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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, Slovakia, Hungary, and Turkey (Schwarz 1936, Athanasiadis 1986 a). 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), Mavrokorphi (783 m), Mavri Zoni (898 m), Strouga (920 m), Mavri koriphi (1179 m), Kroussia (1161 m), Flamouri (1042 m), and Lophos (850 m) (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             |

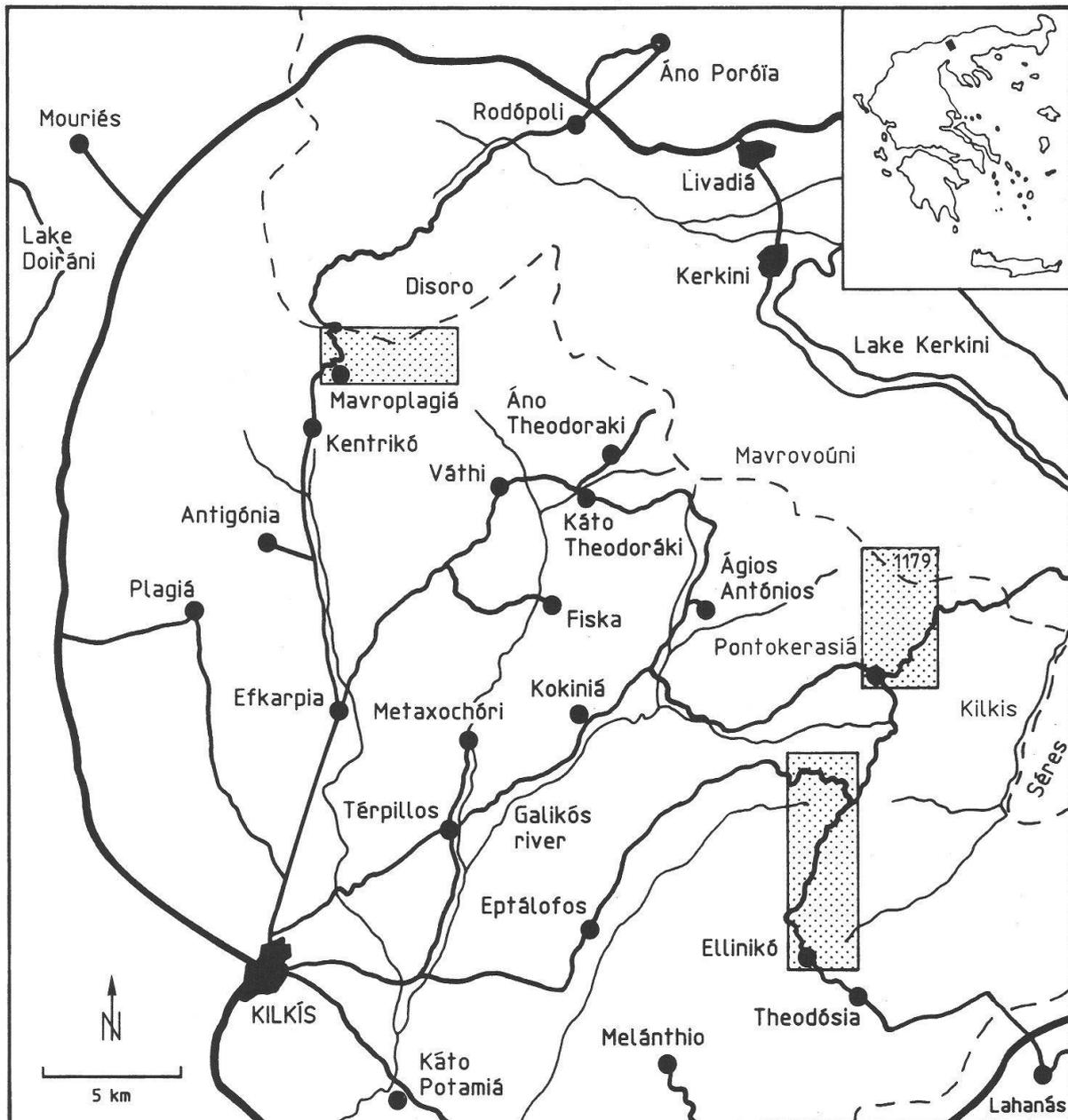


Fig. 1. Study area in Central Macedonia, Greece.

