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Plant functional types in Mediterranean enclaves in Western Black Sea Region of Turkey

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Abstract: Mediterranean-type communities of the Sinop Peninsula were classified as plant functional types (PFTs) by the help of some vegetative and generative traits and 5 PFTs were determined. Some vegetative (specific leaf area (SLA), leaf texture, leaf P concentration, deciduousness, hairiness) and generative (reproductive phenology and fruit type) traits were found to be significant for discrimination of PFTs. It was found that PFT3 and PFT4 were associated with leaf texture, SLA, and leaf P concentration. PFT2 was associated with deciduousness, hairiness, and reproductive phenology, while PFT1 was only associated with fruit type. Generative traits were found to be associated with PFT1 and PFT2. PFT1 included aphyllous plants and they were associated with fruit type. Grime's CSR (competitive, stress-tolerant, and ruderal) strategies were also determined. All of the studied species exhibited transient strategies.

Key words: Functional types, maquis and garrigue vegetation, Grime's CSR strategies, detrended correspondence analysis, Mediterranean, Western Black Sea Region

1. Introduction

Plant functional types (PFTs) have been widely proposed as an ecological alternative to classical taxonomy and include easily measurable traits such as life form, leaf habit, plant height, plant longevity, and specific leaf area (SLA). They exhibit similar responses to environmental conditions and also have similar effects on matter and energy processes in ecosystems (Díaz Barradas et al., 1999). PFTs consist of species that have common morphological and physiological attributes, and classification schemes according to PFTs can include the identification of correlations among quantitative traits that reflect life history trade-off or assignment of species to plant functional groups based on dominant traits (Garcia-Mora et al., 1999; Ni, 2003; Klimešová et al., 2008; Powers and Tiffin, 2010). PFTs may change at local, regional, and global scales and such changes give important clues to understand how plants will respond to environments and global climatic changes (Ni, 2003).

Mediterranean-type communities were traditionally classified as maquis and garrigue (or phrygana in Greek). Maquis vegetation is defined as tall and usually evergreen shrubs occurring on siliceous rock, while garrigue vegetation is defined as low shrubs occurring on calcareous rock. Garrigue is found on abandoned agricultural lands, in poor habitats, and where forest and maquis have been completely cleared. Its height varies between 0.5 and 1 m. Garrigue grows very well on sunny habitats and is very resistant to drought (Atalay, 1994; Şık and Gemici, 1994; Akman, 1995).

Mediterranean-type communities are widespread as enclaves in the Black Sea Region, in addition to the Mediterranean Region and Aegean Region of Turkey. Mediterranean enclaves are called pseudomaquis because of hosting both the Mediterranean and Euro-Siberian elements together. Mediterranean species are also very widespread in Sinop, located outside the grid system of Davis (Kılınç and Karaer, 1995). The study aimed to classify the Mediterranean-type communities of the Sinop Peninsula by the help of some vegetative (leaf traits, growth form, etc.) and generative (pollination mode, reproductive phenology, etc.) traits into PFTs as an alternative to traditional classification, and to examine the most significant traits in the forming of PFTs and similarities and differences among PFTs.

2. Material and methods

2.1. Study area

Sinop is situated in the western part of the Black Sea Region (41°12′N to 42°06′N, 34°14′E to 35°26′E) and the city center was set on the Boztepe Peninsula (Şahin and Kaya, 2011; Ceylan, 2012). The Boztepe Peninsula is connected to the Sinop Peninsula by an elevated tombolo and it is defined as a landform in which an island is attached to the

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mainland or to another island by a narrow piece of land such as a sandbar. The tombolo conjoins this peninsula and the mainland and is linked to the Küre (İsfendiyar) Mountains by an expanding base (Akkan, 1975; Şahin and Kaya, 2011; Ceylan, 2012).

The annual precipitation is 775.6 mm on the Sinop Peninsula. The lowest average monthly rainfall is 30.3 mm in May, while the highest average monthly rainfall is 116.7 mm in October. The annual mean temperature is 14.6 °C. The warmest month is August, with a mean maximum temperature of 27.9 °C, and the coldest month is February, with a mean minimum temperature of 4.6 °C. There was a drought period from the middle of May to early June (Figure 1). The Emberger coefficient is 5.7 and, with reference to this, Sinop exhibits a sub-Mediterranean feature. The pluviometric quotient (Q) is 115. Sinop has a warm and rainy-type Mediterranean climate (Kılınç and Karaer, 1995; Akman, 2011).

