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Research Article

Classification of some plant species according to Grime's strategies in a *Quercus cerris* L. var. *cerris* woodland in Samsun, northern Turkey

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Abstract: This study was carried out on 2 permanent plots of *Quercus cerris* L. var. *cerris* woodland in the Kurupelit region of Samsun, northern Turkey. Grime's CSR strategies were determined for 85 plant species from the 2 study plots (61 and 50 species from plot 1 and plot 2, respectively) according to the method that was applied. Most of the plant species in both plots had secondary and tertiary strategies, and this suggests that plants were exposed to more than one pressure factor. In both plots, CR (competitor-ruderal) was the most common strategy.

Key words: Competition, Grime's CSR strategies, plant traits, *Quercus cerris*, stress, disturbance

Türkiye'nin kuzeyinde (Samsun) bir *Quercus cerris* L. var. *cerris* ormanında bulunan bazı bitkilerin Grime'in stratejilerine göre sınıflandırılması

Özet: Bu çalışma Samsun'un Kurupelit bölgesinde bulunan bir *Quercus cerris* L. var. *cerris* ormanından alınan iki devamlı örnek parselde yürütülmüştür. Örnek parsellerden toplanan bitkilerin Grime'in CSR stratejileri belirlenmiştir. Araştırma kapsamında 1. örnek parselden 61, 2. örnek parselden 50, toplamda 85 türün CSR stratejisi belirlenmiştir. Araştıma sonuçlarına göre, her iki alanda da bitkilerin büyük bir kısmı ikincil ve üçüncül strateji göstermektedir. Bu da bitkilerin birden fazla baskıya maruz kaldığını ifade etmektedir. Her iki örnek parselde de en çok bulunan bitki stratejisi CR'dir (competitor-ruderal).

Anahtar sözcükler: Bitki özellikleri, Grime'in CSR stratejileri, *Quercus cerris*, rekabet, stres, tahribat

Introduction

Because of habitat diversity and environmental factors in different combinations, there are various functional modifications in plants. Survival and growth potentials of plants are determined by their adaptation and competitive ability. "Understanding the distribution of plant species across environmental gradients requires bringing theories together regarding the construction of plants, as well as their interactions with the environment, and the assembly of communities" (Craine, 2005).

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Some "eco-ethological" classifications of plants have been proposed, the greatest ones being those based on biological types, ecological groups, method of diaspore dispersal, morphological types, adaptative strategies, and demographic strategies. These classifications are sometimes labelled as plant-ecology-strategy schemes, since they have as their goal predicting patterns in species distribution rather than predicting the effects of diversity on the provision or maintenance of ecosystem function (Decocq & Hermy, 2008). A plant strategy may be defined as a grouping of similar or analogous genetic characteristics recurring widely among species or populations, which leads to similarities in ecology (Grime, 1977; Garbey et al., 2004). The use of functional traits has repeatedly been advocated to understand and predict the distribution and abundance of plant species in natural habitats (Grime et al., 1988; Keddy, 1992; Westoby, 1998; Weiher et al., 1999; Lavergne et al., 2003).

Plant characteristics, such as life form and strategy, have been used to explain succession (Bazzaz, 1987; Grime, 1987; Grubb, 1987; Tilman, 1990; Rydin & Borgegara, 1991). Grime's model (Grime, 1977, 1979, 1987; Grime et al., 1988) tries to explain the course of succession in terms of the CSR strategies (C: competitive, S: stress tolerant, R: ruderal) linked to different stages of succession (Ecke & Rydin, 2000).

The triangular model (Grime, 1974) describes the various equilibria that are possible between competition, stress, and disturbance and recognizes 4 main types of secondary strategies that appear to have evolved in relation to particular equilibria (Grime, 1977). In addition to the 3 primary and 4 secondary strategies, Grime et al. (1988) distinguished 12 additional intermediate strategies.

