CIHEAM
Options Méditerranéennes

Response of vegetation to exclusion and grazing in Mediterranean high-mountain wet pastures (Sierra Nevada, Granada, Spain)

Robles A.B., Ramos M.E., Salazar C., González-Rebollar J.L.

in

Casasús I. (ed.), Lombardi G. (ed.).
Mountain pastures and livestock farming facing uncertainty: environmental, technical and socio-economic challenges

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 116

2016
pages 241-245

Article available on line / Article disponible en ligne à l'adresse :

---

http://om.ciheam.org/article.php?IDPDF=00007453

To cite this article / Pour citer cet article

Robles A.B., Ramos M.E., Salazar C., González-Rebollar J.L. **Response of vegetation to exclusion and grazing in Mediterranean high-mountain wet pastures (Sierra Nevada, Granada, Spain).** In : Casasús I. (ed.), Lombardi G. (ed.). *Mountain pastures and livestock farming facing uncertainty: environmental, technical and socio-economic challenges.* Zaragoza : CIHEAM, 2016. p. 241-245 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 116)

CIHEAM
Centre International de Hautes Etudes Agronomiques Méditerranéennes

http://www.ciheam.org/
http://om.ciheam.org/

CIHEAM

Response of vegetation to exclusion and grazing in Mediterranean high-mountain wet pastures (Sierra Nevada, Granada, Spain)

A.B. Robles[1,*], M.E. Ramos[1], C. Salazar[2] and J.L. González Rebollar[1]

[1]Group of Grassland and Mediterranean Silvopastoral Systems, Estación Experimental del Zaidín (CSIC)
Profesor Albareda,1, 18009 Granada (Spain)
[2]Dpt. of Animal Biology, Vegetal Biology and Ecology, University of Jaén, 23071 Jaén (Spain)
*e-mail: abrobles@eez.csic.es

Abstract. This study aims to determine the effect of medium-term livestock exclosure on two types of high-mountain wet pastures in the Sierra Nevada National Park: (1) "borreguil", with a predominance of *Carex nigra* and *Nardus stricta*, and (2) fescue pasture (FP), with a predominance of *Festuca iberica*. In February 2008, for each type of pasture, 5 plots were excluded to grazing, and 5 non-excluded plots were set up. The vegetation was assessed in July of 2008 and 2014. In this study, we analyse changes in the biomass production, plant cover, species richness, diversity and species composition after 6 years (2008 *vs.* 2014) of non-grazed plots as compared to grazed plots. In both types of pasture, biomass production showed significant differences between treatments and between years. In 2014, biomass was ten-fold higher in non-grazed plots and five-fold higher in grazed plots as compared to 2008 levels; with FP proving to be more productive than borreguil pastures. We also detected a slight downward trend in plant cover, richness and diversity in non-grazed plots, while these parameters appeared to increase in grazed plots, although a statistically significant change was only observed in FP plant cover. With regard to floristic composition, exclosures appeared to adversely affect small graminoids (only in borreguil pastures), *F.iberica* and legumes; on the other hand, exclosures had a positive effect on grasses, particularly *N. stricta,* in FP.

Keywords. *Festuca iberica* – *Nardus stricta* – Biomass production – Species richness – Diversity.

Réponse de la végétation à l'exclusion et au pâturage en estives humides méditerranéennes (Sierra Nevada, Grenade, Espagne)

Résumé. *L'objectif de cette étude est de déterminer l'effet à moyen terme de l'exclusion au bétail sur deux types d'estives dans le parc national de Sierra Nevada: (1) "borreguil", dominé par* Carex nigra *et* Nardus stricta*, et (2) FP, pelouse dominé par* Festuca iberica*. Dans chaque type d'estive, 5 parcelles ont été exclues au pâturage, et 5 parcelles ont été pâturées. La végétation a été évaluée en Juillet 2008 et 2014. Nous analysons l'évolution de la production de biomasse, la couverture végétale, la richesse d'espèces, la diversité et la composition des espèces après 6 ans (2008* vs. *2014), en comparant les parcelles non pâturées par rapport aux pâturées. Dans les deux types d'estives, la production de biomasse a montré des différences significatives entre les traitements et entre les années. En 2014 elle était dix fois plus élevée qu'en 2008 dans les exclusions, et cinq fois plus élevée dans les parcelles pâturées. Aussi, FP s'est montré plus productive que borreguil. Nous avons détecté une légère tendance à la diminution de la couverture végétale, la richesse et la diversité dans les parcelles non pâturées, ces paramètres semblent augmenter dans les parcelles pâturées, malgré le fait que des différences significatives n'ont été observées que dans le couvert végétal de la FP. Concernant á la composition floristique, l'exclusion parait affecter négativement les petites graminoïdes (uniquement dans les pâturages borreguil),* F. iberica *et légumineuses; d'autre part, les exclusions ont eu un effet positif sur les graminées, en particulier* N. stricta *dans les pelouses FP.*