A *Quercus ilex* community lies in the northeastern part of the Boztepe Peninsula (42°02′11″N, 35°12′35″E and 42°02′48″N, 35°11′30″E). This community is found at about 150 m a.s.l and covers about 53 ha in area. An *Erica arborea* community is located in the northern part of the İnceburun Peninsula (42°04′22″N, 35°02′19″E and 42°03′38″N, 35°02′29″E). It covers approximately 40 ha in area along a narrow coastline at about 50 m a.s.l. This community occupies rocky places and stony areas. A *Sarcopoterium spinosum* community (42°02′16″N, 35°10′18″E and 42°01′07″N, 35°11′57″E) occurs on steep slopes in the north-south direction compared to east-west, and the highest place is a flat plateau, at up to 190 m a.s.l. This community covers about 230 ha on the Boztepe Peninsula (Figure 2).

2.2. Sampling and analysis

Permanent sample plots were selected and plot size was determined by minimal area method. The sample plots were 100 m^2 for the *Q. ilex* and *E. arborea* communities and 50 m^2 for the *S. spinosum* community, and 5 plots were chosen from each community. The traits were chosen according to the criteria defined by Díaz Barradas et al. (1999). According to these criteria, the traits should express plant morphology and reproductive phenology (i.e. pollination mode and fruit traits) and should be related to stress factors, resource availability (i.e. leaf N concentration), and successional stages (i.e. colonization of new areas or reestablishment after disturbance), and should be easily measurable. We studied only persistent or arido-active species. These species have aerial active shoots throughout the year and thus adapt to drought season (Pérez Lattore and Cabezudo, 2006). We selected 24 traits that are measurable at individual plant level (Table 1). At least 10 individuals belonging to the species were selected from each species to determine the traits and these individuals were flagged to observe phenological status monthly. Five individuals were used for each species to determine leaf traits (SLA, leaf area, leaf dry content, leaf N, and leaf P).

SLA (cm^2/g) values were calculated as the ratio of leaf area to leaf dry mass. For the determination of leaf dry weight, leaf samples were dried for 24 h at 105 °C until a constant weight was reached. The percentage of the leaf dry matter content of leaves was calculated as % ratio of mean dry weight (mg) to mean fresh weight (mg).

Leaf nitrogen (N) concentration was determined by the micro-Kjeldahl method with an Eflab-2010 analyzer after digesting the samples in concentrated H_2SO_4 with a selenium catalyst. Phosphorus (P) was determined colorimetrically using molybdate and metavanadate after wet digestion in nitric and perchloric acid. The absorbance was measured at 430 nm with a Helios Gamma spectrophotometer (Kaçar and İnal, 2008).

Plant height was estimated for each species using a Haglof hypsometer. Pollination mode was determined on

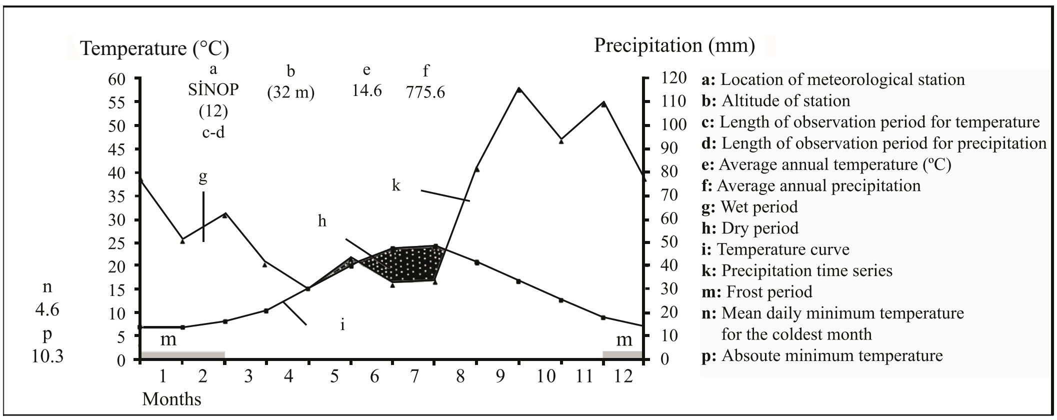

Figure 1. The climatic diagram of Sinop Peninsula.

