; Peloritani: Pizzo Toscana al V.ne Soldato (Triscari), Frazzano` Giammello (Venturella et al. 1990). LAMPEDUSA – Isola di Lampedusa (Calcara 1847); Vallone dello Scoglio (Gussone 1842; Lojacono 1904).

Study area

The Madonie Mountains are one of the biodiversity hotspots of the Mediterranean basin because of their varied ecology and the remarkable richness of the flora, which includes more than 20% of endemic taxa (Quézel 1985; Médail and Quézel 1997, 1999; Blondel and Aronson 1999). Previous floristic and ecological studies (Pignatti et al. 1980; Raimondo 1980; Brullo 1984) have confirmed this high level of diversity and originality but it remains not fully explored. In fact, recent studies have allowed us to describe new taxa (Raimondo and Di Gristina 2007; Marino et al. 2012; Raimondo et al. 2012) and to characterize new communities (Marino, Guarino and Bazan 2012).

Our researches were carried out on the Tyrrhenian slope of the Madonie Mountains (Figure 1), i.e. their northeastern portion: the catchment area of the torrents Cava and Vicaretto, in the municipality areas of Castelbuono and Geraci Siculo. The first specific reports on the occurrence of the laurel in this area were provided by Raimondo, Mazzolo and Castiglia (1980; see also Raimondo et al. 2012).

Materials and methods

Following the phytosociological approach (Braun-Blanquet 1964; Géhu 1988; Biondi 2004), 12 vegetation relevés were sampled in the study area. The chord distance algorithm was adopted to calculate the pairwise dissimilarity coefficients between the 12 new relevés, plus 51 relevés from all the Sicilian laurel communities described so far. Then, the comparison was extended to the whole Mediterranean and Atlantic Region where laurel forests are occurring, through the processing of 65 synoptic tables taken from available literature. All numerical analyses were performed by means of the Syntax 2000 package (Podani 2001). Species recorded only once in the processed relevés were discarded.

The distribution of *Laurus nobilis* in Sicily was mapped on the basis of literature, herbarium specimens and field data (Figure 1). The map grid follows Ehrendorfer and Hamann (1965).

The syntaxonomical arrangement of the 12 new relevés agrees with the syntaxonomical lists of Rivas-Martínez et al. (2002) and Brullo et al. (2001, 2008, 2012). The description of the new association conforms to the international code of phytosociological nomenclature (Weber, Moravec and Theurillat 2000). Plant nomenclature follows Giardina, Raimondo and Spadaro (2007) and Raimondo, Domina and Spadaro (2010). Bioclimatic classification follows Rivas-Martínez et al. (2002). The approach for the climatic gradients assessment followed Mazzoleni, Lo Porto and Blazi (1992).