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.

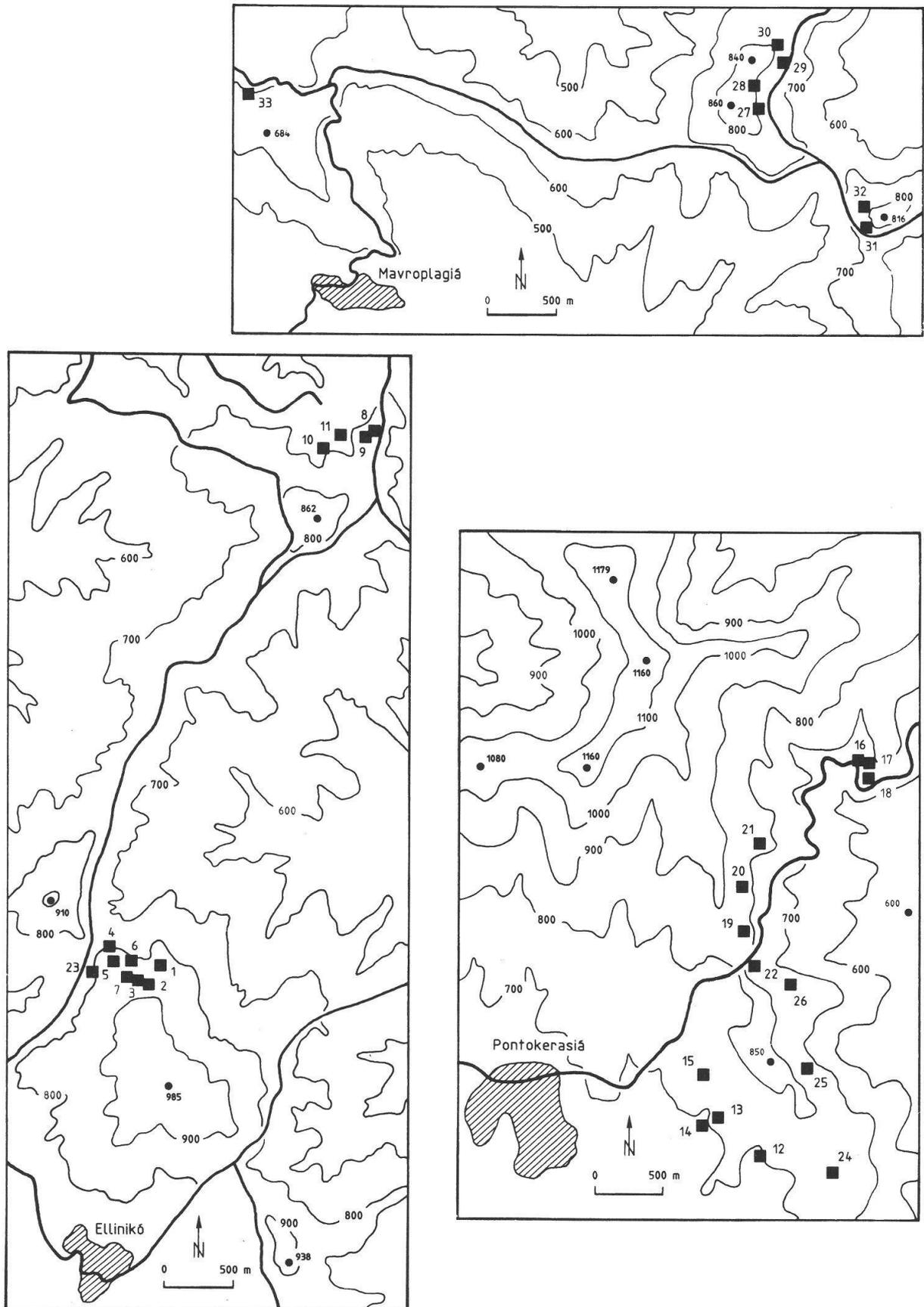


Fig. 2. Localisation of the sample plots within three *Quercus dalechampii* forest areas.

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<sup>2</sup>, 3 plots 200 m<sup>2</sup> only. For each sample plot, elevation, exposition, slope, macro- and micro-relief (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<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>). 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       |      |                     |       |                     |      |
|-------------------------------|-----------------------|------|----------------------|------|---------------------|-------|---------------------|------|
|                               | <i>Q. dalechampii</i> |      | <i>S. torminalis</i> |      | <i>P. aquilinum</i> |       | <i>Q. frainetto</i> |      |
|                               | Plots                 | %    | Plots                | %    | Plots               | %     | Plots               | %    |
| <b>Exposition</b>             |                       |      |                      |      |                     |       |                     |      |
| 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  |
| <b>Inclination</b>            |                       |      |                      |      |                     |       |                     |      |
| 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  |
| <b>Elevation</b>              |                       |      |                      |      |                     |       |                     |      |
| 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  |
| <b>Macro- and Microrelief</b> |                       |      |                      |      |                     |       |                     |      |
| 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 (1986 b).

#### 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 <sub>00</sub> | 5-3    | -          | -   | -  | -  | -  | -   | -  | -    | -    | -    | -    |
|                            | A <sub>0</sub>  | 3-0    | -          | -   | -  | -  | -  | -   | -  | -    | -    | -    | -    |
