Plant functional traits in relation to seedling recruitment and light conditions in sub-Mediterranean oak forests of Greece

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Abstract. We present the first results of a database containing plant functional traits in sub-Mediterranean oak forests of Greece. Data collected so far concern deciduous oak forests of NW Greece (Bourazani, Epirus), subjected to overgrazing by ruminants and non-ruminants for the last 30 years. To associate seedling recruitment capacity with certain functional traits, fruit and seed mass of 19 plants (14 woody and 5 herbaceous taxa) were measured. Preliminary germination results of these plants are furnished. Specific Leaf Area (SLA) values for 16 plants were determined and correlated with the prevailing Photosynthetic Active Radiation (PAR) under canopy and open-light conditions. The perspectives of developing a predictive tool of functional traits on the resistance and resilience of deciduous oak woodlands towards overgrazing are discussed.

Key words: fruit mass, functional traits, Greece, Photosynthetically Active Radiation (PAR), seed mass, Specific Leaf Area (SLA)

Introduction

Predicting the response of vegetation to environmental and land use changes remains a matter of major concern in recent theoretical and applied ecological research (McIntyre & al. 1999a, b). Plant functional types are diagnostic tools for disturbance processes and elaboration of long-term strategies in ecosystem management and ecological restoration projects (Gondard & al. 2003).

Specific Leaf Area (SLA) is a key variable in our understanding of forest ecosystem function (Ellsworth & Reich 1993; Pierce & al. 1994; Landsberg & Waring 1997). The ratio of leaf surface area to leaf mass describes the efficiency with which the leaf captures light and is inversely correlated with maximum photosynthetic rate (Marshall & Monserud 2003). Dispersule size and shape, as well as seed mass are good indicators of plants' response to disturbance, such as herbivory or overgrazing, and their competitive strength (Cornelissen & al. 2003). From the functional point of view, grazing acts as a filter of succession (De Bello & al. 2005). Pigs disturb the soil creating sites for seedling establishment and favouring early successional short-lived species (Chapin & al. 1997).

Objectives of this study are to: a) set the basis of creating a predictive plant functional pattern of species' response to different grazing regimes in sub-Mediterranean oak forests of NW Greece; b) record literature data and measure 17 functional plant attributes; c) correlate the monthly values of Photosynthetic Active Radiation (PAR) in light and under-canopy conditions with the calculated SLA of 16 plant species; d) measure seed and fruit mass, as regenerative traits in 19 plant species (14 tree and 5 herbaceous taxa) and compare them to find possible associations with seedling recruitment capacity.

Study area

The studied sub-Mediterranean deciduous oak forests are located in Bourazani area, 12 km NW of the municipality of Konitsa (Epirus, NW Greece) and approximately 5 km from the Greek–Albanian borders. The climate of the area (classified in the sub-humid bioclimatic zone) is sub-Mediterranean (average annual precipitation: 700 mm, rainy cold winters: most rainfall in November–December). The bedrock consists mainly of flysch of paleogenic origin which is substituted locally by limestone covered by shallow rendzina soils (IGME 1973). The present forest vegetation consists of mixed deciduous woodlands with a high proportion of oak species (*Quercus pubescens*, *Q. frainetto*, *Q. cerris*, *Q. trojana* and more rarely *Q. petraea* subsp. *medwediewii* and *Q. coccifera*), accompanied by *Carpinus orientalis*, *Fraxinus ornus* and *Ostrya carpinifolia* (Tsaliki & al. 2005). The research is carried out in an enclosed forest area (112 ha) grazed for over 30 years and divided into two fenced parts (one is grazed by ruminants: 86 ha, and the other by wild boars: 26 ha). Hence, in this area three types of grazing regime have been practiced since 1974: a) ruminant overgrazing, b) wild-boar overgrazing and c) non grazed forests outside the fences (grazing practised sporadically by goats).

Table 1. Functional attributes of the 23 species occurring in overgrazed deciduous oak woodlands.

