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Atlantic mountain grassland-heathlands: structure and feeding value

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Abstract

Atlantic mountain pastures are composed by mosaics of semi-natural grasslands and heathlands. A knowledge of their structure and feeding value is useful to understand their livestock use and improve management of these communities. This study was carried out in the Gorbeia Natural Park in northern Spain. Pasture composition, sward height and nutritive value were measured over four grazing seasons (spring, summer, late summer and autumn) in three plant communities: grassland (GR), open heathland (OH) and dense heathland (DH). The grassland community had lower sward height and better nutritive value. In less favoured grazing periods, when sward height in GR becomes limiting livestock move to OH with higher pasture height and lower sward cover and nutritive value. Even both heathlands have similar height and quality, the selection of OH, and avoiding of the dense one, could be due to its higher sward cover, which could make it easier to look for feed. Moreover, considering the woody component the estimated nutritive value of DH does not cover the minimum required for livestock production.

Additional key words: nutritive value, pasture composition, sward, shrublands.

Resumen

Pastos herbáceos y brezales de la montaña atlántica: estructura y valor nutritivo

Los pastos de las zonas de montaña atlántica están compuestos por comunidades herbáceas en combinación con brezales. El conocimiento de su estructura y valor nutritivo resultan útiles para entender su utilización por el ganado y mejorar el manejo de estas comunidades. El estudio se llevó a cabo en el Parque Natural de Gorbeia (Norte de España). La composición del pasto, la altura de la hierba y el valor nutritivo se midieron en cuatro estaciones de pastoreo (primavera, verano, finales de verano y otoño) en tres comunidades vegetales: pasto herbáceo (GR), brezal ralo (OH) y brezal denso (DH). Los pastos herbáceos presentaron menor altura y mejor valor nutritivo. En los periodos menos favorables, cuando la altura de la hierba se vuelve limitante, el ganado se mueve al OH, donde la altura es mayor, aunque la cobertura herbácea y su calidad sean menores. Aunque ambos brezales tengan una altura y calidad similar, la selección del OH puede ser debida a la mayor cobertura de hierba, lo que hace que la búsqueda de alimento sea más fácil. Además, cuando en la estimación de la calidad se considera el componente arbustivo, el DH no cubre los mínimos para mantener al ganado.

Palabras clave adicionales: composición del pasto, pastos arbustivos, pastos herbáceos, valor nutritivo.

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Abbreviations used: ADF (acid detergent fibre), ADL (acid detergent lignin), AU (animal unit), CC (soluble cellular component), CP (crude protein), DH (dense heathland), GR (grassland), h (heather), hg (heather + gorse), asl (above sea level), NDF (neutral detergent fibre), NV (nutritive value), OH (open heathland), PD (potential digestibility), RA (relative abundance), SD (standard deviation), sh (sward + heather), shg (sward + heather + gorse).

Introduction

Atlantic mountain pastures are composed of a mosaic of semi-natural grasslands and heathlands. In western Europe there are extensive regions dominated by these heathlands (Alonso *et al.*, 2003). Considering in Atlantic and the Pyrenean pastures, mountain shrubland represent about 14% of the area (Osoro *et al.*, 1999). The ecological value of these communities is considered in natural habitats of community interest (Habitats Directive 97/62/EU; OJ, 1997).

Traditionally, a significant proportion of livestock has ranged over these pastures from late spring to autumn in a mixed, unguarded system, with several breeding and grazing calendars, stocking rates, etc. In recent decades these areas have suffered remarkable changes in land abandonment, use and livestock systems. As results of this a trend of shrub encroachment into grasslands and open heathlands is being observed (Amezaga *et al.*, 2004; Bartolome *et al.*, 2005; Bernues *et al.*, 2005; Casasus *et al.*, 2005; Mandaluniz *et al.*, 2007), reducing their biodiversity. A similar trend has been observed in many parts of the world during last century (Distel *et al.*, 1995; Ghersa *et al.*, 2002; Goslee *et al.*, 2003).