|                            | A <sub>1</sub>  | 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 <sub>00</sub> | 6-3    | -          | -   | -  | -  | -  | -   | -  | -    | -    | -    | -    |
|                            | A <sub>0</sub>  | 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 <sub>00</sub> | 4-2    | -          | -   | -  | -  | -  | -   | -  | -    | -    | -    | -    |
|                            | A <sub>0</sub>  | 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 <sub>00</sub> | 5-2    | -          | -   | -  | -  | -  | -   | -  | -    | -    | -    | -    |
|                            | A <sub>0</sub>  | 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 <sub>00</sub> | 5-3    | -          | -   | -  | -  | -  | -   | -  | -    | -    | -    | -    |
|                            | A <sub>0</sub>  | 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<sub>2</sub>O, 1:5); 6=Sand (in %); 7=Silt (in %); 8=Clay (in %); 9=Soil texture; 10=CaCO<sub>3</sub> 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             |
| Inclination(%)                               | NEWWEWNWWWNN EEWN EEENNEWWEWWEWWWWW   |
|  | 6346464533364 5432 4441333432462123   |
| Macrorelief (UPper,Middle,LOwer)             | 2850772021212 5000 1843405260010892   |
|  | UMUUUMUUMLU MUUU UMUUUUUUUMUMUUM      |
|  | PIPPPIPIPIOP IPPP PIPPPPPPIPIPIPI     |
| Microrelief(PLane,CURved=convex,<br>CONcave) | CPPPPPPPCPPC PPCP PCPCCCPCPPPPPPPP    |
|  | ULLLLLLLLULLLU LLUL LULUUULULLLLLLLLL |
| Cover of trees(%)                            | 7977888877887 8888 8776677786777766   |
|  | 0000000000000 0000 0000000000000000   |
| Cover of shrubs(%)                           | 3112223252212 2132 4212322143 3342    |
|  | 0500000000000 0000 000000000550000    |
| Cover of herbs(%)                            | 8378787877778 7675 596787779687787    |
|  | 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**

