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Quercus dalechampii forests in Central Macedonia, Greece

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Abstract

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Most forested areas of Greece are formed by different species of oaks (*Quercus*). Under submediterranean climate, deciduous oaks predominate. The Kroussia mountains (Mavrovouni-Disoro, Central Macedonia, Greece) are covered by oak forests with *Q. frainetto, Q. dalechampii*, and *Q. pubescens*. Limited stands of *Fagus spec.* occur only in very few places, mostly in N, NE expositions, along streams or cavities. The climate of the area is submediterranean. Metamorphic rocks prevail as geological substrates. Soils are shallow to medium deep, sandy-loamy, representing moderately acid brown forest soils.

Q. dalechampii occurs in small stands as well as in large-scale forests. All stands are more or less strongly affected by man. Synsystematically, these forests were classified as *Q. dalechampii*-community in the alliance Quercion confertae (= Quercion frainetto; Quercetalia pubescentis, Querco-Fagetea). Further subdivisions along an environmental gradient result in three types, representing transitions towards beech forest on moister sites, and towards *Q. frainetto* forests on drier sites. The *Q. dalechampii* forests apparently represent an azonal community, mainly because their loam and clay content in the soil, and not climate, seems to govern competition between the oak species.

Key words: Quercus dalechampii, submediterranean, forest, Greece.

1. Introduction

Quercus dalechampii ("Balkanische Traubeneiche") is closely related to *Quercus petraea*, and seems to replace this species towards southeastern Europe (Adler et al. 1994). It forms deciduous oak forests in Italy, the Balkan peninsula, Slowakia, Hungary, and Turkey (Schwarz 1936, Athanasiadis 1986a). In Greece, this species forms forests mainly in the northern and northeastern areas. Southeastern outliers of *Q. dalechampii*-forests are located on Euboea island (Jalas & Suominen 1976).

This study contributes to a synsystematic and ecological study of *Q. dalechampii* forests. Aims are to describe (1) the floristic composition of *Q. dalechampii* forests at Mt. Kroussia (Mavrovouni, Disoro); (2) a systematic classification and description of environmental factors related to distinctly defined vegetation units; and (3) to relate these forest communities to the general forest pattern of the submediterranean belt in Greece.

2. Study area

2.1 Geography and geology

The Kroussia mountains (Mavrovouni, Disoro) are located near the borders of Greece to Bulgaria and former Yugoslavia, at the northeast and northwest parts of the Kilkis and Serres prefecture respectively. They extend from northwest to southeast between the lakes of Doirani and Kerkini, northeast of Kilkis city (Fig. 1). Relevés were recorded near Ellinikó, Mavroplagiá, and Pontokerasiá (Fig. 2).

Major summits from NW towards SE are Mavrovouni (860 m a.s.l.), Pholea (816 m), Mavrokoriphi (783 m), Mavri Zoni (898 m), Strouga (920 m), Mavri koriphi (1179 m), Kroussia (1161 m), Flamouri (1042 m), and Lophos (850m) (G.A.S. 1969, 1970).

The Kroussia mountains belong to the Serbomacedonian Massif and within this to the Vertiskos Range (Mountrakis 1985). Metamorphic rocks dominate, e.g. amphibolites, gneisses, and schists with marble intercalations. Locally, amphibolites, granites, granodiorites, and monzonites are found. Late-tectonic and post-tectonic sediments of the Pleistocene have accumulated as lacustrine and continental deposits including clay, loam, sand, conglomerates, and red-clayey material (IGME 1983).

2.2 Climate

Climate data are available from the meteorological stations of Metaxochori, Ano Theodoraki and Melanthio, which are below the *Q. dalechampii* forests (Table 1). These stations correspond to the "Cfa climatic type" according to Köppen's classification. This "humid" climate type is characterized by "longlasting and very hot summers, mild winters, and humid seasons all over the year". The area of Lahanas meteorological station is classified to the "Csa climatic type" according to Köppen, representing continental mediterranean climate with "very hot and dry summers and mild winters" (Flocas 1990; Athanasiadis et al. 1993).

The climate within the submediterranean forest zone of the Kroussia mountains becomes less extreme with increasing elevation. Bioclimatically, this area can be regarded as semi-humid, with "cold to very cold" winters (Mavrommatis 1980). The bioclimate of

Tab. 1. Climatic data from four meteorological stations near the Kroussia mountains.

	Elevation (m a.s.l.)	Precipitation (mm)	Temperature (°C)
Metaxochori	277	597	14.1
Ano Theodoraki	442	496	12.9
Melanthio	553	547	13.0
Lahanas	634	590	11.6
Kroussia Mountains	up to 1179 m	>600	<11

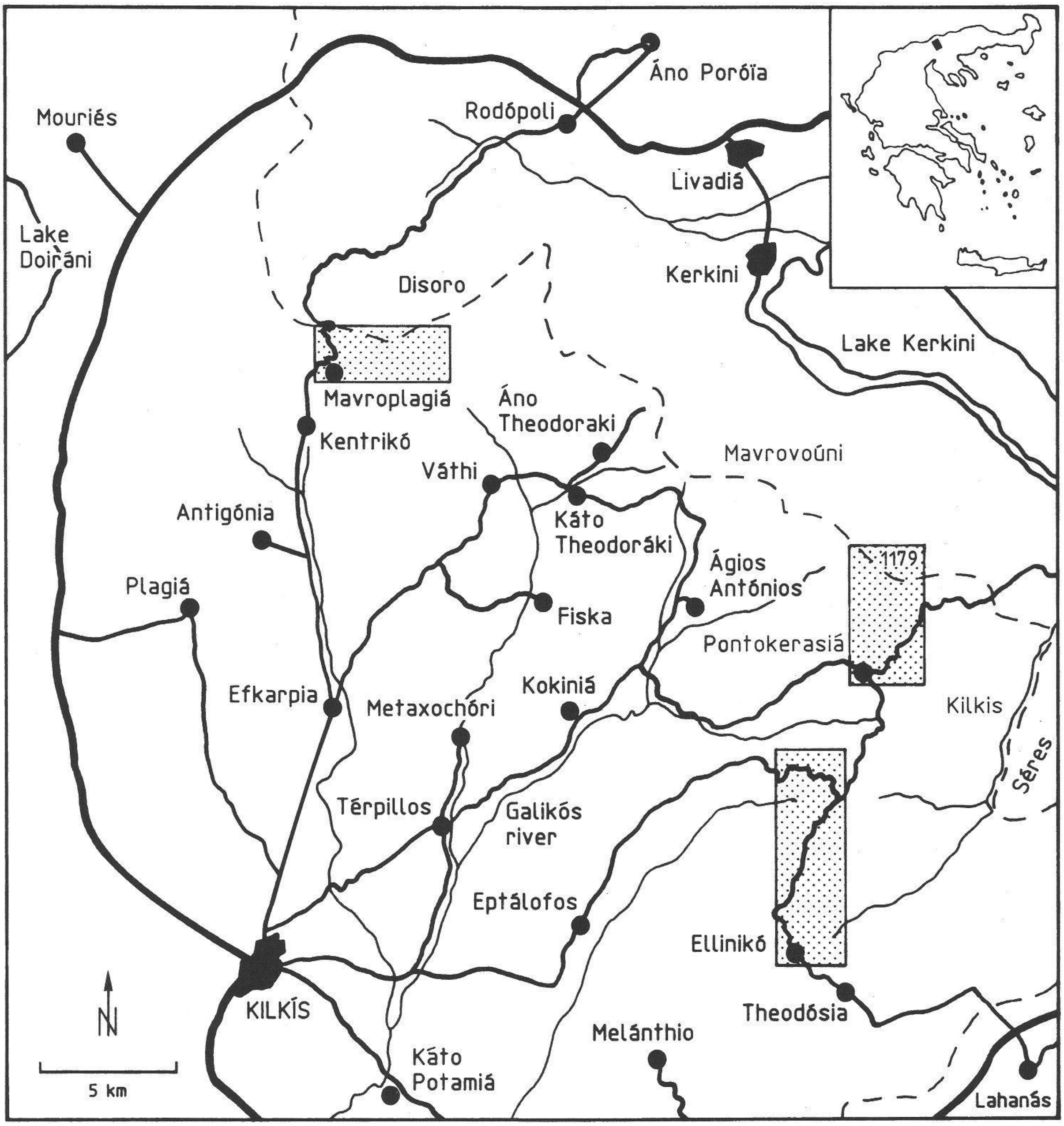

Fig. 1. Study area in Central Macedonia, Greece.

the Kroussia mountains is of a submediterranean character, with less than 40 dry days (Mavrommatis 1980; Athanasiadis et al. 1993).

