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Protection from grazing: A way to restore vegetation in semiarid grasslands in Northern Greece

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Abstract. Long term studies in the Mediterranean region have shown no clear distinction between the benefits of conservation and the negative effects of heavy grazing as concerns ecosystem stability, expressed through the species diversity. Grazing animals represent a key factor to avoid the activation of successional processes, which causes the replacement of herbaceous communities with shrub communities. Thus, it is of interest to investigate the effects of protection from grazing on biodiversity at different successional stages. The study was conducted in two grasslands located near Thessaloniki, in a semiarid area of northern Greece. The first grassland was at an early stage of succession (ESS) while the second one was at a late stage of succession (LSS). Changes in ground cover, species composition, species richness and relative abundance were studied in each of two grasslands that were protected from grazing for 7 years (measurements were taken at years 5, 6 and 7). The results showed an increase of the percentage of perennial grasses and legumes in the LSS, while the proportion of annual legumes and forbs was higher in the ESS. Species biodiversity tended to increase as the protection period from grazing increased. Moreover, after seven years of protection from grazing, habitat stability was higher in LSS than in ESS and consequently the influence of grazing was higher on ESS. Our results provide an example of grassland recovery under natural conditions in a low elevation semiarid area, and they suggest that short-term protection from grazing may provide an effective natural management practice to restore vegetation.

Keywords. Successional process – Biodiversity – Overgrazing.

La mise en repos: Une voie de restauration de la végétation des parcours du nord de la Grèce

Résumé. *Les études à long terme dans la région méditerranéenne n'ont pas montré de différence nette entre les avantages de la conservation et les effets négatifs du pâturage intensif qui affectent la stabilité des écosystèmes, exprimée à travers la diversité des espèces. Les animaux pâturant représentent le facteur clé permettant d'éviter l'activation des processus de la succession, qui cause le remplacement de la végétation herbacée par la communauté arbustive. Il est donc important d'étudier les effets de la mise en défens sur la biodiversité à différents stades de succession. Cette étude a été conduite dans deux parcours à proximité de Thessaloniki, dans la zone semi-aride du nord de la Grèce. Le premier parcours était en début de stade de succession (ESS) alors que le second était au stade fin de succession (LSS). La variation du taux de recouvrement, de la composition floristique, de la diversité des espèces et l'abondance relative ont été étudiées au niveau de chaque type de parcours mis en repos pendant 7 ans (les mesures ont été faites pendant les années 5, 6 et 7). Les résultats ont montré une augmentation du pourcentage des graminées pérennes et des légumineuses avec le traitement LSS, alors que la proportion des légumineuses annuelles était plus élevée avec le traitement ESS. La biodiversité des espèces avait tendance à augmenter lorsque la durée de mise en repos augmentait. En outre, après 7 années de mise en repos, la stabilité de l'habitat a été plus élevée avec ESS. Nos résultats donnent un exemple de réhabilitation d'un parcours en conditions naturelles dans une zone semi-aride à basse élévation. Ces résultats suggèrent aussi que la mise en repos de courte durée peut représenter une technique efficace de gestion naturelle permettant la restauration de la végétation.*

Mots-clés. *Processus de succession – Biodiversité – Surpâturage.*

I – Introduction

Mediterranean grasslands are rich in species that contribute to herbage composition and production. The characteristics of grassland communities (species composition, primary production) are strongly oscillating in space and time according to plant species composition, successional stages, herbivore pressure, human activities as well as climatic conditions (Pineda *et al*., 1981; Ortega and Fernández Ales, 1988; Fernández Ales *et al*., 1993; Espigares and Peco, 1995; Gatti *et al.*, 2005).

Uncontrolled and heavy livestock grazing in several Mediterranean areas, particularly in arid and semi-arid ones, has been practiced for several years resulting in soil and vegetation changes. Heavy grazing generally regarded as a dominant factor for grassland degradation (Le Houérou, 1981; Smith, 1988; Zhang, 1998). On the other hand, long-term studies in the Mediterranean region have shown no clear distinction between the benefits of conservation and the negative effects of heavy grazing as concerns ecosystems stability, expressed through the species diversity (Noy-Meir *et al.*, 1989; Tsiouvaras *et al*., 1993). Grazing animals represent a key factor to avoid the activation of the successional processes, which causes the replacement of herbaceous communities with shrub communities (Rook *et al*., 2004; Gatti *et al.*, 2005).

