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ORIGINAL ARTICLE

Composition and ecology of the *Quercus coccifera* L. communities along the eastern Adriatic coast (NE Mediterranean)

N. JASPRICA[1], Ž. ŠKVORC[2], K. DOLINA[1], M. RUŠČIĆ[3], S. KOVAČIĆ[4], & J. FRANJIĆ[2]

[1]*Institute for Marine and Coastal Research, University of Dubrovnik, Kneza Damjana Jude 12, P.O. Box 83, HR-20000 Dubrovnik, Croatia;* [2]*Faculty of Forestry, University of Zagreb, Svetošimunska 25, HR-10000 Zagreb, Croatia;* [3]*Faculty of Natural Sciences, Mathematics and Education, University of Split, Teslina 12, HR-21000 Split, Croatia and* [4]*Botanical Garden, Faculty of Science, University of Zagreb, Marulićev trg 9a, HR-10000 Zagreb, Croatia*

Abstract
The aim of this study is to classify and describe all plant communities with *Quercus coccifera* covering the entire eastern Adriatic coast and islands from north Croatia to south Albania, and to relate their species composition, chorotypes and life forms to environmental factors using Pignatti ecological indicator values. From total 70 phytosociological relevés, we identified and described four floristically and ecologically distinctive vegetation communities (two new proposed subassociations, one association and stand each) using TWINSPAN and the Braun-Blanquet classification scheme. In Croatia and Montenegro, *Q. coccifera* is forming macchia within the *Fraxino orni–Quercetum cocciferae pistacietosum lentisci*. *Quercus coccifera* occurs only sparsely in south Croatia as a shrubland within *Fraxino orni–Quercetum cocciferae nerietosum oleandri* subassociation or macchia within the *Erico arboreae–Arbutetum unedonis* association. Despite the difference in biogeographic position and bioclimates, low shrubby Albanian *Q. coccifera* stands are more closely related to the *Q. coccifera* communities from the western Mediterranean. Eastern Adriatic communities appear exclusively within the *Querceta ilicis* vegetation zone and spread within the meso-Mediterranean belt. They nevertheless are an important part of the region's natural heritage and management plans must ensure that all forms of land are used in a sustainable way.

Keywords: *Phytosociology,* Quercetea ilicis, Quercus coccifera, *syntaxonomy, new subassociations, eastern Adriatic*

Introduction

Kermes oak (*Quercus coccifera* L. s.l., Fagaceae) is distributed across almost the entire Mediterranean basin, apart from Egypt (Ozenda 1964). The area of its distribution extends from the northern Adriatic coasts of Croatia (the island of Mali Lošinj, 44°32′ N) to southern Israel (region of Negev, 31°00′ N) and from the Atlantic coast of Portugal (region of Cascais, 9°30′ N) to western Syria (Moutains of an-Nusayriyah or Alaouites, 37°00′ E) (Horvatić 1957; Cañelas 1993). In the south-western part of the Adriatic Basin, it occurs in the most south-eastern Italian region of Puglia (Salento area). In addition, in Italy, the species also occurs in the Ionian side of the Basilicata region, and on Sicily and Sardinia (Conti et al. 2005). *Quercus coccifera* is a common member of the Mediterranean macchia. It also dominates low and high shrub formations in the southern France (Lossaint & Rapp 1971; Poissonet et al. 1978), Spain (Loidi et al. 1994; Terradas 1999), Greece (Papachristou 1998) and in Italy (La Mantia & Gianguzzi 2003; Biondi et al. 2004). The *Q. coccifera* communities are frequently subject to wildfires, associated with cutting and grazing, over the whole Mediterranean area (Türkmen & Düzenli 2005; Pausas et al. 2008).

According to Greuter et al. (1986) and Tutin et al. (1993), Kermes oak corresponds only to *Quercus coccifera* L. Actually, for Italy two species: *Quercus coccifera* L. and *Q. calliprinos* Webb have been recognized (Pignatti 1982; La Mantia & Gianguzzi 2003). By contrast, more recently, again for Italy, Conti et al. (2005) accept only one taxon. In this study, we also recognize one taxon that is referred to as *Q. coccifera* and includes the possible presence of *Q. calliprinos*. Finally, we accepted the results of Toumi and Lumaret (2010) who suggest that

Correspondence: K. Dolina, Institute for Marine and Coastal Research, University of Dubrovnik, Kneza Damjana Jude 12, P.O. Box 83, HR-20000 Dubrovnik, Croatia. Tel: +385 20324728. Fax: +385 20323872. Email: katija.dolina@unidu.hr

Q. calliprinos and *Q. coccifera* are, in fact, two morphotypes closely related genetically and constitute two components of the same species.

The phytosociology of *Q. coccifera*-dominated vegetation formations has been studied across the Mediterranean region, and many different associations and/or subassociations have been described (Tsiourlis et al. 2009 and references therein). In some cases, the same associations were classified under different plant communities. This was explained by the variation in local conditions, despite the fact that there is a constant presence of diagnostic taxa. For example, the very common association *Querco cocciferae–Pistacietum lentisci* was distinguished in subassociations due to local floristic influences and variations in local ecological conditions (Rivas-Martínez et al. 2002). However, the most recent and a very comprehensive description of *Q. coccifera* stands and their character-species in the Mediterranean region, especially in Greece, were given by Tsiourlis et al. (2009).

The amount of *Q. coccifera* cover in three eastern Adriatic countries (Croatia, Montenegro and Albania) is estimated at $<1\%$ of the country's forest area. According to Trinajstić (1975), Kermes oak is considered as helenopalaeophyte, introduced to this part of the Balkans in the time of Ancient Greece. Along the eastern Adriatic, the *Q. coccifera* stands can be found in scattered and mutually isolated formations and may be divided into four sections: (i) northernmost area, including several localities on the north Adriatic island of Mali Lošinj; (ii) southern Croatian localities (region of Dalmatia) covering sites on the islands of Korčula and Mljet, as well as the peninsula of Pelješac, and a few localities in the vicinity of Dubrovnik (Konavle); (iii) a very limited area (only a few hectares) in south Montenegro; (iv) southernmost region, including Albanian stands near the city of Valona (Vlorë, Figure 1). Croatian populations have been statutorily protected since 1969, and most of them are included within the Important Plant Areas of Croatia (Alegro et al. 2010). Kermes oak stands do not have economic value in the investigated area, but their role in local ecology (e.g. protection against erosion) and the aesthetics of landscape seems to be important.

Stands with *Q. coccifera* have been described by Horvatić (1958) in south Croatia as "*Orno-Coccifer-*