2.3 *Vegetation*

Sclerophyllous, evergreen vegetation with *Q. coccifera* reaches its local northern boundary on drier sites of the southeastern foothills of the Kroussia mountains. The forest vegetation further inland is formed predominantly by several deciduous oak (*Quercus*) species. These forests belong to the submediterranean vegetation zone (Quercetalia pubescentis), which can be subdivided into the Ostryo-Carpinion subzone at lower elevations, and the Quercion frainetto subzone up to the highest summits.

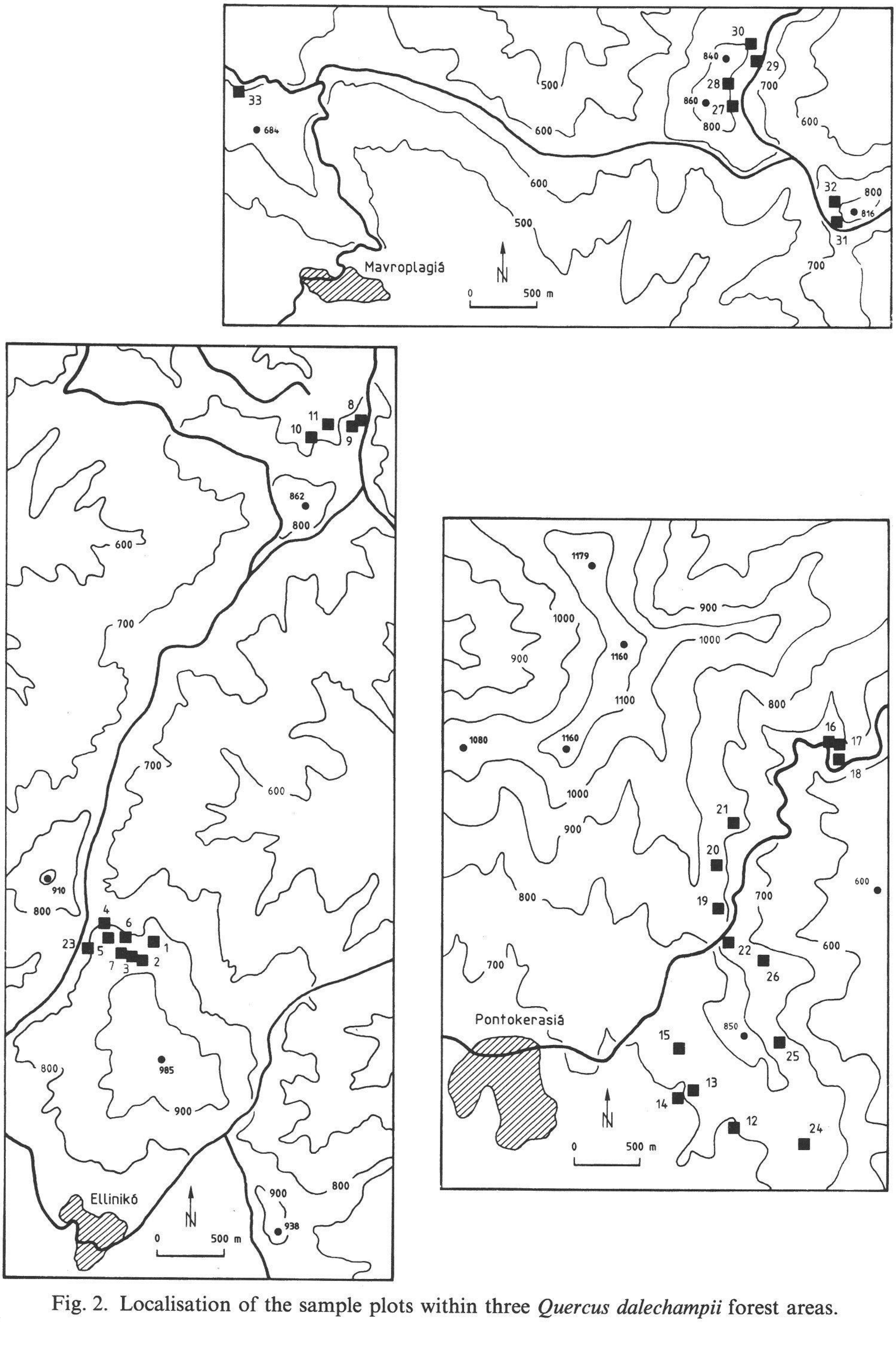

Fig. 2. Localisation of the sample plots within three *Quercus dalechampii* forest areas.

In the Ostryo-Carpinion subzone, *Q. pubescens* predominates up to 400–500 m a.s.l. ("Quercetum pubescentis"). The most prevalent woody species of this subzone are *Q. pubescens, Q. frainetto, Carpinus orientalis, Fraxinus ornus, Ostrya carpinifolia, Crataegus monogyna, Lonicera etrusca, Clematis vitalba, Acer campestre, Pistacia terebinthus, Clematis flammula, Paliurus spina-christi*, and *Pyrus amygdaliformis*. In the southeast, *Carpinus orientalis* forms a locally rare forest type on shade slopes ("Carpinetum orientalis"). Further to the southwest, a "Coccifero-Carpinetum" with *Quercus coccifera* has outliers at ca. 160 m a.s.l. in the area of Kato Potamia.

The Quercion frainetto subzone begins at ca. 300 m a.s.l. in northern expositions, and 500 m in southern ones. It stretches to the highest summits of the area at ca. 800–1140 m a.s.l. Within the Quercion frainetto subzone, *Q. frainetto* and *Q. pubescens* are forming a "Quercetum frainetto" at lower elevation in contact with Quercetum pubescentis forests. At higher elevations, *Q. frainetto*-forests still are frequent, but *Q. dalechampii* locally dominates in a "Quercetum montanum". Towards the east, *Tilia tomentosa* is associated in gullies and shade slopes (transition to "Tilietum tomentosae").

The results of the longlasting and intense anthropogenic influence are obvious everywhere in the study area. On large areas in the Ostryo-Carpinion subzone, forest has been replaced by fields or pastures. Parts of these pasture lands recently have been reafforested with pine species, including *Pinus brutia, P. nigra*, and *P. pinaster*.

The remaining forest stands are fragmented and of low height. All oak forests were and continue to be subject to intense human impact, including grazing and management by the Forest Service as "coppice forest" or "coppice forest with standards".

Deciduous forests formed by beech (*Fagus moesiaca*, rarely also *F. orientalis*) occur extrazonally in few places at higher elevations, mostly along streams, in gullies, or on shady slopes. In these forests, the dominant beech (*Fagus*) trees are mixed with *Q. dalechampii, Carpinus betulus, Carpinus orientalis, Acer platanoides, Corylus avellana, Cornus mas, Acer hyrcanum, Clematis vitalba, Acer campestre*, and few others. Because of longlasting and intense anthropogenic influence including coppicing these beech forests are also suffering in structure and species composition from severe degradation.