The effects of cessation of grazing vary with vegetation composition, grazing history, soil conditions and precipitation (Smith and Rushton, 1994). The time needed for degraded overgrazed rangelands to recover and reach an excellent condition through natural succession differs depending on the climate soil and vegetation type (Bai *et al*., 2001). The low annual precipitation in the Mediterranean region combined with natural hazards of environmental degradation make an imperative need to detect plants or successional stages which discourage the degradation and ensure environmental stability and high productivity (Bolle, 1995). The present study aimed to investigate the effects of protection from grazing on biodiversity in grasslands at different successional stages.

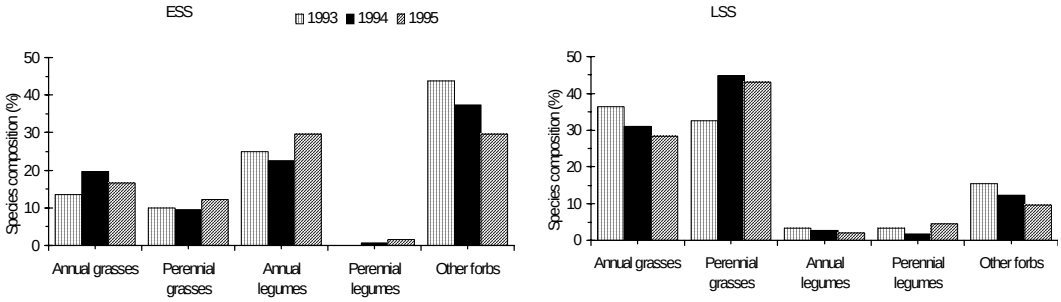
II – Materials and methods

The study was conducted during 1993, 1994 and 1995 at low elevation grasslands in Northern Greece. The experimental area was located close to Melissohori village (lat. 40°58N, log. 28°01E), 25 km north-east of Thessaloniki, at an altitude of 170 m a.s.l. The climate of this area is classified as Mediterranean semiarid with average monthly temperatures ranging from 4.9 to 25.6℃. During the experimental period the annual average precipitation was 476.5 mm. Data were collected from two fenced (10 x 20 m) neighbouring areas with the same orientation (north-east) and slope 10-12%. At the onset of the experiment the first was an abandoned crop field (early stage of succession, ESS) while the second one was a permanent grassland (late stage of succession, LSS) being grazed for at least 20 years before protection. The two areas had been excluded from grazing since 1989 (four years before the beginning of the study). Prior fencing both areas was uncontrolled grazed by sheep and goats.

In both ESS and LSS grasslands, ground cover and species composition were recorded each year at the end of May with the line and point method (Cook and Stubbendieck, 1986). Seventeen stable transect lines of 10 m long were used in each habitat. Species richness was measured from two 0.5 x 0.5 m^2 quadrats in every transect line. From these measurements the ecological indices of Simpson and Shannon-Wiener were calculated (Hayek and Buzas, 1997). Biodiversity was determined at the species level by the number of species or "species richness" and by the relative abundance. Species richness was estimated for five groups of species: (i) annual grasses; (ii) perennial grasses; (iii) annual legumes; (iv) perennial legumes; and (v) broad leaved forbs. In each grassland the frequency of appearance was estimated and classified as constant (>50%), frequent (25-50%) and random (<25%). Data were statistically analysed and the LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

Figure 1 gives the participation of the various plant groups in vegetation composition of the two grasslands from year 5 to year 7 after protection. In ESS the annual species, especially forbs and legumes, participate with significantly higher percentage compared to other plant groups. On the other hand, in LSS we observed significantly higher participation of annual and perennial grasses. The contribution of the various plant groups was significantly different between the two grasslands, and it was changing among the years of the study.



LSD for ESS = 11.12, LSD for LSS = 12.01.

Fig. 1. Average composition (%) of group of species in: (i) early succession grassland (ESS) and (ii) late succession grassland (LSS) during the experimental period 1993-1995.

During the experimental period, as the protection time was increasing, in ESS we noticed a gradual decrease in the percentage of participation of forbs in relation to the other plant groups. Respectively, in LSS we observed an increase of perennial grasses in relation to other groups that showed a decreasing tendency. Increase in perennials, as a response to increasing time of protection is important, because perennials have more constant populations and communities as well than annuals. Therefore community structure improved as the time protected from grazing increased (Zhang *et al.*, 2005).

In the Mediterranean regions annual species coexist with perennial ones under the pressure of disturbance, human activities and summer drought (Pignati, 1978; Naveh and Whittaker, 1979; Fernández Ales *et al*., 1993). The variation in contribution of the various annual plant groups in vegetation composition could be attributed to oscillation of rainfall and temperature among the years (Espigares and Peco, 1995; Koukoura and Papanastasis, 1997). The high percentage of annual grasses 28-36% in LSS could be attributed to high participation of *Dasypyrum villosum* (L.) P. Candargy in the vegetation composition. *D. villosum* although is an annual grass, it very often grows in low elevation grasslands with perennial grasses (Karatassiou, 1999). According to Pendleton (1989) in the Mediterranean regions the earliest perennial species were replaced with annual ones that contribute to increase herbage production. Same results were reported in Mediterranean grassland of Israel after five years of protection from grazing (Noy-Meir, 1998). The changes in participation of the various plant groups have been attributed to climatic conditions and vegetation succession (Levassor *et al*., 1990).