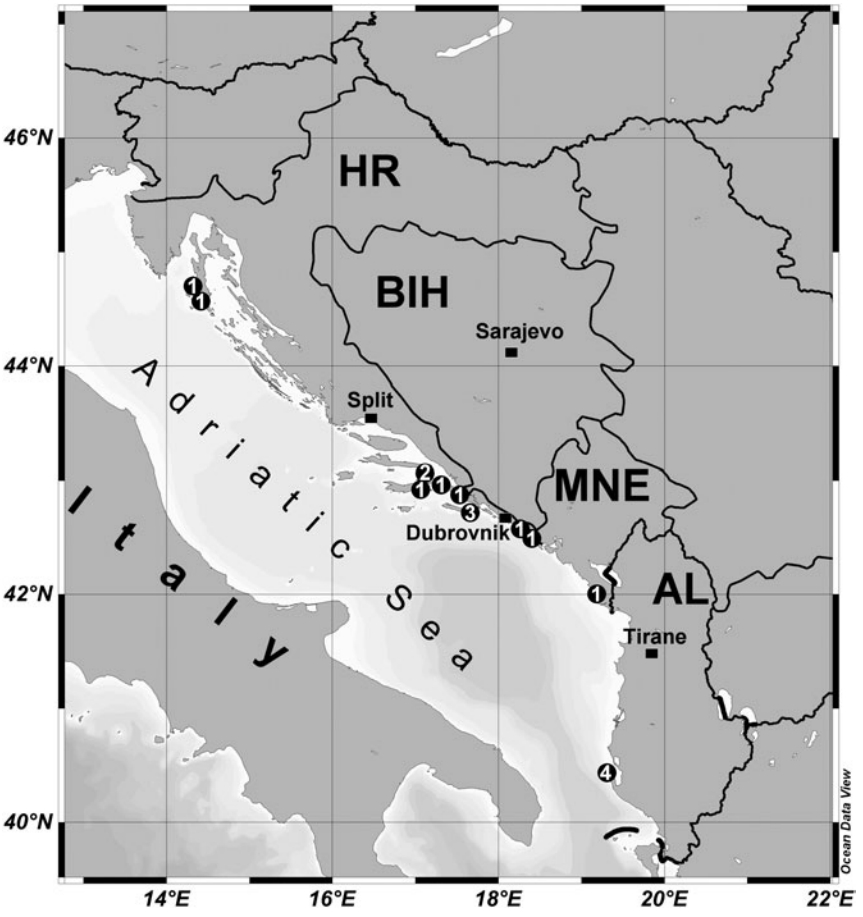

Figure 1. Location of sampling sites and distribution of the *Q. coccifera* communities along the eastern Adriatic Sea. 1, *Fraxino orni–Quercetum cocciferae* subass. *pistacietosum lentisci*; 2, *Fraxino orni–Quercetum cocciferae* subass. *nerietosum oleandri*; 3, *Erico arboreae–Arbutetum unedonis*; 4, Albanian stands – HR, Croatia; BIH, Bosnia and Herzegovina; MNE, Montenegro; AL, Albania.

etum", now noted as the *Fraxino orni–Quercetum cocciferae* association (*sensu* Weber et al. 2000) within the *Quercion ilicis* alliance, namely *Fraxino orni–Quercion ilicis* (*sensu* Biondi et al. 2003). The same association is recorded in Montenegro (Trinajstić 1985) and in south Albania (Hoda & Mersinllari 1996; Dring et al. 2002). Until now, no information on the floristic composition and syntaxonomic characteristics of *Q. coccifera* stands from the other sites along the eastern Adriatic coast and islands has been available. This study is focused on all known sites with *Q. coccifera* stands along the eastern Adriatic coasts.

In this study, for the first time in Croatia, we accepted the opinion of Biondi et al. (2003) that the distribution area of *Quercion ilicis* (*sensu* Braun-Blanquet) is restricted to the Iberian Peninsula, whereas the *Quercus ilex* forests of the entire Italian peninsula (Sicily and Sardinia included) and of the Dinarids have to be ascribed to the amphi-Adriatic alliance *Fraxino orni–Quercion ilicis*.

The objectives of this study were: (i) to bring together all of the available published and recently collected data and investigate the phytosociology and syntaxonomy of *Quercus coccifera*-dominated Mediterranean formations along the eastern Adriatic coasts; (ii) to determine the relation between environmental parameters and the floral compositions of the *Q. coccifera* communities. The results will contribute to the scarce syntaxonomic knowledge on these formations within the *Quercetea ilicis* vegetation zone in the Adriatic Basin.

Study area

The study area of *Quercus coccifera*-stands covers most of the east Adriatic coast, which is the northernmost arm of the Mediterranean Sea, extending from the Strait of Otranto (where it connects to the Ionian Sea) to the northwest and the Po Valley. The investigated area stretches along the western coasts of the Balkan Peninsula – that is, the eastern coast and islands of the Adriatic Sea – from 44°35′ N at the northern Croatian island of Mali Lošinj to 40°29′ N at the Albanian island of Sazani on the south. The whole of the study area is situated in the Mediterranean region, Eastern Mediterranean subregion, Adriatic province and Epiro-Dalmatian Sector (Rivas-Martínez et al. 2004a). Geologically, the area consists mostly of Cretaceous and Eocene limestone (Dimitrijević 1982). Mediterranean limestone soil (calcic cambisol) has developed on this geological formation (Verheye & de la Rosa 2005). According to the bioclimatic classification of Rivas-Martínez (1993, 1997), Rivas-Martínez et al. (1999) and the Bioclimatic Map of Europe (Rivas-Martínez et al. 2004b), the study area has a Mediterranean pluviseasonal-oceanic bioclimate and is situated within the meso-Mediterranean belt. Phytogeographically, the area lies within the *Quercetea ilicis* vegetation zone, where the climate is typically Mediterranean: mild and rainy winters, warm and dry summers, and an extended period of sunshine throughout the year. Over the study area, however, the climatic conditions vary: from the semi-dry conditions of the southern Albanian stands to the relatively subhumid conditions of northern Adriatic coasts (island of Mali Lošinj). Human pressures could not be ignored for some of the investigated sites, particularly in Montenegro.

Material and methods

Communities and relevé data

From 1995 to 2011, 61 phytocoenological relevés were made in Croatia and Montenegro, and nine relevés were taken from the literature for Albania. Relevés were collected using the Braun-Blanquet (1964) approach. In Croatia, seven relevés were collected on the north Adriatic island of Mali Lošinj (44°35′20.88″ N, 14°23′06.06″ E); 44 relevés originated from Dalmatia (south Croatia) of which 27 were taken from the Pelješac peninsula (42°54′37.99″ N, 17°27′11.70″ E); seven were taken from the island of Korčula (42°56′45.66″ N, 17°09′04.48″ E); five were taken from the island of Mljet (42°41′42.60″ N, 17°44′21.84″ E) and five from the vicinity of the city of Dubrovnik (Konavle area, 42°32′45.64″ N, 18°16′33.60″ E). In Montenegro, 10 relevés were collected near the town of Ulcinj (41°57′01.37″ N, 19°10′49.66″ E). In addition, nine relevés from Albanian *Q. coccifera* shrublands (the island of Sazani, 40°29′09.84″ N, 19°17′15.91″ E) were used from Hoda and Mersinllari (1996). Most of the plot sizes were set at 100 m^2, and every effort was made to achieve high ecological and physiognomic homogeneity within each plot (Moravec et al. 1994). The plots were located at various altitudes, expositions and inclinations. The distribution of *Q. coccifera* communities and sampling localities are shown on the map (Figure 1). The system of characterizing species and the nomenclature of higher taxa was derived from Horvat et al. (1974), Mucina (1997) and Rivas-Martínez et al. (2002). The nomenclature of the plant communities was typified, and the criteria necessary to define a new syntaxon were used in accord with the third edition of the International Code of Phytosociological Nomenclature (Weber et al. 2000). The nomenclature of plant species follows the Flora Europaea (Tutin et al. 1964–1980, 1993; Royal Botanic Garden Edinburgh 2011), except for two Croatian endemics [in Table I

Table I. Synoptic table of the studied vegetation communities.

