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Interaction of climatic conditions and transhumant livestock system on two mountainous rangelands in Greece

M. Karatassiou*, Z.M. Parissi and P. Sklavou

Department of Forestry and the Natural Environment,
Aristotle University of Thessaloniki, 54124 Thessaloniki (Greece)
*e-mail: karatass@for.auth.gr

Abstract. In this study the impact of climatic conditions and long term grazing of transhumant sheep and goats on the vegetation and productivity of two mountainous rangelands of Greece was investigated. The experiment involved two high-elevation Mediterranean rangelands (Lakmos and Psilorites mountains) of the Northern and Southern part of Greece respectively. Three plots of 9 m² in each rangeland were fenced in the spring of 2012 in order to be protected from grazing. Measurements were carried out in middle of June 2013. The vegetation cover and forage production were measured; composition and the richness of the species were calculated. The index of similarity and Shannon Index (H') were also estimated. The results revealed differences between the two rangelands regarding the (a) dominant functional groups, (b) composition of vegetation, (c) species richness and (d) forage production. The percentage of vegetation cover was different in the two rangelands, and the similarity index was small.

Keywords. Production – Functional plant groups – Sheep – Goats – Similarity index.

Interaction des conditions climatiques et du système d'élevage transhumant sur deux parcours de montagne en Grèce

Résumé. *Cette étude a examiné l'impact des conditions climatiques et du pâturage à long terme d'ovins et caprins transhumants sur la végétation et la productivité de deux parcours montagneux de la Grèce. L'expérience a porté sur deux parcours méditerranéens en altitude (montagnes de Lakmos et Psiloritis) dans le nord et le sud de la Grèce, respectivement. Trois parcelles de 9 m² dans chaque parcours ont été mises en défens au printemps 2012 afin de les protéger du pâturage. Des mesures ont été effectuées vers la mi-juin 2013. La couverture végétale et la production de fourrage ont été mesurées ; la composition et la richesse en espèces ont été calculées. L'indice de similarité et l'indice de Shannon (H) ont aussi été estimés. Les résultats ont révélé des différences entre les deux parcours concernant (a) les groupes fonctionnels dominants, (b) la composition de la végétation, (c) la richesse en espèces et (d) la production de fourrage. Le pourcentage de couverture végétale était différent dans les deux parcours, et l'indice de similarité était faible.*

Mots-clés. *Production – Groupes fonctionnels de plantes – Ovins – Caprins – Indice de similarité.*

I – Introduction

Rangelands compose ~25% of the world's land and include a large number of economically important species and ecotypes, support approximately 50% of the world's livestock and provide forage for both domestic and wildlife populations (Allen-Diaz *et al*., 1995; Alkemade *et al*., 2013). The rangelands in Greece constitute 40% of the total area (NSSG, 1991) include grasslands, "phrygana", shrublands and woodlands which extend from lowland to uplands and have been used for grazing of transhumant, nomadic and commercial animals. The intermediate and high elevation (pseudo-alpine rangelands mainly used by transhumant livestock system from May to October (Karatassiou *et al*., 2014).

Rangelands are under pressure from livestock, fire, climate change, soil type and nutrients and habitat fragmentation (Alkemade *et al*., 2013). However, Mediterranean region includes a wide range of climatic and edaphic conditions and vegetation has been created by natural selection under the pressure of a distinct climate and human activities. In this region rainfall and its distribution are the main determinants of rangeland structure and function; and degradation and habitat loss are among the major factors causing biodiversity loss (Pereira *et al*., 2010). The response of grassland to changes in rainfall will have significant consequences on global patterns of productivity and diversity under future climate scenarios. However, grazing can possibly modify the effects of climate changes on grassland productivity and biodiversity (Koerner *et al*., 2014). The aim of this study was to investigate the impact of climatic conditions and grazing of transhumant sheep and goats on the vegetation and productivity of two mountainous rangelands of Greece.

II – Material and methods

The study was conducted in two grazed high elevation rangelands located near the village Chaliki (Lakmos mountain) and Anogia (Psilorites mountain) in Crete island, in the northern west and the southern part of Greece respectively (Fig. 1), in an altitude 1200-1300 m. Both areas are grazed mainly by transhumant sheep and goats from May to October. According to the bioclimatic map of Greece the climate of the Lakmos and Psiloritis mountain is characterized as cold sub axeric and meso Mediterranean (Mavromatis 1978), with mean annual temperature approaching 10.44°C and 15.06°C respectively. The annual average precipitation is 1760 mm for Lakmos and 908 mm for Psilorites mountain.

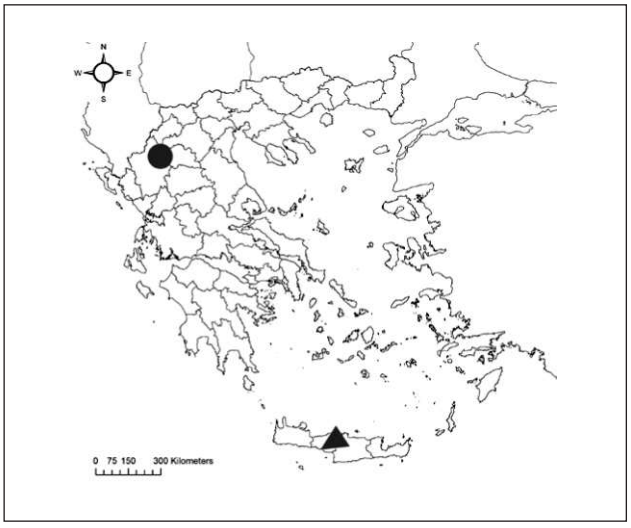

Fig. 1. The two exprerimental areas Lakmos (●) and Psilorites mountain (▲).