No.	Taxon	SLA (g/cm^2)	Fruit mass (g)	Seed mass (g)	Emergent seedlings %	Dispersal mode
1	***Quercus frainetto***	121.51	1.7951	0.421	0	Accumulation*
2	***Quercus cerris***	132.14	5.4037	1.5935	0	Accumulation*
3	***Quercus pubescens***	192.34	2.4127	0.8265	0	Accumulation*
4	***Quercus trojana***	117.16	6.12	1.157	0	Accumulation*
5	***Phillyrea latifolia***	83.11	0.0177	0.0503	0	Accumulation*
6	***Fraxinus ornus***	141.99	0.0343	0.0248	22.5	Anemochory
7	***Carpinus orientalis***	228.05	0.0124	0.0062	0	Anemochory
8	***Juniperus oxycedrus***	96.00	0.1912	0.0011	0	Unassisted
9	***Paliurus spina-christi***	–	0.1923	0.0240	5	Anemochory
10	***Cercis siliquastrum***	155.24	–	0.0304	2	Endo-zoochory
11	***Crataegus monogyna***	182.55	0.3289	0.0046	0	Endo-zoochory
12	***Acer monspessulanum***	185.67	0.0369	0.0102	0	Anemochory
13	***Arbutus unedo***	63.64	–	–	–	Endo-zoochory
14	***Pistacia terebinthus***	147.27	0.0527	0.0101	30.77	Endo-zoochory
15	***Cotinus coggygria***	262.86	–	–	0	Endo-zoochory
16	***Sorbus torminalis***	178.62	–	–	–	Unassisted
17	***Clematis vitalba***	–	0.0041	0.0028	0	Anemochory
18	***Dorycnium hirsutum***	–	0.0670	0.0041	23.26	Endo-zoochory
19	***Psoralea bituminosa***	–	0.0222	0.0179	9.5	Endo-zoochory
20	***Briza humilis***	–	0.0038	0.0016	5	Exo-zoochory
21	***Bromus benekenii***	–	0.0104	0.0011	8	Exo-zoochory
22	***Trifolium arvense***	–	0.0005	0.0003	2.86	Anemochory
23	***Helleborus odorus* subsp. *cyclophyllus***	118.01	–	–	–	Endo-zoochory

Accumulation*: dispersal by hoarding (dispersal of seeds buried by mammals); (–): measurement not made.

Material and methods

The list of 112 taxa occurring in the deciduous oak forests of the studied area was compiled in order to build a functional traits database. The recorded functional attributes are distinguished in three groups and listed below:

- Group I (vegetation) – life-form (Raunkiaer), growth form, plant height at maturity, evergreen/deciduous, annual/biennial/perennial, Specific Leaf Area (SLA), leaf size, leaf dry mass;
- Group II (regeneration) – fruit mass, seed mass, fruit type, dispersal mode, dispersal unit, flowering season, vegetative regeneration;
- Group III (morphology) – fruit, seed and leaf scans/pictures.

In the studied grazed sites, on the basis of their cover-abundance, 23 plant taxa were considered for plant trait measurements, including fruit mass, seed mass, Specific Leaf Area (SLA) and seedlings recruitment capacity measurements (Table 1). For SLA measurements standard methods were followed (Garnier & al. 2001); the SLA value for each taxon was estimated as the average of 20 measurements. Fruits and leaves were selected and stored from spring to autumn of 2005; for fruit and seed mass measurements, the field collections and experimental work follow the methodology proposed by Cornelissen & al. (2003) with samples of 100 fruits per taxon from selected populations. For both fruit and seed mass, the value was calculated as the average of 100 measurements.

To estimate the amount of light received by the potentially established seedlings and adult individuals of the studied taxa in the field, 3 micro-climatic stations were installed in the grazed and non-grazed areas and data were collected by two PAR sensors under shadow and in the light. The mean monthly PAR values were correlated with the mean SLA values in order to graphically represent the variation of the growth potential of the studied taxa.

Seed samples of 19 plant species (Table 1) were collected during the seed mass collections. The seeds were wet-stratified (2–6 °C) for one month in the dark. Afterwards, seed samples (10 to 30 seeds) were placed at constant 22 °C (10 h daily light) and emerged seedlings were recorded for six months. The seedling recruitment capacity (% percentage of the number of emerged seedlings divided by the number of seeds in a sample) was measured. Raunkiaer's (1934) classification system was followed for the assignment of the considered taxa in life-forms (Fig. 1).