Mots-clés. Festuca iberica – Nardus stricta – *Production de biomasse – Richesse des espèces – Diversité.*

I – Introduction

High-mountain wet pastures are of great importance for livestock feeding during the summer months in the semiarid Mediterranean region. Some of these plant communities, which belong to the *Nardion* alliance, have been designated priority habitats in the 92/43/ECC directive (Bedia and Busqué, 2013).

The Sierra Nevada, a national park, is the highest mountain range in the southern Iberian Peninsula. Transhumance (sheep, goat and cattle herds) has traditionally been practised in these mountains. The abandonment of traditional practices has negatively affected the survival of wet pastures. In order to implement management plans in these pastures, it is necessary to know the characteristics (floristic composition, structure and fodder yield) of these grassland.

This study therefore aims to determine the effect of medium term livestock exclosure on two types of high-mountain wet pastures in the Sierra Nevada National Park: (1) "borreguil", with a predominance of *Carex nigra* (L.) Reichard and *Nardus stricta* L.; and (2) pasture with a predominance of *Festuca iberica* (Hack.) K. Richt. We compared the changes in biomass, plant cover, species richness and diversity as well as species composition after 6 years (2008 as compared to 2014) in grazed and non-grazed areas.

II – Materials and methods

This study was conducted in the Sierra Nevada National Park (Aldeire, province of Granada, SE Spain) (37º 24' N and 3º 4' W at 2000-2150 m a.s.l.). The site has a typical mountain Mediterranean climate, with hot dry summers and snow in autumn and winter. During the survey, annual rainfall was 485 (2008), 681 (2009), 740 (2010), 301 (2011), 482 (2012), 507 (2013) and 518 mm (2014).The lithological substratum is siliceous. The sampling site was in a grazing area of approximately 550 ha. Two flocks of Segureña sheep (a total of 620 in 2008 and 550 in 2014), herded by shepherds, grazed the area from late May until late September. Approximately 50 to 70 heads of shepherdless cattle also erratically grazed there after the snow melted.

Two types of mountain pastures were evaluated: 1) "borreguil", with a predominance of *C. nigra* and *N. stricta*, develops after the snow melts, which frequently occurs in swamped soils, and 2) fescue pastures (FP), with a predominance of *F. iberica* and very low *N. stricta* cover, develop in drier, nonswamp soils.

1. Experimental design and sampling

Five blocks were randomly located in each type of pasture. Each block comprised two plots (each 3x3 m) in: i) a permanent exclosure (non-grazed plot); and ii) an unfenced area (grazed plot) located next to the exclosure. The exclosures were set up in March 2008. Samplings were carried out at the end of July in two sampling years (2008 and 2014). Biomass was determined by cutting and collecting all above-ground biomass in eight 25 cm x 25 cm quadrats per subplot. This material was oven-dried at 60ºC. Composition and plant cover were estimated using the point-intercept method. Two 2-m-long transects were performed in fixed crossed lines. Every 4 cm, a thin stick was vertically placed in the vegetation, and all species in contact with the recording stick were sampled. The data obtained from this procedure enabled us to determine: (i) plant cover, with frequent overlapping resulting in values of over 100% (see Tables 1 and 2), (ii) richness, with the number of species per plot, (iii) biodiversity, quantified by the Shannon index, using the natural logarithm ($\log_2$), and (iv) floristic composition, with only the dominant and more interesting pastoral species and functional groups (grasses, legumes and tall and small graminoids) being shown. Graminoids include only species belonging to the *Cyperaceae* family.

2. Statistical analyses

Data were analyzed using the two-way repeated measure ANOVA procedure of the SPSS general linear model (GLM) to estimate the overall significance of the effect of the treatment. In this model, “year” (2008 and 2014) is regarded as a within-subject (repeated) factor, treatment (non-grazed and grazed) as a between-subject factor, with the block factor as the random effect. The factors examined in the model were treatment, year and their interaction. Mauchly’s test indicated that the model accomplished the assumption of sphericity. Tukey’s HSD post hoc test was used for multiple comparisons. Some data were transformed using the Log N for biomass and arcsin for plant cover.