Group no.	1	2	3	4
No. of relevés	46	10	5	9
Quercetea ilicis				
Quercus coccifera L. (incl. *Q. calliprinos* Webb)	100	100	100	100
Asparagus acutifolius L.	78		80	22
Phillyrea latifolia L.	74	70	80	
Smilax aspera L.	61		40	22
Quercus ilex L.	54		80	33
Rubia peregrina L.	48		60	44
Arbutus unedo L.	39	10	100	
Pinus halepensis Miller	28	30	20	
Pistacia lentiscus L.	87		100	22
Pistacia terebinthus L.	20	100	20	22
Lonicera implexa Aiton	67		100	
Clematis flammula L.	63	20		
Viburnum tinus L.	57		80	
Juniperus oxycedrus L. ssp. *oxycedrus*	52	90		
Juniperus oxycedrus L. ssp. *macrocarpa* (Sibth. et Sm.) Ball	39	40		
Myrtus communis L.	33			33
Erica arborea L.	30		100	
Olea europaea L. var. *sylvestris* Brot.	28			22
Laurus nobilis L.	26	20		
Juniperus phoenicea L. ssp. *turbinata* (Guss.) Nyman	20		100	
Calicotome villosa (Poiret) Link (incl. *C. infesta* (C. Presl) Guss.)	11		60	
Cyclamen repandum Sibth. et Sm.	9		20	
Ceratonia siliqua L.	7		20	
Carex hallerana Asso	4	10		
Prasium majus L.	2			44
Ephedra fragilis Desf. ssp. *campylopoda* (C.A. Meyer) Ascherson et Graebner	2	20		
Teucrium flavum L.		30		33
Phillyrea angustifolia L.			100	56
Osyris alba L.	24			
Rosa sempervirens L.	24			
Rubus ulmifolius Schott	24			
Ruscus aculeatus L.	17			
Asplenium onopteris L.	13			
Querco–Fagetea sylvaticae				
Tamus communis L.	22			
Veronica chamaedrys L.	7			
Sorbus domestica L.	7			
Colutea arborescens L.	7			
Fraxinus ornus L.	72	50		
Hedera helix L.	35	10		
Frangula rupestris (Scop.) Schur	15	50		
Cyclamen hederifolium Aiton	13			22
Coronilla emerus L. ssp. *emeroides* (Boiss. et Spruner) Hayek	50	20	60	
Celtis australis L.	9	10		
Paliuretea				
Paliurus spina-christi Miller	15			
Rhamnus intermedius Steudel et Hochst.		30		
Erico-Cistetea				
Spartium junceum L.	37	10		
Cistus creticus L. ssp. *eriocephalus* (Viv.) Greuter & Burdet**	11			78
Fumana thymifolia (L.) Spach ex Webb	9			33
Fumana ericoides (Cav.) Gand.	4		20	
Cistus creticus L. ssp. *creticus***	35	70	100	
Cistus salvifolius L.	35	20	80	
Dorycnium hirsutum (L.) Ser.	11		40	89
Erica manipuliflora Salisb.	13	70	100	33
Teucrium fruticans L.			100	
Thero-Brachypodietea ramosi				
Piptatherum miliaceum (L.) Cosson	20			
Carex divulsa Stokes	13			
Stipa bromoides (L.) Dörfl.	11			
Trifolium angustifolium L.	9			

TABLE I – *continued*

Group no.	1	2	3	4
No. of relevés	46	10	5	9
Micromeria graeca (L.) Bentham ex Reichenb.				44
Andropogon distachyos L.				44
Asphodelus aestivus Brot.				33
Psoralea bituminosa L.	33	40		
Dactylis glomerata L. ssp. *hispanica* (Roth.) Nyman	17	10		
Hyparrhenia hirta (L.) Stapf	13	10		
Briza maxima L.	13			22
Scorpiurus muricatus L.	9		40	
Tanacetum cinerariifolium (Trev.) Schultz Bip.	9	80		
Allium subhirsutum L.	7		40	
Crucianella latifolia L.	4	40		
Carlina corymbosa L.	4			56
Brachypodium distachyon (L.) Beauv.	2			44
Reichardia picroides (L.) Roth	2		40	
Convolvulus althaeoides L. ssp. *tenuissimus* (Sibth. et Sm.) Stace	2	30		
Ononis reclinata L.	2	50		
Allium sphaerocephalon L.		20		44
Brachypodium retusum (Pers.) Beauv.	76	100	100	22
Euphorbia characias L. ssp. *wulfenii* (Hoppe ex Koch) A.R. Sm.	15			
Teucrium polium L. ssp. *capitatum* (L.) Arcangeli	9			
Satureja visianii Šilić*		50		
Allium croaticum Bogdanović, Brullo, Mitic et Salmeri*		40		
Urospermum picroides (L.) Scop. ex F. W. Schmidt		30		
Erysimum sp.		30		
Anagallis foemina Miller				44
Urginea maritima (L.) Baker				33
Pallenis spinosa (L.) Cass.				33
Blackstonia perfoliata (L.) Hudson	2			56
Asyneuma limonifolium (L.) Janchen		30		22
Centaurium erythraea Rafn				44
Festuco vallesiacae–Brometea erecti				
Acinos arvensis (Lam.) Dandy	13			
Bupleurum baldense Turra ssp. *gussonei* (Arcangeli) Tutin	11			
Brachypodium pinnatum (L.) Beauv.	7			
Festuca rupicola Heuffel	7			
Fumana procumbens (Dunal) Gren. et Godron		100		
Jurinea mollis (L.) Reichenb.		80		
Sesleria tenuifolia Schrader		60		
Edraianthus tenuifolius (Waldst. et Kit.) A. DC.		50		
Teucrium montanum L.		30		
Muscari comosum (L.) Miller			40	
Salvia officinalis L.	24	70		
Micromeria juliana (L.) Bentham ex Reichenb.	24	70		
Euphorbia spinosa L.	15	90		
Hypericum perforatum L.	7	20		
Teucrium chamaedrys L.	7			33
Helichrysum italicum (Roth) G. Don	7	50		
Dianthus sylvestris Wulfen ssp. *tergestinus* (Reichenb.) Hayek	4	20		
Galium lucidum All.	4	80		
Aethionema saxatile (L.) R.Br.	4	40		
Genista sylvestris Scop.	4	30		
Satureja montana L.	2	40		
Petrorhagia saxifraga (L.) Link	20	70		44
Melica ciliata L.	11	80		33
Desmazeria rigida (L.) Tutin	9	70		44
Koeleria splendens Presl.	7	70	20	
Teucrium polium L.	4	50		44
Anthyllis vulneraria L.	2		20	44
Dorycnium pentaphyllum Scop. ssp. *herbaceum* (Vill.) Rouy	11			
Gladiolus illyricus Koch	2	20	40	
Lotus corniculatus L.	9			
Asperula scutellaris Vis.		30		
Bromus hordeaceus L.				44

TABLE I – *continued*

Group no.	1	2	3	4
No. of relevés	46	10	5	9
Parietarietea judaicae				
Cheilanthes acrostica (Balb.) Tod.		40		
Sedum dasyphyllum L.		30		
Geranium purpureum Vill.	7	50		
Ceterach officinarum DC.	11	80		11
Asplenietea trichomanis				
Inula verbascifolia (Willd.) Hausskn.		60		
Phagnalon rupestre (L.) DC.		50		
Campanula pyramidalis L.		40		
Portenschlagiella ramosissima (Portenschl.) Tutin		30		
Sedum ochroleucum Chaix	11	80		
Asplenium trichomanes L.	9	60		
Nerio oleandri–Tamaricetea africanae				
Nerium oleander L.		100		
Thlaspietea rotundifolii				
Scutellaria rubicunda Hornem.				78
Stellarietea mediae				
Avena fatua L.				44
Cisto cretici–Micromerietea julianae				
Anthyllis hermanniae L.				33

Notes: Groups: 1, *Fraxino orni–Quercetum cocciferae* subass. *pistacietosum lentisci*; 2, *Fraxino orni–Quercetum cocciferae* subass. *nerietosum oleandri*; 3, *Erico arboreae–Arbutetum unedonis*; 4, Albanian stands. Species values are expressed as percentage frequencies.

marked with an asterisk (*)] and a few taxa [marked with two asterisks (**)] where the Flora Croatica Database and Med-Checklist were used, respectively (Greuter et al. 1984; Nikolić 2014). Biological form was verified in the field and denoted according to categories reported in Pignatti (1982), these being based on the classification of Raunkiaer (1934). Regarding chorological form, reference was also made to Jasprica and Kovačić (1997), as well as to the monographs used for taxonomic nomenclature.

Statistical analysis

To identify vegetation types, relevés were classified by TWINSPAN (Hill 1979) using Juice 7.0 software (Tichý 2002). TWINSPAN pseudospecies cut levels for species abundances were set to 0–5–25 percentage scale units. Initially, six division levels were chosen. Later, different levels of division were accepted resulting in four groups interpretable in terms of ecology.

The resulting classification were projected onto an ordination diagram using non-metric multidimensional scaling (NMDS) performed on a matrix of Bray–Curtis dissimilarities. Ordination was calculated using the R program (R Development Core Team 2012) and its vegan package (Oksanen et al. 2012).

For further interpretation of the ecological conditions of the studied vegetation types, unweighted average indicator values were used (Pignatti 2005) calculated in the JUICE 7.0. Average indicator values were presented with Box–Whiskers diagrams made in the STATISTICA 7.1 (STATSOFT inc. 2005).