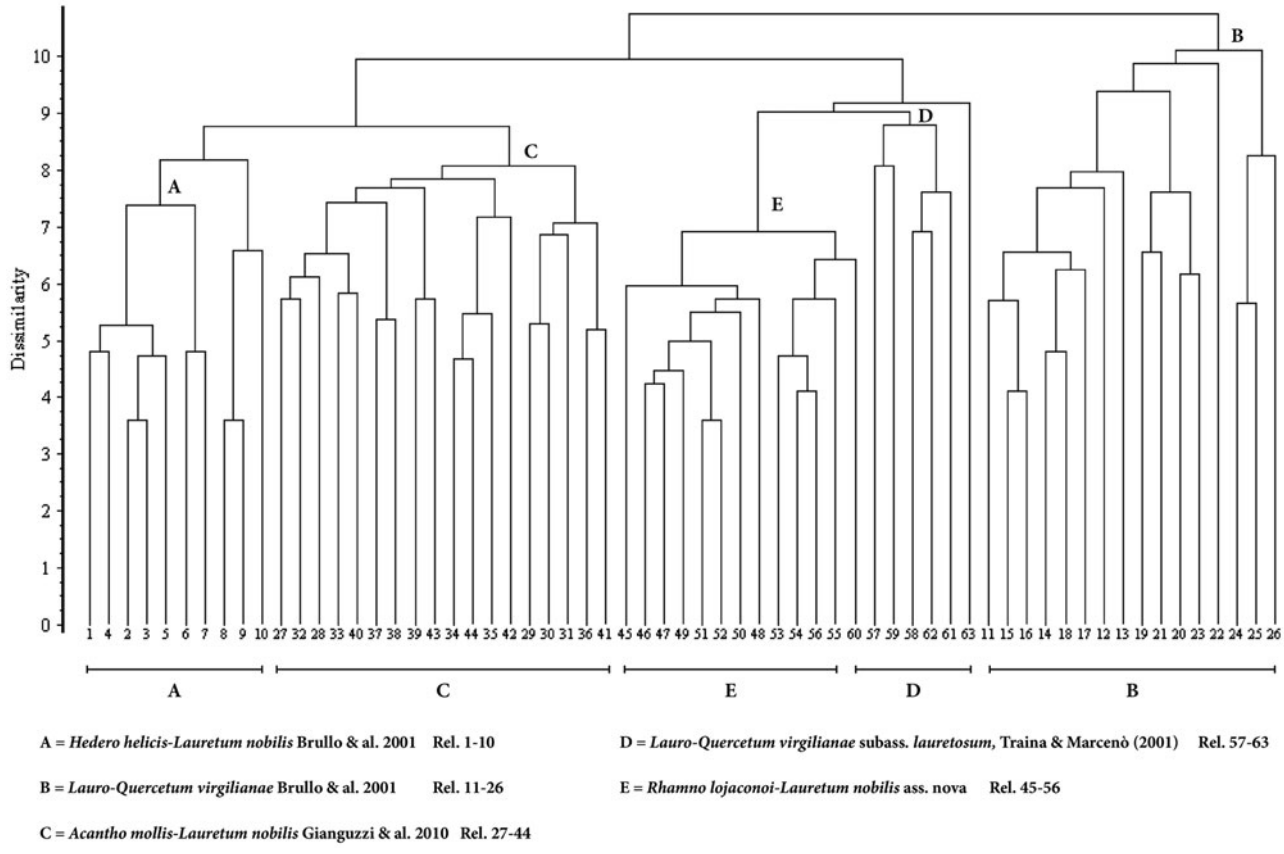

Figure 2. Dendrogram of the 63 Sicilian relevés. Algorithm: complete link, euclidean distance, frequency data.

Results

The cluster diagram of the Sicilian laurel vegetation is shown in Figure 2. Five main clusters can be recognized, as follows:

- *Cluster A* comprises 10 relevés of *Hedero helicis–Lauretum nobilis* of southern Sicily, by Brullo, Costanzo and Tomaselli (2001).
- *Cluster B* comprises 16 relevés of *Lauro–Quercetum virgilianae* relevés, by Brullo, Costanzo and Tomaselli (2001).
- *Cluster C* comprises 18 relevés of *Acantho mollis–Lauretum nobilis* of the Sicani Mountains, by Gianguzzi, D'Amico and Romano (2010).
- *Cluster D* comprises seven relevés of *Lauro–Quercetum virgilianae lauretosum* of Oreto River near Palermo, by Traina and Marcenò (2001).
- *Cluster E* comprises 12 relevés of a new association, here proposed and named *Rhamno lojaconoi–Lauretum nobilis* (*typus nominis*: Table 1, relevé nr. 2, *hoc loco*). Basing on its floristic settlement, this new association can be framed into the alliance *Quercion ilicis*, the order *Quercetalia ilicis*, the class *Quercetea ilicis*. In a more restrictive view, emphasizing the floristic autonomy of the Italian peninsula, the new association could also be framed into the alliance *Fraxino orni–Quercion ilicis*, recently proposed by Biondi, Casavecchia and Gigante (2003).

Character species

Laurus nobilis (loc.), *Rhamnus lojaconoi*.

Differential species

Vitis vinifera subsp. *sylvestris*

Description

Thermo-mesophilous thicket vegetation localized in north-facing river valleys in the Madonie Mountains. It is characterized by the local abundance of *Laurus nobilis* and by the occurrence of *Rhamnus lojaconoi*. This very rare and highly localized endangered species is a Sicilian endemic, closely related to *R. glandulosa* of the Canary Islands. It confers to the community an Atlantic connotation and a markedly relict character (Raimondo 1979). *Vitis vinifera* subsp. *sylvestris*, quite a rare floristic element in Sicily, highlights the riverine character of the association. *Laurus nobilis* forms the tree layer, together with *Quercus ilex* and *Q. virgiliana*. Others taxa of *Quercetalia ilicis* with high frequency are: *Asplenium adiantum-nigrum*, *Rubia*