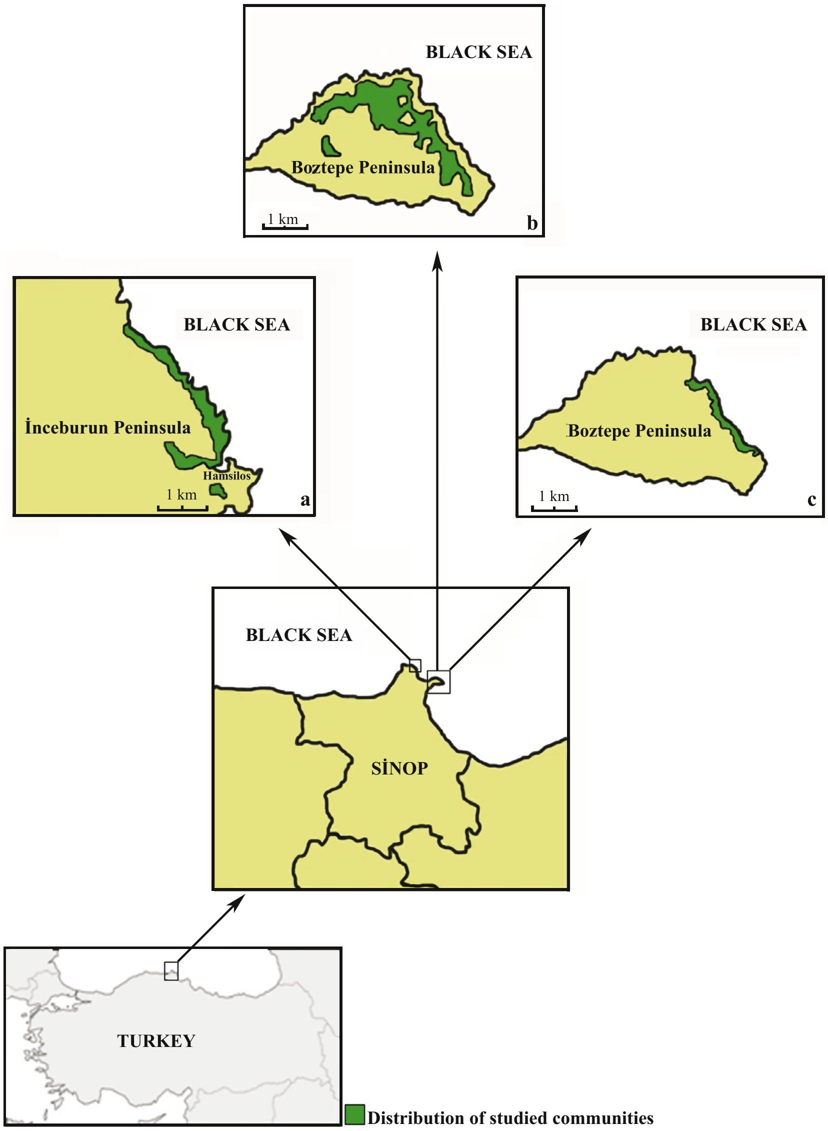

Figure 2. Distribution of studied communities (a: *Quercus ilex*, b: *Sarcopoterium spinosum*, c: *Erica arborea*).

the basis of the literature. Reproductive phenology was determined in flagged individuals of each species during 2 years of field study. Seeds were collected after ripening and at least 15 seeds were used to determine the seed size. The other traits were determined visually. Raunkiaer's life forms of plants were determined according to Ellenberg and Mueller-Dombois (1967).

Grime's CSR strategies (competitive, stress-tolerant, and ruderal) were calculated following the method of Hodgson et al. (1999) by using canopy height, leaf dry matter content, flowering period, flowering start, leaf dry weight, lateral spread, leaf area, and SLA (Table 2). Grime's strategies were not applied to aphyllous species, so Grime's CSR strategies were not used for *Ruscus aculeatus* and *Spartium junceum* (Wilson et al., 1999; Grime, 2002).

Taxonomic nomenclature followed that of Güner et al. (2012).

2.3. Data analysis

To identify main PFTs, multivariate ordination and classification methods were used. The plant traits were transformed into categorical or binary scales before analysis. The matrix of 24 traits × 11 species was subjected to 2-way indicator species analysis (TWINSPAN) for identifying the groups of species with similar traits. Detrended correspondence analysis (DCA) was used to determine the most significant plant characters. DCA and TWINSPAN

Table 1. The studied traits for Mediterranean-type communities.