Grime et al. (1988) applied this system to 502 common British species. Several studies have also confirmed the central assumption and predictions of the CSR model or modified versions (Kautsky, 1988), including the decreasing stress and disturbance (Wilson & Keddy, 1986; Campbell & Grime, 1992; Turkington et al., 1993; White et al., 1997). Moreover, predicted species traits in particular habitat types have also been confirmed (Kautsky, 1988; Rørslett, 1989; Murphy et al., 1990; Campbell & Grime, 1992; White et al., 1997; Greulich & Bornette, 1999).

On the other hand, several studies, such as those by Craine (2005) and Westoby (1998), recommended Grime's CSR system by comparing Grime's strategies with other suggested life strategies. According to Craine (2005), Grime does little to address whether his theories can accommodate plants that can tolerate the stress of shade and eventually overtake faster growing, less shade-tolerant species as better competitors for light. Craine (2005) stated that in CSR theory, disturbance is assumed not to be important in the event of a low nutrient supply, yet, at the same time, Grime asserted that disturbance is important in removing species from these same habitats (Grime, 2007). Tilman (2007) asserted that consumer-resource mechanisms are a building block for theories that incorporate other trade-offs faced by plants, such as those between competitive ability and dispersal.

Turkey has the richest flora in the temperate zone, with approximately 10,000 vascular plants. Along with its rich flora, it also has a wide diversity of habitats (Kandemir, 2009). The aim of our study was to determine the CSR strategies of a number of plants in 2 permanent plots with distinct disturbance levels in a *Quercus cerris* L. var. *cerris* woodland in northern Turkey, to get valuable information about the plant community structure of the area.

Materials and methods

This study was carried out in a *Quercus cerris* L. var. *cerris* forest (Turkey oak) in the Kurupelit region of Samsun, northern Turkey (41°21.982'N, 36°11.152'E). In the study area, the annual mean temperature is 14.2 °C, the mean maximum temperature is 27.1 °C in August, the mean minimum temperature is 3.5 °C in February, and the total annual precipitation is 668.9 mm. The climate is Mediterranean, with a dry period of 2 months (July-August). The mean altitude of the study area from sea level is 200 m. The soil type of the study area is grey-brown and podzolic. Because of the precipitation due to rainfall, the colours of the upper horizon (A) and the deep layers of these soils are grey and brown, respectively (Özen & Kılınç, 1988). The study area is a woodland about 20 ha in size. *Quercus petraea* (Mattuschka) Liebl. subsp. *iberica* (Steven ex M.Bieb.) Krassiln., *Quercus cerris* L. var. *cerris* L., and *Carpinus orientalis* Mill. are the dominant species at the tree layer, and *Crataegus monogyna* Jacq. subsp. *monogyna* Jacq., *Ligustrum vulgare* L., *Smilax exelsa* L., and *Clematis vitalba* L. are the dominant species at the shrub layer. Additionally, there are some Mediterranean elements, such as *Phillyrea latifolia* L., *Ruscus aculeatus* L. var. *aculeatus* L., and *Cistus creticus* L. In the herbaceous layer, *Lathyrus laxiflorus* (Desf.) Kuntze subsp. *laxiflorus* Desf., *Asperula arvensis* L., *Cyclamen coum* Mill. var. *coum* Mill., *Geranium asphodeloides* Burm. Fil. subsp. *asphodeloides* Burm. Fil., *Primula vulgaris* Huds. subsp. *sibthorpii* (Hoffmanns.) W.W.Sm. & Forrest, *Lithospermum purpurocaeruleum* L., and *Viola odorata* L. are the important species (Özen & Kılınç, 1988).

In the study area, 2 permanent plots (60 × 20 m) with different disturbance levels were selected. The first plot was highly disturbed by the lumbering of some of the trees and the harvesting of all plants at the herb and shrub layers of the woodland 2 years ago for regeneration, timber production, and management. The second was comparatively less disturbed, with only the harvesting of some of the herbs and shrubs about 5-7 years ago for regeneration. The less disturbed plot had 65% canopy cover, while the highly disturbed plot had 45% canopy cover.