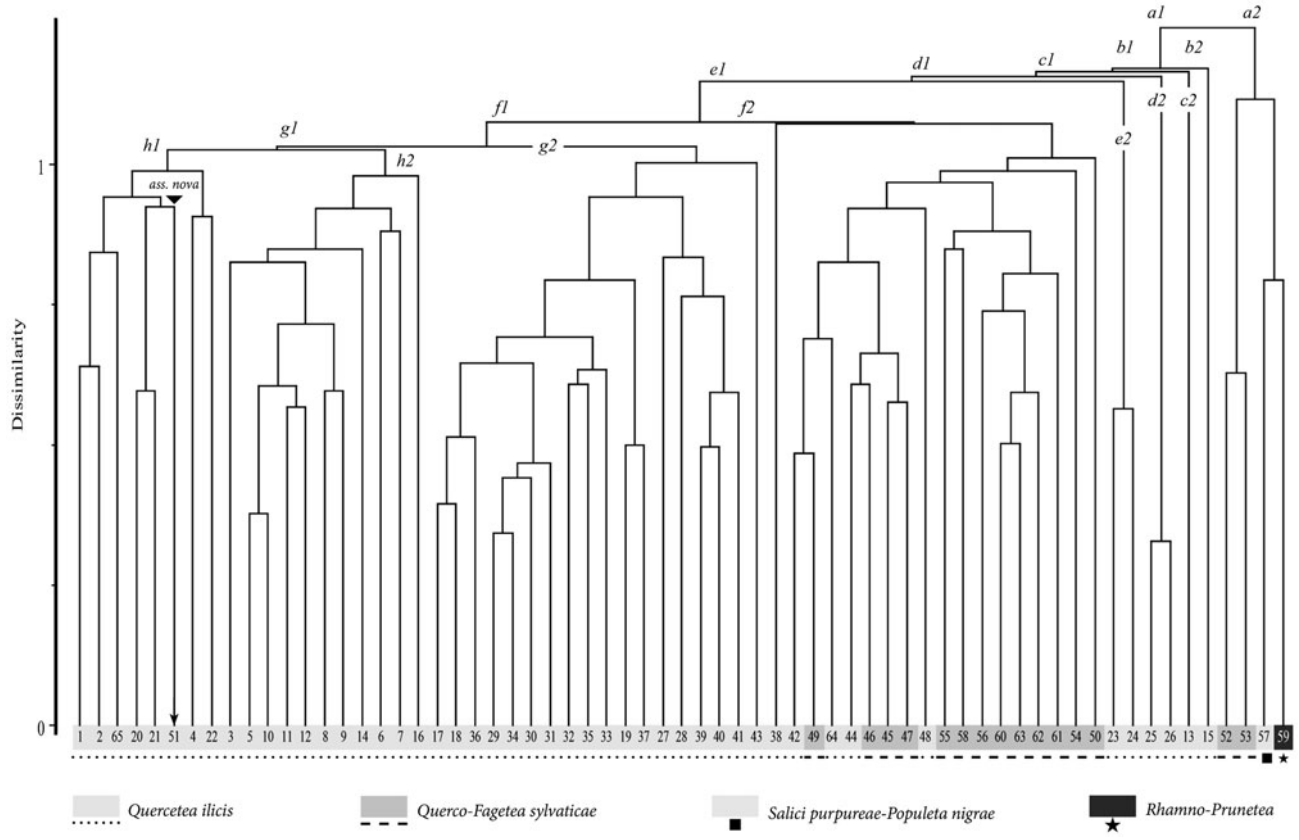

Figure 3. Dendrogram of the 65 Mediterranean and European laurel woodlands cited in Table 2. Algorithm: complete link, chord distance, frequency data.

Table 1. *Rhamno lojaconoi–Lauretum nobilis* ass. nova.

	Progressive number	1	2	3	4	5	6	7	8	9	10	11	12		
	Altitude (m)	530	530	520	550	560	530	560	350	450	300	350	400		
	Area (m^2)	100	120	150	150	180	120	150	100	180	200	150	120		
	Slope (%)	10	12	15	15	18	12	15	10	18	20	15	12		
	Exposure	NW	NW	NW	W	NW	W	NW	N	N	NE	NW	W		
Biotypes	Number of taxa	34	28	34	23	39	30	22	27	28	24	23	15	Presence	Costancy
	Car. *Rhamno lojaconoi–Lauretum nobilis*														
P	*Laurus nobilis* L.	5	3	3	3	3	2	2	3	4	3	3	3	12	V
P	*Rhamnus lojaconoi* Raimondo	.	**1**	.	.	.	.	.	.	.	.	.	.	1	I
	Differential														
P	*Vitis vinifera* subsp. *sylvestris* (C. C. Gmel.) Hegi	+	+	+	.	.	+	.	.	.	.	.	.	4	II
	Car. *Quercetea ilicis* and *Quercetalia ilicis*														
T	*Rubia peregrina* L. subsp. *peregrina*	2	1	1	2	+	+	+	1	+	1	+	+	12	V
Ch	*Ruscus aculeatus* L.	2	1	1	+	1	1	+	1	1	1	3	.	11	V
H	*Asplenium adiantum-nigrum*	+	+	+	1	+	2	+	+	.	+	1	.	10	V
NP	*Asparagus acutifolius* L.	+	.	+	.	+	+	.	+	+	+	+	+	9	IV
P	*Quercus ilex* L.	+	2	2	2	2	2	1	2	1	.	.	.	9	IV
NP	*Smilax aspera* L.	2	+	2	+	1	+	+	+	.	.	.	.	8	IV
P	*Phillyrea latifolia* L.	+	+	1	1	+	2	+	+	.	.	.	.	8	IV
P	*Quercus virgiliana* (Ten.) Ten.	.	.	+	+	+	1	.	.	+	+	1	1	8	IV
H	*Asplenium trichomanes* subsp. *Quadrivalens* D. E. Mey	+	.	.	.	+	+	+	+	+	.	.	.	6	III
G	*Cyclamen hederifolium* Aiton subsp. *hederifolium*	+	1	+	+	1	+	.	+	.	.	.	.	7	III
P	*Erica arborea* L.	+	+	+	.	1	2	.	.	.	.	.	.	5	III
G	*Tamus communis* L.	+	+	+	.	.	.	+	+	.	.	.	.	5	III
NP	*Rosa sempervirens* L.	.	.	.	.	.	.	+	.	+	+	+	+	5	III
P	*Arbutus unedo* L.	.	.	.	2	+	+	.	.	.	+	.	.	4	II
P	*Rhamnus alaternus*	.	.	.	.	.	.	.	+	.	+	1	1	4	II
H	*Teucrium scorodonia* subsp. *Crenatifolium* (Guss.) Arcang.	.	.	+	.	+	.	.	.	.	.	.	.	2	I
P	*Calicotome infesta* subsp. *intermedia* (C. Presl) Greuter	.	.	.	.	.	.	.	.	+	.	+	.	2	I
NP	*Euphorbia characias* L.	.	.	.	.	.	.	.	.	+	.	.	+	2	I
H	*Carex distachya* Desf.	.	.	.	.	+	.	.	+	.	.	.	.	2	I
P	*Ulmus canescens* Melville	.	.	.	.	.	.	.	.	.	.	1	.	1	I
	Characteristics of Querco–Fagetea sylvaticae* and *Fagetalia sylvaticae														
P	*Hedera helix* L. subsp. *helix*	3	1	2	2	2	+	+	+	+	+	2	+	12	V
G	*Polystichum setiferum* (Forssk.) Woynar	2	1	1	+	+	+	+	+	+	+	+	+	12	V
P	*Euonymus europaeus* L.	+	+	+	.	+	+	+	+	.	.	.	.	7	III
H	*Lamium flexuosum* Ten.	+	+	+	+	+	.	.	.	+	.	+	.	7	III
P	*Daphne laureola* L.	+	+	+	+	+	+	.	.	.	.	.	.	6	III
T	*Geranium robertianum* L. subsp. *robertianum*	+	+	+	.	+	.	+	+	+	.	.	.	7	III
H	*Clinopodium vulgare* subsp. *orientale* Bothmer	.	.	.	.	+	.	.	.	.	+	.	.	2	I

