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Impact of different grazing intensities on rangelands soil characteristics in central Greece

D. Rapti[1]*, A.G. Papaioannou[2], Z.M. Parissi[1] and M. Karatassiou[3]

[1]Laboratory of Range Science (236), Department of Forestry and Natural Environment
Aristotle University of Thessaloniki, 54124 Thessaloniki, (Greece)
[2]Laboratory of Forest Soil Science (271), Department of Forestry and Natural Environment
Aristotle University of Thessaloniki, 54124 Thessaloniki, (Greece)
[3]Laboratory of Rangeland Ecology (286) Department of Forestry and Natural Environment
Aristotle University of Thessaloniki, 54124 Thessaloniki, (Greece)
*email:dimrap206@gmail.com

Abstract. Grazing is a crucial factor that influence soil characteristics and restrict some of its components. The purpose of this study was to investigate the effect of grazing of small ruminants on soil characteristics in Central Greece. Two rangelands were selected, one with heavy grazing (80%) and one with moderate grazing (40%). In each of the above experimental areas, soil samples were taken from two depths, 0–10 and 10–20 cm, for chemical analyses, pH, organic matter, macronutrients (N, P, K, Ca, Mg, Na) and micronutrients (Cu, Fe, Zn, Mn). According to the results, heavy grazing had no effect on organic carbon (C %),organic matter and the macronutrients N, P, K, although the concentrations of Na and Ca and Fe were decreased under the heavy grazing compared to the mediate one. The concentration of N and K was significantly higher at depth of 0-10 cm. Moreover, the micronutrients Fe and Zn were positively affected by soil depth, while Cu and Mn were not affected by grazing intensity or soil depth. Finally, soil pH had increased under heavy grazing.

Keywords. Small ruminants – Plant biomass – Soil – Organic matter – Nutrients.

Effet de différentes intensités de pâturage sur les caractéristiques du sol des parcours dans le centre de la Grèce.

***Résumé**. Le pâturage est un facteur crucial qui influence les caractéristiques du sol et limite certaines de ses composantes. Le but de cette étude est d'examiner l'effet du pâturage des petits ruminants sur les caractéristiques du sol des parcours en Grèce centrale. Deux parcours ont été choisis, l'un avec pâturage intensif (80%) et l'autre avec pâturage modéré (40%). Dans chacune des zones expérimentales ci-dessus mentionnées, des échantillons de sol ont été pris sur deux profondeurs, 0-10 et 10-20 cm, pour les analyses chimiques de pH, matière organique, macronutriments (P, K, Na, Ca, N, C) et micronutriments (Cu, Fe, Zn, Mn). Selon les résultats, le pâturage intensif n'a eu aucun effet sur le carbone organique, la matière organique et les macronutriments N, P, K, bien que les concentrations de Na, Ca et Fe aient diminué dans ce type de pâturage en comparaison avec le pâturage modéré. La concentration de N et K est significativement plus élevée dans la profondeur de 0-10 cm. En outre, les micronutriments Fe et Zn ont été positivement affectés par la profondeur du sol, alors que le Cu et le Mn n'ont pas été affectés par l'intensité de pâturage ou la profondeur du sol. Enfin, le pH du sol a augmenté sous le pâturage intensif.*

***Mots-clés.** Petits ruminants – Biomasse des plantes – Sol – Matière organique – Nutriments.*

I – Introduction

Grazing is recognized as an important ecological factor in rangelands which can affect soil attributes as well as ecosystem functions (Liebig *et al.,* 2006). Livestock influence soil properties through two main mechanisms: trampling compress the soil which increases bulk density (Warren *et al.,* 1986; Trimble and Mendel, 1995) and grazing decreases plant cover (Coughenour, 1991). However, when grazing is well managed, it can be valuable to the environment since it enhances nutrient cycling (Bilotta *et al.,* 2007). On the other hand, heavy grazing with improper management can lead to environmental degradation (Noellemeyer *et al.,*

2006) and soil erosion. The aim of this study was to evaluate the effect of different grazing intensities of small ruminants on two rangelands soil characteristics.

II – Materials and methods

The study was conducted in the village Rodia, prefecture of Larisa, Thessaly, central Greece on altitude of 140 m. The climate is continental semi-arid (Mavromatis, 1978) with a mean annual temperature of 14.73°C and mean annual precipitation of 579 mm. The average maximum temperature is 25.6°C and minimum is 6.1°C. Most soils are clay loam, but there are some that are loamy or sandy loam or sandy (Municipality of Tirnavos, 2002). The area is mainly grazed by sheep and goats. Two rangelands with different vegetation composition and different grazing intensity were selected, one with heavy grazing (80%) and one with moderate grazing intensity (40%). Grazing intensity was determined from the forage utilization percentage (FUP), (Heady and Child, 1994). Thus, in each rangeland, two plots of 9 m^2 were fenced in the spring of 2013 in order to protect the vegetation from grazing. The difference among herbage yields of fenced and open plots was used to calculate the FUP.

