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ARCHITECTURAL PATTERNS OF "MACCHIA" SHRUBS IN MEDITERRANEAN ITALY

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Nomenclature follows S. Pignatti (1982). Flora d'Italia. Edagricole.

Abstract: Patterns of architectural variation of some "macchia" woody species (*Cistus monspeliensis, Erica multiflora, Pistacia lentiscus, Myrtus communis* and *Quercus ilex*) were studied in different post-fire physiognomic types of Circeo National Park (Central Italy): *Ampelodesmos* grassland, *Erica arborea* open-shrubland, *Cistus monspeliensis* shrubland and *Quercus ilex* tall-shrubland. Principal Component Analysis (PCA) was carried out based on data from all stands and species using the variables plant height, basal stem diameter, number of stems, first-leaf height and height/mean crown diameter ratio. Different architectural patterns could be described. *C. monspeliensis* has a vertical spatial arrangement and few stems in all situations ("stable" architectural type). *E. multiflora, M. communis* and *P. lentiscus* show lateral spreading and many stems in open stands, but show both horizontal or vertical spatial arrangements in closed-canopy stands ("plastic" architectural type). *Q. ilex*, though not found in all situations, seemed to belong to this latter group. The high competitive ability of *Q. ilex* may be related to its greater growth capacity.

Introduction

While plant growth is coordinated by genetic factors operating at the level of the whole plant, environmental factors (e.g. temperature, herbivory and fire, and the availability of light, water and nutrients) also affect plant development. In other words, plant architecture may express phenotypic plasticity (Küppers 1989). The quantitative description of plant architecture provides useful information for analyzing both plant growth and plant interactions. Indeed, architectural traits related to an individual's photosynthetic ability should reflect the niche of a species within the community (Kohyama 1987).

There are many studies on morphological attributes of plants in Mediterranean ecosystems (Specht 1969, Parsons 1976, Orshan 1986, Pignatti and Pignatti 1985), as well as studies relating morphological characters to environmental variation (e.g. Mooney and Dunn 1970 a,b, Shmida 1981, Margaris 1981, Box 1987, Montalvo et al. 1991). However, the architectural response of woody species to different growth conditions has not been clearly described. The objective of this study is to describe architectural patterns of some dominant woody species of the Mediterranean "macchia" in central Italy, and to examine patterns of architectural variation among different post-fire physiognomic types.

Materials and Methods

Study area

The field survey was performed in the spring and summer of 1992 on Mt. Circeo Promontory (locality "Quarto caldo"), and on Zannone Island (Archipelago Ponziano). Both locations occur in the Circeo National Park, Latium. Mt. Circeo is a calcareous, coastal promontory abruptly emerging from the surrounding flat sedimentary plain. Zannone is an acid Plio-Pleistocene vulcanite island located 27.5 km from the promontory.

The macroclimate has a typical Mediterranean character, belonging to the thermo-Mediterranean thermotype (*sensu* Rivas-Martinez 1983). Annual precipitation varies from 727 to 1133 mm, and the mean monthly temperature is 17°C. The main "macchia" vegetation types occurring in the Park were sampled, including four physiognomically different post-fire situations on the promontory and an open shrubland on Zannone Island (Table 1). All stands had a northern aspect, and were topographically similar (slopes ranging between 10-15%).

Table 1. Site descriptions for the five stands of Mediterranean "macchia" vegetation.

Stand	Physognomic type	Shrub cover	Major woody species	Year of last fire
1	*Ampelodesmos* grassland	15%	*Cistus monspeliensis, Erica multiflora.*	1990
2	*Ampelodesmos* grassland	20%	*Cistus monspeliensis, Erica multiflora, Myrtus communis.*	1987
3	*Erica arborea* open shrubland	60%	*Cistus monspeliensis, Erica arborea*	1979
4	*Cistus monspeliensis* shrubland	90%	*Cistus monspeliensis, Erica multiflora, Myrtus communis*	1977
5	*Quercus ilex* tall-shrubland	85%	*Quercus ilex, Myrtus communis, Erica multiflora.*	unburned during the last 40 years.

Sampling design and data analysis

Five woody species were studied: *Cistus monspeliensis, Myrtus communis, Erica multiflora, Pistacia lentiscus* and *Quercus ilex*. The first three species occurred in all stands.