(*Continued*)

Table 1. (*Continued*).

Biotypes															
	Progressive number	1	2	3	4	5	6	7	8	9	10	11	12		
	Altitude (m)	530	530	520	550	560	530	560	350	450	300	350	400		
	Area (m^2)	100	120	150	150	180	120	150	100	180	200	150	120		
	Slope (%)	10	12	15	15	18	12	15	10	18	20	15	12		
	Exposure	NW	NW	NW	W	NW	W	NW	N	N	NE	NW	W		
	Number of taxa	34	28	34	23	39	30	22	27	28	24	23	15	Presence	Costancy
	Trasgressives of *Salici purpureae–Populetea nigrae*														
H	*Brachypodium sylvaticum* (Huds.) P. Beauv.	+	+	+	.	+	+	.	+	.	+	.	.	7	III
P	*Salix pedicellata* Desf.	.	.	+	+	.	.	.	.	.	1	+	+	6	III
G	*Arum italicum* Mill.	+	+	+	.	.	+	.	.	+	.	.	.	5	III
P	*Ficus carica* L.	+	.	+	.	.	.	.	.	.	.	+	.	3	II
NP	*Hypericum hircinum* subsp. *majus* (Aiton) N. Robson	+	.	.	.	+	+	.	.	.	.	.	.	3	II
P	*Sambucus nigra* L.	.	.	.	.	+	.	.	.	.	.	.	.	1	I
NP	*Solanum dulcamara* L.	.	.	.	.	.	.	.	.	.	.	+	.	1	I
P	*Salix alba* L. subsp. *alba*	.	.	.	.	.	.	.	.	.	.	+	.	1	I
	Trasgressives of *Rhamno–Prunetea*														
NP	*Rubus ulmifolius* Schott	+	1	1	+	+	+	+	+	+	+	+	+	12	V
P	*Clematis vitalba* L.	+	+	+	.	+	+	.	+	1	+	+	+	10	V
P	*Crataegus monogyna* Jacq. var. *monogyna*	+	+	+	.	+	+	+	.	.	.	.	.	6	III
P	*Prunus spinosa* L.	.	.	.	.	.	.	.	.	+	+	+	+	4	II
NP	*Rosa canina* L.	.	.	.	.	.	.	.	.	.	+	+	.	2	I
	Companions														
Ch	*Selaginella denticulata* (L.) Spring	+	+	+	.	+	+	+	+	.	+	+	.	9	IV
G	*Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*	+	+	1	+	+	+	+	+	.	.	.	.	8	IV
H	*Bituminaria bituminosa* (L.) E. H. Stirton	1	+	1	+	+	+	.	+	+	.	.	.	8	IV
H	*Acanthus mollis* L.	+	+	.	.	+	.	.	.	+	+	.	.	5	III
H	*Calamintha nepeta* (L.) Savi subsp. *nepeta*	+	+	+	.	+	.	+	+	+	.	.	.	7	III
H	*Polypodium cambricum* L.	+	.	.	.	+	.	+	2	+	.	.	.	5	III
NP	*Cistus salvifolius* L.	.	.	+	.	+	+	.	+	+	.	.	.	5	III
H	*Prunella vulgaris* L.	.	.	+	+	+	+	.	.	.	.	.	.	4	II
P	*Corylus avellana* L.	.	.	.	.	.	.	.	.	.	+	+	+	3	II
T	*Hyoseris radiata* L.	.	.	.	+	.	+	+	.	.	.	.	.	3	II
NP	*Coronilla valentina* L.	.	.	.	.	.	.	.	+	+	.	.	.	2	I
H	*Agrimonia eupatoria* L.	.	.	.	.	.	.	.	.	.	+	.	+	2	I
P	*Sorbus domestica* L.	.	.	.	+	+	.	.	.	.	.	.	.	2	I
	Accidental species	1	0	1	2	2	0	1	0	4	2	0	0		

Table 2. List of Mediterranean and European laurel associations used for statistical analysis.