3. Methods

Data from 33 sample plots were recorded in June of 1993, using the Braun-Blanquet approach (Braun-Blanquet 1964, Westhoff and van der Maarel 1973). All plots were located on sites where *Q. dalechampii* was dominating the forest canopy ("older phase" in coppice forests). Plot size was 300 m^2, 3 plots 200 m^2 only. For each sample plot, elevation, exposition, slope, macro- and microrelief (Table 2), ground cover of the tree-, shrub-, and herb layer were recorded. Five soil profiles were studied in representative sample plots, including a systematic description and laboratory analyses* for each soil horizon (Table 3). The laboratory analyses comprised: (1) mechanical analysis (siphon method); (2) determination of pH (electrometric method in suspension of soil: water 1:5, pH-meter Beckman); (3) content in organic carbon (C %) (method of liquid acidity with acidic medium $K_2Cr_2O_7$). The calculation of the content of organic matter is based on the relation: Organic matter = organic carbon % × 1.724); and (4) content of total nitrogen (N %) (by Kjeldahl method; according to Papamichos & Alifragis 1988).

Vascular plants were identified using "Flora Europaea" (Tutin et al. 1964–1980), and the publications of Diapoulis (1939–1949), Kavvadas (1956–1964), Davis (1965–1985), Jordanov et al. (1963–1989), Krendl (1988), Strid (1989), and Strid & Tan (1991).

* The analyses were done in the laboratories of Silviculture of Aristoteles University of Thessaloniki, and Soil Science at Forest Research Institute of Thessaloniki.

Tab. 2. Physiography of the plots of the *Quercus dalechampii*-community.

	Community		Community type					
	Q. dalechampii		*S. torminalis*		*P. aquilinum*		*Q. frainetto*	
	Plots	%	Plots	%	Plots	%	Plots	%
Exposition								
N	7	21.2	4	30.8	1	25.0	2	12.5
NNE	1	3.1	1	7.6	0	0.0	0	0.0
NE	4	12.1	0	0.0	1	25.0	3	18.8
ENE	3	9.1	1	7.7	1	25.0	1	6.3
E	1	3.0	0	0.0	0	0.0	1	6.2
SE	1	3.0	0	0.0	0	0.0	1	6.2
WSW	1	3.0	1	7.7	0	0.0	0	0.0
W	6	18.2	2	15.4	0	0.0	4	25.0
WNW	2	6.1	0	0.0	1	25.0	1	6.2
NW	7	21.2	4	30.8	0	0.0	3	18.8
Total	33	100	13	100	4	100	16	100
Inclination								
0–30%	8	24.3	0	0.0	2	50.0	6	37.5
31–60%	21	63.6	10	76.9	2	50.0	9	56.3
>61%	4	12.1	3	23.1	0	0.0	1	6.2
Total	33	100	13	100	4	100	16	100
Elevation								
600–700 m	8	24.2	5	38.5	0	0.0	3	18.8
701–800 m	16	48.5	5	38.5	0	0.0	11	68.7
801–900 m	9	27.3	3	23.0	4	100.0	2	12.5
Total	33	100	13	100	4	100	16	100
Macro- and Microrelief								
Plane (u)	14	42.4	5	38.5	2	50.0	7	43.8
Convex (u)	8	24.3	3	23.1	1	25.0	4	25.0
Concave (u)	0	0.0	0	0.0	0	0.0	0	0.0
Plane (m)	9	27.3	4	30.8	1	25.0	4	25.0
Convex (m)	1	3.0	0	0.0	0	0.0	1	6.2
Concave (m)	0	0.0	0	0.0	0	0.0	0	0.0
Plane (l)	1	3.0	1	7.6	0	0.0	0	0.0
Convex (l)	0	0.0	0	0.0	0	0.0	0	0.0
Concave (l)	0	0.0	0	0.0	0	0.0	0	0.0
Total	33	100	13	100	4	100	16	100

u = upper slope; m = middle slope; l = lower slope

The nomenclature of taxa follows "Flora Europaea" (Tutin et al. 1964–1980). Exceptions are the species of the genus *Hieracium* which were identified by Gottschlich** (Tübingen), and of *Galium exaltatum* (Krendl 1988). The species *Clinopodium vulgare* includes the two subspecies *vulgare* and *orientale* (nomenclature according to Greuter et al. 1986). The plant list contains 226 species and subspecies.

** We thank Mr. G. Gottschlich (Tübingen) for identifying species of genus *Hieracium*, and Dr. T. Raus (Berlin) for confirming species of genera *Campanula, Knautia, Doronicum*.

The vegetation table was processed with the program SORT 2.5 (Ackermann and Durka 1991; table 4). Syntaxonomy follows Bergmeier (1990). For inferior phytosociological units, the terms "type" and "subtype" were used. The definition of "zones" and "subzones" follows Dafis (1973, 1975) and Athanasiadis (1986b).

4. *Quercus dalechampii*-forests of the Kroussia mountains (Mavrovouni, Disoro)

4.1. *Forest types*

In the Kroussia mountains in greek central Macedonia, limited stands as well as extensive forests of *Q. dalechampii* exist. Large stands can be found on Mount Mavrovouni (1179 m) northeast of the village of Pontokerasia, and smaller ones between the villages of Elliniko and Pontokerasia. On Mount Disoro (860 m), this forest type occurs on the top with some smaller stands adjacent (Fig. 1). Below and around the *Q. dalechampii* forests there are transitions towards forests of *Q. frainetto*. Some other stands are in contact with *Fagus* forests which occur mostly on shaded slopes and along streams.

The plots were sampled at elevations between 610–850 m (600–700 m: 24.2%, 701–800 m: 48.5%, 801–900 m: 27.3%), on slopes with inclinations of 13–67% (0–30%: 24.3%, 31–60%: 63.6%, >61%: 12.1%), in various expositions (N: 21.2%, NE+NNE: 15.2%, E: 3.0%, SE: 3.0%, WSW: 3.0%, W: 18.2%, NW+WNW: 27.3%) and mostly in the upper parts of plane and curved slopes (66.7%) or in the middle parts of plane slopes (27.3%) (Tab. 2). The geological substrate is formed by metamorphic rocks, including amphibolites, gneisses, and schists with marble intercalations. Soils are shallow to medium deep, have mostly sandy loam (SL) and loamy sand (LS), and are moderately acid brown forest soils* (Tab. 3). Soil structure is fine to medium, subangular.

The canopy of the *Q. dalechampii*-community was dominated by the name-giving species. The shrub layer consisted of *Cornus mas, Carpinus orientalis, C. betulus, Sorbus domestica*, and juveniles of tree species. On the ground, juveniles of *Q. dalechampii, Fraxinus ornus, Carpinus betulus, Carpinus orientalis* and a few others were found. *Rosa arvensis* was constantly present, together with a large number of herbs.

Phytosociologically, the *Q. dalechampii* forests belong to the alliance Quercion frainetto (Table 4). The analysis of the floristic composition has not revealed any character species, except perhaps *Q. dalechampii* itself. Therefore these forests were assigned to the alliance of Quercion frainetto as Quercus dalechampii-community. Because of environmental variation, 3 forest types can be distinguished, a *Sorbus torminalis*-type, a *Pteridium aquilinum*-type, and a *Q. frainetto*-type.

4.1.1. *Sorbus torminalis*-type

The *Sorbus torminalis*-type has 11 differential species and appears on relatively moist sites on Mt. Mavrovouni as well as on Mt. Disoro (Table 4/1-13). The sample plots were from elevations between 610–850 m, mostly in N, NW and W expositions, and slopes of 31–67% inclination. Soils were shallow to medium deep, with loamy sand (LS) and sandy loam (SL), representing moderately acid to neutral brown forest soils (Table 3/plot 32, 22).

* The soil profile in plot 8 presents on expressed clay horizon B yellowish red which is usually met in *Quercus frainetto* forests (Dafis 1966) but also in the worst site qualities of *Q. dalechampii* forests (Dafis 1966: 59) whereas the soil-profile in plot 32 presents neutral soil with pH 6.8.

Tab. 3. Soil characteristics of the plots of the *Quercus dalechampii*-community.

