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Abstract. Grazing can affect the structure and species composition of plant communities. This impact varies widely in space and time according to habitat characteristics (abiotic factors) and primary consumers (biotic factors). The effect of grazing on ground cover, species composition, and species richness was studied in various habitats of Pertouli area (Central Pindus mountains, Greece) from 2000 to 2006. The selected habitats were: (i) high altitude grassland; (ca. 1200 m a.s.l.) grazed by cattle and horses; (ii) fir forest at 1200-1600 m a.s.l., grazed mainly by cattle; and (iii) subalpine grassland from 1600 to 2060 m a.s.l. grazed by cattle and horses. The ground cover was around 70% and did not significantly differ among the habitats and the years. The mean utilization percentage across the years was 70, 48 and 32% in the grassland, fir forest and subalpine habitats respectively. There was an increasing trend in the contribution of desirable plants for grazing animals in the composition of grasslands and fir forest, while at the same time there was a significant decrease of species richness. On the other hand, there was an opposite trend in sub alpine grassland. It seems that the high percentage of utilization, combined with the herbivore species favoured the dominance of specific plant species, resulting in decreased species richness for the grassland and fir forest.

Keywords. Grazing – Herbivores – Utilization percentage – Grass species.

Effets à long terme du pâturage sur la composition dans différents habitats de la zone montagneuse de la Grèce Centrale

Résumé. *Le pâturage peut affecter la structure et la composition floristique de la communauté végétale. Cet impact varie dans l'espace et le temps en fonction des caractéristiques de l'habitat (facteurs abiotiques) et des premiers consommateurs (facteurs biotiques). L'effet du pâturage sur le taux de recouvrement, la composition floristique, et la richesse végétative a été étudié dans différents habitats de la zone de Pertouli (montagnes du Pindus Central) en Grèce pendant la période 2000 à 2006. Les habitats sélectionnés sont : (i) une prairie en haute altitude (environ 1200 m du niveau de la mer) pâturée par des bovins et des chevaux ; (ii) une forêt à sapins située à 1200-1600 m au-dessus du niveau de la mer pâturée essentiellement par des bovins ; (iii) une prairie subalpine située de 1600 à 2060 m au-dessus du niveau de la mer pâturée par des bovins et des chevaux. Le taux de recouvrement était d'environ 70% et n'a pas été affecté par l'habitat et les années. Le pourcentage moyen d'exploitation tout au long des années est de 70, 48 et 32% pour, respectivement, la prairie, la forêt de sapin et les habitats subalpins. Il y avait une tendance vers une augmentation de la contribution des plantes préférées par les animaux en pâturage, dans la composition floristique des prairies et des forêts de sapin, et en même temps une diminution significative de la richesse végétative. En revanche, il y avait une tendance opposée pour la prairie subalpine. Il semble que le pourcentage d'exploitation élevé, combiné avec les espèces herbivores, a favorisé la dominance de certaines espèces végétales spécifiques, entraînant une diminution de la richesse végétative au niveau de la prairie et de la forêt de sapin.*

Mots-clés. *Pâturage – Herbivores – Pourcentage d'exploitation – Espèces herbacées.*

I – Introduction

Grasslands are a major component for livestock feeding in the Mediterranean region and are often characterized by abundance of species, which contribute to the variability of herbage composition and production (Maranon, 1985). The herbage composition of grasslands is strongly linked to habitat characteristics (abiotic factors) and primary consumers (biotic factors) (Gatti *et al.*, 2005). It

is well known that herbivores' grazing has substantially modified the composition and structure of grasslands throughout the world (Briske and Noy-Meir, 1998).

Grazing could either increase or decrease species richness and diversity in herbaceous plant communities, depending mainly on foraging behaviour of the herbivores in relation to the dominant plant species (Zhang, 1998). These changes occur in response to selective grazing and the subsequent modification of interspecific competitive interactions (Briske and Noy-Meir, 1998). Moreover, plant biodiversity depends critically upon the level of grazing. Overgrazing may often lead to land degradation and decline of biodiversity, while very light grazing may lead to succession from grassland to woodland and loss of grassland habitat (Watkinson and Ormerod, 2001; Gatti *et al.*, 2005). The latter is common in mountain grasslands especially in Mediterranean region (Papanastasis, 1999). The aim of this study was to estimate the effect of grazing on herbage composition of three mountainous habitats.

II – Materials and methods

The study was conducted, at Portaikos-Pertouli area on the mountains of Central Pindus, Greece, from 1999 to 2006. The climatic conditions of the study area are summarized in Table 1. Mean annual precipitation was 1080 mm and mean annual temperature was 9.4°C for the experimental period 1999-2007. In this area, the following three habitats were selected: (i) high altitude grassland (ca. 1200 m a.s.l.) grazed by cattle and horses; (ii) fir forest at 1200-1600 m a.s.l., grazed mainly by cattle; and (iii) subalpine grassland from 1600 to 2060 m a.s.l. grazed by cattle and horses. Also sheep were grazed in the subalpine grassland up to the year 2002.