In each stand, 15 individuals of each species (when available) were randomly selected for enumeration (in a few stands, only 10-14 individuals were available for enumeration). The following plant dimension and gross architecture variables were recorded: total height, maximum and minimum crown diameters, stem diameter, number of reiterated stems, and first-leaf height. Total height was defined as the maximum vertical distance from the ground to the highest point of the shrub. Maximum and minimum crown diameters were used to determine mean crown diameter. Basal stem diameter was measured with vernier callipers at ground level. When multiple stems were found, the largest one was measured. First-leaf height was measured as the distance between the ground and the first leaf insertion. The ratio of height to mean crown diameter (H/C) was determined to characterize growth patterns: values >1 and <1 indicate 'vertical' or 'horizontal' growth forms respectively.

In order to detect species architectural trends among stands, the matrix of enumerated individuals (292 individuals x 5 characters) was analyzed using principal component analysis (PCA) based on a correlation matrix. PCA allows the examination of several traits simultaneously and thus provides a useful approximation of the overall architectural variation. The analysis was undertaken using the SYNTAX 5.0 package (Podani 1993).

Results

In the ordination of all individuals based on architectural variables, the first component accounted for 46.64% of the total variation, and the second 31.41%. Characters reflecting plant 'dimension' (total height, stem diameter, first leaf height) were positively weighted on the first PCA axis. Conversely, the number of stems and the H/C ratio were most strongly weighted at opposite ends of the second axis (Fig. 1a). Thus, the first axis reflects increasing plant size (total biomass), while the second axis is related to above-ground spatial arrangement (that is, the architectural arrangement of biomass in space).

Individual species are depicted separately in Figs. 1 b-f. *Cistus monspeliensis* shows a high H/C ratio mainly in stands 1 and 2, and a low number of stems in all situations. A different pattern is shown by *Myrtus communis* and *Erica multiflora*. These species have a relatively low H/C ratio and a tendency toward basal shooting in the first two stands and at Zannone (stand 3), whereas in stands 4 and 5 the variability among individuals increases along the second axis. In stands 4 and 5, the smaller individuals (lower scores on the first axis) tend to have a more vertical spatial arrangement (higher H/C ratio), whereas larger individuals show a relatively more horizontal spatial arrangement. *Pistacia lentiscus* shows a similar pattern regarding the second PCA axis, but with a noticeable increment of scores along the first axis. This reflects the relatively higher growth capacity of this species in closed-canopy stands. *Quercus ilex* showed the maximum dispersion along the first axis, and the highest values of plant dimension.

Discussion

Distinct architectural patterns for the five species are apparent. In both open and close-canopy stands, *Cistus monspeliensis* consists of one or a few stems showing a mainly vertical spatial arrangement ("stable" architectural type). This species demonstrates a characteristic "fire-behaviour": extensive seed germination following a fire results in the production of mostly even-aged stands (Trabaud and Lepart 1980). *C. monspeliensis* is an efficient colonizer of canopy-gaps, but a weak competitor in closed forests (Mazzoleni and Pizzolongo 1990).

In the first two stands (*Ampelodesmos* grasslands) and in the open shrublands of Zannone (stand 3), *Pistacia lentiscus, Erica multiflora* and *Myrtus communis* were multistemmed and had a mainly horizontal spatial arrangement (the result of lateral spreading of the crown). In closed shrublands (stands 4 and 5), variability along the second ordination axis increased, indicating greater variation in spatial arrangement