					Particle-size distribution								
1	2	3	4	5	6	7	8	9	10	11	12	13	14
32	A_{00}	5–3	–	–	–	–	–	–	–	–	–	–	–
	A_0	3–0	–	–	–	–	–	–	–	–	–	–	–
	A_1	0–5	10 YR 4/4	6.8	85	9	6	LS	0	0.98	1.69	0.06	16.3
	A	5–14	10 YR 5/8	6.8	83	7	10	LS	0	0.64	1.1	0.06	10.7
	R	14+	–	–	–	–	–	–	0	–	–	–	–
22	A_{00}	6–3	–	–	–	–	–	–	–	–	–	–	–
	A_0	3–0	–	–	–	–	–	–	–	–	–	–	–
	A	0–30	7.5 YR 6/8	5.9	56	20	24	SCL	0	0.76	1.31	0.04	19.0
	B	30–52	7.5 YR 5/8	5.9	69	18	13	SL	0	0.31	0.53	0.02	15.5
	R	52+	–	–	–	–	–	–	0	–	–	–	–
2	A_{00}	4–2	–	–	–	–	–	–	–	–	–	–	–
	A_0	2–0	–	–	–	–	–	–	–	–	–	–	–
	A	0–7	7.5 YR 5/8	5.5	63	25	12	SL	0	1.23	2.12	0.07	17.6
	B	7–20	7.5 YR 6/8	5.8	49	34	17	L	0	0.64	1.1	0.04	16.0
	R	20+	–	–	–	–	–	–	0	–	–	–	–
8	A_{00}	5–2	–	–	–	–	–	–	–	–	–	–	–
	A_0	2–0	–	–	–	–	–	–	–	–	–	–	–
	A	0–31	7.5 YR 6/8	5.7	66	17	17	SL	0	0.68	1.17	0.04	17.0
	B	31–49	5 YR 5/8	5.9	50	15	35	SCL	0	0.47	0.81	0.03	15.7
	B/C	49–64+	7.5 YR 5/8	5.5	56	8	36	SC	0	0.25	0.43	0.02	12.5
29	A_{00}	5–3	–	–	–	–	–	–	–	–	–	–	–
	A_0	3–0	–	–	–	–	–	–	–	–	–	–	–
	A	0–15	7.5 YR 5/6	5.7	85	6	9	LS	0	0.68	1.17	0.03	22.7
	R	15+	–	–	–	–	–	–	0	–	–	–	–

1 = Plot No.; 2 = Soil horizon; 3 = Soil depth (in cm); 4 = Soil color (after Munsell color system); 5 = pH (in H_2O, 1:5); 6 = Sand (in %); 7 = Silt (in %); 8 = Clay (in %); 9 = Soil texture; 10 = $CaCO_3$ content (0 = no reaction in HCl); 11 = Carbon-content (in %); 12 = organic matter (C-content in % × 1.724); 13 = Nitrogen-content (in %); 14 = C/N-ratio.

The *Sorbus torminalis*-type was subdivided into a pure subtype (Table 4/1-6) and a *Fagus moesiaca*-subtype (Table 4/7-13), with the differential species *Fagus moesiaca, Acer campestre* and *Cardamine bulbifera*. The sample plots of the pure subtype were from elevations between 610–790 m, and from various expositions on mostly steeper shaded slopes (38–67%). The sample plots of the *Fagus moesiaca*-subtype were from elevations between 640–850 m, in N, NW and W expositions and on slopes of 31–61% inclination.

4.1.2. *Pteridium aquilinum*-type

This type was differentiated by *Pteridium aquilinum, Cruciata laevipes* and *Lysimachia punctata* (Table 4/14-17). Besides this differential group, this type contained species of *Sorbus torminalis*-type (*Melittis melissophyllum ssp. albida, Melica uniflora, Fagus moesiaca*) as well as species of the *Q. frainetto*-type (*Crataegus monogyna ssp. monogyna, Rubus*

Table 4 : *Quercus dalechampii*-community in Mt. Kroussia (Mavrovouni, Disoro), Greece

1-13: *Sorbus torminalis*-type (1-6 = pure subtype; 7-13 = *Fagus*-subtype);
14-17: *Pteridium aquilinum*-type;
18-33: *Quercus frainetto*-type (18-24: pure subt.; 25-33: *Carex flacca*-subtype);
1-26: Mount Mavrovouni; 27-33: Mount Disoro.

Running number		1111	1111	1122222222223333
		1234567890123	4567	8901234567890123
Plot number		321321 21 1	1 2	32 22212231111
		3572285606467	9210	3089813744913215
Size of plot(m2 x 100)		3333333333333	3233	3332332333333333
Elevation (m a.s.l. x 10)		6767768768868	8888	8787787767777767
		1565942682045	2553	4901129996731074
Exposition		E NW	E W	E W
		N NNS NNN	NNN	NNN SNNNN N
		NEWWEWNNWWWWN	EEWN	EEENNEWEWWEWWWWW
Inclination(%)		6346464533364	5432	4441333432462123
		2850772021212	5000	1843405260010892
Macrorelief (UPper,MIddle,LOwer)		UMUUUMUUMUMLU	MUUU	UMUUUUUUUMMUMUUM
		PIPPPIPPIPIOP	IPPP	PIPPPPPPPIIPIPPI
Microrelief(PLane,CUrved=convex, COncave)		CPPPPPPPPCPPC	PPCP	PCPCCCPCPPPPPPPP
		ULLLLLLLLULLU	LLUL	LULUUULULLLLLLLL
Cover of trees(%)		7977888877887	8888	8776677786777766
		0000000000000	0000	0000000000000000
Cover of shrubs(%)		3112223252212	2132	4212322143 3342
		0500000000000	0000	0000000000550000
Cover of herbs(%)		8378787877778	7675	5967877779687787
		0000000000000	0500	0000000000000000
Height of trees(m)		111 111111111	1111	11111111111 1111
		3678372231483	5255	3440230043382221
Diameter of trees(cm)		1211122122122	1122	1111111111111111
		8296830520500	8733	7789974789877788
Number of species		4334434445456	6454	4565846566667666
		7813881482932	3657	4003059991641386
Differential species of the Sorbus torminalis-type				
Sorbus torminalis	T	......+......	....	....
Sorbus torminalis	S	.++++2++++.+1	+...	....+.......1...
Sorbus torminalis		..+r+.r.rrrrr	+...	.......r....r...
Acer hyrcanum	T	......+.....+	....	.......1........
Acer hyrcanum	S	...+..+1+....	....	.......1........
Acer hyrcanum		.r.+r.rrr....	....	....
Physospermum cornubiense		1+.1+.1+1+r+.	+...	....r.r.r...+...
Trifolium medium ssp. balcanicum		.r++r..1++.1r	..r.	.r..........1..+
Polygonatum odoratum		..++.+r.+.+1r	.r..	....+...+...r...
Mycelis muralis		....+r.r+.r.+	.r..	......r.......r.
Lathyrus niger ssp. niger		.12..+..1.+1.	....	....r.........+.
Lathyrus venetus		1..1..1+..+..	....	....
Symphytum bulbosum		....2..+.+.r+	1...	1...1...........
Melitis melissophyllum ssp. albida		.r+.++++.++++	+r+r	....+.+.........
Melica uniflora		2+12211221111	1111	..1...+2........
Differential species of the Fagus moesiaca-subtype				
Fagus moesiaca	T	......++1.+.+	.111	+.....+.........
Fagus moesiaca	S	....+.1+++1++	.+2+	+...............
Fagus moesiaca		......1.++2.+	.1.r	+...r...r.....r.
Acer campestre	T	....	....	+...............

Acer campestre	S	.+....+..++++	+...	............+...
Acer campestre		.r..r....+..+	.r..	............r..
Cardamine bulbifera		.....2..+3r+	....	....