Knowledge of the structure and feeding value to these communities could be useful in understanding their livestock use, as they are considered as a potential tool to manage these communities. The importance of heathlands as feedstuff has been reported by several authors (Papachristou and Nastis, 1996; Torrano, 2001; Frutos *et al.*, 2002; Hervas *et al.*, 2003; Ammar *et al.*, 2004; Riedel, 2004; Rogosic *et al.*, 2006; Osoro *et al.*, 2007), but many of the reports focussed on sward or woody component independently and there are not many evaluations which consider both components together. Knowledge of parameters such as structure and feeding value of these areas could give a useful approach to the study of these systems making them compatible for both, livestock production and conservation.

The objectives of this paper were to (i) determine pasture composition (plant cover of botanical groups), (ii) analyse herbage height, (iii) analyse the nutritive value of the different plant components, sward and shrubs, and (iv) estimate the average nutritive value considering the sward and woody components of the different plant communities in Atlantic mountain pastures.

Material and methods

Study areas

The study was carried out in the Gorbeia Natural Park (43ºN 2.5ºW) in the Atlantic region of the Basque Country of northern Spain. This protected natural area is near the Cantabric Sea, with an area of 20,016 ha with altitude between 320 and 1,482 m asl. Geologically, sedimentary rocks are dominant and round siliceous hills and abrupt limestone cliffs are combined in the park. The annual rainfall is 1,000-1,300 mm with a maximum of 2,000 mm in the hills and the annual average temperature is 8-12ºC.

The Park is mainly covered in native forests (mainly *Fagus sylvatica* in the North and *Quercus pyrenaica* in the South), grassland and shrubland cover about 25% of the Park (1,338 and 3,576 ha, respectively). The average stocking rate for grazing is 0.75 animal units (AU) ha^{-1}, with a heterogeneous pressure, from 0.27 to 1.72 AU ha^{-1}, depending on plant community (Casasús *et al.*, 2005).

Two traditional grazing areas, in the limestone area, in the Park were selected for the study. They were located between 900-1,300 m asl. Three plant communities were defined: (*i*) grassland (GR), composed of *Festuca rubra*, *Agrostis capillaris* and *Trifolium repens*; (*ii*) open heathland (OH), composed of herbage and a mosaic of heather (*Erica vagans* and *E. cinerea*) with cover of less than 50% and (*iii*) dense heathland (DH), in which heathers (mainly *E. vagans, E. cinerea, E. tetralix* and *Calluna vulgaris*), gorse (*Ulex europaeus)* and fern (*Pteridium aquilinum)* cover more than 50% of the surface.

Sampling for plant composition, height and nutritive value was carried out in spring; (end of May and June); summer: (July-August); late summer: (September) and autumn: (October-early November) throughout the grazing period.

Pasture structure

Pasture composition

The composition of each of three plant communities was determined by the point intercept method on 5-10 parallel transects (minimum separation of 10 m between them) according to community availability in each grazing area. Transects were 20 m long and vertical interceptions were made at every 20 cm giving 100 contacts per transect. Plants contacted at each point were grouped into the following botanical groups: graminoids (including species of the families Poaceae, Juncaceae and Cyperaceae), non-graminoids (including all dicotyledons and non-graminoid monocotyledons), heather (*Erica* ssp. and *Calluna vulgaris*), gorse (*Ulex* ssp.), fern (*Pteridium aquilinum*) and "others" (litter, dead material, bare ground, dung).

Pasture composition was estimated as plant cover (%) of botanical groups in each community.

Herb-layer height

Herb-layer height was measured with a manual stick (HFRO, 1979), to 0.5 cm precision. It was measured randomly counting 100 points in each plant community. Measurements were taken from communities grazed by cows (GR, OH and DH) by monitoring herds during the same seasons of the year (spring, summer, late summer and autumn). Measurements were taken at six different times during the day (7:00, 9:00, 11:00, 16:00, 18:00 and 20:00).

