Journal of Biological Research-Thessaloniki **8**: 177 – 187, 2007
J. Biol. Res.-Thessalon. is available online at http://www.jbr.gr
Indexed in: WoS (Web of Science, ISI Thomson), CAS (Chemical Abstracts Service) and DOAJ (Directory of Open Access Journals)

Life-form and chorological spectra of the vegetation units of Mount Hymettus (C Greece)

MARKOS GOUVAS and KONSTANTINOS THEODOROPOULOS*

Laboratory of Forest Botany-Geobotany, Faculty of Forestry and Natural Environment, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece

Received: 19 April 2007 Accepted after revision: 30 November 2007

The life-form and the chorological spectra of the vegetation units of Mt. Hymettus were investigated in the present study. The spectra were produced using both the Raunkiaer's and the Tüxen-Ellenberg's methods. The first method was used mainly to compare our spectra with those of existing floristic studies in Greece, while the second one was used to determine the differences between the vegetation units of Mt. Hymettus. The results revealed the general climatic character of the study area and the significant variations of the spectra between the vegetation units due to their different environmental conditions (altitude, bedrock, soil, etc.).

Key words: Greece, Mount Hymettus, spectra, *Pinus halepensis*, phrygana.

INTRODUCTION

Mount Hymettus is the closest mountain to the centre of Athens and is located in the Prefecture of Attiki. The forest and forested areas of Mt. Hymettus play an important role in regulating air quality, temperature, water runoff during the rainy season, and the aesthetic value of the capital's environment. The forest also attracts the city's inhabitants for recreation. The countless fires, soil erosion, and pressures for building plots and grazing are expected to become intensified in the future, if one considers the fears of some scientists regarding the severe influences of the greenhouse effect in the Mediterranean basin (intense drought, desertification, etc.), and the predicted building activities resulted from the construction of the new Athens International Airport at Spata. The above activities will have repercussions on the natural environment of Mt. Hymettus and there is a danger that the mountain, together with other forested areas of Attiki, will become isolated.

The most thorough botanical studies on Mt. Hymettus are those by Zerlentis (1965), Margaris (1976) and Gouvas (2001). Gouvas (2001) by analysing the data of a total of 198 relevés, that were taken using the Braun-Blanquet method, investigated the vegetation succession, the degree of degradation, and the syntaxonomy of the vegetation units of Mt. Hymettus.

The aim of the present study was to investigate the life-form and the chorological spectra of the vegetation units of Mt. Hymettus.

MATERIALS AND METHODS

Study area

Mount Hymettus (1026 m a.s.l.) is the sixth highest mountain in the Prefecture of Attiki, after Parnitha (1413 m a.s.l.), Kitheronas (1409 m a.s.l.), Gerania (1351 m a.s.l.), Pateras (1131 m a.s.l.) and Pendeli (1109 m a.s.l.). It is an isolated, steep, mountainous mass located on the eastern edge of the Attiki basin with a general orientation from the north to the south and a length of *ca*. 23 km. The mountain (Fig. 1) can be separated into two parts: the northern part (Megas Hymettus, according to Theofrastus), in the centre of which is the highest peak (Evzonas 1026 m a.s.l.), and the southern part (named Ellaton or Anydros Hymettus), with the peaks of Profitis Ilias (659 m a.s.l.), Mavrovouni (770 m a.s.l.), Stroma (725 m a.s.l.), Dasomeni Koryfi (641 m a.s.l.) and Stavraetos (628 m a.s.l.). The study area extends from 37°50′11″ to 38°00′15″ N and from 23°45′31″ to 23°50′48″ E.

* Corresponding author: tel.: +30 2310 992765, fax: +30 2310 992773, e-mail: ktheodor@for.auth.gr