Differential species of the Pteridium aquilinum-type

Pteridium aquilinum		....	+222	........+.......
Cruciata laevipes		.........r..r	++++	.........r...+..
Lysimachia punctata		....	+rr+	.r...r..r....r.r

Differential species of the Quercus frainetto-type

Crataegus monogyna ssp. monogyna	S	......+...+..	.+++	+++.++.+.+..++..
Crataegus monogyna ssp. monogyna		r.....r..rr..	rr+r	..rr..r.rrr.r+rr
Rubus sanctus	S	...........+.	...+	.+.......+......
Rubus sanctus		....	+.++	....r+.....+.+++
Rosa gallica		....	+...	.....1...1...2+.
Festuca valesiaca		.......r1...2	.rrr	r..2+++++++3+1++
Teucrium chamaedrys		...r.........	+rrr	++.1r1++.11112+1
Poa angustifolia		.......+..+..	++++	...+..r.11+.+2++
Muscari neglectum		.........+..+	.r+r	1..rrr+.r+..+1++
Quercus frainetto	T	2..1+....1...	..+.	.1211.11.1.+211+
Quercus frainetto	S	+......+.....	....	.+.++....+..1+1+
Quercus frainetto		...r.........	....	.......+..+.....
Hypericum perforatum		r..rr..rr....	+...	.+1r++++++1+r+r+
Silene italica ssp. italica		...+.........	...r	+++++r+++.+2+.11
Trifolium alpestre		.....r...r...	.r..	r++r+r1+1.+1++..
Rorippa thracica		....	....	...rrrr.r1++11++
Thymus sibthorpii		...+.........	....	...1+rr..++11++1
Genista carinalis		....	....	...1+.r.++..+112
Anthoxanthum odoratum		....	....	...++.+...r1+++1
Lychnis viscaria ssp. atropurpurea		....	....	....+.rrrr.+.+++
Muscari comosum		....	.+r.	..r..r.+.+rr.rr.
Lactuca viminea ssp. viminea		....	....	..+r.r.r..++rr..
Vicia tetrasperma		1.......+..+.	....	.r+.+..r+...+.++
Hieracium bauhini ssp. magyaricum		....	....	.r..+.r.r.r+..+r
Lathyrus sphaericus		....	....	..r+r.....rr..+.
Vicia hirsuta		.....r.....+.	....	....1.r.....+.++

Differential species of the Carex flacca-subtype

Carex flacca ssp. flacca		....r........	...+	...1...+.++.+2.1
Luzula multiflora ssp. multiflora		....	....	.......rr+r+.+.r
Cardamine hirsuta		..+.....r..r.	....	......r.1r.r1.r+
Hieracium hoppeanum ssp. troicum		....	....	......r.rrr+.r.1
Anthemis tinctoria ssp. australis		....	....	..r...r...r1r.rr
Ferulago sylvatica		....	r...	.....+..+1..++.+
Carex divulsa ssp. leersii		.....r.......	....	.....r.r.+r..+r.
Potentilla recta		....	....	...+...r..+r.rr.
Dorycnium pentaphyllum ssp. herbaceum		....	....	.........+..++2r
Rumex acetosella		....	....	.......r..rrr..r
Knautia macedonica		....	....	.........+..r+rr
Geranium columbinum		....	....	.........1r.rr..
Lotus corniculatus		.....+.......	....	........+r..r..+
Ajuga genevensis		....	....	..r....+r...r.r.

Dominant species of the Quercus dalechampii-community

Quercus dalechampii	T	3544554544554	4543	4444444354444444
Quercus dalechampii	S	112+11.12111.	.+1+	+1+222.+321.1232
Quercus dalechampii		+1+++++++11++	11.+	1+1++2++111111++

Character-species of Quercion confertae (=Quercion frainetto-cerris)

a) Trees and shrubs

Tilia tomentosa	T	........+....	....	....
Tilia tomentosa	S	.......++....	...+	....
Tilia tomentosa		.........r.r.	....	....

b) Herbs

Potentilla micrantha		+++111.+1+.++	1.++	.11.1+111...+.r+

Scutellaria columnae ssp. columnae		1r.+1.11+1+++	+.+.	+++.1.+r+.+.r.+.
Lathyrus laxiflorus		1.21111222111	1.1.	.2+...1+1.r.1...
Helleborus cyclophyllus		+..++.r..r+++	1rr.	r++.r.++++..r..+
Lychnis coronaria		+..+....r..r.	....	..+r+rr+......r.
Huetia cynapioides ssp. cynapioides		+........+.r	....	....1...r.......
Silene viridiflora		.........+r.	....	...+1.........r.
Digitalis lanata		....	....	....r+r.......r.
Leontodon cichoraceus		.........+...	....	...+1..........

Character-species of Quercetalia pubescentis

a) Trees and shrubs				
Cornus mas	T	....	+..+	....
Cornus mas	S	++..1+.++++1+	+++1	++.++1+111..1+++
Cornus mas		+.....+..+rr+	.r.1	.r+..+.r.rr..rrr
Fraxinus ornus	T	+++++..++....	....	..+....2........
Fraxinus ornus	S	21+..1+1+++++	....	.+...+.+.++.+.+.
Fraxinus ornus		+11+++.+...1+	r...	r.1rrrr+..++rr.r
Carpinus orientalis (O.-C.)	T	++.+.....+...	...+	1++....1........
Carpinus orientalis (O.-C.)	S	21.2+.+++1.+.	+...	221.+.21+..12.++
Carpinus orientalis (O.-C.)		+r....r..+rr.	....	+.....++....rrrr
Sorbus domestica	T	....	....	...+............
Sorbus domestica	S	++.....++....	+..+	.+...+......++.+
Sorbus domestica		++..r.++...r.	r...	...r.r..r.....r.
Lonicera etrusca		.r......+....	....	1...+....+.rr...
Prunus spinosa	S	....	..+.	....
Prunus spinosa		......r......	...+	......r...+......
Rubus canescens	S	....	....	..+.............
Rubus canescens		....	....	...1......+.....
Rosa canina	S	....	+.+.	............+..+
Chamaecytisus hirsutus		........rr..r	....	r..........r....
b) Herbs				
Luzula forsteri		1r+++.++111++	+1+1	11111+1+1..+1.11
Clinopodium vulgare		..++.1..+..++	+++1	++1+1+r++r+1+11+
Campanula persicifolia		+r.rr+.+.r+rr	.r.+	.+r.+.1.1.+11.+1
Viola hirta		.+r+..+..++rr	1111	1+1..1.1+r..+.+r
Festuca heterophylla		+r+++.+1+211+	+.+.	.11.+.++.r....1.
Silene vulgaris ssp. vulgaris		+.r+r...r..+r	r.1.	.++.rr.1+..rr...
Vicia grandiflora		+.1..1.....1.	+..r	..r1r..r.1+.1+1.
Cephalanthera longifolia		.+..+..+r.rr.	+..1	....r1..rr.....r
Cyclamen hederifolium		.+....1.+r+.r	.r+.	...r1.+.......r.
Cardamine graeca		1.31.3......r.	....	.12...+2..1+....
Geranium lucidum		+...r.r...r.r	....	.....r..1..r.....
Tamus communis		..r..r.....+.	+.+.	........rr......
Hypericum montbretii		.....r.......	...r	.......r.r..+..r.
Carex depauperata		....+........	....	r.r..+....+.....
Vicia dalmatica		....	.r..	...+.1.......r..
Trifolium ochroleucon		....	....	.r.....r...+....

