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# Evaluation of sheep grazing as a tool to restore mountain pastures invaded by *Euphorbia polygalifolia*

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**SUMMARY –** Two experiments were conducted to (i) study whether sheep grazing pastures infested by a spurge (*Euphorbia polygalifolia)* consume this invasive weed and its consequences on animal performance, and (ii) detect differences between sheep and cattle in ruminal degradation of infested pastures. In the first trial, sheep grazed fenced paddocks highly invaded by spurge at instantaneous stocking rates of 120 ewes/ha/week. Spurge offtake, sward height and ewes' body weight were measured weekly from mid-June to September. An average of 63% of the initial spurge growing points was defoliated per week. Sward height showed a negative curvilinear relationship with the proportion of spurge defoliated, with high spurge defoliation occurring when sward height was lower than 4 cm. Variation in body weight was mainly related to sward height ($r = 0.86$; $P<0.10$) and apparent signs of intoxication were never observed. In the second experiment, 6 cows and 8 ewes were distributed according to a factorial design: 2 species (cattle *vs* sheep) $\times$ 2 grazing areas (infested *vs* non-infested pastures). After seventeen days, rumen fluids were used to study ruminal fermentation of invaded and non-invaded pastures using the *in vitro* gas production technique. Gas production was always higher in sheep than in cows when the invaded substrate was incubated ($P<0.05$). The highest values were found in sheep grazing infested pastures and the lowest in cattle maintained in non-infested pastures. This suggests not only a better ruminal degradation of *E. polygalifolia* by sheep but also a likely adaptation to its consumption

**Keywords:** Cattle, ewes, rumen degradation, spurge offtake.

***RESUME*** *– "Evaluation d'ovins au pâturage comme instrument pour restaurer les pâtures de montagne infestées par* Euphorbia polygalifolia". *Deux expériences ont été réalisées (i) pour étudier si l'ovin au pâturage sur pâtures infestées par* Euphorbia polygalifolia *consomme cette mauvaise herbe envahissante et les conséquences sur les performances animales, et (ii) pour détecter des différences entre les ovins et les bovins dans la dégradation ruminale de ces pâturages infestés. Dans la première expérience, les ovins ont été sur des prés clôturés fortement envahis par* E. polygalifolia *aux taux instantanés de 120 brebis/ha/semaine. L'utilisation de* E. polygalifolia*, la hauteur de l'herbe et le poids des ovins ont été mesurés une fois par semaine à partir de la mi-juin jusqu'en septembre. Une moyenne de 63% des points initiaux de croissance d'*Euphorbia *a été défeuillée par semaine. La hauteur de l'herbe a montré un rapport curviligne négatif avec la proportion de* E. polygalifolia *défeuillée, avec un maximum de défoliation quand la hauteur de l'herbe était inférieure à 4 cm. La variation du poids corporel a été principalement liée à la hauteur de l'herbe ($r = 0,86$ ; $P<0,10$) et on n'a jamais observé de signes apparents d'intoxication. Dans la deuxième expérience, 6 vaches et 8 brebis ont été distribuées selon un modèle factoriel : 2 espèces (bovins* vs *ovins)* $\times$ *2 zones de pâturage (pâtures infestées* vs *non infestées). Après dix-sept jours, des fluides de rumen ont été employés pour étudier la fermentation ruminale des pâturages envahis et non envahis en utilisant la technique in vitro de production de gaz. La production de gaz était toujours plus haute chez les ovins que chez les bovins quand le substrat envahi était incubé ($P<0,05$). Les valeurs les plus élevées ont été trouvées chez les brebis sur pâturages infestés et le plus bas dans les vaches sur pâturages non infestés. Ceci suggère non seulement une meilleure dégradation ruminale de* E. polygalifolia *par les ovins mais également une adaptation probable à sa consommation.*

***Mots-clés :*** *Bovin, ovin, dégradation ruminale, utilisation d'*Euphorbia polygalifolia*.*

## Introduction

As a result of its invasive behaviour and rejection by cattle, a species of spurge, *Euphorbia polygalifolia*, is becoming a serious threat to the productivity of mountain pastures of the Cordillera Cantábrica, in the north of Spain (Busqué *et al.*, 2004). Sheep have been reported to consume considerable amounts of another species of highly invasive spurge (*Euphorbia esula*) in rangeland ecosystems of North America, thus promising to be a cost-effective biological control agent (Bangsund *et al.*, 2001).