|   |   |               |                     |
|---|---|---------------|---------------------|
| <i>Sorbus torminalis</i>                  | T | .....+......  | .....               |
| <i>Sorbus torminalis</i>                  | S | ++++2++++.1   | +... ..+......1...  |
| <i>Sorbus torminalis</i>                  |   | ..+r+.r.rrrrr | +... ..r....r...    |
| <i>Acer hyrcanum</i>                      | T | .....+......+ | .....1.....         |
| <i>Acer hyrcanum</i>                      | S | ...+.1+....   | .....1.....         |
| <i>Acer hyrcanum</i>                      |   | .r.+r.rrr.... | .....               |
| <i>Physospermum cornubiense</i>           |   | 1+.1+.1+1+r+  | +... ..r.r.r...+... |
| <i>Trifolium medium ssp. balcanicum</i>   |   | .r++r..1++1r  | ..r. r.....1..+     |
| <i>Polygonatum odoratum</i>               |   | ..+++.r.+1r   | ..r. ....+.+.r...   |
| <i>Mycelis muralis</i>                    |   | ....+r.r+r.+  | ..r. ....r.....r.   |
| <i>Lathyrus niger ssp. niger</i>          |   | .12...+.1+.1  | .... ..r.....+      |
| <i>Lathyrus venetus</i>                   |   | 1..1..1+...+  | .... ..             |
| <i>Symphytum bulbosum</i>                 |   | ....2...+.r+  | 1... 1...1.....     |
| <i>Melitis melissophyllum ssp. albida</i> |   | .r+.++++.++++ | +r+r .....+.+       |
| <i>Melica uniflora</i>                    |   | 2+12211221111 | 1111 ..1...+2.....  |