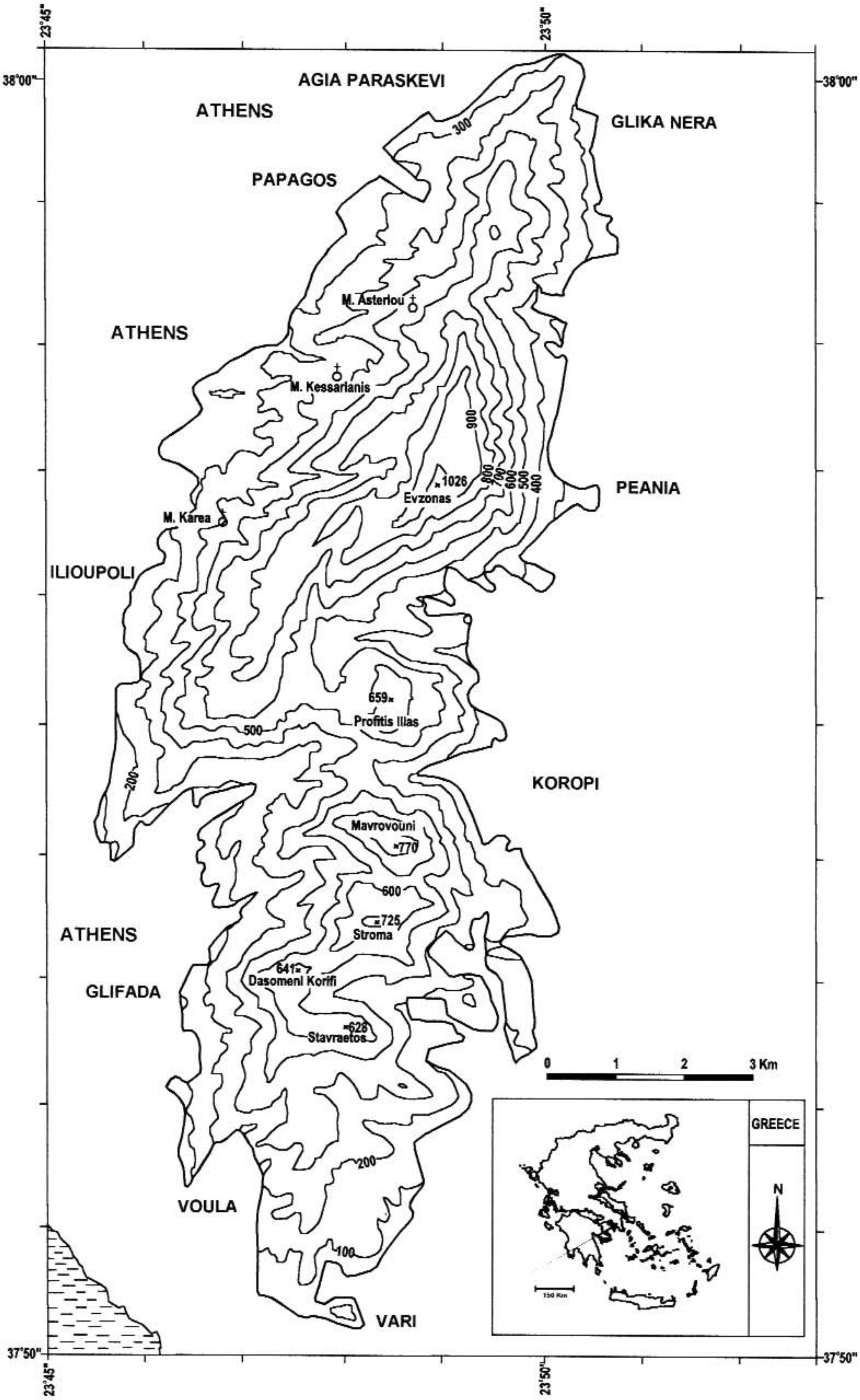

FIG. 1. Schematic map of Mt. Hymettus.

The geological formations of Mt. Hymettus belong to the Attic-Cycladic zone, and more precisely to the Attica Unit (Mountrakis, 1985). The mountain is comprised mainly of marbles and schists (I.G.M.E., 1983). The soils of Mt. Hymettus are very shallow (less than 30 cm), and bare rock and stone cover is abundant. Throughout the area, soil pH values are greater than 7. Soils show intense erosion and in some areas, especially those close to the summits, plant growth is limited to rock fissures (Gouvas, 2001).

The climate of the study area is typical Mediterranean, with mild winters and dry hot summers (Csa according to Köppen's classification), while on its highest summit the summers are classified as warm (Csb). Mountain slopes up to 600 m in altitude (semi-arid bioclimatic layer) belong to the temperate semi-arid Mediterranean climate, and those above 600 m (cold bioclimatic layer), belong to the cool sub-humid Mediterranean climate, according to Emberger's classification. The summer drought period is long and ranges from five to seven months, according to data of the meteorological stations on the mountain (Gouvas, 2001).

In relation to its surface area, Mt. Hymettus has a large variety of plant taxa that number over 600 (Zerlentis, 1965). Physiognomically, its vegetation can be distinguished into forests of *Pinus halepensis* (and *P. brutia*), degraded oaks (areas with *Quercus coccifera*), phrygana, with or without sparse *Q. coccifera*, and agricultural areas. The *P. halepensis* forests have a wide range of cover and are generally found throughout the mountain. These forests, originated from reforestation, cover all the western slopes north of the Kareas monastery and the area above Voula, and grow mainly on schist substrates. The other *P. halepensis* forests are mainly natural, while around the monasteries of Kareas, Kesariani and Asterios, several *P. brutia* trees have been planted.

Oaks cover the majority of the mountain and comprise large or small stands of *Q. coccifera*, interspersed with clearances filled with *Cistus* and other phryganic taxa, and many herbaceous plants. *Pistacia terebinthus* and *Phillyrea latifolia* occur occasionally, while below 600 m a.s.l. they grow along with *Pistacia lentiscus, Olea europaea* var. *sylvestris* (often planted in reforestation efforts), *Erica manipuliflora, Calicotome villosa*, etc. Locally, mainly on the eastern slopes, *Juniperus phoenicea* occurs and in some cases its cover values reach 40%. *Juniperus oxycedrus* subsp. *oxycedrus* is observed in a very small area, just south of the Evzonas summit at 800-850 m a.s.l. Individual trees of *J. oxycedrus* subsp. *macrocarpa* also grow above Panagos up to 500 m a.s.l. Oaks growing on soils that originate from marble substrates, are accompanied by *Phlomis fruticosa* and *Euphorbia acanthothamnos*, while those on schists and other substrates are accompanied by *Sarcopoterium spinosum* and *Genista acanthoclada*.