Field surveys were carried out March-August 2005 in the plant growing season, since the CSR system (Grime, 1974, 1977, 1979) involves the established (or adult) phase of plant life histories (Hodgson et al., 1999). During the field studies, phenological observations were also recorded. The study area was visited weekly and certain numbers of plant individuals were taken from both plots. Taxonomic nomenclature followed that of Davis (1965-1985) and Davis et al. (1988), and Latin names were updated following Brummitt and Powell (1992). Plant specimens were deposited in the Ondokuz Mayıs University Herbarium (OMUB). Predictor variables were then established to determine the CSR strategies of each species according to Hodgson et al. (1999) (Table 1).

Table 1. Definitions of predictor variables required for CSR allocation of plant species (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 largest fully hydrated and fully expanded leaves (%)		
Flowering period	Normal 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, before leaves in spring
Lateral spread	Six-point classification	1	Plant short-lived
	(in graminoids)	2	Loosely tufted ramets radiating about a single axis, no thickened root-stock
	(in nongraminoids)	2	Compactly tufted about a single axis, no thickened root-stock
	(in graminoids)	3	Compactly tufted ramets appressed at base
	(in nongraminoids)	3	Compactly tufted about a single axis, thickened root-stock present
		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 and fully expanded leaves (mg), plus 3		
Specific leaf area	Mean of area/dry weight quotient in the largest fully hydrated and fully expanded leaves (mm^2/mg)		

Canopy heights of plants were measured and lateral spreads were determined in the field. The canopy height was measured with a meter from the ground level to the maximum point of the plant canopy for shrubs and herbs, and with a Suunto mark clinometer for trees. Lateral spreads of each plant species were determined according to the 6-point classification of Hodgson et al. (1999).

Additionally, the flowering start and flowering periods of plants were determined by weekly phenological observations in the study plots. "Flowering period" means the duration of flowering in months, and "flowering start" indicates when the first flowering bloom was observed for each plant species. The flowering period variable is only required for nongraminoids (Hodgson et al., 1999).

For calculation of specific leaf area, leaf dry matter content, and leaf dry weight, the largest and fully expanded fresh leaves of adult individuals of each plant species were collected from the plots. Multitudinous leaf samples of each plant species were taken for repetition.

The largest and fully expanded leaves of adult individuals of each plant species were digested in the laboratory. Any petioles were removed and, for compound leaves, the individual leaflets were removed to include only laminar material. For leaves with massive midrib support structure, such as those of *Petasites hybridus* L., a plot of lamina was excised from a leaf (Wilson et al., 1999). Humid weights of leaves were established by using Kern PLS 360-3 scales. Leaves were then put into a drying oven at 60 °C for about 48 h until reaching constant weight. When the weights of the leaf samples became stable, they were weighed again, and their dry weights were established. The percentage of the dry matter content of leaves was calculated by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Mean dry weight (mg)}}{\text{Mean humid weight (mg)}} \times 100 \quad \text{Eq. 1.}$$

For specific leaf area (SLA) calculations of plant species, the largest fully expanded and fully hydrated leaves of adult individuals of each plant species were used. Leaf area measurement software produced by the University of Sheffield was used to determine mean leaf areas of plants. SLA values of each species were calculated by using the following equation, as mm^2/mg:

$$\text{SLA} = \frac{\text{Mean leaf area (mm}^2\text{)}}{\text{Mean leaf dry weight (mg)}} \quad \text{Eq. 2.}$$

For allocating plant species to CSR strategies, 2 customised spreadsheets (for grasses and for nongrasses), developed to perform all of the necessary calculations by Hodgson et al. (1999) (written in Microsoft Excel for Windows^{TM}, Version 5.0), were used. After 7 predictor variables (for graminoids, 6 predictor variables) were established for each species, these variables were put into spreadsheets, and then the CSR strategies of the plant species were determined by automatic data transformation. The CSR strategy of a species is determined in 5 steps. These steps are data assembly, regression, transformation, adjustment, and identification of CSR type. In the spreadsheets, there are special lines for transforming data. For detailed explanations (working procedure) of the spreadsheets, see Hodgson et al. (1999).