Table 1. Average monthly air temperature (T ℃) and monthly and total rainfall (R, mm) in Pertouli, Central Pindus 1999-2006

	Years											
	1999		2000		2002		2003		2005		2006	
	T (℃)	R (mm)	T (℃)	R (mm)	T (℃)	R (mm)	T (℃)	R (mm)	T (℃)	R (mm)	T (℃)	R (mm)
January	1.3	100	–0.46	99.5	–0.3	14.0	2.4	190.0	–0.4	37.5	–2.5	35.0
February	–0.2	89	–1.00	117.5	4.8	22.0	–4.2	420.0	–1.8	53.0	0.0	166.0
March	3.8	159	–0.44	113.5	5.7	56.5	1.4	2.0	3.6	88.5	4.3	119.5
April	8.0	71	6.13	112.0	7.0	197.0	5.4	23.5	7.2	37.0	9.0	127.5
May	13.9	12	13.37	65.0	12.4	34.0	15.0	45.5	13.6	81.0	13.2	191.0
June	18.1	15	16.65	26.5	18.0	18.0	17.9	32.5	15.7	43.5	16.0	73.0
July	19.1	29	18.68	99.5	19.7	62.5	20.2	53.0	19.8	66.0	17.6	7.5
August	20.4	15	19.11	78.5	17.7	52.0	19.5	29.5	19.1	14.5	19.7	15.5
September	15.4	42	12.84	136.0	13.3	178.5	13.7	66.5	15.2	52.0	14.5	150.5
October	11.6	69	8.15	190.5	10.4	81.5	11.3	329.0	9.2	14.5	10.4	84.0
November	5.3	401	6.79	282.5	7.2	53.0	6.8	82.0	4.3	94.0	4.5	75.5
December	4.0	200	3.46	98.5	1.7	190.5	1.1	89.5	1.6	218.0	2.5	34.5
Mean	10.0		8.6		9.8		9.2		8.9		9.1	
Total		1202		1420		960		985		800		1080

Source: University Forest Station (Pertouli-Trikala).

The number of grazing animals in the three habitats is given in Table 2. The effect of grazing on herbage production and species composition was recorded in the years 2000, 2003 and 2006. Ground cover and species composition were measured by using the line and point method (Cook and Stubbendieck, 1986) at the end of August. Twenty transect lines of 25 m long were used in

each habitat. Species richness of desirable for grazing species was estimated for three groups of species: (i) grasses; (ii) legumes; and (iii) forbs by using four 0.5 × 0.5 m quadrats in the grazed areas. Herbage production was measured in the same period by harvesting the above ground biomass of the herbaceous plants from four 0.5 × 0.5 m quadrats in protected exposure cages (Cook and Stubbendieck, 1986). Production in the grazed areas was measured in the same way. All herbage samples were oven-dried at 60℃ for 48 hours and they were used to calculate the utilization percentage (UP). General linear models procedures (SPSS 14 for Windows) were used with habitats as fix and years as random factors. The Least Square Difference test at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

Table 2. Number of grazing animals in the Pertouli area

Animals/years	2000	2003	2006
Sheep	717	700	680
Cattle	201	228	261
Horses	24	18	20
Total	942	956	961

Source: University Forest Station (Pertouli-Trikala).

III – Results and discussion

Ground cover was similar among the habitats and the years. The average percentage of ground cover in the three habitats was around 70% (Table 3). The utilization percentage (UP) significantly increased from 2000 to 2006 in fir forest, whereas it decreased in grassland and subalpine grassland. Regarding the habitats, grassland had high UP (70%), fir forest moderate (48%) and subalpine low (32%). According to the high UP in grassland, it was expected a lower percentage of ground cover, as overgrazing could reduced it (Brady *et al.*, 1989). However, in case of the grassland in Pertouli area the heavy grazing did not affect the ground cover perhaps due to deep and rich soil and the high precipitation prevailing in the area.

Table 3. Ground cover (%) and utilization percentage (UP) (%) for the three habitats

Years/parameters	Fir forest		Grassland		Subalpine	
	Cover (%)	UP (%)	Cover (%)	UP (%)	Cover (%)	UP (%)
2000	68 a	43 a	75 a	76 b	73 a	43 c
2003	70 a	50 b	68 a	65 a	72 a	30 b
2006	68 a	51 b	70 a	69 a	70 a	23 a
Mean	69	48	71	70	71	32

a, b, c: means differ significantly at $P < 0.05$.

The percentage of perennial grasses and legumes increased, while the percentage of undesirable species decreased in grasslands. Similar trend was observed in fir forest, but the percentage of undesirable species for grazing herbivores remained steadily high (around 75%) throughout the experimental years and it was higher than in the other habitats. On the contrary, the percentage of perennial grasses decreased, whereas the percentage of legumes and undesirable species increased in the subalpine grassland (Fig. 1). It seems that the continuously high UP in grasslands restrict the persistence of undesirable plant species, the moderate UP in fir forest maintained them

at a constant percentage whereas the low UP in the subalpine grassland increased the percentage of undesirable species.