Table 1 gives the total species richness in various plant groups in the two grasslands. In ESS during the experimental period we recorded 43 plant species while in LSS 55. Forbs and annual legumes were the dominant species in ESS while annual and perennial grasses and forbs were dominating in LSS. The species richness is in agreement with the species composition as it is given in Fig. 1, and showed that the group species with the higher abundance participated with higher

percentage in vegetation composition of the two grasslands. The results suggested that seven years of protection favoured biodiversity and species richness more in LSS than in ESS.

Table 1. Total species richness in plant groups for the two grasslands

Plant groups	ESS†	LSS††
Annual grasses	8	9
Perennial grasses	3	10
Annual legumes	11	6
Perennial legumes	1	3
Forbs	20	27
Total	43	55

†ESS = Early succession grassland.
††LSS = Late succession grassland.

The number of species with constant and frequent appearance (Table 2) was higher in LSS. The constant species of each grassland could be used as indices of best adapted species to climate and soil conditions as well as to grazing history (Koukoura *et al*., 1998). The LSS with more constant perennial species has a higher stability than the ESS.

Table 2. Frequency of appearance (R = random, F = frequent, C = constant) in various plant groups of two grasslands during the experimental period

Plant groups	ESS†			LSS††		
	R	F	C	R	F	C
Annual grasses	5	1	2	3	2	4
Perennial grasses	2		1	1	3	6
Annual legumes	6	2	3	1	2	3
Perennial legumes	1				2	1
Annual forbs	2	2	1	1	1	
Perennial forbs	7	7	1	9	10	6
Total	23	12	8	15	20	20

†ESS = Early succession grassland.
††LSS = Late succession grassland.

Table 3 gives the Shannon-Wiener and Simpson's indices, which are the two nonparametric measures of species diversity (Lande, 1996). There were no significant differences ($P > 0.05$) between the two grasslands for both indices in 1993 and 1994 (5 and 6 years of protection from grazing respectively). However, differences became significant ($P < 0.05$) in the 7th year of protection from grazing (1995). The higher values of Shannon and lower values of Simpson's index in LSS indicate that the diversity after seven years of protection was higher in LSS, than in ESS.

The influence of protection from grazing in vegetation composition was investigated also with the ration annual/perennial species. Our results showed that in ESS maintained an almost stable ratio (2.4-2.9) while in LSS decreased from 1.2 into 0.6 after seven years protection. The high and almost constant ratio in ESS could be due to high percentage of annual forbs in vegetation composition. Also the reduction in LSS could be attributed to the increase of perennial species as a result from cessation of grazing and vegetation succession (Noy-Meier *et al*., 1989; Tsiouvaras *et*

al., 1998). The two grasslands responded differently in protection from grazing and the changes in vegetation composition depend also on other factors such as the region conditions, the history of disturbance and the successional stage (Noy-Meir and Briske, 1996).

Table 3. Shannon-Wiener (H) and Simpson's (D) indices in two grasslands during the experimental period

Grassland†	1993		1994		1995	
	H	D	H	D	H	D
ESS	2.86 a	0.09 a	2.78 a	0.099 a	2.93 a	0.088 a
LSS	2.94 a	0.089 a	2.90 a	0.084 a	3.31 b	0.081 a

†ESS = Early succession grassland; LSS = Late succession grassland.
a, b: Different letters within column indicate significant differences ($P < 0.05$).

According to Noy-Meir (1998) the Mediterranean region includes a wide range of climatic and edaphic conditions so that it is difficult to generalize the results from one region or one ecosystem for all the Mediterranean areas. However, our results suggested that the stage of grassland succession is an important factor which influences the evolution of vegetation composition and diversity after cessation of grazing in low elevation Mediterranean grasslands.

IV – Conclusions

In the light of our findings and also considering the short time of our experimentation it is difficult to recommend an optimal duration of protection to regenerate the semi arid grassland of Northern Greece. The time of recovery depends greatly upon the climatic conditions and the successional stage of vegetation. Short terms protection (seven years) may provide an effective natural management practice to restore vegetation especially in LSS grasslands. Seven years protection increased more the stability and biodiversity of grassland in LSS than in ESS.

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