In this study, Grime's CSR strategies (1979, 2002) were determined for 61 plant species collected from a highly disturbed plot and a less disturbed plot, according to the method applied by Hodgson et al. (1999).

However, we omitted some of the plant species from both plots because of their unsuitability for CSR allocation as reported by Hodgson et al. (1999). For example, *Ruscus aculeatus* L. was excluded because of its stem metamorphosis. The stem is the major photosynthetic organ for *Ruscus aculeatus*, but predictor variables related to leaves (e.g. SLA, dry matter content, leaf dry weight) cannot be determined correctly.

Results

In the present study, 61 plant species from the highly disturbed plot (plot 1) and 50 plant species from the less disturbed plot (plot 2), a total of 85 plant species from both plots, were collected, and their CSR strategies were determined. Twenty-seven plant species were common to both plots. Most of the plant species collected from both plots were nongraminoid annual, biennial, or perennial herbs. There were also several trees, shrubs, and graminoids.

From the highly disturbed plot, the 61 plant species collected were allocated into 10 different functional types (CR, C/CR, C/SC, SC, C, R/CR, SC/CSR, S/SC, C/CSR, and S/CSR) (Table 2). The

Table 2. Plant species and their CSR allocations, collected from plot 1 and plot 2, and comparison of plants' CSR strategies to Grime's results.

Taxa	Plot 1	Plot 2	Grime et al.	Taxa	Plot 1	Plot 2	Grime et al.
Lathyrus laxiflorus	C/SC	C/SC		*Asperula arvensis*	CR	CR	
Helleborus orientalis	C/SC	C/SC		*Campanula glomerata*	CR		S
Geranium asphodeloides	CR	C/CR		*Astrodaucus orientalis*	C/CR		
Ornithogalum sigmoideum	CR	CR		*Viola odorata*	C/CR	C/CR	CSR
Ajuga reptans	C/CR	CR	CSR	*Hypericum perforatum*	CR	CR/CSR	CR/CSR
Ranunculus constantinopolitanus	CR	CR		*Plantago lanceolata*	CR		CSR
Lithospermum purpurocaeruleum	C/SC			*Trifolium physodes*	CR		
Geranium sanguineum	CR	CR	S/CSR	*Trifolium arvense*	CR		SR
Viola siehana	CR	CR		*Anthemis cretica* subsp. *cretica*	CR		
Myosotis sicula	R/CR	R/CR		*Holcus lanatus*	C/CR		CSR
Asperula orientalis	CR			*Origanum vulgare*	CR		
Stachys annua subsp. *annua*	R/CR			*Parentucellia latifolia* subsp. *latifolia*	S/SC		
Scrophularia scopolii var. *scopolii*	CR			*Medicago x varia*	C		
Filipendula vulgaris	C/SC		S	*Salvia forskahlei*	C/CR		
Hymenocarpus circinnatus	R/CR			*Chaerophylum byzantinum*	CR		
Myosotis ramosissima	R/CR		SR	*Circium pseudopersonata* subsp. *pseudopersonata*	C/CR		
Ligustrum vulgare	C/CR		SC	*Rosa canina*	C	C	SC
Vicia lutea	C/CR			*Tragopogon aureus*	CR		
Festuca heterophylla	S/CSR	SC/CSR		*Crataegus monogyna* subsp. *monogyna*	C/SC	C/SC	SC
Brachypodium sylvaticum	SC/CSR	SC/CSR	S/SC	*Setaria glauca*	C/CSR		
Carex divulsa subsp. *divulsa*	S/SC			*Epilobium hirsutum*	CR	CR	C
Dactylis glomerata	C/CSR	C/CSR		*Coronilla varia*	C		
Silene dichotoma	CR			*Hedera helix*	C/CSR	C/CSR	SC
Euphorbia stricta	CR	CR		*Acer campestre*	C/SC		SC
Prunella vulgaris	CR	CR	CSR	*Fraxinus oxycarpa*	C/SC		
Trifolium subterraneum	SC			*Quercus petrea* subsp. *iberica*	C/SC	C/SC	
Lapsana communis subsp. *communis*	CR	CR	R/CR	*Carpinus orientalis*	SC	SC	
Vicia cracca	C/CR		C/CSR	*Ulmus glabra*	C		
Galium aparine	CR	CR		*Cornus sanguinea*	C		
Clematis vitalba	CR		SC	*Quercus cerris* var. *cerris*	C/SC	C/SC	SC
Primula vulgaris	CR	CR	S/CSR	*Smilax excelsa*	C/CR		
Rubus discolor		C		*Cyclamen coum*		CR	
Holosteum umbellatum		CR		*Sedum pallidum* var. *bithynicum*		R/CR	
Veronica pectinata var. *pectinata*		SC		*Myosotis sparsiflora*		R/CR	
Lathyrus inconspicuus		CR		*Ranunculus ficaria* subsp. *ficariiformis*		SC	
Galium odoratum		CR	SC/CSR	*Geum urbanum*		SC	
Stellaria holostea		CR	CSR	*Trifolium fragiferum*		C/CR	CR/CSR
Oenanthe pimpinelloides		CR		*Verbascum blattaria*		CR	
Cynosurus cristatus		C/CSR		*Carduus pycnocephalus*		CR	
Sonchus oleraceus		C/CR		*Phleum exaratum* subsp. *exaratum*		C/CSR	
Phillyrea latifolia		C/SC		*Vicia hirsuta*		CR	R/CSR
Ranunculus sceleratus		CR		*Myosotis sparsiflora*		R/CR	
Anagallis arvensis		R/CR	R/SR				