Forage nutritive value

Forage samples for nutritive value determination were taken from these samples, giving 46 herbaceous, 42 *Erica* ssp. and 26 *Ulex europaeus* samples. Herbage samples were taken by "hand plucking" simulating cattle grazing (WallisDeVries, 1995). This allows samples to be taken which are similar to what is eaten by cows. Shrubby vegetation was sampled by cutting distal buds of shrubs with scissors (simulating browsing). A subsample of each herbaceous sample was processed in the laboratory separating graminoids and non-graminoids by hand.

All samples were dried in an oven (60ºC, 48-96 h) and ground to 1 mm. Forage nutritive value was estimated by crude protein (CP) and potential digestibility (PD). Nitrogen content was determined by Kjeldalh (AOAC, 1999) and converted into CP by multiplying by 6.25. Fibre was analysed by Ankom 220 according to the Van Soest (1982) method and PD was estimated by the Equation 1 following Van Soest (1982):

$$PD = 0.98CC + \{[147.3-78.9 \log (100ADL/ADF)] \times NDF/100\} \quad [1]$$

where CC is the soluble cellular component (CC = total sample-NDF), ADL = acid detergent lignin, ADF = acid detergent fibre and NDF = neutral detergent fibre.

The mean nutritive value of each community (Y_{ij}) was estimated considering the nutritive value of each component (grass, heather and gorse) to their plant cover in each community, considering sward + heather (sh) or sward + heather + gorse (shg) as feedstuff [Equation 2]. Fern and "others" were not considered.

$$Y_{ij}=\sum RA_{ij} \times NV_i \quad [2]$$

where RA_{ij} is the plant cover of *i* component (% grass, % heather or % gorse) on *j* plant community (GR, OH and DH) and NV_i is the nutritive value (CP and PD) of *i* component.

Data analysis

Mean values are given with standard deviation (mean ± SD). All data were analysed using the Statistical Analysis System (SAS, 2003). One-way ANOVA model, including grazing season (spring, summer, late summer and autumn), and plant community (GR, OH and DH) as fixed effects were used to analyse plant cover (graminoids, non-graminoids, heather, gorse, and "others"), herb-layer height and feeding value (CP, fibres and PD). Multiple mean comparisons were analyzed using the T-test and differences were declared significant at $P < 0.05$.

Independent analysis of variance was used to analyse the effect of the different parameters of nutritive value (CP and PD) of heathlands considering: only sward, sward + heather, or sward + heather + gorse.

Results

Pasture structure

Pasture composition

The pastures were mainly composed of herbaceous plants (62%, being 43% graminoids and 19% non-graminoids), followed by shrubs (23%, being 12% heather and 11% gorse). The rest of the land surface was covered by "others" (15%) (Table 1). Pasture composition was significantly affected by plant community (Table 1); herbaceous groups covered 97% in GR, 58% in OH and only 29% in DH, while shrubs covered 0%, 34% and 40% in each community, respectively. Other components as "others" comprised the rest of the cover in each plant community at 3%, 8% and 31 %, respectively.

Table 1. Pasture composition, pasture height and nutritive value (CP, fibres and PD) by plant herbage community and shrubs in the Natural Park of Gorbeia