III – Results and discussion

Biomass production showed significant differences between treatments and between years in the borreguil and FP plots. In 2014, biomass was ten-fold higher in non-grazed plots and five-fold higher in grazed plots than in 2008 (Tables 1 and 2). After exclusions were set up in March 2008 (see Materials and methods), their effect on non-grazed plots in 2008 was moderate, and biomass was lower than in 2014, although rainfall was similar in both years. The differences between the years in the grazed plots could be related to lower grazing pressure in 2014. In this regard, Bedia and Busque (2013) point out that grazing utilization is a factor that alters productivity in pastures dominated by *N. stricta*. Biomass production in “Borreguil” grassland in 2014 is similar to that found by these authors in *Nardus* grasslands in northern Spain.

Table 1. Biomass production (Biomass), vegetal cover, richness and diversity in two types of pasture in the high mountain areas of the Sierra Nevada for two different years and two treatments

Pasture type	Year	Treatment	Biomass (g DM ha^{-1} $year^{-1}$)	Plant cover† (%)	Richness (# sp)	Diversity (bits)
Borreguil	2008	Non-grazed	44.6 ± 5.5	219 ± 16.6	15.2 ± 1.4	2.8 ± 0.2
		Grazed	21.6 ± 4.8	182 ± 19.0	10.6 ± 1.8	2.2 ± 0.3
	2014	Non-grazed	539 ± 52.2	198 ± 8.3	11.8 ± 1.5	2.3 ± 0.3
		Grazed	114 ± 16.0	215 ± 5.4	14.6 ± 2.0	2.7 ± 0.2
Fescue pasture	2008	Non-grazed	82.9 ± 21.7	269 ± 18.0	11.8 ± 0.9	2.7 ± 0.1
		Grazed	31.9 ± 3.4	204 ± 7.2	10.4 ± 1.1	2.5 ± 0.1
	2014	Non-grazed	986 ± 220.3	207 ± 11.7	10.2 ± 1.3	2.5 ± 0.2
		Grazed	150 ± 19.8	229 ± 7.2	9.6 ± 1.1	2.5 ± 0.2

† Vegetal cover data are all over 100 as more than one species overlapped in each sampling point.

Table 2. ANOVA table for biomass production (Biomass), plant cover, species richness and diversity in two types of pasture (F = F values, P = p-values in the Anova analysis)

Type of pasture	Source	Biomass†	Plant cover	Richness	Diversity
Borreguil	Treatment (F, P)	37.8, **<0.001**	0.7, 0.438	0.18, 0.682	0.02, 0.884
	Year (F, P)	597.8, **<0.001**	0.2, 0.704	0.08, 0.779	0.00, 0.978
	Treatment† Year (F, P)	20.6, **0.002**	3.3, 0.106	12.85, **0.007**	10.35, **0.012**
Fescue pasture	Treatment (F, P)	43.62, **<0.001**	6.22, **0.037**	0.53, 0.489	0.17, 0.688
	Year (F, P)	137.32, **<0.001**	1.60, 0.242	2.88, 0.128	0.75, 0.413
	Treatment† Year (F. P)	7.50, **0.026**	9.39, **0.016**	0.32, 0.587	0.53, 0.486

† Data were log-transformed for the purposes of the analysis. Significant differences are marked in bold.

After 6 years of exclusion, in both types of grassland, we observed a slight downward trend in plant cover, richness and diversity in non-grazed plots, while these parameters appeared to increase in grazed plots, although statistically significant changes were only found in plant cover for FP (Tables 1 and 2). Nonetheless, this trend is reflected by significant interactions ("Treatment x Year") in "borreguil" pastureland for richness and diversity and, in FP, for plant cover. Regarding plant composition (richness and diversity), Sternberg *et al*. (2000) found that, in Mediterranean grassland, grazing altered the competitive interactions among species through livestock feeding preferences and shortfalls caused by biomass removal and trampling. This could enable the establishment of less competitive species, thus leading to an increase in species richness.

In "borreguil" pastureland, no significant differences were found between treatment and year for any of the species sampled (Table 3). Only tall graminoids increased in the second year (Table 3, $F = 8.96$, $p = 0.017$). In addition, significant or almost significant "Treatment x Year" interactions were found in *F. iberica* (F = 13.03, P = 0.007), small graminoids and legumes (F = 13.03 and 2.36, P = 0.051 and 0.057, respectively), indicating that exclosures seem to have a negative impact on their specific contributions (Table 3).