Diagnostic, constant and dominant species were determined for each defined association. Diagnostic species of the associations were determined using the *phi* coefficient, measuring the fidelity of species to a particular association (Sokal & Rohlf 1995; Chytrý et al. 2002). Only species with a *phi* coefficient >0.30 and a probability of the observed pattern of species occurrence under random expectation <0.01 (Fisher's exact test) were considered to be diagnostic for each association. Constant species were defined as those with a frequency $>30\%$ inside the vegetation unit. Dominant species were defined as those occurring in at least 10% of relevés of a vegetation unit with a cover value $>25\%$.

Results

The communities with *Quercus coccifera* on the eastern Adriatic coast belong to the macchia (sclerophyllous scrubs) or degraded scrub vegetation occurring in Mediterranean bioclimatic strata at 0–450 m a.s.l. Based on TWINSPAN, four distinctive vegetation units were identified (Figure 2), and, following the Braun–Blanquet approach, were classified under one association and two new proposed subassociations. In our analysis Albanian stands are also retained as a separate group. Table I shows the frequencies of the diagnostic species for the corresponding vegetation units. According to these

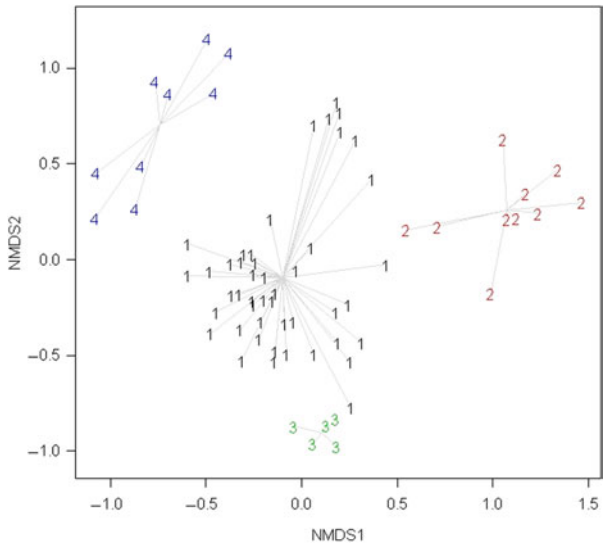

Figure 2. NMDS ordination diagram with projected cluster membership of the relevés. For group abbreviations see capture of Figure 1 or Table I.

results, the syntaxonomic synopsis of the *Q. coccifera* communities on the eastern Adriatic coast is:

Class Quercetea ilicis *Braun-Blanquet 1947*

Order Quercetalia ilicis *Braun-Blanquet 1947*

Alliance Fraxino orni-Quercion ilicis *Biondi, Casavecchia & Gigante* ex *Biondi, Casavecchia & Gigante in Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante & Pesaresi 2013*

Association Fraxino orni–Quercetum cocciferae *(Horvatić 1958) Trinajstić 1985*

pistacietosum lentisci *subass. nova hoc loco Jasprica & Škvorc 2015*

nerietosum oleandri *subass. nova hoc loco Jasprica & Škvorc 2015*

Alliance Oleo sylvestris–Ceratonion siliquae *Braun-Blanquet* ex *Guinochet & Drouineau 1944*

Association Erico arboreae–Arbutetum unedonis *Allier & Lacoste 1980*

Analysis of ecological factors, life forms and floral elements

Pignatti indicator values showed that the highest light intensity is characteristic of the subassociation *nerietosum oleandri*, followed by Albanian stands and *Erico-Arbutetum* (Figure 3). In contrast, the subassociation *pistacietosum lentisci* shows the lowest indicator value for light. The lowest temperature value was indicated for the subassociation *nerietosum oleandri*, and the highest for *Erico-Arbutetum*, while the subassociation *pistacietosum lentisci* and Albanian stands had an intermediate position. With regard to moisture, the subassociation *pistacietosum lentisci* and Albanian stands showed the greatest range. The communities differed considerably in relation to substrate reaction. The subassociation *nerietosum oleandri* showed the highest reaction value, whereas *Erico-Arbutetum* showed the lowest. The communities with low nutrient values were the subassociation *nerietosum oleandri* and the association *Erico-Arbutetum*. With respect to continentality, and quite the opposite to temperature values, subassociation *nerietosum oleandri* had the highest value, and *Erico-Arbutetum* had the lowest.

The analysis of plant life forms showed that *Erico-Arbutetum* was dominated by phanerophytes (54%), whereas phanerophytes and hemicryptophytes contributed equally (30%) in *Fraxino orni–Quercetum coccifera pistacietosum lentisci* (Table II). Hemicryptophytes prevailed in the *Fraxino orni–Quercetum coccifera nerietosum oleandri* (35%) and Albanian stands (25%), respectively. Mediterranean floral elements (57–88%), mostly circum-Mediterranean plants, followed by a considerable proportion of South European plants (7–23%), dominated in all communities (Table III).

Fraxino orni–Quercetum cocciferae *(Horvatić 1958) Trinajstić 1985 (Table I, Figure 2)*

– pistacietosum lentisci *subass. nova Jasprica & Škvorc 2015,* hoc loco

Holotypus: [Rel. number 1, *hoc loco*: Croatia: Pelješac Peninsula: village of Ruskovići, the coordinate 42°59′06.48″ N, 17°10′25.40″ E, 20 November 1995 by N. Jasprica; altitude 200 m, slope 10°, aspect SE, surface 200 m^2, vascular plant cover 90%]. Characteristic species: *Quercus coccifera* (4.4), *Fraxinus ornus* (+), dif. subass. *pistacietosum lentisci Pistacia lentiscus* (1.2); Oleo sylvestris–Ceratonion siliquae: *Juniperus oxycedrus* ssp. *macrocarpa* (+), *Pinus halepensis* (+); Fraxino orni–Quercion ilicis: *Juniperus oxycedrus* ssp. *macrocarpa* (+), *Pistacia terebinthus* (+), *Lonicera implexa* (+), *Clematis flammula* (+), *Asparagus acutifolius* (+), *Smilax aspera* (+), *Rubia peregrina* (+), *Spartium junceum* (+), *Laurus nobilis* (+), *Rosa sempervirens* (+); Companions: *Brachypodium retusum* (2.4), *Micromeria juliana* (+), *Tanacetum cinerariifolium* (+), *Petrorhagia saxifraga* (+), *Ceterach officinarum* (+), *Psoralea bituminosa* (+), *Coronilla emerus* ssp. *emeroides* (+), *Asplenium trichomanes* (+), *Hedera helix* (1.1), *Helichrysum italicum* (+), *Cistus salvifolius* (+), *Convolvulus althaeoides* ssp. *tenuissimus* (+), *Piptatherum miliaceum* (+), *Leontodon autumnalis* (+), *Fumana ericoides* (+), *Tamus communis* (+), *Celtis australis* (+), *Verbascum sinuatum* (+), *Astraga-*