Trait	Description	Description of classes in matrix
Growth form (GF)	Canopy shape	1: Leafless shrub; 2: Dwarf shrub; 3: Shrub; 4: Tree
Life form (LF)	The position of renewable bud of plant in unsuitable seasons	1: Woody frutescent dwarf-shrubs (Chfrutcaesp) 2: Caespitose nanophanerophytes (NPcaesp) 3: Caespitose microphanerophytes (MiPcaesp) 4: Caespitose megaphanerophytes (MePcaesp) 5: Geophytes with rhizome (Grhiz)
Deciduousness (D)		0: Aphyllous or evergreen; 1: Semideciduous; 2: Deciduous
Height (Ht)	Average plant height (cm)	1: <60; 2: 60–150; 3: 150–300; 4: 300–600
Ramification (R)	Number of stems at ground level	1: Single trunk; 2: 2–10; 3: >10
Vegetative spreading (VS)	Capacity to produce expanding clones	0: No evident clonal expansion; 1: Evident clonal patches
Spininess (Sp)	Presence of spines	1: Absent; 2: With spine
Stem diameter (SDia)	Measured at ground level (cm)	1: <2; 2: >2–5; 3: >5–10; 4: >10
Bark consistency (BC)		1: Smooth; 2: Fibrous
Rate of leaf/stem (L/S)	Number of leaves per 10 cm of stem	1: >50; 2: 50–100; 3: >100
Leaf area (LA)	Based on laboratory measurements (cm^2)	0: Aphyllous; 1: <0.1; 2: >0.1–1.0; 3: >1.0–5.0; 4: >5.0–10.0; 5: >10.0
Specific leaf area (SLA)	Estimation of leaf area: leaf dry weight ($cm^2 g^{-1}$)	0: Aphyllous; 1: 10–100; 2: >100–150; 4: >150
Leaf dry matter content (LDMC)	Dry matter content of fully expanded leaf (%)	0: Aphyllous; 1: 0–50; 2: 50–100
Leaf N (L-N)	Nitrogen content (%)	0: Aphyllous; 1: >0–2; 2: >2–3
Leaf P (L-P)	Phosphorus content (%)	0: Aphyllous; 1: >0–0.1; 2: >0.1–0.2; 3: >0.2
Leaf color (LC)		0: Aphyllous; 1: All green; 2: Green and white
Leaf margin (LM)		0: Aphyllous; 1: Entire; 2: Undulate; 3: Parted; 4: Serrate
Leaf texture (LT)		0: Aphyllous; 1: Sclerophyll; 2: Malacophyll; 3: Deciduous
Leaf hairiness (LH)		0: Aphyllous; 1: Hairy at the leaf base; 2: Hairy on 1 side; 3: Hairy on 2 sides
Pollination mode (PM)	Pollination mode	1: Anemochore; 2: Zoochore; 3: Anemochore + zoochore
Fruit dehiscence (FD)		1: Dry indehiscent; 2: Dry dehiscent; 3: Fleshy
Fruit type (FT)		1: Capsule; 2: Berry; 3: Acorn; 4: Drupe; 5: Legume
Seed size (SS)	Seed length	1: <2 mm; 2: 2–4 mm; 3: >4–10 mm; 4: >10 mm
Reproductive phenology (RP)	Seasonality of maximum production of flowers and fruits	1: No evident peak; 2: Spring, summer, autumn; 3: Spring, summer; 4: Winter, spring, early summer

were performed by using the Community Analysis Package software program. Grime's CSR strategies were determined according to Hodgson et al. (1999). The differences of leaf traits (SLA, leaf dry content, leaf N, leaf P) among the studied species were evaluated by one-way ANOVA in SPSS 20.

3. Results

We distinguished 5 functional types according to TWINSPAN classification (Figure 3). DCA analysis showed that the main trend of variation (axis 1) separated plants according to leaf texture, SLA, and leaf P concentrations at the positive end and fruit type at the negative end. The second trend of variation (axis 2) separated plants according to hairiness and reproductive phenology at the positive end and leaf defoliation at the negative end. Fruit type was associated with PFT1, while hairiness and reproductive phenology were associated with PFT2. Leaf texture, leaf P content, and SLA were associated with PFT3 and PFT4. PFT5 was associated with deciduousness and leaf texture (Figure 4).

Table 2. Definition of the predictor variables of the CSR allocation of plant species (from Hodgson et al., 1999).

Variable		Definition	
Canopy height	Six-point classification	1	1–49 mm
		2	50–99 mm
		3	100–299 mm
		4	300–599 mm
		5	600–999 mm
		6	>999 mm
Dry matter content	Mean of percent dry matter content in the fully hydrated and expanded leaves (%)		
Flowering period	Duration of flowering period (months)		
Flowering start	Six-point classification	1	First flowering in March or earlier
		2	In April
		3	In May
		4	In June
		5	In July
		6	In August or later or before leaves in spring
Lateral spread	Six-point classification	1	Plant short-lived, compactly tufted about a single axis, no thickened rootstocks
		2	Compactly tufted ramets appressed to each other at base (in graminoids)
		3	Compactly tufted about a single axis, thickened rootstock present (in nongraminoids)
		4	Shortly creeping, <40 mm between ramets
		5	Creeping, 40–79 mm between ramets
		6	Widely creeping, >79 mm between ramets
Leaf dry weight	Natural logarithm of mean dry weight in the largest, fully hydrated, fully expanded leaves (mg), plus 3		
Specific leaf area	Mean of area/dry weight quotient in the largest, fully hydrated, fully expanded leaves (mm^2/mg)		

PFT1: Aphyllous shrubs. PFT1 is represented by *Ruscus aculeatus* and *Spartium junceum* and this group includes the species pollinated by animals (Table 3).