	Mean values	P value [2]	Plant community [1]		
			GR	**OH**	**DH**
Herbage height (cm)	4.53 ± 2.9	**	$3.3^{a} \pm 0.1$	$4.2^{b} \pm 0.1$	$4.2^{b} \pm 0.1$
Plant cover (%)					
– Graminoids	42.5 ± 21.9	***	$65.6^{a} \pm 3.4$	$40.3^{b} \pm 4.7$	$20.6^{c} \pm 3.4$
– Non-graminoids	19.2 ± 13.0	**	$31.1^{a} \pm 3.4$	$18.0^{ab} \pm 4.8$	$8.0^{b} \pm 3.4$
– Heather	12.2 ± 12.1	***	$0.2^{a} \pm 0.5$	$30.5^{b} \pm 0.7$	– $15.0^{c} \pm 0.5$
– Gorse	10.6 ± 12.7	***	$0.0^{a} \pm 1.8$	$3.3^{a} \pm 2.6$	$24.9^{b} \pm 1.8$
– “Others”	15.4 ± 13.8	***	$3.2^{a} \pm 0.8$	$7.7^{b} \pm 1.1$	$31.4^{c} \pm 0.8$
Herbage nutritive value (%)					
– CP[3]	14.5 ± 3.6	Ns	13.5 ± 0.8	14.8 ± 1.1	13.3 ± 0.6
– ADF	36.3 ± 5.8	Ns	36.1 ± 0.8	36.4 ± 1.0	38.1 ± 0.6
– ADL	8.6 ± 3.0	*	$7.0^{a} \pm 0.5$	$9.1^{b} \pm 0.7$	$9.0^{b} \pm 0.4$
– NDF	61.9 ± 7.5	Ns	62.7 ± 1.2	64.7 ± 1.5	63.0 ± 1.0
– PD	76.6 ± 13.6	*	$72.8^{a} \pm 3.9$	$60.9^{b} \pm 4.8$	$61.9^{b} \pm 3.1$
		Species (S)			
		P value	**Heather**	**Gorse**	
Wood nutritive value (%)					
– CP	10.7 ± 3.4	***	$9.7^{a} \pm 0.4$	$14.0^{b} \pm 0.4$	
– ADF	44.2 ± 8.6	Ns	45.2 ± 1.9	43.4 ± 1.9	
– ADL	25.8 ± 10.3	**	$31.8^{a} \pm 1.9$	$15.5^{b} \pm 1.9$	
– NDF	56.9 ± 7.0	*	$55.3^{a} \pm 1.5$	$61.0^{b} \pm 1.5$	
– PD	49.7 ± 11.1	**	$45.6^{a} \pm 2.9$	$59.2^{b} \pm 2.9$	

[1] GR: semi-natural grassland, OH: open heathland and DH: dense heathland. [2] ***, P<0.001; ** , P<0.01; *, P<0.05; Ns: P>0.05. Lsmeans with different superscripts are different (P<0.05) within each line of each factor. [3] CP: Crude protein; ADF: acid detergent fibre; ADL: lignin; NDF: Neutral detergent fibre; PD: potential digestibility [Equation 1].

As the grazing period progresses heather cover increased significantly (Table 2), while the other groups did not change.

Herb-layer height

Mean herbage height was 4.5 ± 2.9 cm and was affected by plant community and grazing season (Figure 1a). Grassland had a significantly lower herb-layer height than heathlands (Table 1) and the herb-layer was significantly taller in spring and decreased significantly during the grazing season (Table 2).

Pasture nutritive value

Sward nutritive value

Herbage CP and PD mean values were 14.1 ± 2.9% and 65.8 ± 9.2%, respectively, the non-graminoids had higher values than the graminoids (16.3 ± 3.45 *vs* 13.8 ± 3.4% and 84.0 ± 15.9% *vs* 72.9 ± 14.8%, respectively). These nutritive value means differed significantly according to the plant community and grazing season (Figure 1b). Grassland herbage had significantly lower ADL values and higher PD values than heathlands, which were similar to each other (Table 1). Over time the CP and PD values were highest in spring and summer, and fell in late summer. This reduction was significant for CP but not significant for PD (Table 2). This change coincided with a significant increase in fibre content after summer.