In the area south of Glyfada at altitudes up to 400 m a.s.l., the oaks start to thin out until they disappear from some areas, whereas the taxa *Pistacia lentiscus, Olea europaea* var. *sylvestris, Calicotome villosa* and *Juniperus phoenicea* dominate. Within this area, *Cistus parviflorus* grows. This taxon prefers soils of schist substrates, while *Phlomis fruticosa* and *Euphorbia acanthothamnos* prefer marble-based soils.

The agricultural areas occurring within the study area are restricted to the lower regions of Mt. Hymettus close to the Mesogeion plane and comprise mainly olive groves and vines. A small olive grove is also found in the area of the Kesariani monastery.

Finally, it should be noted that during reforestation, apart from *Pinus halepensis* and *P. brutia*, large numbers of *Cupressus sempervirens* and smaller numbers of *Ceratonia siliqua, Cercis siliquastrum, Medicago arborea, Eucalyptus* sp. and other taxa were also planted.

Methods

This work uses the data of the phytosociological tables and the resulting vegetation units of Mt. Hymettus (Tables 1, 2) (Gouvas, 2001) to produce and interpret the life-form and the chorological spectra of the mountain. Elaboration of the spectra was performed following the method used for floristic studies (Raunkiaer, 1910), as well as the Tüxen & Ellenberg (1937) method which is preferred for phytosociological studies. In accordance with the first method, within each phytosociological table, the sum of taxa of each life-form and the chorological type were calculated, followed by their percentages.

According to the second method, not only the participation of every life-form or chorological type was used, but also the presence of the species in the vegetation units (presence in the phytosociological tables). The spectra were calculated using the equation: percentage = (A/B) × 100, where A is the number (indicating the presence) of each life-form or chorological type in the phytosociological table and B is the total number (indicating the presence) of all taxa in the phytosociological table. These spectra (Scamo-

TABLE 1. Syntaxonomic-synsystematic synopsis of the vegetation of Mt. Hymettus (Gouvas, 2001)

CLASS: Cisto-Micromerietea julianae Oberd. 1954
ORDER: Sarcopoterietalia spinosi Eig 1939
ALLIANCE: Hyperico empetrifolii-Micromerion graecae Barb. et Quez. 1989
SUBALLIANCE: Phlomido fruticosae-Euphorbienion acanthothamni Barb. et Quez. 1989
ASSOCIATION: Dorycnio hirsuti-Micromerietum graecae Barb. et Quez. 1989
VARIATION: var. from *Sedum acre*
VARIATION: var. from *Ptilostemon chamaepeuce*
VARIATION: var. from *Ononis pusilla*
VARIATION: var. from *Globularia alypum*
VARIATION: var. from *Thesium humile*
VARIATION: var. from *Hirshfeldia incana*
SUBALLIANCE: Hyperico-Micromerienion Barb. et Quez. 1989
ASSOCIATION: Origano vulgare-Ericetum arboreae Barb. et Quez. 1989
SUBALLIANCE: Helichryso orientale-Phagnalenion graeci Barb. et Quez. 1989
ASSOCIATION: Micromerio graecae-Hypericetum empetrifolii Barb. et Quez. 1989
SUBASSOCIATION: Typicum
SUBASSOCIATION: Cistetosum parviflori Gouvas 2001
ASSOCIATION: Helianthemo hymetii-Cistetum parviflori Gouvas 2001
CLASS: Quercetea ilicis Br.-Bl. ex A. De Bolòs Y Vayreda 1950
ORDER: Pistacio-Rhamnetalia alaterni Rivas-Martinez 1975
ALLIANCE: Ceratonio-Rhamnion oleoidis Barb. et Quez. 1979
ASSOCIATION: Pinetum halepensis Gouvas 2001
SUBASSOCIATION: Arbutetosum unedi Gouvas 2001
SUBASSOCIATION: Pistacietosum lentisci Gouvas 2001

TABLE 2. The vegetation units of Mt. Hymettus, their distribution altitudes and preferred bedrock (Gouvas, 2001)