PFT2: Formed by evergreen trees with sclerophyllous leaves. In this group, the number of leaves per unit is high and nitrogen content is low. Leaves are glabrous or hairy on one side. In this group that sees pollination by air or animal, there is no peak in reproductive phenology for some species, while some exhibit seasonality as spring-summer-autumn. The fruits are fleshy or dry (berry or acorn) and the seed size is variable. This group includes *Q. ilex*, *Phillyrea latifolia*, *Laurus nobilis*, and *Arbutus unedo* (Table 3).

PFT3: Tall shrubs with a high number of small leaves per stem unit, represented by *E. arborea*. Individuals had leaves with low dry matter and nitrogen and phosphorous content. The stem is fibrous. The pollination is achieved by

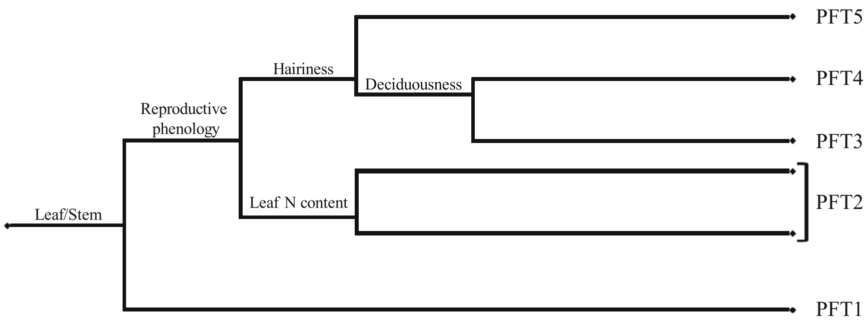

Figure 3. Plant functional types defined by the TWINSPAN analysis and the main trait indicators for each division.

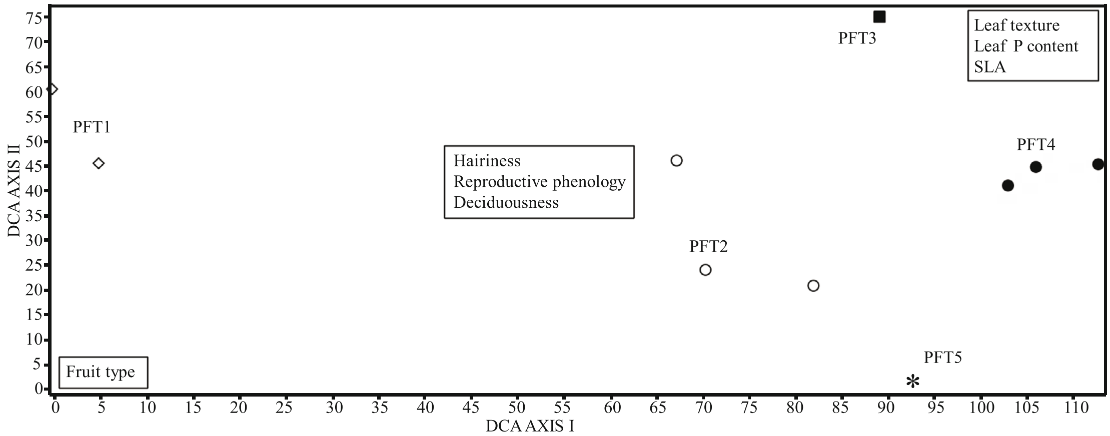

Figure 4. DCA ordination of the traits × species matrix.

animals or air. Fruits are dry and indehiscent (capsules). Reproductive peak was observed several times during winter, spring, and early summer (Table 3).

PFT4: Formed by semideciduous dwarf shrubs, with malacophyll leaves hairy on 2 sides. Leaf N concentration is low. Stems are fibrous. This group loses its leaves in the drought period. They are pollinated by animals and have a reproductive peak in spring-summer. Fruits are dry and dehiscent (capsules) or fleshy (berries). PFT4 is represented by *Cistus creticus*, *C. salviifolius*, and *S. spinosum* (Table 3).