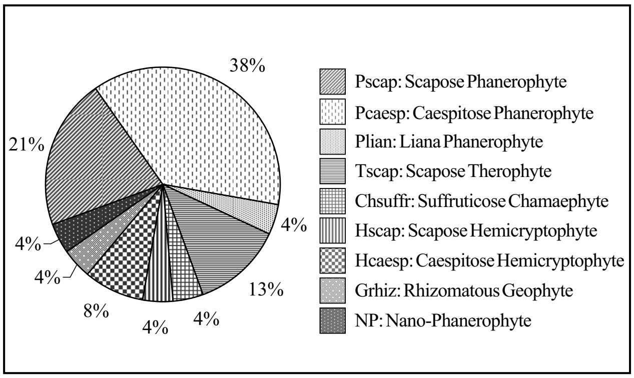

Fig. 1. Life-form spectrum of the 23 taxa used for plant trait measurements.

Results

The plant taxa of the overgrazed sites are banded into the life-form spectrum of Fig. 1, with the highest percentage represented by caespitose Phanerophytes.

The calculated SLA values (g/cm^2), fruit mass (fresh weight in g), seed mass (g) and seedling recruitment capacity, as well as the dispersal mode of 23 taxa are recorded and qualitatively related to the seed mass values (Table 1). For example, a heavy fleshy seed of *Quercus frainetto* is dispersed by hoarding (accumulation), while a tiny *Trifolium arvense* seed is dispersed by wind (anemochory).

Fig. 2 presents a graph of SLA values for 16 plant taxa in relation to the PAR values, as they fluctuate for a time period of 16 months under gap and shadowed conditions. *Cotinus coggygria* appears to have the highest SLA value of the tree taxa, while *Quercus pubescens* (192.34 g/cm^2) has the highest value among *Quercus* species. *Quercus trojana* (the most sclerophyllous of the *Quercus* species) shows the lowest SLA (117.16 g/cm^2). The most sclerophyllous tree taxa *Phillyrea latifolia*, *Arbutus unedo* and *Juniperus oxycedrus* are characterized by the lowest SLA values. PAR mean value in the light (50.61 uE) is much higher than PAR under canopy (8.90 uE) for this time period. PAR shows maximum values from end of March to the end of April, under canopy and in light conditions.

In Fig. 3, fruit fresh weight values of 19 selected plant species are compared to seed mass values of the same species and correlated with seedling recruitment capacity values. *Crataegus monogyna*, *Juniperus oxycedrus*, *Paliurus spina-christi* and all *Quercus* species have much higher fruit mass values than seed mass values. The first germination results showed an increased recruitment capacity for plant species that do not exhibit great variation between their fruit and seed masses. Such species are *Dorycnium hirsutum*, *Pistacia terebinthus*, *Fraxinus ornus*, *Psoralea bituminosa* and *Bromus benekenii*.

Discussion

PAR levels differ much in the field and under different light conditions. The useful for photosynthesis light, which can be absorbed by leaves, has a crucial role on

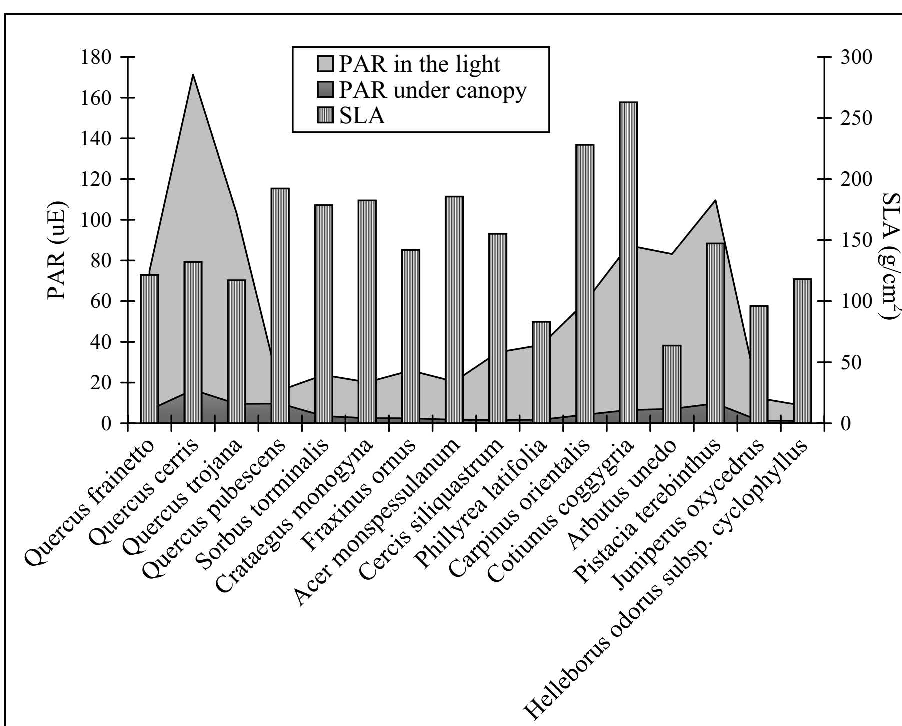

Fig. 2. Specific Leaf Area values (g/cm^2) of 16 plant species in grazed sites of the study area and Photosynthetically Active Radiation values (uE) in light and under canopy.