Character-species of Querco-Fagetea

a) Trees and shrubs				
Rosa arvensis (F.)		+r.r1++++1+.1	2+1+	+++++++.++r.++r.
Carpinus betulus (F.)	T	....1.1.21+.+	2+.3	..+...+.....1+..
Carpinus betulus (F.)	S	++..2.1+3...1	1..2	++...++.++..1+.+
Carpinus betulus (F.)		.r..+.+r11..1	+r.+	..r.....r.r.....
Corylus avellana	S	....	..++	.............+.+
Corylus avellana		....	...+	............r...
Rubus hirtus (F.)	S	....	....	..+.............
Rubus hirtus (F.)		......+...+..	.1.+	....
Hedera helix ssp. helix		.+r....rr..r.	....	........+........
Prunus avium (F.)	S	....	..+.	....
Prunus avium (F.)		.......r.....	.r..	....r.........+.
Clematis vitalba	S	....	....	.....1..........
Clematis vitalba		....	r..r	.....+....r.....
Lonicera caprifolium		....	..1.	.......r..1......
b) Herbs				
Poa nemoralis		2+32131211123	2111	121.1+1+11+.111+
Euphorbia amygdaloides ssp. amygdaloides		1++1+1.1+++1+	1+11	121r+++1+++.++++

Veronica chamaedrys ssp. chamaedrys		1+111+r111.1+	.r+.	r11+1r1+.+++1.11
Aremonia agrimonoides ssp. agrimonoides		.+.++.++r++r1	2121	1++1rrr.1+..1.1+
Brachypodium sylvaticum ssp. sylvaticum		+..+.....+..+	+122	1++1+.1++2++.1++
Primula vulgaris ssp. vulgaris		+.rrr.1++11+1	.r+.	+r+.r.++r...r...
Lapsana communis ssp. communis		+r+.++r...+++	+...	r++.+.r1++.+..+1
Fragaria vesca		......+++11.1	1121	2+++....11...+11
Viola reichenbachiana (F.)		.....r+..++++	.r+.	+...r.r.+r....+.
Geum urbanum		......+..r..+	r.+.	r++...r1r.r..r..
Campanula trachelium ssp. athoa		....r..r....+	r..r	r.....r.rr..+...
Asplenium trichomanes ssp. trichomanes		...r.........	r...	......r...rrr...
Digitalis grandiflora		+............	.r..	.+r.....r.......
Myosotis sylvatica ssp. subarvensis		r............	....	............+r.r
Arum maculatum (F.)		......r...r..	r...	r...............
Platanthera chlorantha		.r...........	rr..	.....r..........
Thalictrum aquilegifolium (F.)		............r	.rr.	....
Neotia nidus-avis (F.)		........+....	r..r	....

Companion species

a) Trees and shrubs				
Pyrus pyraster	S	....	..+.	...+..........+.
Pyrus pyraster		.........r...	.r.+	.............r..
Chamaecytisus supinus	S	........+....	.++.	.+.....+..+.....
Chamaecytisus supinus		....	....	......rr..r.....
Malus domestica	T	............+	..+.	....
Malus domestica	S	....	+..+	.............+..
Malus domestica		....	r...	......r.........
Ulmus procera	S	....	+...	......+..+...1..
Ulmus procera		....	....	.............+..
Prunus sp.		........r....	....	...r.r..........
P. amygdaliformis		....	....	...r.........r.r
b) Herbs				
Dactylis glomerata		+++1.++++r1++	1111	2111211111212121
Galium aparine		....1r.r+r.rr	+.1.	++222r.1121+2111
Galium exaltatum		.r1..+.1...1+	1r+1	+1+..11.+1+r++.+
Asplenium onopteris		1rr+..r+rr+++	r...	.++.1.+r+.r1+...
Cystopteris fragilis		+..1+1+r.+1r1	+...	1++.+.r++...r...
Epipactis atrorubens		....rr+..rr.+	r.1r	r++......rr.rr+.
Hieracium cf. racemosum		r.r.+...1++r1	rr..	...r+.r.r......+
Campanula sparsa ssp. sphaerothrix		.r.rr..r.r.r.	....	.rr.....++.++..r
Vicia cassubica		..+..+...r...	.+1+	...rr...+++....+
Fritillaria pontica		...rr.......r	r...	..r....rrr......
Stachys plumosa		.....r.......	....	.+r....r..rr....
Aristolochia rotunda		....	....	..rr.r.r......r.
Lamium maculatum		..........+.r	r...	....+.+.........
Stefanoffia daucoides		..........r..	....	r...+......r....
Eryngium campestre		....	....	...+.....rr..r..
Trifolium campestre		.....r.......	....	....r....r.r....
Centaurea cf. affinis		....	....	...r......rr...r
Vincetoxicum speciosum		r..+.........	....	........+r......
Galium verum ssp. verum		............r	..r.	...r.........+..
Lathyrus nissolia		....	....	...r...r.+..r...
Viola tricolor ssp. tricolor		...r.........	....	.+......r.+.....
Lactuca serriola		...........r.	....	..........+r...r
Glechoma hirsuta		+........+..+	....	......r.........
Stellaria graminea		1............	r...	..............+.
Myrrhoides nodosa		....r........	....	+.......1.......
Hieracium rechingeriorum		+..........+..	....	....1...........
Sanguisorba minor ssp. muricata		....	....	........r.r..r..
Sedum cepaea		....	....	........r..r+...
Arabis sagittata		....	....	..........rr.r..
Hieracium sp.		....	....	........r...+r..
Bromus sterilis		....	....	............rr.r
Knautia ambigua		....	....	r.+....+........

Species in one or two plots:
Woody species: Acer platanoides T (13:+); Acer platanoides (13:r); Juniperus oxycedrus ssp. oxycedrus S (21:+; 22:+); Juniperus oxycedrus ssp. oxycedrus (21:r); Quercus pubescens T (29:+); Fagus orientalis T (13:+); Populus tremula S (16:+); Ruscus aculeatus S (2:+); Clematis flammula (21:r); Juniperus communis ssp. communis (33:r); Cistus incanus ssp. creticus (33:r);
Other species: Vicia villosa ssp. villosa (28:+; 29:+); Vicia villosa ssp. varia (21:+; 31:+); Acinos alpinus ssp. majoranifolius (28:r; 29:+); Ceterach officinarum (28:r; 29:r); Knautia arvensis (24:r; 32:+); Bupleurum commutatum ssp. commutatum (28:r; 29:r); Veronica hederifolia ssp. hederifolia (11:r; 13:r); Poa bulbosa (13:r; 24:r); Moehringia trinervia (5:r; 13:r); Astragalus glycyphyllos (22:r; 26:r);Trifolium repens (20:r; 22:r); Trifolium subterraneum (21:r; 22:+); Veronica officinalis (8:+; 10:r); Myosotis ramosissima ssp. ramosissima (22:r; 32:r); Torilis arvensis (14:r; 22:r); Arabidopsis thaliana (26:+; 33:1); Epilobium lanceolatum (2:r; 26:r); Trifolium hirtum (29:+; 33:r); Bilderdykia convolvulus (3:r; 6:r); Medicago lupulina (6:r; 22:r); Torilis ucranica (4:+; 29:+); Galium pseudaristatum (1:1; 5:r); Leontodon crispus ssp. crispus (20:r; 24:r); Vincetoxicum fuscatum (31:+); Hieracium piloselloides ssp. piloselloides (22:+); Solanum dulcamara (16:r); Stachys palustris (18:r); Alliaria petiolata (22:r); Polypodium vulgare (22:r); Orchis laxiflora ssp. palustris (22:r); Galium spurium (22:+); Ornithopus compressus (22:r); Limodorum abortivum (21:r); Verbascum phoeniceum ssp. flavidum (32:r); Doronicum hungaricum (32:r); Polystichum setiferum (1:+); Euphorbia taurinensis (1:r); Dianthus cruentus ssp. turcicus (31:r); Hieracium umbrosum ssp. umbrosum var. abietinum (1:+); Brachypodium pinnatum ssp. pinnatum (30:+); Valerianella locusta (30:r); Achillea clypeolata (29:r); Achillea millefolium ssp. millefolium (29:r); Trifolium arvense (29:r); Petrorhagia illyrica ssp. haynaldiana (29:r); Orlaya daucoides (29:r); Sonchus asper ssp. asper (6:r); Torilis leptophylla (29:+); Hieracium cymosum (29:r); Hieracium erythrodontum (29:r); Melilotus sp. (29:+); Allium paniculatum ssp. paniculatum (14:r); Lysimachia nummularia (17:+); Poa compressa (23:+); Polygonatum latifolium (5:r); Hieracium cf. marchesettianum (24:r); Hieracium umbellatum (2:r); Scrophularia nodosa (20:r); Lathyrus aphaca (20:r); Carex distachya (20:r); Berteroa obliqua (29:r); Linaria genistifolia ssp. genistifolia (29:r); Phleum pratense ssp. pratense (29:+).