Vegetation units	**Altitude (m a.s.l.)**	**Bedrock**
ASSOCIATION: Dorycnio hirsuti-Micromerietum graecae Barb. et Quez. 1989		
VARIATION: var. from *Sedum acre*	> 600	marbles
VARIATION: var. from *Ptilostemon chamaepeuce*	500-650	marbles
VARIATION: var. from *Ononis pusilla*	300-600	marbles
VARIATION: var. from *Globularia alypum*	300-600	marbles
VARIATION: var. from *Thesium humile*	< 300	marbles
VARIATION: var. from *Hirshfeldia incana*	< 300	marbles
ASSOCIATION: Micromerio graecae-Hypericetum empetrifolii Barb. et Quez. 1989		
SUBASSOCIATION: Typicum	< 500	schists
SUBASSOCIATION: Cistetosum parviflori Gouvas 2001	< 500	schists
ASSOCIATION: Helianthemo hymettii-Cistetum parviflori Gouvas 2001	< 500	schists
ASSOCIATION: Origano vulgare-Ericetum arboreae Barb. et Quez. 1989	> 300	schists
ASSOCIATION: Pinetum halepensis Gouvas 2001		
SUBASSOCIATION: Pistacietosum lentisci Gouvas 2001	< 700	marbles, schists
SUBASSOCIATION: Arbutetosum unedi Gouvas 2001	> 300	schists

ni, 1963; Braun-Blanquet, 1964; Knapp, 1971; Theodoropoulos & Athanasiadis, 1993; Chasapis *et al*., 2004) give a clearer picture of the vegetation physiognomy.

The classification of the taxa into life-forms was performed according to Raunkiaer (1934). Chorological types follow mainly the chorological division of Europe, as proposed by Oberdorfer (1990). Moreover, data by Tutin *et al*. (1968-1980, 1993), Stefanaki-Nikiforaki (1981), Sarlis (1981, 1994a, b), Pignatti (1982), Christodoulakis (1986) and Dimopoulos (1993) were also used.

RESULTS AND DISCUSSION

Analyses of the life-form and of the chorological spectra of the vegetation of Mt. Hymettus were performed on each vegetation unit individually. In a similar way, Theodoropoulos & Athanasiadis (1993) and Chasapis *et al*. (2004) provided the respective spectra for the vegetation units of the Aristotle University of Thessaloniki forest on Mt. Cholomon (Taxiarchis, Chalkidiki) and on Mt. Chortiatis (Thessaloniki).

The life-form and the chorological spectra of the vegetation of Mt. Hymettus (as produced using the Raunkiaer's method) are shown in Tables 3 and 4, while those produced according to the Tüxen and Ellenberg's method, are shown in Tables 5 and 6. The main conclusion we draw from Table 3 is that therophytes are the dominant life-form within all the phryganic communities of the study area. The predominance of therophytes, even within the vegetation units of the higher altitudes of Mt. Hymettus, reveals the existence of an intense dry summer period, which is a typical characteristic of Mediterranean climates. Dominance of therophytes was also reported by Dimopoulos (1993) in the thermo- and meso-Mediterranean bioclimatic zones of Mt. Killini (Peloponnisos). However in this case, hemicryptophytes dominate within the supra-Mediterranean and higher zones (mean lowest temperature of the coldest month less than 0°C).

The life-form spectra of the majority of the phryganic communities on Mt. Hymettus approximate those given by Raunkiaer for arid and warm areas (Cyrenaica Peninsula) (Braun-Blanquet, 1932). Compared with other life-form spectra studies undertaken in Greece and neighbouring areas such as Agistri Island (Stefanaki-Nikiforaki, 1981) and the islands of the southern Euboean Gulf (Sarlis, 1981), Mt. Hymettus has a higher percentage of chamaephytes. Within the mountain's phryganic communities, the chamaephytes range from 13 to 20% (Table 3), while in other Greek floristic studies they reach 13% (Sarlis, 1994a). However, the number of geophytes on the mountain is low and reaches only 7%. These differences may be due to the sampling methods used in floristic and phytosociological research, and to the fact that Mt. Hymettus relevés were taken only during the months of May and June, which is the most suitable period for phytosociological research on the mountain.

The life-form spectra of the mountain's dense *Pinus* forest are noteworthy, as therophytes comprise only 2% of the total flora in Pinetum halepensis

TABLE 3. Life-form spectra of the vegetation units of Mt. Hymettus according to the Raunkiaer's (1910) method

Vegetation units	Life-form spectra				
	Th (%)	Ch (%)	H (%)	G (%)	Ph (%)
Dorycnio hirsuti-Micromerietum graecae var. from *Sedum acre*	46	18	20	7	9
″ var. from *Ptilostemon chamaepeuce*	45	19	21	6	9
″ var. from *Ononis pusilla*	51	14	23	5	8
″ var. from *Globularia alypum*	51	14	17	7	11
″ var. from *Thesium humile*	57	13	15	4	12
″ var. from *Hirshfeldia incana*	60	13	15	5	7
Origano vulgare-Ericetum arboreae	40	18	20	6	16
Helianthemo hymettii-Cistetum parviflori	39	20	19	7	16
Micromerio graecae-Hypericetum empetrifolii typicum	51	16	18	5	11
Micromerio graecae-Hypericetum empetrifolii cistetosum parviflori	57	14	14	6	9
Pinetum halepensis arbutetosum unedi	2	31	18	4	44
Pinetum halepensis pistacietosum lentisci	18	27	26	7	23