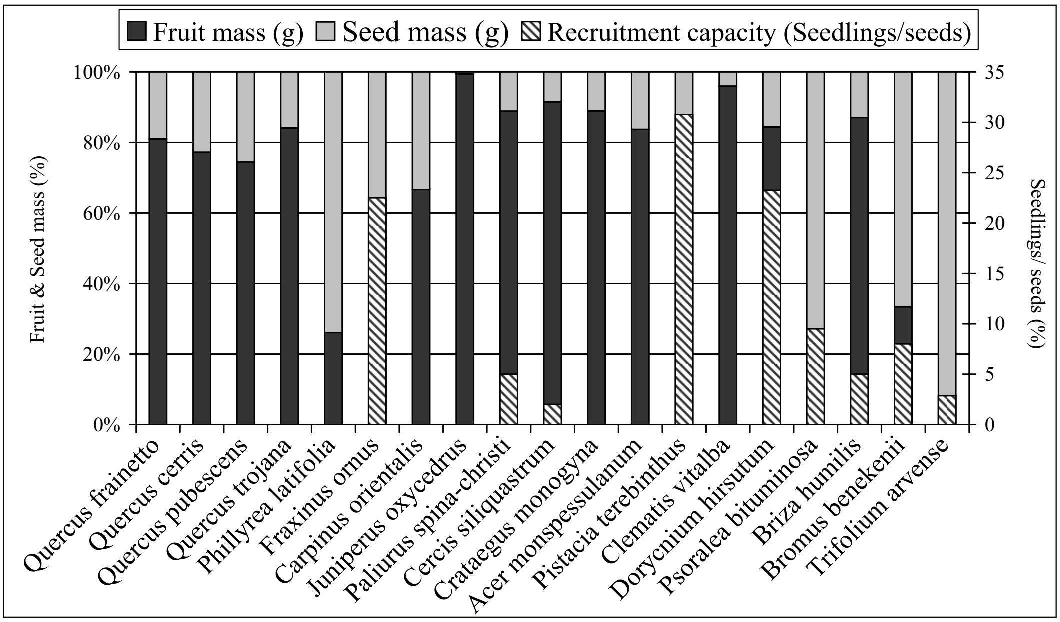

Fig. 3. Fruit mass (%), seed mass (%) and seedling recruitment capacity (%) for 19 plant taxa in overgrazed sites of the study area.

plant communities' structure as it affects the potential emergence and growth of certain plant taxa. PAR has been related with the vertical structure and position of the leaves for plant taxa such as *Fraxinus ornus*, as well as with seedlings relative growth rate of certain species, in order to explore their capacity to rehabilitate damaged environments.

Management practices or disturbances, such as overgrazing, affect dramatically the variation along gradients of plant communities. The mixed oak forests of the study area represent such a case. Overgrazed forests inside the fence have developed a critically different structure and floristic composition compared to the forests outside fences. Our research sphere is crucial to be considered as a developing study of creating plant and ecological traits predictive patterns of species competition under different grazing regimes. Therefore, SLA measurements are continued in the other two grazing regimes of our study area.

Seed mass, dispersal mode, dispersule shape and size and resprouting capacity are described as satisfactory indicative traits of plant species response to disturbance (Chapin & al. 1993; Díaz & al. 1999; Weiher & al. 1999; Lavorel 2002; Lavorel & Garnier 2002). Although our germination results indicate a potential pattern, they do not yet enable us to reach in a definite conclusion correlating clearly fruit and seed mass to seedlings recruitment under stable conditions; the experiments are going to be repeated and also to be continued for the other grazing regimes.

Further investigations are in progress, as variation is observed in disturbance regimes, floristic composition, vegetative and regenerative attributes of plant species in the under study sub-Mediterranean forest ecosystems. Data collection will continue in non-grazed woodlands to compare the derived functional response groups in grazed and non-grazed conditions. The creation of a database and the determination of plant functional types for these ecosystems remain important.

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