ID	Sintaxa	Location	Classes	Order	Alliance
1	Gianguzzi et al., 2010; Table 1- *Achantho mollis-Lauretum nobilis*	Italy, Sicily (Sicani Mts)	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
2	Brullo et al., 2001; Table1 – *Hedero helicis-Lauretum nobilis*	Italy, Sicily (Iblei Mts)	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
3	Bacchetta et al., 2007; Table 1. rels. 1-15 – *Celtido australis-Lauretum nobilis*	Italy, Sardinia	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
4	Allegrezza et al., 2006; Table 4 – *Fraxino orni-Lauretum nobilis*	Central Italy	*Quercetea ilicis*	*Quercetalia ilicis*	*Fraxino orni-Quercion ilicis*
5	Bueno Sànchez and Fernàndez Prieto, 1991; Table 3 – *Hedero helicis-Lauretum nobilis*	Spain, Cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
6	Loidi et al.,1997; Table 25, rel. 32 – *Hedero helicis-Lauretum nobilis*	North-central, Spain	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
7	Dìas Gonzàles and Fernandez Prieto 1994; rel. type – *Calluno vulgaris- Lauretum nobilis*	Spain, Asturias	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
8	Àlvares Arbesu, 2005 – *Calluno vulgaris-Lauretum nobilis*	Spain, Asturias	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
9	*Calluno vulgaris- Lauretum nobilis* (Rodrìguez Guitiàn et al., 2007; Table 3, rels. 1-27)	Spain, Cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
10	Bueno Sànchez and Fernàndez Prieto, 1991 – *Tamo communis-Lauretun nobilis*; sub *Hedero helicis-Lauretum nobilis* subass. *euphorbietosum amygdaloides*	Spain, Cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
11	Àlvarez Arbesu, 2005; sub *Hedero helicis-lauretum nobilis – Tamo communis-Lauretum nobilis*	Spain, Asturias	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
12	Rodriguez Guitiàn et al., 2007; Table 5, rels. 1-19 – *Tamo communis-Lauretum nobilis*	Spain, cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
13	Honrado et al., 2003- *Omphalodo nitidae-Lauretum nobilis*	Portugal, Galaico-Portuguese e Geresiano	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
14	Rodrìguez Guitiàn et al., 2007; Table 5, rels. 22-30 – *Holco mollis-Lauretum nobilis*	Spain, cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
15		Greece, Kefallonia	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*

(*Continued*)

Table 2. (*Continued*).

ID	Sintaxa	Location	Classes	Order	Alliance
	Bolòs et al., 1996; Table 6 – *Hedero helicis-Lauretum nobilis*				
16	Loidi et al., 1997; Table 25, rel. 32 – *Hedero helicis-Lauretum nobilis*	North-central, Spain	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
17	Loidi et al., 1994; Table 1, rels. 20-38 – *Phyllireo latifoliae-Arbutetum unedonis arbutetosum*	Spain, Cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
18	Loidi et al., 1997; Table 25, rels. 26-31 – *Phyllireo latifoliae-Arbutetum unedonis*	North-central, Spain	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
19	Bueno Sànchez and Fernàndez Prieto, 1991; Table 2 – *Lithodoro diffusae-Oleetum europeae*	Spain, Cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia calliprini*	*Arbuto unedonis-Laurion nobilis*
20	Brullo et al., 2001; Table 2, rels. 1-13 – *Lauro-Quercetum virgilianae lauretosum*	Sicily, Ragusa	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
21	Brullo et al., 2001; Table 2, rels. 14-16 – *Lauro-Quercetum virgilianae mespiletosum*	Sicily, Ragusa	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
22	Montellucci, 1946; rels. p. 46-47 – *Lauro-Quercetum virgilianae*	Italy, Lazio	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
23	Barbero and Quezel, 1994; Table 15 – *Rusco hypopylli-Quercetum canariensis*	Morocco, Spain, Southern France	*Quercetea ilicis*	*Quercetalia ilicis*	*Oleo sylvestris-Quercion rotundifolio-suberis*
24	Barbero et al., 1981; Table 5 – *Rusco hypopylli-Quercetum canariensis*	Morocco, Spain, Southern France	*Quercetea ilicis*	*Quercetalia ilicis*	*Oleo sylvestris-Quercion rotundifolio-suberis*
25	Knapp, 1965; Table 11, D – *Phillyreo-Quercetum calliprini*	Greece	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
26	Knapp, 1965; Table 11, E – *Phillyreo-Quercetum calliprini*	Greece	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
27	Barbero and Quezel,1980; Table 5, rels. 11-18 – *Andracnho-Quercetum ilicis*	Crete	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
28	Horvat. et al.,1974; Table 11, 5 – *Andracnho-Quercetum ilicis*	Croatia	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
29	Navarro 1982; Table 35, by Rivas-Martinez et al. 1991; Table 35, 1 – Lauro-Quercetum ilicis	Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
30	Loidi 1983; Table 42, by Rivas-Martinez et al. 1991; Table 35, 2 – Lauro-Quercetum ilicis	Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
31		Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*