Shrub nutritive value

Generally shrubs had lower nutritive values than the herbaceous component (CP = 11.4 ± 3.5% and PD = = 52.2 ± 9.6%). These values were significantly affected by species (heather or gorse) and grazing season. Gorse had higher CP values than heather and was similar to the herbs (Table 1). In contrast, the gorse PD was higher than in heather, but lower than in herbs. In the case of fibre, heather had a significantly higher ADL

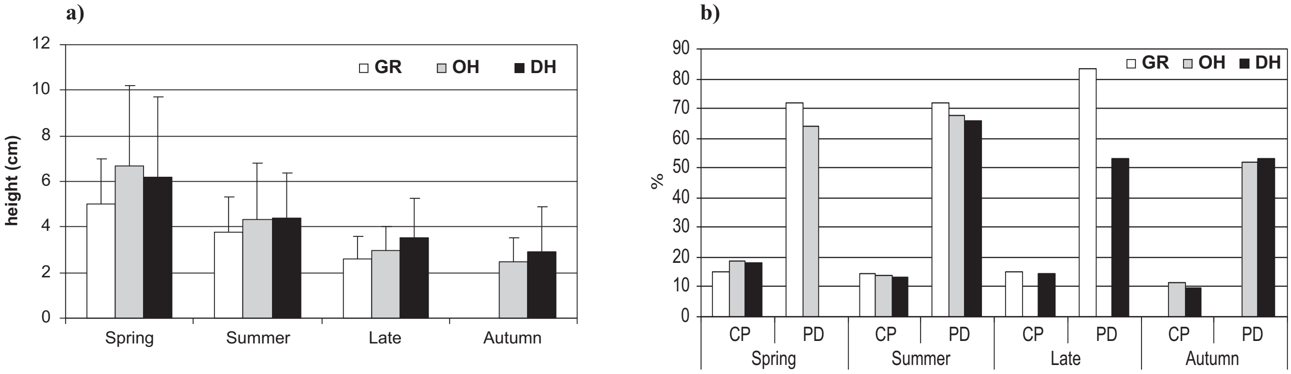

Figure 1. Mean values of herbage height (a) and nutritive value (CP, crude protein, PD, potential digestibility, %) (b) of grassland (GR), open heathland (OH) and dense heathland (DH) over the grazing season (Spring, Summer, Late Summer and Autumn).

and NDF content than gorse, but a similar ADF. Over time the trend in shrubs was similar to that in the herbs with a significant fall in CP and a significant rise in fibre after summer (Table 2).

Nutritive value of heathlands considering the woody component

The woody component significantly reduced the nutritive value (CP and PD) of both heathlands. The reduction was greater in the dense area (Figure 2). There was no significant difference between heather (h) or heather + gorse (hg) for CP (11.1_h% *vs* 11.6_{hg}%) and PD (48.7_h% *vs* 50.6_{hg}%) in open heathland. However in dense heathland there was a similar CP (6.1_h% *vs* 8.7_{hg}%) but a significantly lower PD (25.3_h% *vs* 39.5_{hg}%) when only considering the heather.

Discussion

Sward height in the study area was similar to reported for other Atlantic mountain pastures (Osoro *et al.*, 1999) but lower than that cited for Pyrenean pastures (Riedel, 2004). As in these Atlantic latitudes pasture growth is seasonal, pasture height was reduced over the grazing season. If adequate pasture availability, for livestock production in these ranges, is > 4 cm (Wright and Russel, 1987; Osoro *et al.*, 1999), this amount is present until late summer.

Where pasture height is near the limit for grazing, pasture nutritive value is as important as availability. The mean sward nutritive value was adequate for livestock maintenance (AFRC, 1995), but lower than that reported for grasslands of Atlantic and Pyrenean mountains (Aldezabal, 1997; Marinas *et al.*, 2003). This was a consequence of considering sward from