Dominant species in FP exhibited an opposite trend: *N. stricta* increased after 6 years of exclusion, whereas *F. iberica* decreased, as indicated by the "Treatment x Year" interaction (F = 13.17 and 7.58, P = 0.007 and 0.025, respectively; Table 3). Grasses were significantly higher in the non-grazed plots (F = 9.85, P = 0.013); on the other hand, legumes were higher in the grazed plots (F = 7.17, P = 0.028). The latter showed significant differences between years (higher in 2008, F = 10.21, P = 0.013) and in the interaction (F = 28.24, P = 0.001), indicating the negative effect of exclosures.

Table 3. Botanical composition of "borreguil" pastureland and FP for two different years and two grazing treatments. Mean values (%) ± s.e and ANOVA table. S.gram.: small graminoids (*Carex caryophyllea* Latour., *C. echinata* Murray, *C. nevadensis* Boiss. & Reut.). T. gram.: tall graminoids (*Carex camposii* Boiss & Reut., *C. paniculata* L.). CN: *C. nigra.* NS: *N. stricta*

	Borreguil				Festuca Pasture			
	2008		2014		2008		2014	
	N-grazed	Grazed	N-grazed	Grazed	N-grazed	Grazed	N-grazed	Grazed
Grasses	77.4 ± 10.5	68.4 ± 12	75.8 ± 13.2	69.6 ± 19.9	127.4 ± 6.9	104.60 ± 5.2	116.40 ± 2	106.4 ± 2.2
S. gram.	9.4 ± 3.0	10,0 ± 7.6	2.4 ± 1.47	16.6 ± 5.2	1.4 ± 1.4	4.0 ± 4.0	0.6 ± 0.6	8.0 ± 8.0
T. gram.	11.4 ± 6.8	3.0 ± 1.4	21 ± 11.6	5.2 ± 2.4	10.4 ± 6.5	3.4 ± 2.0	34.2 ± 20.1	3.4 ± 3.4
Legumes	20.0 ± 5.2	13.4 ± 6.1	5.6 ± 5.1	14.2 ± 3.9	63.6 ± 13.9	41.8 ± 7.7	1.6 ± 0.9	62 ± 8.5
AN	0.2 ± 0.2	0.6 ± 0.6	0	0	9.6 ± 9.6	2 ± 1.38	5.4 ± 5.4	8.4 ± 8.4
AO	2.6 ± 1.3	0.2 ± 0.2	2.4 ± 1.6	0.4 ± 0.2	1.6 ± 0.8	2 ± 1.05	17.2 ± 8.6	3.6 ± 2.01
CN	71.6 ± 7.4	69.6 ± 6.8	63.2 ± 3.7	75.4 ± 10.0	5.6 ± 5.6	2.2 ± 2.2	0.4 ± 0.4	0
FI	12.2 ± 2.2	6.6 ± 2.3	4.4 ± 3	15.8 ± 4.9	80.4 ± 8.3	64 ± 8.1	39.8 ± 7.6	72.4 ± 8.9
NS	59,6 ± 11,5	56,8 ± 13,4	68.6 ± 17.1	50.4 ± 20.0	33.4 ± 10.2	33.8 ± 11. 2	50.8 ± 14.2	19.8 ± 9.4

IV – Conclusions

Biomass production is the parameter which best reflects the effect of the factors studied (treatment and year): higher in the excluded plots and in 2014. Moreover, FP was more productive than "borreguil" pastureland. A slight downward trend can also be observed in plant cover, richness and diversity in non-grazed plots. Regarding floristic composition, the exclosures appear to have a negative effect on small graminoids (only in "borreguil" pastures), *F. iberica* and legumes; on the other hand, exclosures favour grasses, particularly *N. stricta* in FP. Nevertheless, our results indicate that, after 6 years of pasture exclusion, few differences between grazed and non grazed plots were found, except in relation to biomass production.

Acknowledgments

This study was funded by the regional government of Andalusia, Spain (ERDF funds) within the framework of the “Extensive Livestock and Biodiversity” project.

References

Bedia J. and Busqué J., 2013. Productivity, grazing utilization, forage quality and primary production controls of species-rich alpine grasslands with Nardus stricta in northern Spain. *Grass and Forage Science*, 68(2), 297-312.

Sternberg M., Gutman M., Perevolotsky A., Ungar E.D. and Kigel J., 2000. Vegetation response to grazing management in a Mediterranean herbaceous community: a functional group approach. *Journal of Applied Ecology*, 37(2), 224-237.