most abundant functional type was CR, the competitor-ruderals (40%). SC/CSR (2%) and S/CSR (2%) were the rarest functional types (Figure 1). Among trees, only *Carpinus orientalis* was SC; the others were C/SC. *Clematis vitalba*, *Smilax excelsa*, and *Hedera helix*, as climbers, were respectively CR, C/CR, and C/CSR. Among other shrubs, *Crataegus monogyna* subsp. *monogyna* was C/SC, *Ligustrum vulgare* was C/CR, and *Cornus sanguinea*, *Ulnus glabra*, and *Rosa canina* were C. Most of the nongraminoids were CR, C/SC, or C/CR. However, graminoids were generally SC/CSR, S/CSR, C/CSR, or S/SC. Competition was the major pressure factor, but disturbance and stress were also effective on the plant species in the highly disturbed plot.

From the less disturbed plot, the 50 plant species collected were allocated into 9 different functional types (Table 2). Most of the plant species collected from the less disturbed plot were allocated into the CR, competitive-ruderal, type (46%) (Table 2), and the others were allocated in turn to the C/SC, C/CR, SC, R/CR, C/CSR, C, SC/CSR, and RC/CSR types (Figure 1). CR/CSR (2%) was the rarest functional type in the less disturbed plot. Of trees, *Quercus cerris* var. *cerris* and *Quercus petraea* subsp. *iberica* were C/SC, and *Carpinus orientalis* was SC. Among shrubs, *Crataegus monogyna* subsp. *monogyna* and *Phillyrea latifolia* were C/SC, *Rosa canina* and *Rubus discolor* were C, and *Hedera helix*, as a climber, was C/CSR. While the CSR strategies of most graminoids in this plot were the SC/CSR or C/CSR types, those of nongraminoid herbs were the CR, SC, C/SC, or C/CR

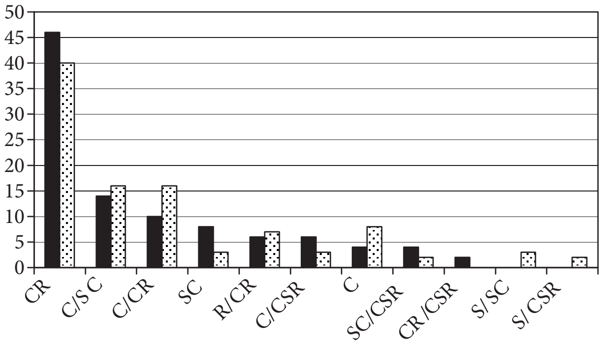

Figure 1. Comparative representation of the functional types of the plant species between plot 1 and plot 2.

types. Similar to the highly disturbed plot, the major pressure factor was competition, but disturbance and stress were also effective. The CSR strategies of annual herbs were mostly CR, R/CR, or C/CR, and those of perennial herbs were SC, S/SC, CR, C/SC, or C/CR, in both plots.