PFT5: Formed by tall deciduous shrubs with glabrous leaves. SLA and N and P concentrations are high and leaf dry content is low. Pollination is achieved by animals. Reproductive peak is seen during spring and summer. The fruits are fleshy (berries). This group is represented by *Crataegus monogyna* (Table 3).

There were significant differences among species with respect to SLA, leaf dry matter content, and leaf N and P concentration (Table 4).

All of the studied species exhibit transient strategies (Table 5). *Q. ilex*, *P. latifolia*, *E. arborea*, *C. creticus*, and *S. spinosum* exhibit a CS strategy, while *L. nobilis*, *A. unedo*, and *C. monogyna* exhibit a C/CS strategy. Only *C. salviifolius* exhibits a S/CS strategy (Table 5).

4. Discussion

It has been found that PFT3 and PFT4 were associated with leaf texture, SLA, and leaf P concentration. PFT2 was associated with deciduousness, hairiness, and reproductive phenology, while PFT1 was only associated with fruit type. On the other end, PFT5 was separated from the other PFTs by having different characters in terms of deciduousness and leaf texture. SLA was found to be a significant trait in Mediterranean-type ecosystems and it seems to be a key trait characterizing the broad-leaved evergreen species (Garnier et al., 2001; Gratani and Bombelli, 2001). Garnier et al. (2004) demonstrated that simple, quantitative, easily measurable plant traits like leaf traits (SLA, nitrogen and phosphorus concentrations, etc.) could yield relevant information on key aspects of ecosystem functioning; these traits also indicate the changes in community structure and composition and they called 'functional markers'. We found SLA, leaf texture, leaf P concentration, deciduousness, hairiness, reproductive phenology, and fruit type as functional markers in the studied Mediterranean-type communities.

The variation between maquis and phrygana vegetation is mainly associated with disturbance factors and reflects the process of maquis degradation. Intensive human activity results in the gradual replacement of maquis species by phryganic ones. However, the differences between maquis and phrygana vegetation may be related to environmental factors. One of the most significant environmental factors is parent rock type. Garrigue communities could represent primary vegetation types, although more evidence is needed to support this theory, and they were formed as a result of the disturbance of maquis vegetation (Şık and Gemici, 1994; Tzanopoulos et al., 2005). PFT2 represented maquis vegetation, while PFT4 represents garrigue vegetation according to traditional classification with respect to species composition and parent rock (Şık and Gemici, 1994; Kılınç and Karaer, 1995). On the other hand, there are limited studies about PFTs in Mediterranean woody species. In Spain, Díaz Barradas et al. (1999) established 6 PFTs. Results of the present study are consistent with Diaz Barradas et al. (1999), except that *P. latifolia* is not clearly distinguished from other species included in PFT2. This result is evidence that species inhabit different PFTs at different environmental scales.

The highest SLA values and leaf nitrogen concentrations were found in *C. monogyna*, while the lowest SLA values and leaf nitrogen concentrations were found in *Q. ilex*. Verroios and Georgiadis (2011) stated that evergreen sclerophyllous *Quercus* forests constitute the final

Table 3. Measured traits for the studied species (A: aphyllous; D: deciduous; M: malacophyllous; S: sclerophyllous; An: anemochore; Z: zoochore).