Three experimental sites were selected in each rangeland. In each experimental site a plot of 9 m^2 was fenced in the spring of 2012 in order to be protected from grazing. Ground cover was measured; composition, species richness and evenness were calculated in grazed and non-grazed areas at the middle of June 2013. Ground cover was measured according to the line and point method (Cook and Stubbendieck, 1986). Thereafter, species composition was presented in four plant groups: (1)

grasses, (2) legumes, (3) other forbs, and (4) shrubs. In order to calculate the species richness (S), and evenness (E), two sampling quadrats of 0.35 m x 0.35 m were used in each experimental site. Species diversity was calculated by the Shannon Index (H´). Also, the richness and the similarity coefficients S_j (Jaccard) and S_s (Sørensen) were calculated using the formulas: $S_j = a/(a + b + c)$ and $S_s = 2a/(2a + b + c)$ where a = number of species common in both areas, b = number of species in the first area only, c = number of species in the second area only (Chuang, 2012). The forage production was measured in the same period by harvesting the above ground biomass of the vegetation from four 0.5 m x 0.5 m quadrats in each protected plots. The samples were oven-dried at 60°C for 48 hours and weighed (Cook and Stubbendieck, 1986). The data were analyzed by ANOVA (Steel and Torrie, 1980) using the SPSS statistical software v. 21.0 (SPSS Inc. Chicago, IL, USA).

III – Results and discussion

The vegetation cover was different, 94% and 79% for Lakmos and Psilorites, respectively. The low vegetation cover in Psilorites provides a poor protection against soil erosion (Lorent *et al*., 2009). There were significant differences in the contribution of the various plant groups in composition ($P \leq 0.001$) regardless of the rangeland and the protection status (Table 1). No differences were detected between the two rangelands and protection status ($P > 0.05$). In Lakmos, the grass and other forbs species participated with significantly higher percentage ($P \leq 0.001$) compared to the other plant groups in grazed areas. On the other hand, in Psilorites, we observed significantly higher participation of forbs ($P \leq 0.05$), while the other plant groups were significantly lower. The different contribution of the various plant groups is probably caused by grazing and different climatic and soil conditions between the two areas (Karatassiou and Koukoura, 2009; Karatassiou *et al*., 2014; Koerner *et al*., 2014).

Table 1. Plant groups composition (%) in protected and grazed treatment in both experimental mountain areas

Plant groups	Lakmos		Psilorites	
	Protected	Grazed	Protected	Grazed
Grasses	38.00 ± 7.57^{a}	55.62 ± 5.35^{a*}	18.60 ± 6.24^{b*}	14.66 ± 7.62^{b**}
Legumes	21.05 ± 4.25^{a}	14.14 ± 2.52^{c}	20.39 ± 0.22^{b}	17.28 ± 5.56^{b}
Other forbs	40.95 ± 3.55^{a}	30.24 ± 3.89^{b}	52.34 ± 5.77^{a}	52.38 ± 7.57^{a}
Shrubs	–	–	8.67 ± 0.25^{c}	15.68 ± 7.03^{b}

Different letters in each column indicate significant differences (* $P \leq 0.001$, ** $P \leq 0.05$).

During the experimental period, in Lakmos 59 plant species (15 grasses, 12 legumes and 26 other forbs) were recorded, while in Philorites one only 27 (7 grasses, 5 legumes, 12 other forbs and 4 shrubs) were recorded. The species richness is in agreement with the species composition (Table 1). It seems that the group species with the higher abundance contributed with higher percentage in vegetation composition of the two areas. There were only fifteen common species. The common palatable species for the two mountainous rangelands were: *Bromus mollis, Cynodon dactylon, Dactylis glomerata, Hordeum bulbosum, Poa bulbosa, Festuca ovina, Trifolium campestre* and *Trifolium hybridum.* These results and the dissimilarity between the two areas, confirmed from the low similarity coefficients (S_j = 15%, S_s = 26%) between the two areas. The difference between the two similarity coefficients due to S_s coefficient had greater "weight" to species common to the quadrats than to those found in only one quadrat (Baselga, 2012; Chuang, 2012). Moreover, as we expected Shannon index and evenness presented the higher values in the Lakmos rangeland and significant differences were detected ($P \leq 0.05$) for both indices between the two rangelands (Table 2).

Table 2. Shannon diversity index (H´) and evenness (E) in protected and grazed treatment in both experimental mountain areas. Values present means ± SE

Experimental area	Shannon diversity index (H´)		Evenness (E)	
	Protected	Grazed	Protected	Grazed
Lakmos	2.863 ± 0.20	2.839 ± 0.17	0.715 ± 0.06	0.600 ± 0.05
Psilorites	1.958 ± 0.18	1.874 ± 0.10	0.445 ± 0.04	0.432 ± 0.02
P	<0.001	<0.001	<0.001	<0.01)

However, the short time of animal exclusion in the protected plots improved species diversity. Forage production was significantly higher for Lakmos area (2166.5 kg DM/ha) compared to Psilorites (1466.9 kg DM/ha). In Psilorites, the combination of the lower annual average precipitation and the higher temperature with transhumance livestock grazing had as a result a lower species diversity and forage production compared to Lakmos (Ali-Shtayeh and Salahat, 2010; Koerner *et al*., 2014, Parissi *et al*., 2014).

IV – Conclusions

The preliminary results of this study point out that areas with cold sub axeric and meso Mediterranean climatic conditions as Psilorites need more concern in grazing management to maintain ecosystem sustainability, but longer studies are required.

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