Most of the plant species in the highly disturbed plot were competitors and ruderals. However, in the less disturbed plot, most of the plant species were also stress-tolerators in addition to competitors and ruderals. Although the S/SC and S/CSR functional types were widely found in the highly disturbed plot, no S/SC or S/CSR functional types were observed in the less disturbed plot. Meanwhile, the CR/CSR functional type was found in the less disturbed plot, but no species from that category were recorded in the highly disturbed plot.

Discussion

According to the results of the present study, the number of plant species in plot 1 was much greater than in plot 2. The vegetation cover of plot 1 may be sparse in comparison to plot 2 because of lumbering. For this reason, the light supply per plant species may be different between the 2 plots (lower in plot 2, higher in plot 1). Thus, the plant species in plot 1 may utilise the light and temperature more than those in plot 2. High light and temperature allows more plant species to grow, and this could be a reason for the differences between the 2 plots. Again, succession levels of the plots may be different. In early phases of succession, fast-growing ruderal species are dominant, but in progressive phases of succession, because of competition, competitors are dominant (Smith et al., 2010). Therefore, plot 1 is rich in ruderal species.

In both plots, most of the plant species were competitor-ruderals (CR), but there were more of these in plot 2 than in plot 1. This functional type occurred under 2 selective pressures, competition and disturbance. Grime (1977) explained competitive ruderals (CR) as adapted to circumstances in which there is a low impact of stress and competition is restricted to a moderate intensity by disturbance (e.g. fertile cattle pastures and meadows). Competitive species, i.e. species with dominant competitive ability

(C s.l. strategy: C+CR+CS), present high vegetative development, ecological plasticity, and occasionally some allelopathic potential (Vidal et al., 2000; Çakır et al., 2010). The results of our study showed that competition and disturbance were the most effective pressure factors in the study area. Competition was defined as the "tendency of neighboring plants to utilize the same quantum of light, ion of a mineral nutrient, molecule of water, or volume of space" and disturbance as "consist[ing] of the mechanisms which limit the plant biomass by causing its destruction" by Grime (1977). Competitor species have some selective advantages, such as rapid growth, and can be dominant in the vegetation. Ruderal species are characterised by rapid growth, high seed production relative to biomass, small stature with limited lateral spread, and high frequency of flowering. CR species have a combination of competitor and ruderal plant traits.

Quercus cerris var. *cerris* was the dominant species in the study area and was allocated to the C/SC functional type in both plots. In CSR classifications, most of the trees were allocated into the SC group (Figure 2; Grime, 1977). Similarly, all trees were allocated to SC and C/SC in the present study. Grime (1977) defined SC as adapted to undisturbed conditions experiencing moderate intensities of stress (e.g. open forest or scrub on infertile soils).

Functional types of plant species showed that more than one pressure was effective in the study area. Competition and disturbance seemed to be major pressure factors, even if there were stress tolerators. We may consider that not all of the species have similar ecological requirements for growth. Consequently, an ecological factor may be limiting and stress-inducing for one species, but not for others. This may be the reason for the coexistence of different functional types in the same area.