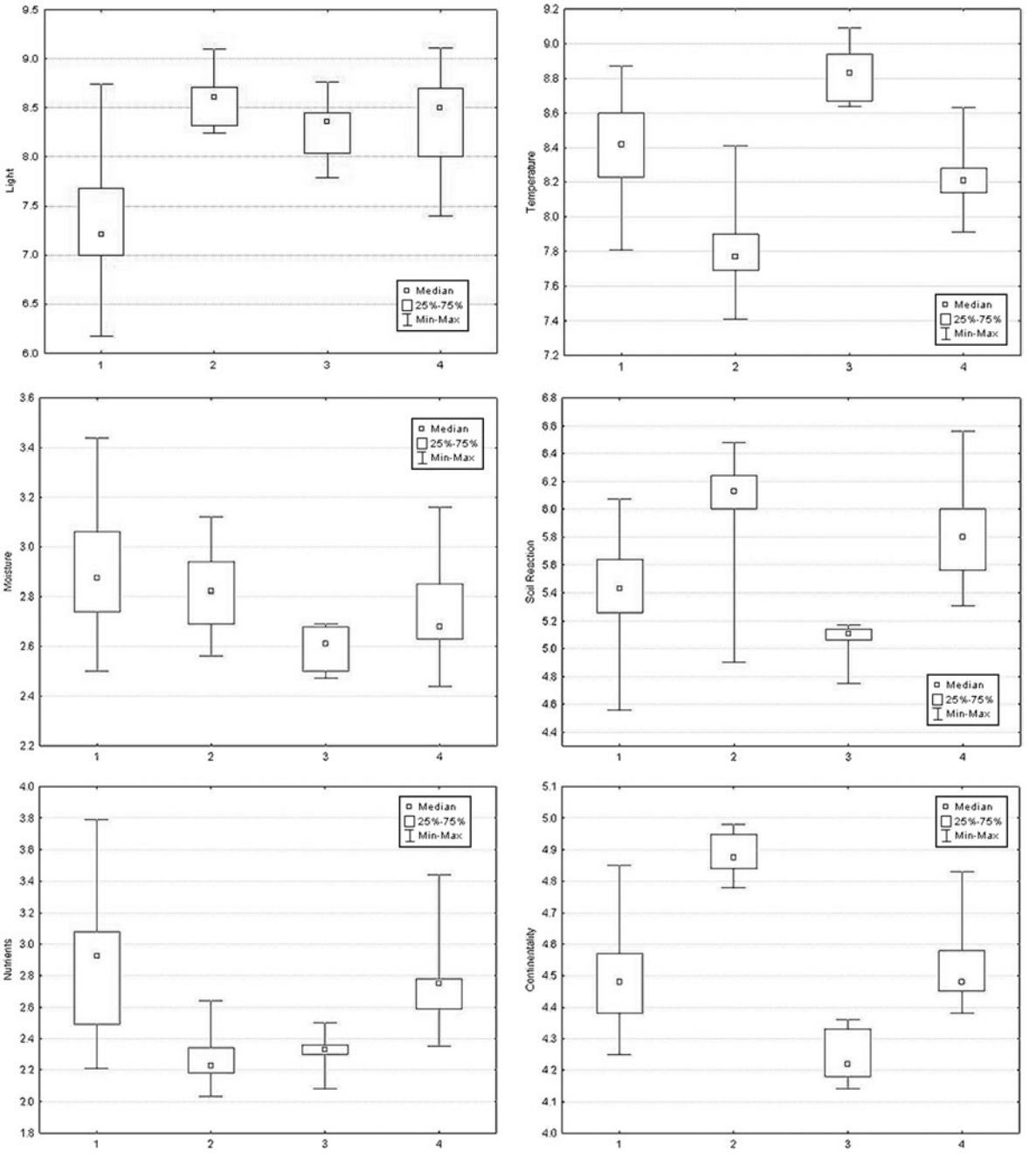

Figure 3. Relationships of the studied vegetation communities to Pignatti indicator values. For group abbreviations see capture of Figure 1 or Table I.

lus hamosus (+), *Lotus corniculatus* (+), *Trifolium angustifolium* (+), *Hippocrepis comosa* (+), *Cyclamen hederifolium* (+).

Constant species: *Quercus coccifera*, *Pistacia lentiscus* (differential from the subassociation *nerietosum oleandri*), *Asparagus acutifolius*, *Brachypodium retusum*, *Phillyrea latifolia*, *Fraxinus ornus*, *Lonicera implexa*, *Clematis flammula*, *Smilax aspera*, *Viburnum tinus*, *Quercus ilex*, *Juniperus oxycedrus* ssp. *oxycedrus*, *Coronilla emerus* ssp. *emeroides*, *Rubia peregrina*, *Juniperus oxycedrus* ssp. *macrocarpa*, *Arbutus unedo*, *Spartium junceum*, *Hedera helix*, *Cistus salvifolius*, *Cistus creticus* ssp. *creticus*, *Myrtus communis*, *Psoralea bituminosa*, *Erica arborea*.

Dominant species: *Quercus coccifera* and *Brachypodium retusum*.

Ecology: The subassociation is developed as xerothermic macchia with an average height of 2–3 m. These subassociations can be found from 4 m (north Adriatic) up to 300 m a.s.l. It appears mostly on southern expositions on the slopes between 5° and 50°. In optimal conditions of development, it is

Table II. Life-form spectra in the plant communities with *Q. coccifera*.

Life forms /communities	Subass. *pistacietosum lentisci*	Subass. *nerietosum oleandri*	*Erico-Arbutetum*	Albanian stands
Phanerophyta	51 (30.54)	24 (23.08)	20 (54.05)	13 (23.64)
Chamaephyta	22 (13.17)	24 (23.08)	3 (8.11)	10 (18.18)
Hemicryptophyta	51 (30.54)	37 (35.58)	5 (13.51)	14 (25.45)
Geophyta	12 (7.19)	5 (4.81)	7 (18.92)	5 (9.09)
Terophyta	31 (18.56)	14 (13.46)	2 (5.41)	13 (23.64)
Total taxa	167 (100.00)	104 (100.00)	37 (100.00)	55 (100.00)

practically impenetrable. The shrub layer cover varies from 70% to 100%. The herbaceous vegetation layer is occupied mainly by *Brachypodium retusum*. Altogether, the subassociation had 167 species. Among those, 134 were companions from 8 vegetation classes. The highest number of species belonged to the *Quercetea ilicis* and *Thero-Brachypodietea ramosi*. The number of species in the relevés was between 14 and 40 species (average 22.7). There were no differences in the average number of taxa per relevé (20.6–22.9) between the northern and southern Adriatic localities. Most of the companions were treated as characteristic species of the *Quercо-Fagetea sylvaticae*, *Erico-Cistetea*, *Thero-Brachypodietea ramosi* and *Festuco vallesiacae–Brometea erecti* communities.

Distribution records: Eastern Adriatic coast and islands; Croatia: the islands of Mali Lošinj (north Croatia) and Korčula, peninsula of Pelješac, Konavle (south Croatia); Montenegro: Bay of Valdanos, village of Bratica, near the town of Ulcinj (south Montenegro).

Nomenclatural and syntaxonomic notes: The association has been described according to three relevés by Horvatić (1958) as "*Orno-Cocciferetum*" (*Fraxino orni–Quercetum cocciferae*) from the Pelješac Peninsula, south Croatia. An analysis of this study allowed us to separate the association into two communities and describe two new subassociations named *pistacietosum lentisci* and *nerietosum oleandri*. The subassociation *pistacietosum lentisci* shares most of the floristic characteristics of *Querco cocciferae–Pistacietum lentisci,* which is widespread in the Mediterranean Basin (Braun-Blanquet 1936).

Fraxino orni–Quercetum cocciferae *(Horvatić 1958) Trinajstić 1985 (Table I, Figure 2)*

– nerietosum oleandri *subass. nova Jasprica & Škvorc 2015,* hoc loco

Holotypus: [Rel. number 11, *hoc loco*: Croatia: Pelješac Peninsula: village of Podgorje above town of Orebić, the coordinate 42°58′48.68″ N, 17°08′54.85″ E, 27 June 2009 by N. Jasprica; altitude 200 m, slope 45°, aspect SE, surface 100 m^2, vascular plant cover 80%]. Characteristic species: *Quercus coccifera* (2.2), dif. subass. *nerietosum oleandri Nerium oleander* (3.3); Oleo sylvestris–Ceratonion siliquae: *Ephedra fragilis* ssp. *campylopoda* (+); Fraxino orni–Quercion ilicis: *Juniperus oxycedrus* ssp. *oxycedrus* (+.1), *Pistacia terebinthus* (+.1), *Clematis flammula* (+), *Laurus nobilis* (+); Companions: *Brachypodium retusum* (2.2), *Micromeria juliana* (+), *Petrorhagia saxifraga* (+), *Salvia officinalis* (+.1), *Euphorbia spinosa* (+), *Fumana procumbens* (+.1), *Ceterach officinarum* (+), *Sedum ochroleucum* (+), *Melica ciliata* (+.1), *Galium lucidum* (+), *Desmazeria rigida* (+.1), *Psoralea bituminosa* (+), *Jurinea mollis* (+), *Hedera helix* (+), *Geranium purpureum* (+),

Table III. Floral elements (in %) in the plant communities with *Q. coccifera*.