	Braun-Blanquet 1967; Table 33, by Rivas-Martinez et al. 1991; Table 35, 3 – Lauro-Quercetum ilicis				
32	Onaindia 1986; Table 6, rels. 2, 6-12, by Rivas-Martinez et al. 1991; Table 35, 4 – Lauro-Quercetum ilicis	Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
33	Onaindia 1986; Table 86, rels 13-18, by Rivas-Martinez et al. 1991; Table 35, 5 – Lauro-Quercetum ilicis	Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
34	Herrera, 1989; Table 79, by Rivas-Martinez et al. 1991;Table 35, 7 – Lauro-Quercetum ilicis	Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
35	Loriente, 1978; Table 3, by Rivas-Martinez et al., 1991; Table 35, 8 – Lauro-Quercetum ilicis	Spain, W-Pirineo and Navarra	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
36	Loidi et al., 1997; Table 19 – *Lauro-Quercetum ilicis*	North-central, Spain	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
37	Bueno et al.1991; Table 4 – *Lauro-Quercetum ilicis*	Spain, Cornisa Cantábrica	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
38	Biondi 1972; rel. 2 p.75 – *Lauro-Quercetum ilicis*	Italy, Marche	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
39	Horvat et al. 1974; Table 11, 9 – *Lauro-Quercetum ilicis*	Croatia	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
40	Horvat et al. 1974; Table 11, 10 – *Lauro-Quercetum ilicis*	Croatia	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
41	Horvat et al. 1974; Table 11, 11 – *Lauro-Quercetum ilicis*	Croatia	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
42	Brullo and Guarino, 1998; Table 2 – *Lauro-Quercetum ilicis*	Northern Italy, Garda	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
43	Barbero and Quezel 1994; Table 5) *Lauro-Quercetum pubescentis*	Southern France	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
44	Biondi 1982; Table 1, rels . 12-18 – *Ostryo-Quercetum ilicis aceretosum obtusati*	Italy, Marche	*Quercetea ilicis*	*Quercetalia ilicis*	*Erico-Quercion ilicis*
45	Ubaldi et al. 1984; Table 3, rels. 3-4 – *Asparago acutifolii-Ostryetum carpinifoliae*	Italy, Marche (Pesaro-Urbino)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
46	Biondi 1982; Table 2, rels. 6-12 – *Asparago acutifolii-Ostryetum carpinifoliae*	Italy, Marche (Ancona)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
47	Ubaldi 1988; Table 13 – *Asparago acutifolii-Ostryetum carpinifoliae*	Italy, Marche (Pesaro-Urbino)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
48		Italy, Sicily (Messina)	*Quercetea ilicis*	*Quercetalia ilicis*	*Erico-Quercion ilicis*

(*Continued*)

Table 2. (*Continued*).

ID	Sintaxa	Location	Classes	Order	Alliance
	Bartolo et al., 1990; Table 8, rels. 8-12 – *Acero obtusati-Ostryetum carpinifoliae tilietosum plathiphylli*				
49	Brullo and Guarino 1998; Table 7 – *Lauro-Ostryetum carpinifoliae*	Italia sett. Lake Garda	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
50	Horvat et al., 1974; Table 29,7 – *Carpinetum orientalis lauretosum*	Croatia	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
51	*Rhamno lojaconoi-Lauretum nobilis* ass. nova	Sicily	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
52	Brullo and Guarino, 1998; Table 9, rels. 1-6 – *Lauro-Alnetum glutinosae salicetosum eleagni*	Itaty, Lake Garda	*Querco-Fagetea*	*Populetalia albae*	*Alno-Ulmion*
53	Brullo and Guarino, 1998; Table 9, rels. 7-10 – *Lauro-Alnetum glutinosae ulmetosum minoris*	Itaty, Lake Garda	*Querco-Fagetea*	*Populetalia albae*	*Alno-Ulmion*
54	Lucchese and Pignatti, 1990; Table 10 – *Lauro-Carpinetum betuli*	Italy, Lazio	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
55	Biondi and Allegrezza, 2004; table 1 – *Roso sempervirentis-Quercetum pubescentis laureetosum nobilis*	Italy, Selva di Gallignano	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
56	Pedrotti and Gafta, 1992 -*Rubio peregrinae-Fraxinetum oxycarpae*	Outhern Italy	*Querco-Fagetea*	*Populetalia albae*	*Alno-Quercion roboris*
57	Issler, 1926 – *Salicetum albae*	Italy, Marche (Ancona)	*Salici purpureae-Populetea nigrae*	*Populetalia albae*	*Salicion albae*
58	Allegrezza and Biondi, 2002 – *Roso sempervirentis-Coryletum avellanae*	Italy, Marche (Ancona)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
59	Biondi and Allegrezza 2004; Table 7 – *Symphyto bulbosi-Sambucetum nigrae*)	Italy, Marche (Ancona)	*Rhamno-Prunetea*	*Prunetalia spinosae*	*Pruno-rubion ulmifolii*
60	Taffetani and Biondi, 1995; Biondi and Allegrezza, 1996; Allegrezza, and al. 2002a – *Lonicera xylostei-Quercetum cerridis* subass. *Loniceretosum xylostei*	Italy, Marche (Ancona)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
61	Taffetani and Biondi, 1995; Biondi and Allegrezza, 1996 – *Lonicera xylostei-Quercetum cerridis subass.*	Italy, Marche (Ancona)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*