Th: Therophytes, Ch: Chamaephytes, H: Hemicryptophytes, G: Geophytes, Ph: Phanerophytes arbutetosum unedi and 18% in Pinetum halepensis pistacietosum lentisci, in contrast to the open phryganic communities. In this case, the dramatic reduction in the percentage of therophytes is due to their inability to grow within the dense pine forest. Thus, the life-form spectra of this vegetation unit do not resemble those of the typical Mediterranean vegetation. In the first subunit, phanerophytes dominate with a percentage of 44%, and in the second, chamaephytes dominate (27%) with a small advantage over the phanerophytes (23%) (Table 3). The Mediterranean character of the forest's climate is shown by the combination of high percentages of phanerophytes and chamaephytes. For comparison, we refer to the area of the Aristotle University of Thessaloniki forest in Taxiarchis Chalkidiki (Mt. Cholomon), where the climate has a more continental character and hemicryptophytes dominate (35-60%) (Theodoropoulos & Athanasiadis, 1993). Additionally, according to Braun-Blanquet (1932), hemicryptophytes dominate in the Meso-European beech forests with a percentage of 51.5%, followed closely by geophytes (40.5%), while phanerophytes dominate in the tropical forests of the Seychelles Islands (61%).

Table 4 shows that within all the communities of Mt. Hymettus, the Mediterranean (med) chorological element dominates (28-48%). This is followed by the eastern Mediterranean element (omed) (16-30%) and the Mediterranean-subMediterranean (med-submed) element (11-19%). The remaining chorological groups are represented with percentages usually below 10%. Of these groups, the numbers of endemic Greek (hel) taxa are notably high. Chorological spectra where med, omed and med-submed elements dominate (but with different percentages) have also been observed on the Greek islands of Syros (Sarlis, 1994a) and Samos (Christodoulakis, 1986). However, on the neighbouring Agistri Island (Stefanaki-Nikiforaki, 1981), the med-submed chorological element (2.2%) is not a significant element of the island's flora.

Summation of the percentages of all the categories in Table 4 (containing the words med, omed, wmed and hel, and those with the term "Mediterranean"), produces a group which represents 86% (Dorycnio hirsuti-Micromerietum graecae var. from *Sedum acre*) to 96% (Pinetum halepensis arbutetosum unedi) of the total flora of Mt. Hymettus. In other chorological studies, this Mediterranean group reaches 77% on the island of Syros (Sarlis, 1994a), and 78% on the island of Samos (Christodoulakis, 1986). The difference (19%) between these values and those of Mt. Hymettus is probably due to the sampling methods used in the floristic and phytosociological research, as mentioned above. Comparing the chorological spectra of Mt. Hymettus with those of Mt. Cholomon (Theodoropoulos & Athanasiadis, 1993), it is clear that the Mediterranean element on Mt. Cholomon is represented by 17-43% per association, and this is due to the continental characteristics of the area's climate.

Tables 5 and 6 present the life-form and chorological spectra of Mt. Hymettus as produced using the Tüxen and Ellenberg's method with the stability element. This method is regarded as more appropriate for phytosociological research than Raunkiaer's method (Theodoropoulos & Athanasiadis, 1993; Chasapis *et al*., 2004) and it can detect the effects of various ecological factors on the life-form and chorological spectra of any area's phytosociological units.

The Dorycnio hirsuti-Micromerietum graecae association, which grows on soils originated from marble, shows a steady rise in the number of therophytes from colder, damper (var. from *Sedum acre*, 37%) to dryer, thermophilic varieties (var. from *Hirshfeldia incana*, 69%) (Table 5). In the same way, the number of hemicryptophytes decreases from the var. from *Sedum acre* (23%) to the var. from *Hirshfeldia incana* (11%). In this association, we have also observed an increasing trend in the numbers of the Mediterranean group (med) from the var. from *Sedum acre* (29%) to the var. from *Thesium humile* (43%) (Table 6), together with a small decrease of the Greek endemic taxa (hel) from 13 to 6%. This decrease in Greek endemics indicates that the higher altitudes of Mt. Hymettus are colonized by relatively psychrophilic endemic taxa with a greater drought tolerance than by taxa of the sub-Mediterranean group that are virtually absent from the study area.