Differences between sheep and cattle on foraging on species of spurge may be related to differences in rumen microbial activity and capacity to tolerate or degrade plant secondary compounds (Kronberg and Walker, 1993).

This work was conducted with the aims of: (i) studying whether sheep grazing infested pastures consume *E. polygalifolia* and its consequences on animal performance; and (ii) detecting differences between sheep and cattle in ruminal degradation of pastures infested by *E. polygalifolia*.

## Material and methods

Two experiments based on livestock grazing on summer pastures of mountain areas in Northern Spain (puertos de Sejos, Cordillera Cantábrica; 1,200 hectares at a mean altitude of 1,700 m) were carried out. Pastures are communal property and support relative high stocking rates (1-2 LSU/ha) by free-ranging cattle from June to September. Vegetation is a complex mixture of different plant communities, where herbaceous species (*Agrostis-Festuca-Nardus-Euphorbia*) and dwarf shrubs (*Calluna-Erica*) dominate.

### Experiment 1

The first experiment was conducted in the summer of 2003 and was part of a more complex factorial design to study the effects of sheep grazing on spurge performance. In this experiment, sheep of Lacha breed with mean body weights of 41.2 kg (SD, 4.21) grazed grasslands with high spurge coverage at instantaneous stocking rates of 120 ewes/ha (24 ewes in paddocks of 2,000 $m^2$). Paddocks were set immediately before each grazing week (12 weeks in total, from mid-June to September) using electric mesh fences.

Within each paddock, three permanent quadrats of 10×10 cm on spurge patches were established. The number of spurge growing points within the quadrats was counted immediately before and after each grazing week. In the last six weeks, sward height and body weight of ewes were also measured. Sward height was measured on grassland patches free of spurge and *Nardus*, as this species is known to be less preferred by sheep ("preferred herbage height"). Body weight was measured at the end of each grazing week.

An analysis of variance was carried out to test the main effect of period of the grazing season (initial, mid and end of summer) on the proportion of spurge growing points at the end of the grazing week with respect to the initial number ("spurge offtake"). Correlation and regression analyses were performed to study the relations among spurge offtake, sward height and daily body weight changes. All analyses were conducted using the Statistical Package for Social Sciences 9.0 (SPSS, 1999).

### Experiment 2

Six cows and 8 ewes were distributed into 4 treatments, according to a factorial design: 2 species (cattle *vs* sheep) × 2 grazing areas (infested *vs* non-infested pastures; +EP *vs* −EP) and located in four experimental paddocks (between 4,000 and 10,000 $m^2$). Two paddocks were set in the area infested by *Euphorbia polygalifolia* and the other two in the non-infested area.

After seventeen days and an overnight fast, rumen fluid (RF) was obtained from each animal, by stomach tube, mixed to prepared two different rumen fluids (replicates) per treatment, and used as microbial inoculum to study ruminal fermentation of invaded (46% of *E. polygalifolia*: 112 g CP/kg DM; 471 g NDF/kg DM; 247 g ADF/kg DM) and non-invaded pastures (131 g CP/kg DM; 570 g NDF/kg DM; 252 g ADF/kg DM) using an *in vitro* gas production technique (Theodorou *et al.*, 1994). Immediately after withdrawal, RF were placed in plastic containers, stored in a chest with crushed ice, and taken to the laboratory within 4 hours (Hervás *et al.*, in press). For each of the 4 treatments, 6 samples [2 replicates (inocula); 3 flasks/replicate] of each substrate (≈500 mg) were incubated in sealed serum flasks at 39ºC with 10 ml strained RF and 40 ml medium (1:4, v:v; McDougall, 1948). Gas production was measured at 6, 12, 24, 46, 72 and 120 h. Pressure values, corrected for the

quantity of substrate organic matter (OM) incubated and gas released from controls (*i.e.*, rumen fluid plus buffer medium, without substrate), were used to generate gas volume estimates using a predictive equation derived from earlier simultaneous pressure and volume measurements (Hervás *et al.*, 2005).