(F.) :Character-species of the Fagetalia sylvaticae Pawl. 1928
(O.-C.):Character-species of the Ostryo-Carpinion orientalis Horvat 1959

ulmifolius, Festuca valesiaca, Teucrium chamaedrys, Poa angustifolia, Muscari neglectum). The presence of these species indicates the transitional character of the *Pteridium aquilinum*-type from the relatively moist to the drier locations of *Q. dalechampii* forests.

The sample plots were from elevations between 820–850 m a.s.l., in WNW, N, NE, ENE expositions and on slopes 20–55% at Mt. Mavrovouni. The soil profile was on shallow, sandy loam (SL), representing a moderately acid brown forest soil (Table 3/plot 2).

4.1.3. *Quercus frainetto*-type

The *Q. frainetto*-type was found in drier locations of the *Q. dalechampii*-forests on Mt. Mavrovouni and Mt. Disoro (Table 4/18-33). It represents a transition towards the "Quercetum frainetto". The canopy was more open, and many light-demanding species were growing on the ground, including *Rubus ulmifolius, Hieracium bauhini ssp. magyaricum, Festuca valesiaca, Crataegus monogyna, Rosa gallica, Teucrium chamaedrys, Poa angustifolia, Hypericum perforatum, Rorippa thracica, Thymus sibthorpii, Anthoxanthum odoratum*, and *Genista carinalis*. Grazing effects are intense, most of the above mentioned species are indicators of the impact of grazing.

The sample plots were from elevations between 670–840 m a.s.l., mainly in W, NW, N and NE expositions and on slopes with 13–48 (–61) % of inclination. Soil are shallow and up to medium deep, moderately acid brown forest soils (Table 3/plot 8, 29). They have loamy sand, sometimes with clay in the subsoil resulting in shallow rooting.

The *Q. frainetto*-type could be subdivided into a pure subtype (Table 4/18-24) and a species-rich *Carex flacca*-subtype (Table 4/25-33). The *Carex flacca*-subtype was differentiated by a species group formed by drought-tolerant and light-demanding species, including *Potentilla recta, Anthemis tinctoria, Dorycnium pentaphyllum ssp. herbaceum, Ajuga genevensis, Rumex acetosella, Ferulago sylvatica, Hieracium hoppeanum ssp. troicum, Lotus corniculatus,* and *Knautia macedonica.*

The plots of the pure subtype were recorded between 710 and 890 m a.s.l., in NW, N, NE and SE expositions, on slopes of 30–48% of inclination, on the upper part of hillsides.

The sample plots of the *Carex flacca*-subtype occurred between 670 and 790 m a.s.l., in W, WNW, NW and E expositions, on slopes 18–42 (–61) %, on upper and middle slopes. Many localities were degraded by intense grazing.

4.2. Syntaxonomic-synsystematic synopsis

Class: Querco-Fagetea Br.-Bl. et Vlieger 1937 in Vlieger 1937
Order: Quercetalia pubescentis Br.-Bl. 1931 ex auct. (in Braun-Blanquet 1931 non valid. publ.)
Alliance: Quercion confertae (=frainetto) Ht. ex Horvat 1958
Community: *Quercus dalechampii*-community
Type: *Sorbus torminalis*-type
Subtype: Pure subtype
Fagus-subtype
Type: *Pteridium aquilinum*-type
Type: *Quercus frainetto*-type
Subtype: Pure subtype
Carex flacca-subtype

Discussion

Research on the phytosociology and site factors of deciduous oak forests in Greece is insufficient and fragmentary. *Q. dalechampii* forests are in contact and transition to *Q. frainetto* forests, and form pure and mixed forests. Physiognomically and floristically, the forest types of these oak species are rather similar.

Vegetation studies in pure and mixed forests containing *Q. dalechampii* were carried out by Dafis 1966 in northeastern Chalkidiki (see also Horvat et al. 1974: 241, Tab. 48); Zoller et al. (1977) in Rodopi, Thrace; Gamisans and Hebrard (1979) in northern Pindos; Gamisans and Hebrard (1980) in Rodopi, Thrace and Central Macedonia; Raus (1980) in eastern Thessaly; Bergmeier (1990) in Lower Olympus; Theodoropoulos (1991) in Cholomontas, and Löblich-Ille (unpubl.) in the Pieria mountains (Table 5, 6). Synsystematically, most authors assigned mixed forests with *Q. dalechampii* to the alliance Quercion frainetto, subdivided by various associations and subunits (e.g., Gamisans and Hebrard 1979, 1980). Due to a lack of character species, pure forests were defined as *Q. dalechampii*-community, and also located into the alliance Quercion frainetto (Table 5, 6). A literature comparison of the site descriptions of greek forests containing *Q. dalechampii* either mixed or pure, gives information about soil and climatic conditions.

Tab. 5. Mixed forests with *Quercus dalechampii* (physiographic characteristics and soil conditions).

Author (study area)	Phytosociological nomenclature	No. of plots	Elevation (m a.s.l.)	Exposition	Inclination (% or °)	Geology	Soil	
							Description	pH
Dafis 1966 (NE Chalkidiki)	"Mixed forest of deciduous broadleaved trees"	5	300–620	N, NE, E	40–70%	Gneiss	Sandy loam	6,4–6,6
Zoller et al. 1977 (Thrace)	"*Quercus dalechampii*-forests"	1	110	ONO	20°	Schist	Loamy sand	5,5
Gamisans & Hebrard 1979 (N Pindos)	'*Quercus dalechampii*-forests"	2	1100	SE, SSE	10°–25°	Quartz, schist	?	?
Gamisans & Hebrard 1980 (W Thrace)	"Symphyto ottomani-*Quercetum frainetto quercetosum dalechampii*"	7	200–550	NW, NNW, W, NE, NNE	25°–40°	Gneiss	?	?
Gamisans & Hebrard 1980 (C. Macedonia, Kerdillion)	"Digitali-*Quercetum frainetto* faciès a *Quercus dalechampii*"	2	400–450	NW, NNW	35°–45°	Quartz	?	?
Gamisans & Hebrard 1980 (Pieria, Pieria)	"Mixed forests of *Quercus dalechampii* and *Ostrya carpinifolia*"	3	550–650	ENE, NE, NNW	10°–45°	Gneiss, schist	?	?
Raus 1980 (E Thessaly, Ossa)	"*Tilio (tomentosae)-Castanetum*"	11	240–400	NW, N, NNW, NE, NNE	6°–25°	Schist, phyllite, gneiss	stony	?
Bergmeier 1990 (NE Thessaly, Lower Olympus)	"*Tilio tomentosae-Castanetum*"	7	490–680	N, NW	15°–30°	Cryst. limestone, dolomite	stony	?

Tab. 6. Pure forests of *Quercus dalechampii* (physiographic characteristics and soil conditions)

Author (study area)	Phytosociological nomenclature	No. of plots	Elevation (m a.s.l.)	Exposition	Inclination (% or °)	Geology	Soil: Description	Soil: pH
Dafis 1966 (NE Chalkidiki)	"*Quercetum montanum*"	19	500–750	NW, W, N, E, SE	30–60%	Granite, gneiss	Sandy loam (sometimes with clay enrichment in subsoil)	4.7–6.2
Zoller et al. 1977 (Rhodope)	"*Quercus dalechampii*-forests"	2	840–1000	SW, SSW	15°–25°	Quartz porphyry	Stony-sandy	5.3–5.8
Zoller et al. 1977 (Thrace)	"*Quercus dalechampii*-forests"	3	400–580	NW, NO	10°–20°	Gneiss	Sandy, stony-sandy, loamy sand	5.2–5.5
Gamisans & Hebrard 1979 (N Pindos)	"*Quercus dalechmpii*-forests"	1	1250	S	15°	Quartz	?	?
Raus 1980 (E Thessaly, Ossa)	"*Quercus dalechampii*-community"	8	380–650	NW, W, NE, ENE	8°–20°	Schist, phyllite, gneiss	Sandy loam or with clay enrichment in subsoil	?
Bergmeier 1990 (NE Thessaly, Lower Olympus)	"*Quercus dalechampii*-community"	4	500–660	S, SO	12°–30°	Metamorphic rocks (Amphibolite-gneiss-schist-complex) and consolidated depris.	Stony (under somewhat moist conditions)	?
Theodoropoulos 1991 (C Chalkidiki, Cholomon)	"*Quercetum montanum* prov."	6	900–1010	S, SW	27–53%	Granite	Sandy loam	4.95–5.90
Present research (Central Macedonia, Kroussia)	"*Quercus dalechampii*-community"	33	610–850	N, NW, W, NE, ENE, WNW, NNE, E, SE, WSW	13–67%	Metamorphic rocks (amphibolites, gneisses, schists with marble intercalations)	Sandy loam and loamy sand (sometimes with clay enrichment in subsoil)	5.5–5.9 (6.8)
Löblich-Ille (unpublished) (Pieria, Pieria)	"*Quercus dalechampii*-community"	10	830–1130	ENE, NE, E	30–45%	?	?	?