Floral elements / Groups	Subass. *pistacietosum lentisci*	Subass. *nerietosum oleandri*	*Erico-Arbutetum*	Albanian stands
Mediterranean	61.21	57.84	88.89	70.91
Illyrian-Balkanic	0.00	1.96	0.00	1.82
South European	19.39	23.53	11.11	7.27
Eeast European-Pontic	1.21	0.00	0.00	0.00
Southeast European	0.61	0.98	0.00	1.82
Central European	0.61	0.00	0.00	0.00
European	2.42	1.96	0.00	0.00
Euroasian	6.06	6.86	0.00	9.09
Circum-Holarctic	0.61	0.00	0.00	0.00
Cosmopolitan	6.67	5.88	0.00	9.09
Cultivate and adventive plants	1.21	0.98	0.00	0.00

Inula verbascifolia (2.2), *Phagnalon rupestre* (+), *Crucianella latifolia* (+), *Urospermum picroides* (+), *Dactylis glomerata* ssp. *hispanica* (+), *Hyparrhenia hirta* (+.1), *Teucrium flavum* (+.1), *Sedum dasyphyllum* (+), *Rhamnus intermedius* (+), *Celtis australis* (+), *Allium sphaerocephalon* (+), *Orobanche purpurea* (+), *Campanula trachelium* (+), *Punica granatum* (+), *Geranium rotundifolium* (+), *Bromus madritensis* (+), *Seseli tomentosum* (+), *Plumbago europaea* (+), *Lactuca viminea* (+), *Calamintha nepeta* ssp. *nepeta* (+), *Carduus pycnocephalus* (+), *Ajuga chamaepitys* (+).

Constant species: *Quercus coccifera*, *Nerium oleander* (differential from the subassociation *pistacietosum lentisci*), *Pistacia terebinthus*, *Fumana procumbens*, *Brachypodium retusum*, *Juniperus oxycedrus* ssp. *oxycedrus*, *Euphorbia spinosa*, *Ceterach officinarum*, *Tanacetum cinerariifolium*, *Sedum ochroleucum*, *Melica ciliata*, *Jurinea mollis*, *Galium lucidum*, *Phillyrea latifolia*, *Petrorhagia saxifraga*, *Cistus creticus* ssp. *creticus*, *Micromeria juliana*, *Salvia officinalis*, *Erica manipuliflora*, *Koeleria splendens*, *Desmazeria rigida*, *Asplenium trichomanes*, *Inula verbascifolia*, *Sesleria tenuifolia*, *Fraxinus ornus*, *Frangula rupestris*, *Teucrium polium*, *Helichrysum italicum*, *Geranium purpureum*, *Phagnalon rupestre*, *Ononis reclinata*, *Satureja visianii*, *Edraianthus tenuifolius*, *Juniperus oxycedrus* ssp. *macrocarpa*, *Psoralea bituminosa*, *Satureja montana*, *Aethionema saxatile*, *Crucianella latifolia*, *Campanula pyramidalis*, *Allium croaticum*, *Cheilanthes acrostica*, *Pistacia lentiscus*, *Pinus halepensis*, *Convolvulus althaeoides* ssp. *tenuissimus*, *Teucrium flavum*, *Urospermum picroides*, *Portenschlagiella ramosissima*, *Sedum dasyphyllum*, *Rhamnus intermedius*, *Asperula scutellaris*, *Erysimum* sp., *Teucrium montanum*, *Genista sylvestris*, *Asyneuma limonifolium*.

Dominant species: *Quercus coccifera*, *Nerium oleander*, *Brachypodium retusum*, *Cistus creticus* ssp. *creticus*, *Erica manipuliflora*.

Ecology: The subassociation may represent low and high shrub formation. Altitudinal range is between 200 and 450 m a.s.l. It appears exclusively on southern expositions on slopes between 40° and 85°. The shrub layer cover varies from 50% to 85%. Altogether, the subassociation had 104 species. Among those, 90 were companions. The highest number of companions belonged to the *Festuco vallesiacae–Brometea erecti* class. The number of species in the relevés was between 18 and 53 (average 37.5).

Distribution records: Eastern Adriatic: Croatia: western part of the peninsula of Pelješac, above town of Orebić. It occupies an area of ca. 4 ha.

Nomenclatural and syntaxonomic notes: This vegetation is associated with the dry grasslands of the *Scorzonero villosae–Chrysopogonetalia grylli* order (Jasprica & Kovačić 2011). This subassociation is characterized by high cover and frequency of *Nerium oleander*, and makes it similar to the associations of *Chrysopogono grylli–Nerietum oleandri* from Croatia (Jasprica et al. 2007) or *Spartio-Nerietum oleandri* from Calabria, Italy (Biondi et al. 1994; Brullo & Spampinato 1997). A common characteristic of all the communities is the great number of the companions from the *Thero-Brachypodietea ramosi* and *Festuco vallesiacae–Brometea erecti* classes, and, on the other hand, connection with the *Oleo sylvestris–Ceratonion siliquae* macchia. The subassociation includes many local stenoendemic species, such as *Satureja visianii* Šilić, *Allium croaticum* Bogdanović, Brullo, Mitic & Salmeri, *Asperula scutellaris* Vis., etc., and some Croatian strictly protected taxa of *Ophrys* spp. and *Orchis* spp.

Erico arboreae–Arbutetum unedonis *Allier & Lacoste 1980* (*Table I*, *Figure 2*)

Constant species: *Quercus coccifera*, *Pistacia lentiscus*, *Phillyrea angustifolia*, *Lonicera implexa*, *Erica arborea*, *Arbutus unedo*, *Juniperus phoenicea* ssp. *turbinata*, *Brachypodium retusum*, *Cistus creticus* ssp. *creticus*, *Erica manipuliflora*, *Teucrium fruticans*, Bryophyta coll., *Asparagus acutifolius*, *Phillyrea latifolia*, *Viburnum tinus*, *Quercus ilex*, *Cistus salvifolius*, *Calicotome villosa*, *Rubia peregrina*, *Coronilla emerus* ssp. *emeroides*, *Smilax aspera*, *Allium subhirsutum*, *Dorycnium hirsutum*, *Scorpiurus muricatus*, *Reichardia picroides*, *Gladiolus illyricus*, *Muscari comosum*.

Dominant species: *Brachypodium retusum* and *Erica manipuliflora*.

Ecology: The association is commonly developed as xerothermic macchia. Depending on the topographic conditions, this association may at least partly represent low and high shrub formation. Altitudinal range is between 8 and 50 m a.s.l. Northwestern expositions are most frequent, whereas the slope varies from 20° to 45°. The shrub layer cover varies from 90% to 100%. The taxa *Erica manipuliflora*, *Teucrium fruticans*, *Cistus creticus* ssp. *creticus* and *C. salviifolius* appeared within this association with high cover and frequency. Ecologically and in terms of physiognomy, the *Erico arboreae–Arbutetum unedonis* association is closely related to the *Erico manipuliflorae–Cistetum cretici* association (the *Cisto cretici–Ericion manipuliflorae* alliance) with which it often borders. Among companions, the species of *Quercetalia pubescentis*, *Cisto cretici–Ericetalia manipuliflorae*, *Scorzonero villosae–Chrysopogonetalia grylli* and *Brometalia erecti* orders are found.

Distribution records: This association, which includes *Q. coccifera*, is restricted to the island of Mljet, south Croatia.