Similar results can be also obtained in the phryganic communities growing on soils originated from schist. An increase in therophytes and a decrease in hemicryptophytes are observed from the colder, damper (Origano vulgare-Ericetum arboreae) to the dryer, thermophilic (Micromerio graecae-Hypericetum empetrifolii cistetosum) vegetation units (Table 5). This was expected, since according to Voliotis (1982) and Christodoulakis (1986), therophytes characterize warmer, dryer climates and hemicryptophytes colder, damper climates. However, this association does not show an increase in the Mediterranean element (med) or a decrease in Greek endemics (hel)

TABLE 4. Chorological spectra of the vegetation units of Mt. Hymettus according to the Raunkiaer's (1910) method (values represent percentages)

Vegetation units	wmed	omed	omed-osubmed	osubmed	med	med-atl	med-euras	med-kont	med-submed	submed, submed-subatl, subatl	hel	balc	euras, euras-kont, paleosubtrop, kosmopol
Dorycnio hirsuti-Micromerietum graecae var. from *Sedum acre*	1	19	2	1	28	3	1	2	18	7	11	3	6
″ var. from *Ptilostemon chamaepeuce*	1	20	2	1	32	2	1	3	18	4	10	4	4
″ var. from *Ononis pusilla*	1	19	2	1	32	2	0	4	18	6	8	4	6
″ var. from *Globularia alypum*	1	17	1	1	35	2	0	3	18	7	7	1	6
″ var. from *Thesium humile*	3	17	1	2	37	2	0	3	17	7	6	2	6
″ var. from *Hirshfeldia incana*	1	16	1	1	39	3	0	3	19	5	6	1	4
Origano vulgare-Ericetum arboreae	1	20	1	0	35	2	0	4	16	4	7	3	4
Micromerio graecae-Hypericetum empetrifolii typicum	1	19	2	2	36	3	0	3	18	5	7	1	6
Micromerio graecae-Hypericetum empetrifolii cistetosum parviflori	1	16	1	2	37	3	0	3	19	5	7	1	6
Helianthemo hymettii-Cistetum parviflori	1	19	1	3	39	1	0	3	17	2	9	0	3
Pinetum halepensis arbutetosum unedi	2	30	0	0	48	0	0	0	11	2	5	0	2
Pinetum halepensis pistacietosum lentisci	1	26	2	0	40	0	0	5	12	4	6	2	2

med: Mediterranean, wmed: west Mediterranean, omed: east Mediterranean, submed: subMediterranean, osubmed: east subMediterranean, atl: Atlantic, subatl: subAtlantic, euras: Eurasiatic, kont: continental, hel: Greek endemic, balc: Balkan endemic, paleosubtrop: paleosubtropical, kosmopol: cosmopolitan

TABLE 5. Life-form spectra of the vegetation units of Mt. Hymettus according to the Tüxen and Ellenberg's (1937) method

Vegetation units	**Life-form spectra**				
	Th (%)	Ch (%)	H (%)	G (%)	Ph (%)
Dorycnio hirsuti-Micromerietum graecae var. from *Sedum acre*	37	21	23	7	13
〃 var. from *Ptilostemon chamaepeuce*	37	24	23	4	13
〃 var. from *Ononis pusilla*	45	17	22	4	12
〃 var. from *Globularia alypum*	45	20	16	5	14
〃 var. from *Thesium humile*	57	16	12	4	11
〃 var. from *Hirshfeldia incana*	69	10	11	4	6
Origano vulgare-Ericetum arboreae	29	24	18	4	25
Helianthemo hymettii-Cistetum parviflori	26	22	21	7	24
Micromerio graecae-Hypericetum empetrifolii typicum	47	22	14	4	14
Micromerio graecae-Hypericetum empetrifolii cistetosum parviflori	58	12	11	5	14
Pinetum halepensis arbutetosum unedi	1	28	15	6	51
Pinetum halepensis pistacietosum lentisci	7	33	23	8	29

Th: Therophytes, Ch: Chamaephytes, H: Hemicryptophytes, G: Geophytes, Ph: Phanerophytes

(Table 6).

The life-form spectrum of the Helianthemo hymettii-Cistetum parviflori is particularly noteworthy. Despite being regarded as a dry, thermophilic association, due to its geographical location, this association has a life-form spectrum similar to that of the Origano vulgare-Ericetum arboreae. Comparing the life-form spectrum of Origano vulgare-Ericetum arboreae (which prefers soils of schist origin) with those of Dorycnio hirsuti-Micromerietum graecae var. from *Ononis pusilla* and var. from *Globularia alypum*, that grow at more or less the same altitude but on marble substrates, we observe that the first association has fewer therophytes (29%) and increased phanerophytes (25%). This is also seen when comparing the life-forms of the vegetation units Micromerio graecae-Hypericetum empetrifolii typicum and cistetosum parviflori, that grow on schist soils, and the Dorycnio hirsuti-Micromerietum graecae var. from *Thesium humile* and var. from *Hirshfeldia incana* growing on marbles at the same altitudes. This may indicate that soils having schists as bedrock (with sandy-loam and loam textures) have better humidity conditions than those having marbles as bedrock (with clay-loam and clay textures). However, in the latter case, the aforementioned differences in the life-form spectra shown in Table 3 (where stability is not considered) are greatly reduced.

Compared with the phryganic communities of Hymettus, the Pinetum halepensis shows a great reduction of the therophytes, an increase of the chamaephytes, hemicryptophytes and phanerophytes (Table 5), and an increase of the Mediterranean (med) and eastern Mediterranean (omed) floristic elements (Table 6). It is noteworthy that the confirmed humid psychrophilic subassociation arbutetosum unedi has less hemicryptophytes than the dry thermophilic pistacietosum lentisci (Table 5).