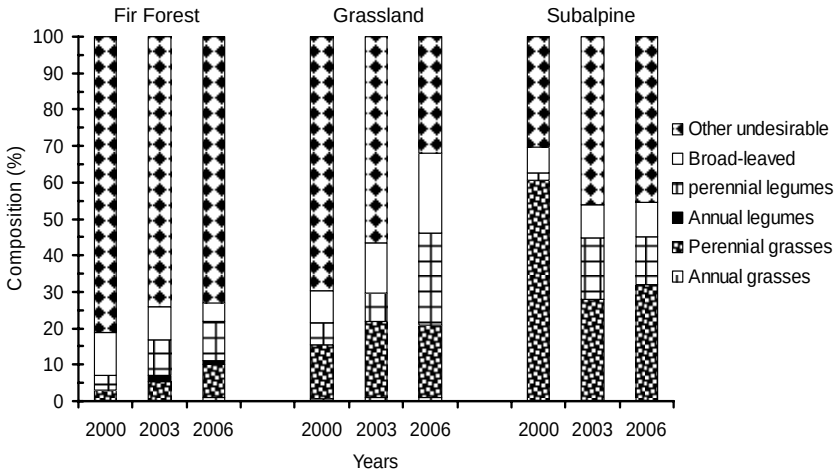

Fig. 1. Species composition (%) of the three habitats during the experimental period 2000-2006.

The increase of perennial grasses in grassland could be attributed to the high occurrence of the species *Festuca ovina* group (50%), which is not particularly desirable for the cattle diet. On the other hand, the high preference of cattle on *Brachypodium pinnatum* L. resulted in the decrease of the perennial grasses in the subalpine grassland. In addition, in the case of fir forest the increase of perennial grasses and legumes could be explained by the moderate utilization percentage (Tsiouvaras *et al*., 1998).

Concerning the desirable for grazing broadleaved species there was a significant increment in the grassland. This is probably due to high occurrence of *Plantago lanceolata* (up to 90% of the total broadleaved species), which is not preferred by cattle for grazing and may explain the above trend. On the other hand the high elevation and the climatic conditions of the area may explain the low percentage of the annual species in all the habitats (Table 1) (Papanastasis and Noitsakis, 1992).

Despite the increased contribution of perennial grasses in the composition of the grassland and fir forest, the number of species belonging to this class gradually decreased along with the years (Table 4). On the other hand their number was maintained in subalpine grasslands although their contribution in the composition decreased. At the same time the number of legume species (Table 4) increased in all habitats. On average, species richness of the desirable grazing species (Table 4) declined through the years in the fir forest and the grassland, while increased in the subalpine grassland. The increase of legumes' contribution to herbage composition and the increased number of legume species could be attributed to the removal of sheep from the area in 2002. Sheep are usually more selective than cattle, preferring forbs and tiny grasses (Biswell and Liakos, 1982). After 2002, the area has been grazed only by cattle which, in contrast, mainly prefer grasses, allowing for legumes' and forbs' spreading in the pasture (Biswell and Liakos, 1982).

The low grazing intensity in subalpine grassland favoured species richness and biodiversity. This is in agreement with the results of Koukoura *et al.* (1998) in the same area. Similar trend about the effect of grazing on biodiversity has been reported and in other Mediterranean grasslands (Grime, 1979; Marriot *et al*., 2004). On the other hand, the high and moderate grazing intensity reduced species richness. The fact that the area is grazed only by one kind of animal species possibly reinforces the stocking rate effect (Theodoridis and Koukoura, 2006). Conversely, the general

theory is that species diversity increases with grazing intensity over a wide range from ungrazed grasslands up to fairly heavy grazing (Noy-Meir, 1998). Probably the relation between grazing intensity and species diversity is more complicated. It could be affected by herbivore species and their grazing behaviour (Van Wieren, 1998) and depends on climate and productivity of the area as well as on the length of the evolutionary grazing history of the vegetation (Milchunas *et al*., 1988). However, more years of observation could be necessary in order pertinent information on the effects of grazing on the composition of these mountainous habitats to be derived.

Table 4. Species richness in plant groups for the three habitats during the experimental period 2000-2006

Species groups	Number of species								
	Fir forest			Grassland			Subalpine		
	2000	2003	2006	2000	2003	2006	2000	2003	2006
Grasses	8	7	6	12	5	5	8	8	7
Legumes	3	6	6	3	2	5	2	4	6
Desirable forbs	8	2	2	3	2	2	1	3	4
Total	19	15	14	17	9	11	11	15	17

IV – Conclusions

It seems that the moderate and high utilization percentage, in the fir forest and the grasslands of Pertouli, Central Pindus mountains, favoured the dominance of *Festuca ovina* and *Plantago lanceolata* and decreased species richness. On the other hand, low utilization percentage in the subalpine grasslands increased species richness but simultaneously increased the contribution of the undesirable plants in pasture botanical composition.

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