	ericetosum arborae (Allegrezza and Biondi, 2002)				
62	Biondi ex Ubaldi, 1995 – *Asparago acutifolii-Ostryetum carpinifoliae* subass. *asparagetosum acutifolii* (Biondi, 2004; Table 3)	Italy, Marche (Ancona)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
63	Allegrezza and Biondi, 2002 – *Asparago acutifolii-Ostryetum carpinifoliae* subass. *fraxinetosum oxycarpae*	Italy, Marche (Ancona)	*Querco-Fagetea*	*Quercetalia pubescentis*	*Ostryo-Carpinion orientalis*
64	Brullo and Guarino, 1998 – *Lauro nobilis-Quercetum ilicis* (Br.–Bl. 1967) Rivas Martinez 1975, *ostryetosum carpinifoliae*	Itaty, Lake Garda	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*
65	Traina and Marcenò, 2001 Table 4 – *Lauro-Quercetum virgilianae* subass. *lauretosum*	Italia, Sicily (Palermo)	*Quercetea ilicis*	*Quercetalia ilicis*	*Quercion ilicis*

peregrina, *Ruscus aculeatus* and *Asparagus acutifolius*. The following transgressive species from the class *Querco–Fagetea* are also very frequent: *Euonymus europaeus*, *Hedera helix*, *Clematis vitalba* and *Daphne laureola*. Besides *Asplenium adiantum-nigrum*, vascular cryptogams are represented by *Polystichum setiferum,* and *Selaginella denticulata*. The overall floristic settlement testifies the microclimatic peculiarity of their growing sites, where they were confined by the climatic vicissitudes which ended the Tertiary age.

Structure and ecology

Dense thicket varying from 6 to 12 m in height; canopy relatively open, with 50–80% cover; shrubby layer very dense, formed by woody climbers and shrubby phanerophytes; herb layer with few geophytes and some hemicryptophytes. These woods are found in ravines and more rarely on open north-facing slopes, at altitudes between 300 and 560 m above sea level; the substratum is rich in debris of quarzarenitic and limestone rocks.

In these shady sites, the microclimate is influenced by the northern exposure and by the proximity to the Tyrrhenian sea, which buffer the seasonal and daily temperature ranges. In spite of the moisture in the air, soils are well drained and fairly dry during the summer period. The inner parts of the river valleys flowing into the Tyrrhenian Sea along the northern coast of Sicily represent a conservative cradle for many species, like *Rhamnus lojaconoi*, that are otherwise doomed to disappear.

Bioclimate

Lower and upper mesomediterranean, with subhumid–humid ombrotype (Bazan et al. 2006).

The statistical analysis of the Sicilian laurel woods (Figure 2) confirms the autonomy of *Rhamno lojaconoi–Lauretum nobilis* with respect to the other Sicilian communities. Its closest similarity is with the laurel community of the Oreto River near Palermo (Figure 2, rel. 57–63), which is geographically the nearest, with the same bioclimatic conditions (Bazan et al. 2006). Within the class *Quercetea ilicis*, all Sicilian associations show ecological and syntaxonomical similarities to various others found on the Iberian peninsula, in France and in southern Italy (Figure 3). In particular, the group *h1* comprises all Sicilian syntaxa, plus the *Fraxino orni–Lauretum nobilis* (clade nr. 4) association described from Central Italy (Allegrezza, Biondi and Felici 2006); the group *h2* includes Sardinian, Spanish, Portuguese and Greek plant communities; the group *g2* again includes Spanish laurel woodlands, especially those of Pyrenees and Navarra, together with Croatian and Cretan associations; the group *f2* includes almost all aspects of *Querco–Fagetea* with the exception of nos. 42 and 48 from the Garda Lake (Brullo and Guarino 1998), 44 from Marche (Biondi 1982), and 64 from northeastern

Table 4. Character *taxa* occurring in the processed relevés (left) and their distribution frequency.

	No. of taxa	Percentage	Frequency	Percentage
Querco–Fagetea sylvaticae	105	32.71%	938	50.59%
Quercetea ilicis	47	14.64%	551	29.72%
Rhamno–Prunetea	3	0.93%	24	1.29%
Salici purpureae–Populetea nigrae	5	1.56%	39	2.10%
Others	161	50.16%	302	16.29%
Total	321	100.00%	1854	100.00%

Sicily (Bartolo et al. 1990); groupings *b2*, *c2*, *d2* and *e2* represent mainly Moroccan and Greek laurel woodlands.

Overall, we processed 65 phytosociological tables of laurel vegetation mentioned in literature (Table 2): 15 ascribed to *Querco–Fagetea*, 48 to *Quercetea ilicis*, one to *Rhamno–Prunetea* and one to *Salici purpureae–Populetea nigrae* (Figure 3). A multivariate analysis of the synoptic Table 3 (see online) highlights two main groups, *f1* and *f2* (Figure 3), plus some minor ones (*b2*, *c2*, *d2*, *e2* etc.). Group *f1* comprises all clades that pertain to *Quercetea ilicis,* whereas grouping *f2* includes those of *Querco–Fagetea*, with the exception of clades nr. 38, 42, 48, 64. All Sicilian laurel woodlands were included in the grouping *h1*.