Comparison of Tables 3 and 5 revealed that the increase in the number of therophytes from the humid psychrophilic Dorycnio hirsuti-Micromerietum graecae var. from *Sedum acre* to the dry thermophilic Dorycnio hirsuti-Micromerietum graecae var. from *Hirshfeldia incana* is 32% according to the Tüxen and Ellenberg method, and 14% according to the Raunkiaer's method. Additionally, the reduction of hemicryptophytes from the first to the last variant reaches 12% according to the Tüxen & Ellenberg method (Table 5), and only 5% when using the Raunkiaer's method (Table 3). Similar conclusions can be drawn when observing the increase of therophytes and the reduction of hemicryptophytes from the Origano vulgare-Ericetum arboreae to the Micromerio graecae-Hypericetum empetrifolii cistetosum parviflori. Therefore, the Tüxen & Ellenberg method reveals more realistically the differences in the life-form

TABLE 6. Chorological spectra of the vegetation units of Mt. Hymettus according to the Tüxen and Ellenberg's (1937) method (values represent percentages)

Vegetation units	wmed	omed	omed-osubmed	osubmed	med	med-atl	med-euras	med-kont	med-submed	submed, submed-subatl, subatl	hel	balc	euras, euras-kont, paleosubtrop, kosmopol
Dorycnio hirsuti-Micromerietum graecae var. from *Sedum acre*	1	17	2	1	29	2	1	2	18	7	13	4	5
″ var. from *Ptilostemon chamaepeuce*	1	21	2	1	29	1	1	3	16	4	13	3	3
″ var. from *Ononis pusilla*	1	18	3	1	34	2	0	3	17	6	10	2	4
″ var. from *Globularia alypum*	2	18	2	1	40	2	0	3	17	6	7	1	3
″ var. from *Thesium humile*	2	17	1	1	43	2	0	3	17	4	6	1	4
″ var. from *Hirshfeldia incana*	2	15	1	1	40	2	0	3	22	5	6	1	4
Origano vulgare-Ericetum arboreae	2	22	2	0	44	1	0	2	14	4	7	2	2
Micromerio graecae-Hypericetum empetrifolii typicum	2	22	1	1	39	1	0	3	17	4	7	1	3
Micromerio graecae-Hypericetum empetrifolii cistetosum parviflori	2	18	1	1	39	1	0	3	21	5	5	1	4
Helianthemo hymettii-Cistetum parviflori	3	22	3	3	39	1	0	4	14	3	7	0	1
Pinetum halepensis arbutetosum unedi	5	22	0	0	57	0	0	0	7	1	6	0	1
Pinetum halepensis pistacietosum lentisci	3	28	1	0	50	0	0	3	5	2	6	1	1

med: Mediterranean, wmed: west Mediterranean, omed: east Mediterranean, submed: subMediterranean, osubmed: east subMediterranean, atl: Atlantic, subatl: subAtlantic, euras: Eurasiatic, kont: continental, hel: Greek endemic, balc: Balkan endemic, paleosubtrop: paleosubtropical, kosmopol: cosmopolitan

TABLE 7. The vegetation units of Mt. Hymettus, the number of relevés taken from each unit and the mean number of species in each relevé

Vegetation units	**No. of relevés**	**Mean no. of species**
ASSOCIATION: Dorycnio hirsuti-Micromerietum graecae Barb. et Quez. 1989	108	63
VARIATION: var. from *Sedum acre*	17	59
VARIATION: var. from *Ptilostemon chamaepeuce*	12	64
VARIATION: var. from *Ononis pusilla*	15	66
VARIATION: var. from *Globularia alypum*	35	61
VARIATION: var. from *Thesium humile*	19	66
VARIATION: var. from *Hirshfeldia incana*	10	63
ASSOCIATION: Micromerio graecae-Hypericetum empetrifolii Barb. et Quez. 1989	36	56
SUBASSOCIATION: Typicum	20	54
SUBASSOCIATION: Cistetosum parviflori Gouvas 2001	16	58
ASSOCIATION: Helianthemo hymettii-Cistetum parviflori Gouvas 2001	10	31
ASSOCIATION: Origano vulgare-Ericetum arboreae Barb. et Quez. 1989	16	45
ASSOCIATION: Pinetum halepensis Gouvas 2001	28	21
SUBASSOTIATION: Pistacietosum lentisci Gouvas 2001	17	26
SUBASSOTIATION: Arbutetosum unedi Gouvas 2001	11	15

spectra between the vegetation units due to environmental factors, compared with the Raunkiaer's method. However, the same is not true for the chorological spectra, as shown in Tables 4 and 6.

Lastly, the association richest in taxa is the Dorycnio hirsuti-Micromerietum graecae, averaging 59-66 taxa per relevé, according to the variant. The other phryganic units follow, averaging from 31 (Helianthemo hymettii-Cistetum parviflori) to 58 taxa per relevé (Micromerio graecae-Hypericetum empetrifolii cistetosum parviflori). The units less rich in taxa are the forest ones of Mt. Hymettus with a mean of 21 taxa (ranging from 15 in the Pinetum halepensis arbutetosum unedi to 26 in the Pinetum halepensis pistacietosum lentisci) (Table 7).