Soil type seems to be most important. *Q. dalechampii* forms pure stands mostly on sandy-loamy soils which are moister than the soil of pure *Q. frainetto* forests. Mixed forests, having *Q. dalechampii* and *Q. frainetto* in the canopy, apparently prefer heavier soils with an enrichment of clay in the subsoil. The generalizing remark of Dafis (1966: 58) still is valid, that the restricted occurrence of *Q. dalechampii* within its area is mainly due to soil, geology, and silvicultural modifications of its synecology. Therefore the forests of *Quercus dalechampii* have to be regarded as an azonal community.

With decreasing loam content, *Q. dalechampii* mixes with other tree species, including *Fagus* sp., *Castanea sativa*, and *Tilia tomentosa* on moister sites or shady slopes, and with *Q. frainetto* and other submediterranean tree species on less loamy (drier?) sites.

Climatic influence seems to be less important. Plots with *Q. dalechampii*-communities were sampled between 380 m (Ossa) and 1250 m a.s.l. (North Pindos), from variously exposed and inclined (Table 6). However, mixed forests seem to be more frequent at lower elevation, indicating a climatic component governing the competition between *Q. dalechampii, Q. frainetto* and other species. More research is needed to analyse competition effects and community formation processes in the submediterranean forests of Greece, and the south balkanic plant associations of the Quercion frainetto in particular (Bergmeier 1990; Theodoropoulos 1991: 127).

References

Ackermann W. and Durka W. 1991. SORT 2.0, Programm zur Bearbeitung von Vegetationsaufnahmen. Bayreuth, 61 S.

Adler W., Oswald K. & Fischer R. 1994. Exkursionsflora von Österreich. Stuttgart & Wien, 1180 S.

Athanasiadis N. 1986a. [Forest Botany. Trees and Shrubs of the Greek Forests] (in Greek). Thessaloniki, 309 pp.

Athanasiadis N. 1986b. [Pflanzensoziologie] (in Greek). Thessaloniki, 119 pp.

Athanasiadis N., Theodoropoulos K. and Eleftheriadou E. 1993. [Contribution to the knowledge of the Mount Kroussia Flora] (in Greek). Scien. Ann. Depart. Forest. and Nat. Environm. (in press).

Bergmeier E. 1990. Wälder und Gebüsche des Niederen Olymp (Kato Olimbos, NO-Thessalien). Ein Beitrag zur systematischen und orographischen Vegetationsgliederung Griechenlands. Phytocoenologia 18: 161–342.

Braun-Blanquet J. 1964. Pflanzensoziologie – Grundzüge der Vegetationskunde. 3. Aufl., Wien, New York, 865 S.

Dafis S. 1966. [Standorts- und ertragskundliche Untersuchungen in Eichen- und Kastanienniederwäldern der nordöstlichen Chalkidiki] (in Greek). Thessaloniki, 120 pp. + Tab.

Dafis S. 1973. [Gliederung der Waldvegetation Griechenlands] (in Greek). Wiss. Jahrb. Fak. Landwirt. Forstwiss. Univ. Thessaloniki 15: 75–88.

Dafis S. 1975. Vegetationsgliederung Griechenlands. Veröff. Geobot. Inst. ETH, Stiftung Rübel, Zürich, 55: 23–36.

Davis P. H. (ed.) 1965–1985. Flora of Turkey and the East Aegean Islands. Edinburgh, 1–9.

Diapoulis C. 1939–1949. [Flora of Greece] (in Greek). Athens, 1–3.

Flocas A. 1990. [Compendium of Meteorology and Climatology] (in Greek). Thessaloniki, 465 pp.

Gamisans J. and Hebrard J. P. 1979. A propos de la végétation des forêts d'Epire et de Macédoine Grèce occidentale. Doc. phytosoc. 4: 290–341.

Gamisans J. and Hebrard J. P. 1980. A propos de la végétation des forêts en Grèce du nord-est (Macédoine orientale et Thrace occidentale). Doc. phytosoc. 5: 243–289.

G.A.S. – Geographical Army Service 1969, 1970. Geographical maps 1:50 000. Sheets: Cherso, Kerkini, Lahanas, Sidirokastro. Athens.

Greuter W., Burdet H.M. & Long G. 1986. Med-Checklist 3. Genève.

Horvat I., Glavac V. & Ellenberg H. 1974. Vegetation Südosteuropas. Stuttgart, 767 S.
I.G.M.E.-Institute of Geology and Mineral Exploration (ed.) 1983. Geological map of Greece 1:500 000. 2. Aufl., Athen.
Jalas J. & Suominen J. 1976. Atlas Florae Europaeae 3 (*Salicaceae* to *Balanophoraceae*). Helsinki.
Jordanov D. et al. (eds.) 1963–1989. Flora Reipublicae Popularis Bulgaricae. Sofia, I–IX.
Kavvadas D. 1956–1964: [Illustrated Botanical-Phytological Lexicon.] I–IX (in Greek). Athens, 4584 pp.
Krendl F. 1988. Die Arten der *Galium mollugo*-Gruppe in Griechenland. Bot. Chron. 6–7 („1986-7"): 5–168.
Mavrommatis G. 1980. [Le bioclimat de la Grèce. Relations entre le climat et la végétation naturelle. Cartes bioclimatiques.] (in Greek). Inst. d. Recherc. Forest. d'Athènes., 63 pp. + Cartes.
Mountrakis D. M. 1985. [Geology of Greece] (in Greek). Thessaloniki, 207 pp.
Papamichos N., Alifragis D. 1988. [Description-Sampling and laboratory analysis of forest soils and plant tissue] (in Greek). Thessaloniki, 149 pp.
Raus T. 1980. Die Vegetation Ostthessaliens (Griechenland). 3. Querco-Fagetea and azonale Gehölzgesellschaften. Bot. Jahrb. Syst. 101: 313–361.
Strid A. (ed.) 1989. Mountain flora of Greece, vol. 1. Cambridge, 822 pp.
Strid A. & Tan K. 1991. Mountain flora of Greece, vol. 2. Edinburgh, 974 pp.
Schwarz O. 1936. Monographie der Eichen Europas und des Mittelmeergebietes. I, II. Rep. Spec. Nov. Regni veg., Sonder-Beiheft D: 1–200.
Theodoropoulos K. G. 1991. [Classification of Vegetation in Taxiarchis University Forest, Chalkidiki] (in Greek). Sci. Ann. Depart. Forest. and Nat. Environm. Thessaloniki 22(18): 200 pp.
Tutin T. G., Heywood V. H., Burges N. A., Valentine D. H., Walters S. M. & Webb D. A. (eds.) 1964–1980. Flora Europaea. 1–5. Cambridge.
Westhoff V. & Maarel E. van der 1973. The Braun-Blanquet Approach. – In: Whittaker R. H. (ed.): Ordination and classification of communities. Handbook of Vegetation Science (The Hague) 5: 617–726.
Zoller H., Geissler P. & Athanasiadis N. 1977. Beiträge zur Kenntnis der Wälder, Moos- und Flechtengesellschaften in den Gebirgen Nordgriechenlands. Bauhinia 6: 215–255.