**Differential species of the *Fagus moesiaca*-subtype**

|                       |   |              |                     |
|-----------------------|---|--------------|---------------------|
| <i>Fagus moesiaca</i> | T | .....++1.+.  | .111 +.....+        |
| <i>Fagus moesiaca</i> | S | ....+.1++1++ | ..+2+ +.....        |
| <i>Fagus moesiaca</i> |   | .....1.+2.+  | .1.r +...r...r...r. |
| <i>Acer campestre</i> | 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+r   |
| 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++..1112+1 |
| Poa angustifolia                   |   | .....+...+    | ++++  | ...+.r..11+.2++   |
| Muscari neglectum                  |   | .....+...+    | .r+r  | 1..rrr+.rt..+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+r..++11++1   |
| Genista carinalis                  |   | .....         | ....  | ...1+.r..++..+112 |
| Anthoxanthum odoratum              |   | .....         | ....  | ...+++.r1+++1     |
| Lychnis viscaria ssp. atropurpurea |   | .....         | ....  | ...+.rrrr.++++    |
| Muscari comosum                    |   | .....         | +r.   | ..r..r..+.rr.r.   |
| Lactuca viminea ssp. viminea       |   | .....         | ....  | ..+r.r.r..++rr..  |
| Vicia tetrasperma                  |   | 1.....+...+   | ....  | .r+.+.r+.+.++     |
| Hieracium bauhini ssp. magyaticum  |   | .....         | ....  | .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.   | lr.r1.r+   |
| Hieracium hoppeanum ssp. troicum      | .....         | .... | .....r.   | rrr+.r.1   |
| Anthemis tinctoria ssp. australis     | .....         | .... | ...r...r. | ...r1r.r   |
| Ferulago sylvatica                    | .....         | r... | .....+    | +1..+++    |
| Carex divulsa ssp. leersii            | .....r.....   | .... | .....r.   | r.+r..+r.  |
| Potentilla recta                      | .....         | .... | ...+...   | r..+r.r.   |
| Dorycnium pentaphyllum ssp. herbaceum | .....         | .... | .....     | ..+.++2r   |
| Rumex acetosella                      | .....         | .... | .....     | r..rrr..r  |
| Knautia macedonica                    | .....         | .... | .....     | ..+.r+r    |
| Geranium columbinum                   | .....         | .... | .....     | ..1r.r.    |
| 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   | ..rlr..r.1+.1+1. |  |
| Cephalanthera longifolia      |  | +.+.+.r.rr.    | +.1   | ....rl..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..+.+.t.....  |  |
| 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+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...r+. |
| Geum urbanum                            | .....+.r...+   | r.+.  | r++...r1r.r...r. |
| Campanula trachelium ssp. athoa         | ....r..r....+  | r..r  | r....r.r.r.+...  |
| 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 pyraister       | S | .....        | ..+. | ...+.....+.       |
| Pyrus pyraister       |   | .....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.r.r  | +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.r.r+   |
| Hieracium cf. racemosum            |  | r.r.+...1++r1   | rr.. | ..r+.r.r.....+    |
| Campanula sparsa ssp. sphaerothrix |  | .r.r.r.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 daucooides             |  | .....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                 |  | l.....          | r... | .....+. ..        |
| Myrrhoides nodosa                  |  | ...r.....       | .... | +.....l.....      |
| Hieracium rechingeriorum           |  | +.....+. ..     | .... | ...l.....         |
| Sanguisorba minor ssp. muricata    |  | .....           | .... | .....r.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 fuscum* (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<br>(study area)                                      | Phytosociological<br>nomenclature   | No.<br>of<br>plots | Elevation<br>(m a.s.l.) | Exposition                | Inclination<br>(% or °) | Geology                       | Soil        |         |
|---|---|--------------------|-------------------------|---------------------------|-------------------------|-------------------------------|-------------|---------|
|   |   |                    |                         |                           |                         |                               | Description | pH      |
| Dafis 1966<br>(NE Chalkidiki)                               | "Mixed forest of<br>deciduous broadleaved<br>trees"   | 5                  | 300–620                 | N, NE, E                  | 40–70%                  | Gneiss                        | Sandy loam  | 6,4–6,6 |
| Zoller et al. 1977<br>(Thrace)                              | " <i>Quercus dalechampii</i> -<br>forests"  | 1                  | 110                     | ONO                       | 20°                     | Schist                        | Loamy sand  | 5,5     |
| Gamisans & Hebrard<br>1979<br>(N Pindos)                    | " <i>Quercus dalechampii</i> -<br>forests"  | 2                  | 1100                    | SE, SSE                   | 10°–25°                 | Quartz, schist                | ?           | ?       |
| Gamisans & Hebrard<br>1980<br>(W Thrace)                    | "Symphyto ottomani-<br><i>Quercetum frainetto</i><br><i>quercetosum</i><br><i>dalechampii</i> " | 7                  | 200–550                 | NW, NNW,<br>W, NE,<br>NNE | 25°–40°                 | Gneiss                        | ?           | ?       |
| Gamisans & Hebrard<br>1980<br>(C. Macedonia,<br>Kerdillion) | " <i>Digitali-Quercetum</i><br><i>frainetto</i> faciès a <i>Quercus</i><br><i>dalechampii</i> " | 2                  | 400–450                 | NW, NNW                   | 35°–45°                 | Quartz                        | ?           | ?       |
| Gamisans & Hebrard<br>1980<br>(Pieria, Pieria)              | "Mixed forests of<br><i>Quercus dalechampii</i><br>and <i>Ostrya carpinifolia</i> "             | 3                  | 550–650                 | ENE, NE,<br>NNW           | 10°–45°                 | Gneiss, schist                | ?           | ?       |
| Raus 1980<br>(E Thessaly, Ossa)                             | " <i>Tilio (tomentosae)-</i><br><i>Castanetum</i> "   | 11                 | 240–400                 | NW, N,<br>NNW, NE,<br>NNE | 6°–25°                  | Schist, phyllite,<br>gneiss   | stony       | ?       |
| Bergmeier 1990<br>(NE Thessaly, Lower<br>Olympus)           | " <i>Tilio tomentosae-</i><br><i>Castanetum</i> "   | 7                  | 490–680                 | N, NW                     | 15°–30°                 | Cryst. limestone,<br>dolomite | stony       | ?       |