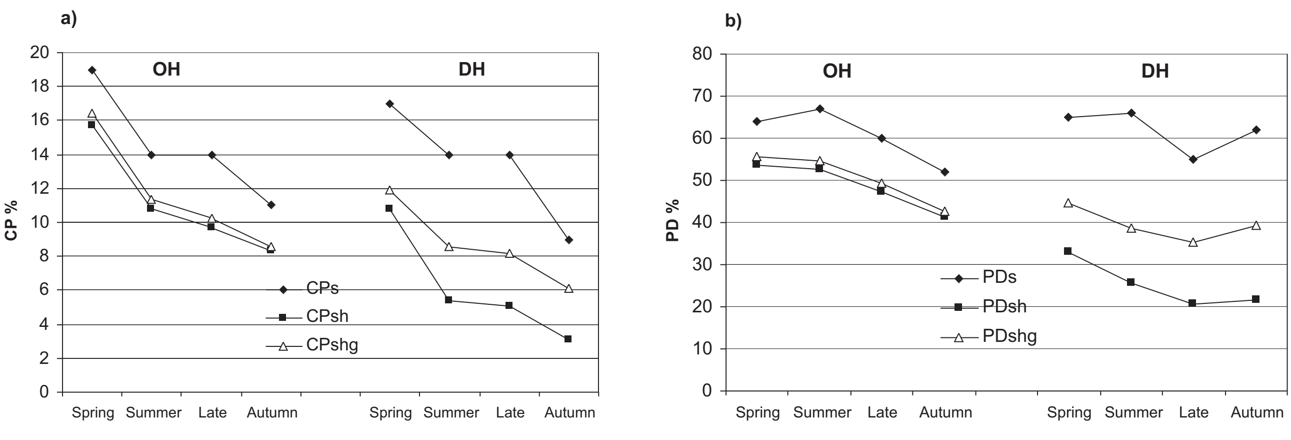

Figure 2. Nutritive value corrected by composition of open (OH) and dense heathlands (DH) over the grazing season. a: Crude protein (CP) and b: potential digestibility (PD) of sward (s), sward + heather (sh) and sward + heather + gorse (shg).

Table 2. Pasture composition, pasture height and nutritive value (CP, fibres and PD) by grazing season (GS) of herbage and shrubs in the Natural Park of Gorbeia

	Grazing season (GS)				P value[1] (GS)
	Spring	Summer	Late Summer	Autumn	
Herbage height (cm)	$6.3^a \pm 0.1$	$4.7^b \pm 0.1$	$3.6^c \pm 0.1$	$2.9^d \pm 0.1$	**
Plant cover (%)					
– Graminoids	45.4 ± 4.5	39.7 ± 4.5	40.0 ± 4.5	43.5 ± 4.5	Ns
– Non-graminoids	22.1 ± 4.5	21.7 ± 4.5	18.8 ± 4.5	13.5 ± 4.5	Ns
– Heather	$11.5^a \pm 0.6$	$13.9^b \pm 0.6$	$17.1^c \pm 0.6$	$18.5^c \pm 0.6$	**
– Gorse	8.0 ± 2.5	8.9 ± 2.5	9.7 ± 2.5	11.0 ± 2.5	Ns
– "Others"	13.0 ± 1.0	15.5 ± 1.0	14.3 ± 1.0	13.4 ± 1.0	Ns
Herbage nutritive value (%)					
– CP[2]	$16.8^a \pm 0.8$	$14.4^a \pm 0.8$	$14.7^a \pm 1.1$	$9.6^b \pm 1.1$	**
– ADF	$30.8^a \pm 0.7$	$32.9^a \pm 0.7$	$39.9^b \pm 1.0$	$43.8^c \pm 1.0$	***
– ADL	$6.4^a \pm 0.5$	$6.5^a \pm 0.5$	$7.5^b \pm 0.7$	$8.9^c \pm 0.7$	**
– NDF	$57.3^a \pm 1.3$	$57.9^a \pm 1.2$	$63.1^b \pm 1.6$	$75.4^c \pm 1.6$	***
– PD	69.1 ± 3.2	68.7 ± 4.3	65.2 ± 4.4	65.1 ± 4.9	Ns
Wood nutritive value (%)					
– CP	$16.3^a \pm 0.7$	$12.2^b \pm 0.5$	$10.6^{bc} \pm 0.5$	$8.4^c \pm 0.5$	***
– ADF	$35.6^a \pm 2.9$	$39.3^a \pm 2.5$	$50.6^b \pm 2.5$	$51.6^b \pm 2.9$	**
– ADL	$15.8^a \pm 2.9$	$20.3^a \pm 2.5$	$28.6^b \pm 2.5$	$30.1^b \pm 2.9$	*
– NDF	$52.6^a \pm 2.3$	$53.^{5a} \pm 1.9$	$62.5^b \pm 1.9$	$64.0^b \pm 2.3$	**
– PD	56.9 ± 4.4	53.4 ± 3.7	48.7 ± 3.7	50.5 ± 4.4	Ns