It is thought that Grime's CSR strategy theory may be disqualified in some cases. As Hodgson et al. (1999) reported, several problems exist within 4 particular groups of species: (1) Those for which the stem is the major photosynthetic organ (e.g. *Juncus effusus*). A similar situation was found in the present study for the individuals of *Ruscus aculeatus* in both plots. Since the stem of *R. aculeatus* is the major photosynthetic organ (stem metamorphosis), the predictor variables related to leaves, such as SLA, leaf dry matter content, and leaf dry weight, could not be determined correctly. For this reason, *R. aculeatus* was excluded from analysis in this study. (2) Succulents

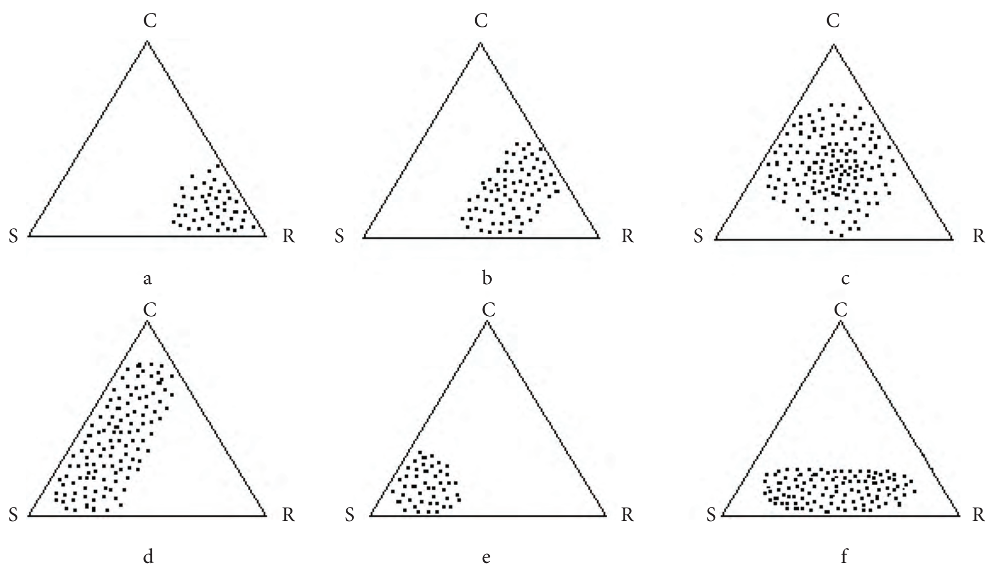

Figure 2. Diagram describing the range of strategies encompassed by a- annual herbs, b- biennial herbs, c- perennial herbs and ferns, d- trees and shrubs, e- lichens, f- bryophytes. From Grime (1977).

(*Sedum acre*), which, using the present predictor regressions, are classified as ruderals because of the very high water content of their thick, fleshy leaves. Similarly, in our study, *Sedum pallidum* in plot 2 was classified as R/CR. More detailed studies in the future may solve the problems of classification of succulents according to the CSR system. (3) Low-growing species of very shaded habitats with thin, watery leaves (e.g. *Oxalis acetosella*) and (4) halophytes, for which a substantial correction for ash content is needed when calculating leaf attributes.

We compared our results with internally stored tables covering approximately 1000 European species. The tool looks up the CSR identity (functional type) of each of the species presented (Hunt et al., 2004). Although some of these plants occurred in our study area, there were differences in the plant strategies between the final classifications of Grime's studies and ours (Table 2). These differences may be explained by several factors, including attributes of the study area (location, altitude, climate, nutrient supply, and soil structure), structure and composition of vegetation, and intra- and interspecific interactions of the species found in the study area. The successional stage of the studied plots might also have affected the final outcomes of the allocations, since CSR strategies may be diverse in different successional phases and the CSR system (Grime, 1974, 1977, 1979) involves the established (or adult) phase of plant life histories (Hodgson et al., 1999). Therefore, further studies that include the factors stated above in their experimental designs are needed to show which factors affect the allocation of plant species into different strategies.

Although the CSR classification, in its current form, is designed only to investigate herbaceous plants (but see Hodgson et al. [1999] for a discussion on possible future developments), it can also allow a functional interpretation of real vegetation in which plant communities are dominated by herbaceous species (Caccianiga et al., 2006). Moreover, the balance between competition, stress, and disturbance is a major determinant of vegetation structure and species composition at any site (McIvor & McIntyre, 1997). In this context, our classification of 85 plant species into CSR strategies (57 of them for the first time) in a woodland in northern Turkey might be useful for further studies on plant community ecology and conservation efforts.

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