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

| Author<br>(study area)                               | Phytosociological<br>nomenclature            | No.<br>of<br>plots | Elevation<br>(m a.s.l.) | Exposition   | Inclination<br>(% or °) | Geology  | Soil  |                  |
|--|--|--------------------|-------------------------|--|-------------------------|--|---|------------------|
|  |  |                    |                         |  |                         |  | Description   | pH               |
| Dafis 1966<br>(NE Chalkidiki)                        | " <i>Quercetum montanum</i> "                | 19                 | 500–750                 | <u>NW, W, N,</u><br>E, SE                                      | 30–60%                  | Granite, gneiss  | Sandy loam<br>(sometimes with<br>clay enrichment<br>in subsoil)                   | 4.7–6.2          |
| Zoller et al. 1977<br>(Rhodope)                      | " <i>Quercus dalechampii</i> -<br>forests"   | 2                  | 840–1000                | SW, SSW  | 15°–25°                 | Quartz porphyry  | Stony-sandy   | 5.3–5.8          |
| Zoller et al. 1977<br>(Thrace)                       | " <i>Quercus dalechampii</i> -<br>forests"   | 3                  | 400–580                 | NW, NO   | 10°–20°                 | Gneiss   | Sandy, stony-<br>sandy, loamy<br>sand   | 5.2–5.5          |
| Gamisans & Hebrard<br>1979 (N Pindos)                | " <i>Quercus dalechampii</i> -<br>forests"   | 1                  | 1250                    | S  | 15°                     | Quartz   | ?   | ?                |
| Raus 1980<br>(E Thessaly, Ossa)                      | " <i>Quercus dalechampii</i> -<br>community" | 8                  | 380–650                 | <u>NW, W, NE,</u><br>ENE                                       | 8°–20°                  | Schist, phyllite,<br>gneiss  | Sandy loam or<br>with clay enrich-<br>ment in subsoil                             | ?                |
| Bergmeier-1990<br>(NE Thessaly,<br>Lower Olympos)    | " <i>Quercus dalechampii</i> -<br>community" | 4                  | 500–660                 | S, SO  | 12°–30°                 | Metamorphic rocks<br>(Amphibolite-gneiss-<br>schist-complex) and<br>consolidated depris.     | Stony (under<br>somewhat moist<br>conditions)                                     | ?                |
| Theodoropoulos 1991<br>(C Chalkidiki,<br>Cholomon)   | " <i>Quercetum montanum</i><br>prov."        | 6                  | 900–1010                | <u>S, SW</u>   | 27–53%                  | Granite  | Sandy loam  | 4.95–<br>5.90    |
| Present research<br>(Central Macedonia,<br>Kroussia) | " <i>Quercus dalechampii</i> -<br>community" | 33                 | 610–850                 | <u>N, NW, W,</u><br><u>NE, ENE,</u><br>WNW, NNE,<br>E, SE, WSW | 13–67%                  | Metamorphic rocks<br>(amphibolites,<br>gneisses, schists with<br>marble intercala-<br>tions) | Sandy loam<br>and loamy sand<br>(sometimes with<br>clay enrichment<br>in subsoil) | 5.5–5.9<br>(6.8) |
| Löblich-Ille<br>(unpublished)<br>(Pieria, Pieria)    | " <i>Quercus dalechampii</i> -<br>community" | 10                 | 830–1130                | <u>ENE, NE, E</u>  | 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 balkan plant associations of the Quercion frainetto in particular (Bergmeier 1990; Theodoropoulos 1991: 127).

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