Traits	*Sarcopoterium spinosum*	*Spartium junceum*	*Quercus ilex*	*Laurus nobilis*	*Ruscus aculeatus*	*Erica arborea*	*Phillyrea latifolia*	*Arbutus unedo*	*Cistus creticus*	*Cistus salviifolius*	*Crataegus monogyna*
GF	Dwarf shrub	A shrub	Tree	Tree	A shrub	Shrub	Shrub	Tree	Dwarf shrub	Dwarf shrub	Shrub
LF	Chfrutcaesp	NPcaesp	MePcaesp	MePcaesp	Grhiz	MiPcaesp	MiPcaesp	MiPcaesp	NPcaesp	NPcaesp	MiPcaesp
D	Semideciduous	A	Evergreen	Evergreen	A	Evergreen	Evergreen	Evergreen	Semideciduous	Semideciduous	D
Ht	46.9	174	593	567	49.4	217	228	305	108	58.1	165
R	10.4	4.3	4.9	9.6	4.1	6.1	3.6	1.3	3.6	1.9	3.2
VS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
S	Yes	No	No	No	Yes	No	No	No	No	No	Yes
SDia	0.75	5.1	14.2	9.04	0.85	3.34	4.3	7.8	2.36	1.1	3.8
BC	Fibrous	Smooth	Fibrous	Smooth	Fibrous	Fibrous	Smooth	Fibrous	Fibrous	Fibrous	Smooth
LT	M	A	S	S	A	S	S	S	M	M	D
L/S	>100	A	>100	>100	A	>100	75	>100	37	59	70
LC	Green-white	A	Green-white	Green	A	Green	Green-white	Green	Green	Green	Green
LM	Parted	A	Undulate	Undulate	A	Entire	Serrate	Serrate	Undulate	Undulate	Serrate
LH	On 2 sides	A	On one side	Glabrous	A	On 2 sides	On base of leaf	Glabrous	On 2 sides	On 2 sides	Glabrous
LA	1 ± 0.07	A	6.9 ± 0.7	23.9 ± 0.96	A	0.05 ± 0.002	4.5 ± 0.2	9.1 ± 0.7	3.4 ± 0.2	3.97 ± 0.7	4 ± 0.5
SLA	101.7 ± 5.9	A	75.9 ± 4.1	104.3 ± 8.7	A	130.6 ± 6.4	106.6 ± 7.3	101.3 ± 3.3	131.6 ± 6.6	141.9 ± 5.4	178.8 ± 16
LDMC	34.14 ± 2.2	A	60 ± 3.2	55.01 ± 5.6	A	46.46 ± 2.4	61 ± 3.3	49.13 ± 2.1	53.54 ± 2.6	53.03 ± 0.8	35.04 ± 2.4
L-N	1.95 ± 0.08	A	1.6 ± 0.09	1.8 ± 0.2	A	1.6 ± 0.08	2.3 ± 0.07	1.95 ± 0.06	1.8 ± 0.11	2.0 ± 0.05	2.6 ± 0.03
L-P	0.16 ± 0.007	A	0.09 ± 0.007	0.1 ± 0.009	A	0.07 ± 0.006	0.22 ± 0.02	0.06 ± 0.005	0.09 ± 0.004	0.14 ± 0.005	0.13 ± 0.01
PM	Z[2]	Z[4]	An[1]	Z[3]	Z[1]	An + Z[1]	An[1]	Z[1]	Z[5]	Z[1]	Z[1]
FD	Fleshy	Dry-dehiscent	Dry-indehiscent	Fleshy	Fleshy	Dry-dehiscent	Fleshy	Fleshy	Dry-dehiscent	Dry-dehiscent	Fleshy
FT	Berry	Legume	Acorn	Berry	Berry	Capsule	Drupe	Berry	Capsule	Capsule	Berry
SS	2.7 ± 0.2	3.5 ± 0.2	20.4 ± 2.1	12.5 ± 0.9	8.1 ± 0.9	1.4 ± 0.2	4.9 ± 0.6	1.3 ± 0.3	1.2 ± 0.1	1.4 ± 0.1	6.7 ± 0.7
RP	Spring-summer	Spring-summer	Spring-summer-autumn	No peak	No peak	Winter-spring-early summer	Spring-summer-autumn	No peak	Spring-summer	Spring-summer	Spring-summer

[1]Aronne and Wilcock (1994); [2]Petanidou and Vokou (1990); [3]Arroyo et al. (2010); [4]Paccini et al. (1997); [5]Manetas and Petropoulou (2000).

Table 4. Comparison of plant traits among the studied species. Means followed by the same letter are not significantly different at 0.05 level according to Tukey's honestly significant difference test (SLA: specific leaf area; LDMC: leaf dry matter content).

Species	SLA	LDMC	Leaf-N	Leaf-P
Quercus ilex	75.9^{e}	60.00^{a}	1.60^{c}	0.09^{a}
Laurus nobilis	104.3^{d}	55.01^{ab}	1.80^{bc}	0.10^{d}
Arbutus unedo	101.3^{d}	49.13^{d}	1.95^{b}	0.06^{d}
Phillyrea latifolia	106.6^{d}	61.00^{a}	2.30^{ab}	0.22^{c}
Erica arborea	130.6^{c}	46.46^{b}	1.60^{c}	0.07^{d}
Sarcopoterium spinosum	101.7^{d}	34.14^{c}	1.95^{b}	0.16^{bc}
Cistus creticus	131.6^{c}	53.54^{ab}	1.80^{bc}	0.09^{ab}
Cistus salviifolius	141.9^{b}	53.03^{ab}	2.00^{ab}	0.14^{bc}
Crataegus monogyna	178.8^{a}	35.04^{c}	2.60^{a}	0.13^{bc}

succession stage of the mesomediterranean vegetation belt; such species are slower-growing species (low SLA and leaf nitrogen concentrations) and usually tend to conserve internal resources more efficiently, while fast-growing species had high SLA and leaf nitrogen concentrations (Garnier et al., 2004; Verroios and Georgiadis, 2011). The lowest leaf P concentrations were found in *A. unedo* and *E. arborea*. Long-lived, thick, and tough leaves with low leaf nutrient concentrations tend to succeed in resource-poor habitats (Grime, 2002; Tecco et al., 2010).