The quantitative and quantitative analyses of classes (Table 4) show a higher proportion of taxa of *Querco–Fagetea sylvatica* (105 taxa, with a relatively high frequency of presence) in comparison with those of *Quercetea ilicis* (47 taxa), *Rhamno–Prunetea* and *Salici purpureae–Populetea nigrae*.

Discussion

The best preserved relict laurophyll vegetation occurs in the Canary Islands (Oberdorfer 1965; Fernández-Palacios et al. 2011), in the Lusitanic and Colchidic floristic provinces (Walter 1968) and, mostly as xeromorphic derivatives, in the Mediterranean region (Schmid 1970). In Sicily, like in the Iberian Peninsula (Benito Garzón and Sainz de Ollero 2002), the response of the old tropical flora to the climatic deterioration gave rise to new vegetation types. The laurel itself may have adapted to the Mediterranean climate, becoming able to withstand both the summer drought and the winter cold stresses. Other species, such as *Chamaerops humilis*, *Arbutus unedo*, *Rhamnus alaternus* and *Phillyrea angustifolia*, which became typical members of the Mediterranean maquis, may have undergone a similar adaptation (Mitrakos 1980a, 1980b), whereas other thermophilous species, like *Rhamnus lojaconoi*, *Ptilostemon greuteri*, *Woodwardia radicans*, *Pteris vittata*, *Cytisus aeolicus*, may have shown limited adaptive potential and persist only as relicts, in refugia characterized by high mean annual precipitation, on northern slopes exposed to the mitigation of the Tyrrhenian Sea, or in sheltered canyons (Pignatti 1979), where the tropical moisture is in part compensated by the running water. Similarly, many other important Tertiary relict taxa persisted in Sicily on north-facing cliffs on the Tyrrhenian Sea.

In Sicily, *Laurus nobilis* is widely cultivated and often becomes naturalized in the vicinity of human settlements. We concur with Filibeck (2006) in considering that few populations can be considered to be native, in particular those found in natural areas, away from modern and/or ancient human settlements. This assumption is supported by the fossil record of the species in Sicily (Béguinot 1929).

All in all, the laurel woods in the Madonie Mountains described here are in good condition and have a fair regeneration capacity. This is consistent with the high degree of naturalness of the ravines and valleys in which the laurel is present, and with the fact that their environs are now little used agriculturally. Nevertheless, *Rhamnus lojaconoi* is a very rare, potentially endangered member of the Sicilian dendroflora, and its growing sites are to be considered a priority habitat according to the EU-Directive 92/43/EEC.

One of the newest issues in the policy of the Sicilian administration is the protection of natural and cultural landscapes. The growing sites of *R. lojaconoi* are included in the Regional Park of Madonie Mountains, which was established in 1989. The aim of the protected area system is to promote conservation strategies for threatened habitats and species. Unfortunately, these intentions, particularly in Sicily, are inevitably constrained by the reality of limited economical resources. In addition, people's perception of protected areas is, in most cases, limited to the recreational or aesthetic function of biotopes and biodiversity: a kind of "playground for ecologists" that can be used for outdoor activities and experiential marketing (Guarino 2011; Guarino, Bazan and Marino 2011). Too many habitats and natural sceneries have been irreparably spoiled by senseless interventions to "improve" accessibility and usability. This is the case, for example, of one of the few known populations of *R. lojaconoi*, where the natural vegetation has been damaged to create a picnic area next to the river. Due to its rarity, implementing strategies for *in situ* and *ex situ* conservation of *R. lojaconoi* would be highly desirable.

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Appendix 1. Syntaxonomic scheme

Quercetea ilicis Br.-Bl. ex A. & O. Bolos 1950

Quercetalia ilicis Br.-Bl. ex Molinier 1934 em. Rivas-Martinez 1975

Fraxino orni-Quercion ilicis Biondi, Casavecchia & Gigante 2003

Rhamno lojaconoi-Lauretum nobilis ass. nova

Appendix 2. Locality and date of the relevés

Rel. 1 - Vicaretto, before Acqua Fetente 14/05/2012;
Rel. 2 - Vicaretto, Acqua Fetente 14/05/2012;
Rel. 3 - Vicaretto, stony of Acqua Fetente 15/05/2012;
Rel. 4 - Vicaretto, above Osmundeto 15/05/2012;
Rel. 5 - Vicaretto 16/05/2012;
Rel. 6 - Vicaretto new station of *Rhamnus* 16/05/2012;
Rel. 7 - Monticelli upper 17/05/2012;
Rel. 8 - Monticelli lower 17/05/2012;
Rel. 9 - Right side of Vallone Cartiera close Ponte di Fridda 18/05/2012;
Rel. 10-11-12 - Vallone dell'Alloro 18/05/2012;

Sporadic species: *Acer campestre* L. (rel. 4), *Arundo collina* Ten (rel. 9), *Asperula laevigata* L. (rel. 5), *Athyrium filix-femina* (L.) Roth (rel. 9), *Fraxinus ornus* L., *Ilex aquifolium* L. (rel. 4), *Lonicera etrusca* Santi (rel. 10), *Lonicera implexa* Aiton (rel. 10), *Melica uniflora* Retz. (rel. 1), *Spartium junceum* L. (rel. 9), *Teucrium flavum* L. (rel. 7), *Trifolium repens* L. subsp. *Repens* (rel. 5).