Procedures described by AOAC (1999) were used to determine DM, ash and Kjeldahl nitrogen (CP = 6.25 × N). Neutral-detergent fibre (NDF), and acid-detergent fibre (ADF) were determined by the methods of Van Soest *et al.* (1991) and Goering and Van Soest (1970).

Data were analysed using the GLM procedure (General Linear Models) of the Statistical Analysis Systems (SAS, 1999).

## Results and discussion

Weekly spurge offtake did not change significantly with the grazing period along the summer (initial *vs* mid *vs* end of summer; P>0.10). An average of 63% (0.92 ± 0.07 s.e. corresponding to the arcsin of the square root of the variable) of the initial spurge growing points disappeared after each grazing week.

A complemented Weibull function (Haefner, 1996) explained significantly (P<0.05) most of the variance of the relationship between preferred herbage height at the start of each grazing week and spurge offtake (Fig. 1). This relationship shows high levels of spurge offtake at sward heights lower than 4 cm, and a steep decrease above that value. Similar patterns have been found in *Nardus* dominated grasslands, where the height of the preferred sward component determined the level of offtake by sheep of the non-preferred *Nardus* (Gordon, 2000), and in *Calluna*-grassland mosaics, with high increases in *Calluna* intake by sheep when preferred herbaceous height reached values below 3 cm (Oliván and Osoro, 1998).

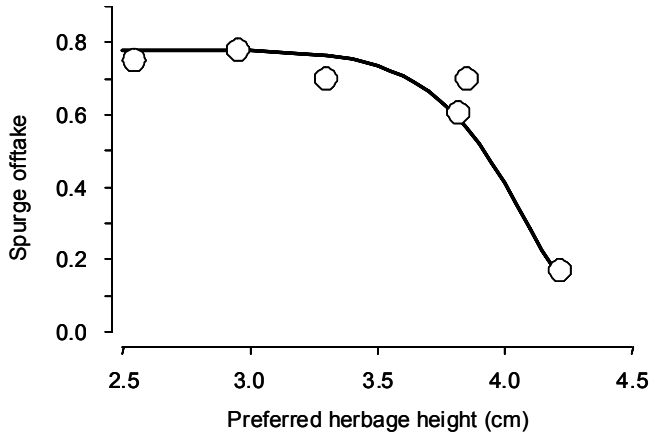


Fig. 1. Relationship between preferred herbage height and spurge offtake (proportion of growing points defoliated) by sheep. The line corresponds to the fitted Weibull function $y = 0.78 \times \exp[-(x / 4.1)^{18}]$ ($R^2 = 0.88$; P = 0.004).

Daily variation in ewe's body weight showed significant correlation (r=0.86; P=0.06) with preferred herbage height, but not with spurge offtake. Figure 2 shows some positive values in mean daily weight variation linked to high spurge offtakes, suggesting the absence of negative short-term effects associated with spurge intake. Apparent signs of intoxication were never observed.

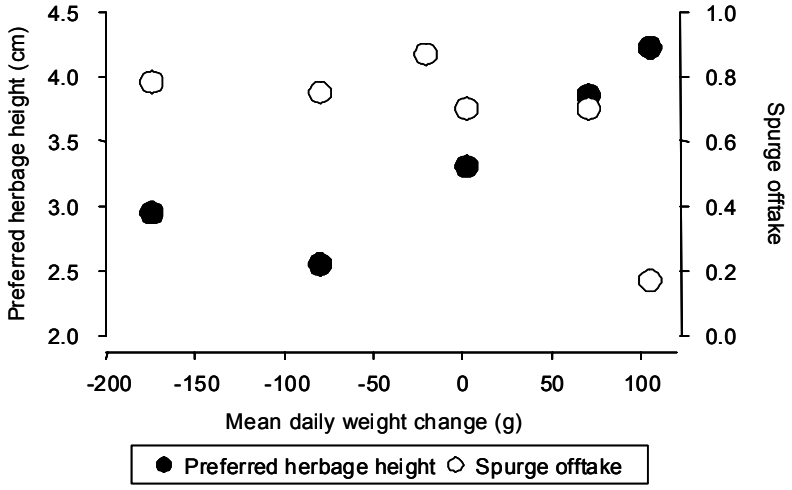


Fig. 2. Relationships between herbage height of the preferred plant species, spurge offtake (proportion of growing points defoliated) and mean daily weight change in ewes.