Nomenclatural and syntaxonomic notes: This association is distributed throughout the western

Mediterranean (Molinier 1937; Allier & Lacoste 1980; Biondi et al. 2001; Brullo et al. 2008), and also found on the eastern Adriatic coast and islands (e.g. Trinajstić 1993; Jasprica & Kovačić 2011). In Croatia, this association (with the absence of *Q. coccifera*) is commonly developed as a progressive stage following wildfire burning of *Pinus halepensis* stands, and often remains as a permanent stage for several decades (Vukelić et al. 2008). The most frequent species of the *Oleo sylvestris–Ceratonion siliquae* alliance are *Pistacia lentiscus* and *Myrtus communis*; and *Erica arborea*, *Arbutus unedo*, *Phillyrea media*, *Quercus ilex* and *Lonicera implexa* of *Fraxino orni–Quercion ilicis* (Trinajstić 1993).

Albanian stands (Table I, Figure 2)

Constant species: *Quercus coccifera*, *Dorycnium hirsutum*, *Cistus creticus* ssp. *eriocephalus*, *Scutellaria rubicunda*, *Phillyrea angustifolia*, *Carlina corymbosa*, *Blackstonia perfoliata*, *Pistacia lentiscus*, *Prasium majus*, *Rubia peregrina*, *Petrorhagia saxifraga*, *Teucrium polium*, *Anthyllis* × *rubicunda*, *Desmazeria rigida*, *Allium sphaerocephalon*, *Brachypodium distachyon*, *Andropogon distachyos*, *Micromeria graeca*, *Avena fatua*, *Centaurium erythraea*, *Anagallis foemina*, *Bromus hordeaceus*, *Myrtus communis*, *Quercus ilex*, *Melica ciliata*, *Erica manipuliflora*, *Teucrium flavum*, *Teucrium chamaedrys*, *Fumana thymifolia*, *Anthyllis hermanniae*, *Urginea maritima*, *Asphodelus aestivus*, *Pallenis spinosa*.

Dominant species: *Quercus coccifera*, *Quercus ilex*, *Pistacia lentiscus*, *Phillyrea angustifolia*, *Erica manipuliflora*, *Teucrium flavum*, *Cistus creticus* ssp. *eriocephalus*.

Ecology: These low shrub formations (0.8–1.2 m) were developed on calcareous substrates between 100 and 270 m a.s.l. The slope varied between 25° and 35°. South-western and western expositions were most frequent. The stands had from 8 to 28 species (average 19.6). Altogether, 44 companions were found from 9 vegetation classes.

Distribution records: The island of Sazani, south Albania. Similar stands can be also found in south Albania, south of Valona (Vlorë), on the western slopes between the village of Kaninë and the Llogara National Park (Hoda & Mersinllari 1996; Ruci et al. 2001; Anonymous 2004).

Nomenclatural and syntaxonomic notes: Albanian stands with *Q. coccifera* have been associated with the *Fraxino orni–Quercetum cocciferae* association (Hoda & Mersinllari 1996). The floristic composition of the stands does not include characteristic shrub (*Fraxinus ornus*) and climbing species of *Fraxino orni–Quercion ilicis*, such as *Clematis flammula*, *Rosa sempervirens*, *Lonicera implexa*, *L. etrusca*, and *Erica arborea*, *Spartium junceum*, *Viburnum tinus*, *Arbutus unedo*, etc. At lower altitudes, *Q. coccifera* is mostly accompanied by *Pistacia lentiscus*, *Phillyrea media* and *Daphne gnidium*, whereas at higher altitudes grows almost alone. The presence of xerophilic species is probably a result of severe grazing.

Discussion

The present investigation revealed the presence of sclerophyllous *Quercus coccifera* plant communities forming macchia or shrubland on the eastern Adriatic coast and islands. Our results suggest that *Q. coccifera* communities in the area appear exclusively within the *Querceta ilicis* vegetation zone and, in contrast to some other areas of the Mediterranean (Bergmeier 1990), extends from the shoreline up to 450 m of altitude, within the meso-Mediterranean belt.

Four plant communities (two subassociations, one association and stand) were found, and they significantly differed both floristically and ecologically from each other. By contrast, analysis of chorotypes (geo-elements) did not show differences among the communities. The chorological spectrum highlights a clear dominance of the steno-Mediterraneans. These data confirm the peculiarity of the surveyed area from the phytogeographic point of view.

Eastern Adriatic communities with *Q. coccifera* consist mainly of sclerophyllous species such as *Q. coccifera*, *Phillyrea latifolia*, *Pistacia lentiscus*, *Juniperus oxycedrus* ssp. *oxycedrus*, while some thermophillous deciduous species frequently occur with higher percentages (e.g. *Fraxinus ornus*, *Pistacia terebinthus*). This agrees with the findings of Mavrommatis (1980) and Tsiourlis et al. (2009) who found that *Ph. latifolia* and *P. lentiscus* are among the most common species in the *Q. coccifera* shrubland of Greece. In our study, only a few species were common for all *Q. coccifera* communities, and among them, only *Brachypodium retusum* had the highest percentages.

The floristic and ecological characterization of the two proposed new subassociations of *Fraxino orni–Quercetum cocciferae* is in line with the ecological and biological spectra. Results of statistical analysis and indicator values for light intensity, temperature, soil reaction and nutrients are clearly related to the identification and division of the association into subassociations. In addition, life form spectra indicate differences between the *Fraxino orni–Quercetum cocciferae pistacietosum lentisci* and *Fraxino orni-Quercetum cocciferae nerietosum oleandri* subassociations. In fact, the floristic composition of *Fraxino orni–Quercetum cocciferae pistacietosum lentisci* and only partly *Fraxino orni–Quercetum cocciferae nerietosum oleandri* are very similar with the *Fraxino orni–Quercetum ilicis* (*Fraxino orni–Quercion ilicis*) (Pandža

et al. 2004) or *Pistacio lentisci–Juniperetum phoeniceae* (*Oleo sylvestris–Ceratonion siliquae*) associations identified by Kovačić et al. (2001) on the Croatian coast and islands. In our study, in 54% of relevés taken from the *Fraxino orni–Quercetum cocciferae pistacietosum lentisci* subassociation, *Q. coccifera* was accompanied by *Q. ilex*.

On the other hand, the high percentage of herbaceous plants in the *Fraxino orni–Quercetum cocciferae nerietosum oleandri* subassociation indicates its close relationship with *Thero-Brachypodietea ramosi* and *Festuco vallesiacae–Brometea erecti* vegetation. Indeed, the subassociation represents mostly shrubby vegetation dominated by hemicryptophytic species, colonizing scarcely developed substrata exclusively on the steep calcareous rocky slopes between the scree and dry grassland vegetation in the north and the *Oleo sylvestris–Ceratonion siliquae* macchia (Aleppo pine forests) in the south. At relatively higher altitudes, moderate grazing and frequent wildfire leads to a lower percentage or absence of characteristic shrubs and climbing species of *Fraxino orni–Quercion ilicis*.

The comparison between the subassociation *Fraxino orni–Quercetum cocciferae nerietosum oleandri* and the *Nerium oleander* stands on the eastern Adriatic (Jasprica et al. 2007) must be stressed. Stands with oleander are sporadic on the eastern Adriatic coast and, owing to heightened coastal development, perhaps in the process of becoming extinct. *Nerium oleander* in some other areas in Croatia and Montenegro, as in the western Mediterranean (Asensi & Díez-Garretas 2011), appears within the *Rubo ulmifolii–Nerion oleandri* alliance (*Tamaricetalia*), mostly growing in rivulets and dry ravines with discontinuous fresh water. This alliance is characterized by the greater biomass of *Nerium oleander* and/or *Vitex agnus-castus* accompanied by *Rubus ulmifolius* and several elements of *Quercetea ilicis*. *Vitex agnus-castus*, *Rubus ulmifolius* and other species from the *Tamaricetalia* order are not presented in the study area.