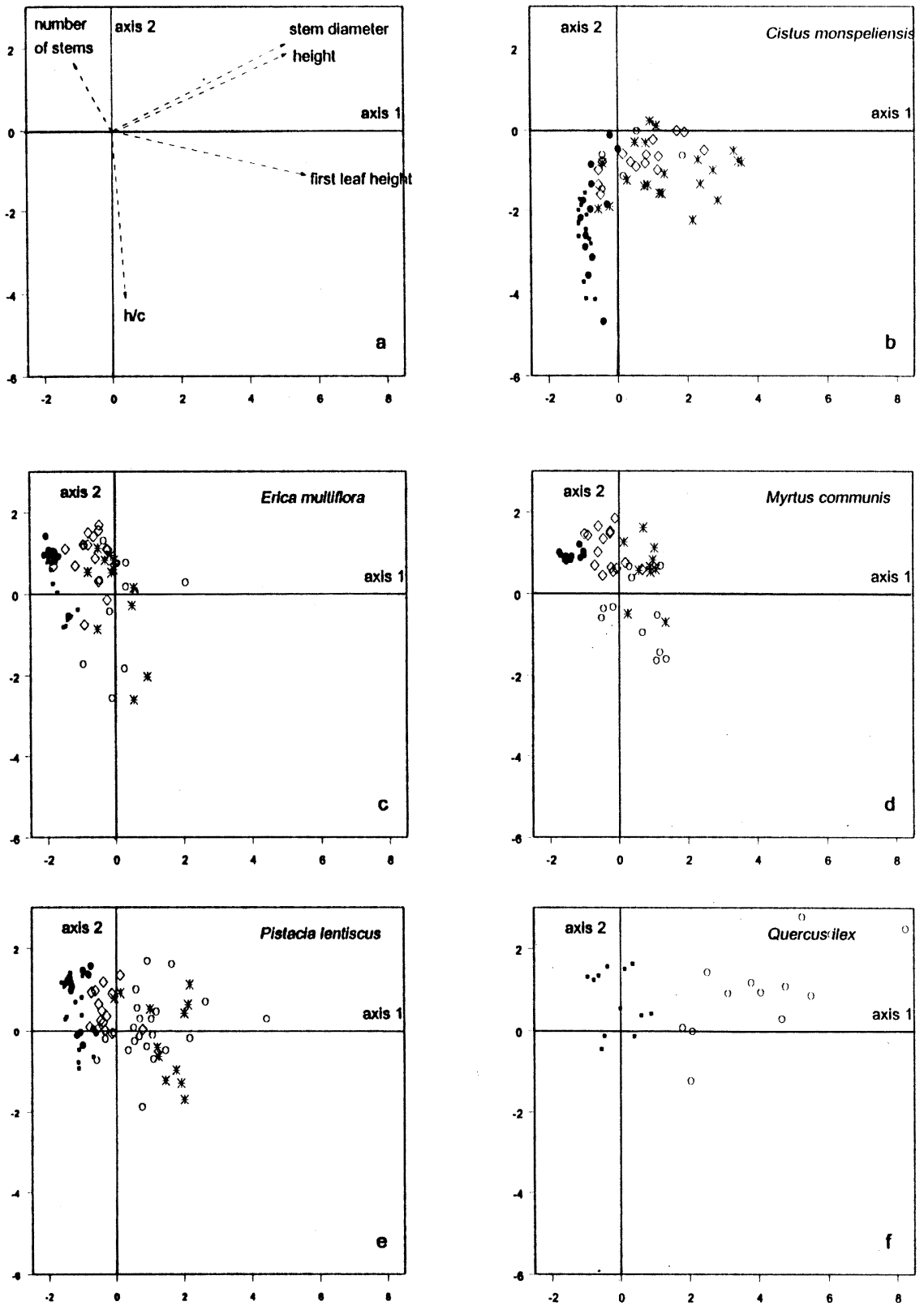

Figure 1. a: Principal Component Analysis plot of characters; b,c,d,e,f: Principal Component Analysis plot of individuals in the five different stands, Circeo National Park. All figures derived from the same analysis are shown separately for clarity. Stand 1 = solid squares; Stand 2 = solid circles; Stand 3 = rhomboids; Stand 4 = circles; Stand 5 = asterisks.

(i.e. both horizontal and vertical forms). Unlike *Cistus*, these species form root-collar sprouts and so demonstrate a more "plastic" architectural type. This strategy favours horizontal space exploration in open sites, but also provides a competitive advantage (for light and space) in closed-canopy stands. Species growing in different light environment (ranging from open *Cistus*-dominated communities to closed *Quercus ilex* forests) could be expected to show higher plasticity in architectural traits. By altering their spatial arrangement under specific conditions, individuals are able to assimilate and utilize resources more efficiently (Givnish 1986). This is particularly evident in *Pistacia lentiscus*, which showed greater variability in the ordination space than either *Erica* or *Myrtus*. In woody species, height gain precludes over-growth by competitors and allows a species to survive (though not necessarily dominate) in late-successional closed forests. Above-ground dominance requires the development of a dense crown that effectively exploits space by outshading other plants (Givnish 1986). Although *Quercus ilex* was not found in all stands, it was the tallest species among those considered in this study. This growth capacity could allow it to be a more efficient competitor in closed-canopy stands.

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