In the second experiment, gas production was always higher in sheep than in cows when the invaded substrate was incubated (P<0.05). On the other hand, no significant differences were in general found with the non-invaded substrate (see Table 1). These results are consistent with previous reports that rumen microbial populations in different ruminant species can have different capacities for degrading foods and, more specifically, foods containing secondary compounds (Duncan *et al.*, 1997). Working with *Euphorbia esula* Kronberg and Walker (1993) suggested that goats, compared to sheep, would have a greater capacity to degrade certain leafy spurge toxins.

Table 1. Cumulative gas production (ml/g OM) at 6, 12, 24, 46, 72 and 120 hours from two substrates [invaded pastures (by *Euphorbia polygalifolia*) *vs* non-invaded pastures] incubated *in vitro* with rumen inoculum from cattle or sheep grazing in paddocks infested (+EP) or non-infested (–EP) by *Euphorbia polygalifolia*

| | | Cattle | | Sheep | | sed | Significance level (P) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | +EP | -EP | +EP | -EP | | Animal sp. | Grazing area | Sp ×Grazing area |
| 6 h | Invaded | 39$^{bc}$ | 36$^{c}$ | 76$^{a}$ | 55$^{b}$ | 5.9 | *** | ** | * |
| | Non-invaded | 37 | 34 | 52 | 46 | 5.7 | ** | NS | NS |
| 12 h | Invaded | 77$^{bc}$ | 74$^{c}$ | 125$^{a}$ | 95$^{b}$ | 7.7 | *** | ** | * |
| | Non-invaded | 75 | 68 | 87 | 83 | 9.7 | NS | NS | NS |
| 24 h | Invaded | 121 | 121 | 163 | 149 | 11.1 | ** | NS | NS |
| | Non-invaded | 135 | 132 | 133 | 138 | 12.7 | NS | NS | NS |
| 46 h | Invaded | 162 | 155 | 197 | 191 | 13.8 | ** | NS | NS |
| | Non-invaded | 193 | 190 | 190 | 200 | 15.4 | NS | NS | NS |
| 72 h | Invaded | 188 | 184 | 234 | 231 | 19.5 | ** | NS | NS |
| | Non-invaded | 236 | 233 | 240 | 248 | 16.1 | NS | NS | NS |
| 120 h | Invaded | 228 | 233 | 274 | 273 | 21.4 | ** | NS | NS |
| | Non-invaded | 266 | 272 | 279 | 280 | 15.6 | NS | NS | NS |

sed = standard error of the difference. Mean values with different letters, in the same row, differ significantly (P<0.10)
NS = non-significant (P>0.10); * = P<0.10; ** = P<0.05; *** = P<0.01.

Differences between sheep and cows were stronger at short post-incubation times (6 and 12h;

species × treatment interaction, P<0.10), where the highest value was observed in sheep grazing infested pastures and the lowest in cattle maintained in non-infested pastures (*e.g.*, 76 *vs* 36 ml/g OM at 6h). Grazing in areas infested by *Euphorbia polygalifolia* seems to improve the ability of ruminants to degrade the invaded substrate. In this respect, it has been demonstrated that a gradual increase in the intake of a secondary compounds-containing plant increases the ability of the ruminant to tolerate or degrade it (Domínguez-Bello, 1996; Duncan *et al.*, 2000), generally because of an adaptation of the rumen microbial population.

## Conclusion

Results of the first trial show that sheep grazing can produce high levels of *Euphorbia polygalifolia* offtake without noticeable adverse effects on animal performance. Results of the second trial suggest not only a better ruminal degradation of this species of spurge by sheep with respect to cattle but also a likely adaptation to its consumption. Therefore, we conclude that sheep grazing can be an effective tool to restore mountain pastures invaded by *E. polygalifolia.*

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