CONCLUSIONS

The determined life-form and chorological spectra of the phryganic vegetation units of Mt. Hymettus, with their predominance of therophytes and pure Mediterranean floristic elements, confirm the Mediterranean climatic character of the wider area. In addition, the influence of high altitudes on the life forms is evident, as they cause variations in the microclimatic conditions. Percentages of therophytes decrease with increased altitude, while hemicryptophytes increase with altitude. This observation was expected as therophytes characterize warm, dry areas and hemicryptophytes humid, cold areas. This study also verifies that the Tüxen & Ellenberg method identifies better the differences in the life-form spectra between the vegetation units due to environmental factors compared with the Raunkiaer's method. Finally, as the forest communities of Mt. Hymettus (Pinetum halepensis) show few therophytes ($<20\%$) their Mediterranean character is shown in the life-form spectra by the combination of high percentages of both phanerophytes and chamaephytes.

REFERENCES

Braun-Blanquet J, 1932. *Plant sociology*. McGraw-Hill Book Company, New York.

Braun-Blanquet J, 1964. *Pflanzensoziologie*. *Grundzüge der Vegetationskunde*. Springer Verlag, Wien.

Chasapis M, Karagiannakidou V, Theodoropoulos K, 2004. Phytosociological research of *Quercus coccifera* L. pseudomaquis on Mount Chortiatis, northern Greece. *Israel journal of plant sciences*, 52: 357-381.

Christodoulakis D, 1986. The flora and vegetation of Samos Island. Ph. D. Thesis, University of Patras (in Greek).

Dimopoulos P, 1993. Floristic and phytosociological research of Mount Killini - an ecological approach. Ph. D. Thesis, University of Patras (in Greek).

Gouvas M, 2001. The plant associations of Mount Hymettus. Ph. D. Thesis, University of Thessaloniki (in Greek).

I.G.M.E. (Institute of Geology and Mineral Exploration), 1983. *Geological map of Greece, 2nd edition*. Athens.

Knapp R, 1971. *Einführung in die Pflanzensoziologie*. Verlag Eugen Ulmer, Stuttgart.

Margaris N, 1976. Structure and dynamics in a phryganic ecosystem. Lectureship Thesis, University of Athens (in Greek).

Mountrakis D, 1985. *Geology of Greece*. University Studio Press, Thessaloniki (in Greek).

Oberdorfer E, 1990. *Pflanzensoziologische exkursionsflora*. Ulmer, Stuttgart.

Pignatti S, 1982. *Flora d'Italia, 1-3*. Edagricole, Bologna.

Raunkiaer C, 1910. Statistik der Lebensformen als Grundlage für die biologische Pflanzengeographie. *Beihefte zum botanischen centralblatt*, 27: 171-206.

Raunkiaer C, 1934. *The life-forms of plants and statistical plant geography*. Clarendon Press, Oxford.

Sarlis G, 1981. The flora and vegetation of the islands and islets of southern Euboean Gulf. Lectureship Thesis, Agricultural University of Athens (in Greek).

Sarlis G, 1994a. The plants of Syra Island. *Syriana grammata*, 26-27: 99-212 (in Greek).

Sarlis G, 1994b. Contribution to the study of the flora of Attica (Greece). *Lagascalia*, 17: 229-256.

Scamoni A, 1963. *Einführung in die Praktische Vegetationskunde*. G. Fischer, Jena.

Stefanaki-Nikiforaki M, 1981. Contribution to the knowledge of flora and vegetation of Agistri Island (Saronikos Gulf). Lectureship Thesis, Agricultural University of Athens (in Greek).

Theodoropoulos K, Athanasiadis N, 1993. Constructive characteristics of the basic vegetation units in the University Forest of Taxiarchis Chalkidiki. *Scientific annals of the department of forestry and natural environment*, 36: 235-254 (in Greek).

Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA, 1968-1980. *Flora Europaea 2-5*. Cambridge University Press, London.

Tutin TG, Burges NA, Chater AO, Edmondson JR, Heywood VH, Moore DM, Valentine DH, Walters SM, Webb DA, 1993. *Flora Europaea 1, 2nd edition*. Cambridge University Press, London.

Tüxen R, Ellenberg H, 1937. Der systematische und der ökologische Gruppenwert. *Mitteilungen der floristisch-soziologischen arbeitsgemeinschaft in niedersachsen*, 3: 171-184.

Voliotis D, 1982. Relations of the climate to the latitudinal situation and altitudinal zonation of vegetation. *Ecologia mediterranea*, 8: 165-175.

Zerlentis K, 1965. Contribution to the study of the flora of Mount Hymettus. *Bulletin agricole (Ministere de l' Agriculture)*, 19: 5-30 (in Greek).