Among all the communities with *Q. coccifera* reported in our study, this species had the lowest cover in the *Erico arboreae–Arbutetum unedonis* association, which we have subordinated to the *Oleo sylvestris–Ceratonion siliquae* alliance (cf. Jasprica et al. 2011). From the floristic point of view, the association showed similarities with those described in Croatia and Italy (e.g. Trinajstić 1993; Brullo et al. 2008; Viciani et al. 2011; Vukelić 2012). In practice, the association represents the xerothermic macchia dominated by numerous species of the *Quercetalia ilicis* order. However, higher percentages of the garrigue species as a common characteristic for the association reported from different areas may be explained by the varying degree of degradation (e.g. deforestation) or specific topographic conditions (Vukelić et al. 2008). In fact, the association is ecologically and physiognomically closely related to the garrigue communities with which it often borders (Jasprica et al. 2011). Similarly, in Sicily, *Q. coccifera* (*Q. calliprinos*) is also recorded from the *Cisto cretici–Ericion manipuliflorae* coenoses fragmented due to fire and deforestation (La Mantia & Gianguzzi 2003).

Albanian stands showed a moderate position for most of the indicator values (except light intensity). In view of the structure of these stands, constituted basically by some characteristic species of the garrigue, dry grassland and scree vegetation, which occurred at higher percentages, we think they should not be subordinated to the *Fraxino orni–Quercetum cocciferae* association (cf. Hoda & Mersinllari 1996; Ruci et al. 2001). There is some similarity with the *Quercetum cocciferae brachypodietosum* identified by Wraber (1952) in southern France and Curcó (1991) in Catalonia (Spain). At present, these stands are the least-known among all *Q. coccifera* communities on the eastern Adriatic and further investigations are needed in order to clarify their syntaxonomy and ecology.

The variability of interpretation of the ecological conditions of particular communities using the indicator values must also be stressed. In fact, species behaviour that varies widely from one region to another suggests caution in the use of indicator values and their extrapolation to other regions (Godefroid & Dana 2007; Schwabe et al. 2007). Ecological indices give only an estimate, and do not fully reflect the conditions in the habitats, which are the result of very complex interactions (Schaffers & Sykora 2000).

In comparison with the synthetic table made by Tsiourlis et al. (2009) in the Mediterranean zone (*Quercetea ilicis*) of Greece, many differences in the floristic composition of our communities can be found. These differences are very difficult to evaluate due to variation in the degree of human presence and differences in taxonomical concepts. However, the most widespread subassociation on the eastern Adriatic – the *Fraxino orni–Quercetum cocciferae pistacietosum lentisci* – shares most of floristic characteristics described for the *Querco cocciferae–Pistacietum lentisci* and its subassociation *typicum*, including the majority of the typical Mediterranean evergreen shrubs. The subassociation *Fraxino orni–Quercetum cocciferae pistacietosum lentisci* shows some similarities with the subassociation *Phillyreo latifoliae–Quercetum calliprini rubio–arbutetosum andrachnes*, described within the thermomediterranean bioclimatic belt on the Ionian island of Cephalonia (Bolòs et al. 1996). However, *Arbutus andrachne* was not present in our relevés.

In particular, an affinity is also seen with the *Arbuto unedi–Quercetum calliprini* (*Oleo sylvestris–Ceratonion siliquae*), and partly with *Hedero helicis–Quercetum calliprini* (*Fraxino orni–Quercion ilicis*) associations described for the south-western Adriatic and Ionian coasts of the Salento peninsula in Italy (cf. Brullo et al. 1987; Biondi et al. 2004). Although *Fraxino orni–Quercetum cocciferae pistacietosum lentisci* shares most of the floristic characteristics, including the majority of the typical Mediterranean evergreen shrubs, with the endemic associations from Sicily (*Junipero turbinatae–Quercetum calliprini*) and Sardinia (*Rusco aculeati–Quercetum calliprini*), from the ecological point of view they differ due to their growth on xeropsamments of consolidated paleodunes (Bacchetta et al. 2009; Gianguzzi et al. 2012). In addition, *Junipero turbinatae–Quercetum calliprini* and, more recently described the *Calicotomo infestae–Quercetum calliprini* association (Minissale & Sciandrello 2013), are characterized by *Chamaerops humilis*, a species not present in the eastern Adriatic territory.

Regarding the effects of human presence, in addition to overgrazing, wildfires have been reported as the main factor that influences the physiognomy and floristic composition of the *Q. coccifera* communities in the Mediterranean. Although wildfires are very common on the eastern Adriatic coast, *Q. coccifera* resprouts vigorously after a fire and no clear signs of degradation have been observed (Jasprica 1999). This agrees with the findings of Trabaud (1991) and Türkmen and Düzenli (2005). In our case, according to the degree of anthropogenic impact, *Q. coccifera* form stands do not usually exceed a height of 2 m, whereas macchia formations up to 4–5 m high are rare. Forests with a height of about 15 m that can be found on some areas in Greece (Barbéro & Quézel 1980) are not presented in the study area.

Finally, the effects of climatic changes, manifested in a decrease of precipitation and an increase of summer temperature in the eastern Mediterranean during the period 1950–1999 (Nastos et al. 2013), could not be ignored, whereas the effect of management regimes (e.g. agricultural land abandonment as one of the main drivers of land use change) is one of the crucial problems in the Mediterranean landscape (Bajocco et al. 2012).

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Appendix

Syntaxonomic units mentioned in the text, but not in the scheme (in alphabetical order):

Arbuto unedi–Quercetum calliprini Brullo, Minissale, Signorello & Spampinato 1987

Asplenietea trichomanis (Braun-Blanquet *in* H.Meier & Braun-Blanquet, 1934) Oberdorfer 1977

Brometalia erecti W. Koch 1926

Calicotomo infestae–Quercetum calliprini Minissale & Sciandrello 2013

Chrysopogono grylli–Nerietum oleandri Jasprica, Ruščić & Kovačić 2007

Cisto cretici–Ericetalia manipuliflorae Horvatić 1958

Cisto cretici–Ericion manipuliflorae Horvatić 1958

Cisto cretici–Micromerietea julianae Oberdorfer *ex*. Horvatić 1958

Erico-Cistetea Trinajstić 1985

Erico manipuliflorae–Cistetum cretici Horvatić 1958

Festuco valesiacae–Brometea erecti Braun-Blanquet & Tüxen *ex* Braun-Blanquet 1949

Fraxino orni–Quercetum ilicis Horvatić (1956) 1958

Hedero helicis–Quercetum calliprini Biondi, Casavecchia, Guerra, Medagli, Beccarisi & Zuccarello 2004

Junipero turbinatae–Quercetum calliprini Bartolo, Brullo & Marcenò 1982

Nerio oleandri–Tamaricetea africanae Braun-Blanquet & O. Bolòs 1958

Paliuretea Trinjastić 1978

Parietarietea judaicae Oberdorfer 1977

Phillyreo latifoliae–Quercetum calliprini rubio–arbutetosum andrachens (Knapp) Barbéro & Quézel 1976

Pistacio lentisci–Juniperetum phoeniceae Trinajstić 1987

Quercetalia pubescentis Braun-Blanquet (1931) 1940

Quercetum cocciferae Braun-Blanquet 1924 *brachypodietosum* Braun-Blanquet 1935

Quercion ilicis Braun-Blanquet 1934 *em*. Rivas-Martínez 1975

Querco cocciferae–Pistacietum lentisci Braun-Blanquet, Font Quer, G. Braun-Blanquet, Frey, Jansen, & Moor 1935 nom. mut. propos. (art. 45) (addenda) [*Querco cocciferae-Lentiscetum* Braun-Blanquet, Font Quer, G. Braun-Blanquet, Frey, Jansen, & Moor 1935]

Querco cocciferae–Pistacietum lentisci typicum

Querco-Fagetea sylvaticae Braun-Blanquet & Vlieger *in* Vlieger 1937

Rubo ulmifolii–Nerion oleandri O. Bolòs 1985

Rusco aculeati–Quercetum calliprini Mossa 1990

Scorzonero villosae–Chrysopogonetalia grylli Horvatić & Horvat in Horvatić 1963

Spartio-Nerietum oleandri Brullo & Spampinato 1990

Stellarietea mediae Tüxen, W. Lohmeyer & Preising *ex* von Rochow 1951

Tamaricetalia Braun-Blanquet & O. Bolòs 1957 *em*. Izco et al. 1984

Thero-Brachypodietea ramosi Braun-Blanquet 1947

Thlaspietea rotundifolii Braun-Blanquet 1948