[1] ***, P<0.001; ** , P<0.01; *, P<0.05; Ns: P>0.05. Lsmeans with different superscripts are different (P<0.05) within each line of each factor.
[2] CP: Crude protein; ADF: acid detergent fibre; ADL: lignin; NDF: Neutral detergent fibre; PD: potential digestibility [Equation 1].

heathlands as a feedstuff and extending the grazing season to October. Considering only the grasslands from June to September the nutritive value was similar to that reported by these authors (12-19% PB and 46-57% PD).

Coinciding with sward height reduction, nutritive value showed the same seasonal variation. Reduction of pasture quality by late summer could be due to plant maturation and its negative effect on nutritive value, due mainly to a low ratio leaf:stem ratio (Arzani *et al.*, 2004). During the first part of the grazing season the livestock are mainly on grassland (Casasus *et al.*, 2005), which could be due to its higher sward cover, absence of a woody component and higher nutritive value, even at lower pasture heights. In unfavourable grazing seasons, as summer evolves, livestock must select between feed quantity of quality, i.e.: the grasslands are lower in height, while the heathlands have lower nutritive value (Figure 1). Under this scenario, quantity becomes most limiting and the animals change from grassland to heathland (Casasus *et al.*, 2005).

In the shrubby communities, OH and DH are even in sward height (4.2 cm in both communities), woody cover (34_{OH}% *vs* 40_{DH}%) and feeding value (PD=60.9_{OH} % *vs* 61.9_{DH} %) (Table 1), very different livestock pressure is observed. The higher pressure on open heathland could be due to its higher sward (58_{HH} % *vs* 29_{DH} %) and lower "others" content (8_{OH} % *vs* 31_{DH} %), which reduces the difficulty of finding sward between shrubs. Moreover, consideration of the woody component as a feedstuff can also help to explain these differences. In this approximation, the question is which element needs to be considered as feedstuff to better simulate grazing of the different plant communities. According to the literature, the value of shrubs as a feedstuff depends on the plant and the animal species (Osoro *et al.*, 2000; Pande *et al.*, 2002; Lopez, 2006; Rogosic *et al.*, 2006).

The mean nutritive value of heathlands is obviously higher when only considering the sward component and is reduced when heather and gorse are included as feedstuffs (Figure 2), due to their lower nutritive value. This reduction in nutritive value is greater on dense heathland, where the woody component cover is higher and nutritive value falls to CP < 10% and PD < 40%. This effect is more marked considering that the main animal species on these ranges, cattle and sheep, consume heather but do not consume gorse (Osoro *et al*., 2000; Mandaluniz *et al*., 2004). Under these conditions the nutritive value of open heathland is similar due to its low gorse content, while it is also much lower in DH. In this community the nutritive value reaches the non-acceptable threshold for the maintenance needs of the animals (AFRC, 1995).

In conclusion, Atlantic limestone semi-natural grasslands show adequate pasture height and nutritive value for livestock production until the late summer. When grazing season becomes unfavourable, in late summer and autumn, the sward height becomes limiting in the grassland. The open heathland could be adequate for feeding livestock due to its greater pasture height and adequate nutritive value.

The different animal pressure on open and dense heathlands can be explained by their different plant composition and nutritive value of the shrub species. The closer the estimated feeding value is to the grazing experienced the easier it will be to explain livestock responses and the ranged will be better managed.

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