Raunkiaer's life forms may not be used in the discrimination of PFTs. For example, *E. arborea*, *P. latifolia*, *A. unedo*, and *C. monogyna* all had the caespitose microphanerophyte life form, but they belonged to different PFTs and leaf characteristics were more significant. It has been implied that vegetative traits are directly relevant to resource use, storage, and release (Díaz et al., 2004). Vegetative traits (leaf/stem ratio, leaf hairiness, and deciduousness) were found to be significant for the discrimination of PFTs in the study area. Generative traits were found to be associated with PFT1 and PFT2, and PFT1 includes aphyllous shrubs.

Table 5. Grime's strategies for the studied species (C: competitive; S: stress-tolerant).

Species	Strategy type
Quercus ilex	CS
Laurus nobilis	C/CS
Phillyrea latifolia	CS
Arbutus unedo	C/CS
Erica arborea	CS
Cistus creticus	CS
Cistus salviifolius	S/CS
Sarcopoterium spinosum	CS
Crataegus monogyna	C/CS

Prévosto et al. (2011) demonstrated that the ruderals declined towards climax stage in some European habitats and pure C or transient strategies increased. Evergreen sclerophyllous oak forests constituted the final succession stage of Mediterranean-type communities (Verroios and Georgiadis, 2011). *Q. ilex* and *L. nobilis* exhibit CS and C/CS strategies, respectively, and represent the climax stage in the *Q. ilex* community according to Grime's strategy types. The late successional species generally exhibit C or CS strategies because of the size effect. These species have longer-lived leaves, larger seeds, and higher leaf dry matter content than earlier successional species (Navas et al., 2010). In addition to this, *Q. ilex* also had low SLA and leaf nitrogen concentrations and high leaf dry matter content, and such species represent the climax stage (Garnier et al., 2004). The species exhibit a C/CS transient strategy and usually show lateral spread (Hüseyinova et al., 2013).

Mediterranean-type communities are traditionally classified as maquis, which indicates woody and sclerophyllous-leaved shrubs and garrigue (or phrygana) dwarf shrubs (Díaz et al., 1999). However, at least 4 or 5 subgroups can be distinguishable according to different plant traits, even at local scales. Some vegetative (SLA, leaf texture, leaf P concentration, deciduousness, hairiness) and generative (reproductive phenology, fruit type) traits were found to be significant for discrimination of PFTs. In the discrimination of aphyllous plants (*R. aculeatus*, *S. junceum*), fruit type was significant, and this was probably due to the lack of leaves as photosynthetic products will be allocated to reproductive parts (Kutbay and Kılınç, 1996). SLA may be compensated for by the fact that it is more directly relevant to carbon assimilation and nutrient conservation, and SLA is also a key trait for Grime's classification system (Vendramini et al., 2002).

The classification of plant species using Grime's CSR system allows the determination and investigation of primary plant functional types and ecosystem processes over landscape scales (Pierce et al., 2013).
Leaf characteristics, reproductive phenology, and fruit characteristics of plant species and Grime's strategy categories should be used in the discrimination of Mediterranean-type communities as an alternative approach to traditional classification schemes.

It has been found that different PFTs exhibit different CSR strategy types. For example, *Q. ilex* and *E. arborea* exhibit a CS strategy, although these species belong to different PFTs. Similar studies showed that CSR strategy types and PFTs may be different (Pywell et al., 2003; Ansquer et al., 2009). Westoby (1998) proposed that easily measurable traits such as leaf area and canopy height may be used properly as an alternative to Grime's CSR scheme and PFTs may be applied to a larger scale. Grime (2002) pointed out that the CSR strategy appears to be more appropriate in the prediction of vegetation processes at the local scale, while a much higher number of more precise plant functional types seem most useful for determining functional composition of the vegetation (Díaz et al., 2002; Ansquer et al., 2009). PFTs are strongly modulated by environmental factors because they are coordinated through physiological trade-offs (Fujita et al., 2012).

There is no study that compares the use of PFTs and Grime's CSR system, which have different classification schemes, for understanding ecosystem processes. The present study showed that the PFT system is more efficient in defining and classifying Mediterranean-type plant communities, while the CSR system is more appropriate in evaluating plant communities in term of succession processes.

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