Soil samples were taken from the two experimental areas during May of 2014. In each area, three samples were collected at 0–10 cm and 10–20 cm depth, respectively. All soil samples were air dried and sieved through 2 mm mesh screens. Particle size distribution of mineral soil was determined according to Bouyocos (1962) and the pH of the mineral soil was determined on a soil water suspension (1:1, by weight) using a glass electrode. Soil organic matter was determined by means of wet oxidation (Nelson and Sommers, 1982). Organic N was determined by the Kjeldahl method (Stevenson, 1982) and available P was extracted with 0.5N $NaHCO_3$ at pH 8.5 and measured spectophotometrically (Olsen and Sommers, 1982). Exchangeables Ca, Mg, K and Na were determined using the CH_3COONH_4 – pH 7 method (Grant, 1982).The extracted cations were then measured by atomic absorption spectophotometry and heavy metal concentration by the DTPA method (Lindsay and Norvell, 1978).

For all measured parameters, differences between the two grazing intensities and the two soil depths were calculated using two-ways ANOVA. All statistical analyses were performed using the Gen stat v.11application. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

The soil pH (across soil depth) was significantly higher for the site with heavy grazing intensity (Table 1). Increase of soil pH due to grazing was also found by Ruess and McNaughton (1987) in rangelands. The organic carbon (C %), organic matter, and concentration of N, P and K were not significantly ($p>0.05$) affected by grazing intensity (Table 1). This result is on line with that of Dahlgren *et al. (*1997) who founded that light to moderate grazing intensity had no effect on soil organic matter in a *Quercus douglasii* woodland. The concentration of macronutrients Ca, Mg and Na was significantly lower in the heavy grazed rangelands than in moderate grazed ones. The difference for Na concentration is probably due to the different exposure in relation to air currents starting from sea level (Papaioannou, 2015). Moreover, difference in Ca concentration maybe due to the bedrock. Similar result was found by Li *et al*. (2005) who reported that the amount of Na was significantly higher under moderate than heavy grazing. Cayley *et al*. (2002) and Fornara and du Toit (2008) had also found that Mg concentration in soil decreased under higher grazing intensity.

Table 1. Effect of grazing intensity and soil depth on pH, organic matter, carbon, and concentration of macro and micronutrients of the rangelands soil characteristics

	Treatments		Depth (cm)	
	Heavy grazing	**Moderate grazing**	**0-10**	**10-20**
pH	5.695a	5.442b	5.597a	5.54a
Organic carbon (%)	1.65a	2.13a	2.06a	1.72a
Organic matter (%)	2.84a	3.67a	3.55a	2.96a
P mg/100gr soil	1.69a	2.34a	2.54a	1.49a
Ca (cmol/kg)	5.59b	7.33a	6.61a	6.31a
K (cmol/kg)	0.366a	0.253a	0.391a	0.228b
Na (cmol/kg)	0.0882b	0.1269a	0.1042a	0.1109a
Mg (cmol/kg)	1.55b	2.165a	1.699a	2.016a
Fe (μg/gr)	29.8b	38a	37.6a	30.2b
Zn (μg/gr)	1.41a	1.39a	2.02a	0.79b
Cu (μg/gr)	0.68a	3.51a	2.46a	1.72a
Mn (μg/gr)	7.44a	11.03a	11.07a	7.4a

Means in the same row for the same parameter followed by the same letter are not significantly different (P≥0.05)

On the other hand, Parissi *et al.* (2014) found that grazing had no effect on Mg, Na and K of herbage production in a coppice *Quercus frainetto* forest. Concerning the micronutrients, there were no significant differences in the tested micronutrients expect for Fe which was significantly higher under moderate grazed rangelands than under heavy grazed. Similarly, in the same study, the authors found that grazing had no significant effect on the above micronutrients including Fe.

Soil pH, organic carbon (C%), organic matter and soil P were not significantly different between the two depths and across the grazing intensity (Table 1).The concentration of N and K was significantly higher at 0–10 cm. The highest concentration of N at 0–10 cm was probably due to the animal excrement and urine (Tamartash *et al.,* 2007). High K values in the topsoil of areas with heavy grazing are probably due to rapid decomposition and release of this component from the organic materials and thus the faster enrichment of mineral soil due to the greater mobility of this monovalent cation (Staaf and Olsson, 1994). As long as micronutrients are concerned there was no significant difference in the concentration of Cu and Mn in soil depth. On the contrary, concentrations of Fe and Zn were significantly higher for 0-10 cm depth probably due to small claims in mineralogical composition of bedrock.

IV – Conclusions

Heavy grazing by small ruminants impaired soil properties of rangelands and caused significant decrease in some of their components such as Ca, Mg, Na and Fe. Moreover, soil depth affected the concentrations of some macronutrients (N, K) and micronutrients like Zn and Fe as well. However, there was no effect of grazing intensity or soil depth on C% and organic matter.

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