The effect of *Calluna vulgaris* cover on the performance and intake of ewes grazing hill pastures in northern Spain

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**Abstract**

The effect of the proportion of *Calluna vulgaris* cover on diet composition, intake and performance of sheep grazing hill vegetation communities in northern Spain is examined. A total of 591 non-lactating Gallega ewes grazed for five consecutive grazing seasons (June to September) on replicated plots of hill pastures (1700 m.a.s.l.) composed principally of *Festuca*, *Agrostis*, *Nardus* and *Calluna* spp. but with different proportions of *Calluna vulgaris* cover, either 0·3 or 0·7 of the total area. In 1 year, twenty-eight ewes suckling single lambs also grazed the plots. The mean stocking density over the 5 years was 8·7 ewes ha–1. On treatment C0·3, daily liveweight gains (33 g d–1) of non-lactating ewes were significantly (>0·001) greater than on treatment C0·7 (12 g d–1). Likewise in lactating ewes the difference in mean daily liveweight change was 40 g d–1 (–5 vs. –45 g d–1 for C0·3 and C0·7 treatments respectively; >0·001). Liveweight gains of lambs were only 80–100 g d–1 from June to August and lambs only maintained live weight during August and September. The effect of lactational status on liveweight changes was not significant. Liveweight gains of non-lactating ewes increased significantly (>0·001) from the first to the last year of the experiment on both treatments.

The composition of the diet was significantly affected by treatment (>0·001), with a higher proportion of grass species on the C0·3 treatment and a higher digestibility of the diet in the first half of the grazing season (>0·001). The proportion of *C. vulgaris* in the diet was significantly (>0·001) higher on the C0·7 treatment and increased significantly (>0·001) from July to September on both treatments. There were no significant differences in the composition of the diet selected by lactating and non-lactating ewes.

The results demonstrate that on hill vegetation communities, in which the grass components (*Festuca rubra*, *Agrostis capillaris*, and *Nardus stricta*) cover at least 0·3 of the area and on which the preferred grass component (*Festuca and Agrostis* spp.) is maintained at a sward height of at least 2·5 cm, non-lactating ewes can increase their live weight and body condition, but this increase is influenced by the proportion and quantity of species of grass in the diet, which is affected in turn by the species of grass available and their nutritive quality. However, ewes suckling lambs were not able to maintain their live weight and body condition except when *Calluna cover* was 0·3 and grass height was more than 3·5 cm.

It is concluded that these indigenous vegetation communities can be used in sheep production systems to complement the use of improved pastures at other times of year. In particular, they can be utilized during the non-lactating period (summer) to increase body condition before the beginning of the mating period in autumn.

**Introduction**

Heather (*Calluna vulgaris*) is an important component of hill pastoral resources in large areas of Europe (e.g. northern Spain, Scotland). In many areas, *C. vulgaris* occurs with mosaics of grass species such as *Agrostis* and *Festuca* spp. and *Nardus stricta*. Milne (1974) showed the low intake, digestibility and nutritive value of *C. vulgaris*. Milne (1974) also showed that only the shoots of the current season harvested in July provided sufficient intake of digestible organic matter (DOM) to maintain the live weight of sheep.

The proportion of green shoots available is related to the level and pattern of utilization in the previous season (Grant *et al.*, 1978; 1982). Nevertheless, the
voluntary intakes of *Calluna* are much lower than would be predicted for grasses and legumes at similar levels of digestibility, because of the presence of tannins in heather (Milne, 1974). However, heather intakes increase slightly with the proportion of grass in the diet (up to a proportion of 0·30), as a consequence of the nitrogen available from grass (Milne and Bagley, 1976). Thus, a proportion of grass in the diet of sheep grazing heather-dominant hills is important. A diet containing a proportion of at least 0·50 of grass is likely to provide a total daily intake that is at least equivalent to the requirements for maintenance of non-productive sheep (Milne and Bagley, 1976). Also Maxwell *et al.* (1986) suggested that to meet the energy and nitrogen requirements for sheep for maintenance of live weight, 0·50 of the diet would require to be derived from grass with a dry-matter digestibility of 0·70 and, if this is not possible, supplementary feeding is necessary.

Therefore the performance of ewes grazing heather will be greatly influenced by the proportion of grass in the diet and this may in turn be influenced by the proportion of the grazed area covered by grass and by heather, as well as by the species of grass available. The objective of this work was to study the effect of the proportion of *C. vulgaris* cover on liveweight changes, intake and dietary components of sheep grazing hill vegetation communities in northern Spain. The *C. vulgaris* heathland comprised either 0·3 or 0·7 of the grazed area while the remainder comprised an *Agrostis–Festuca–Nardus* grassland.

**Materials and methods**

**Experimental site and design**

The experiment was conducted at Cueva Palacios Research Station in Quiroés, Asturias, Spain (latitude 43°02′N, longitude 5°36′W), on a 20-ha site at an altitude of 1600–1800 m above sea level. The principal species in the vegetation communities were *Festuca rubra*, *Agrostis capillaris*, *N. stricta* and *C. vulgaris*. One-half of the site was dominated by the herbaceous species and the other by *C. vulgaris*. Four plots of 5 ha each were established, two comprising 0·3 *C. vulgaris* and 0·7 grass species by area (Treatment *C*0·3), and two on an area with 0·7 *C. vulgaris* and 0·3 grass species (Treatment *C*0·7), providing two replicates of each pasture combination. The experiment was conducted over five consecutive grazing seasons (June to September) from 1990 to 1994.

**Animals**

The experimental animals comprised, over 5 years, a total of 591 mature non-lactating Gallega ewes and, in 1 year only, twenty-eight lactating ewes of the same breed. The Gallega breed is local to Galicia (NW Spain). The ewes had all lambed during January and February and grazed low-ground pasture (75 m above sea level) with their lambs from March to June. After weaning in June, the ewes were transferred to the experimental site. In 1 year only (1991), twenty-eight-lactating ewes were also transferred with their single lambs to the experimental site. The mean live weight and age of the lambs at this time was 13·3 kg (s.e.d. 0·50) and 93 d (s.e.d. 6·1) respectively. The ewes were allocated to the experimental treatments (*C*0·3 and *C*0·7) and replicates on the basis of live weight and body condition score at the beginning of each of the five grazing seasons. During 1992, 1993 and 1994, a total of 242 non-experimental ewes also grazed the plots. No measurements were made on these sheep, but they were present to maintain the required stocking rate. The number of ewes on each plot and the stocking rates are given in Table 1. Minor differences occurred in stocking rates within years because of deaths or removal of ewes because of ill health.

**Measurements**

**Vegetation**

The mean sward surface heights of the grass community were estimated weekly, using an HFRO sward stick (Barthram, 1986) taking 80 readings at random in each plot.

**Animal live weight and body condition**

Ewe live weights were recorded at the beginning, middle (except in 1990 and 1994) and end of each grazing season. Body condition score was assessed to the nearest 0·25 score on the 0–5 scale of Russel *et al.* (1969) by the same operator at the same time as the live weight was recorded. Lamb live weights were recorded at the same time as those of their mothers (beginning, middle and end of the grazing season in 1991).

**Herbage intake**

Daily herbage dry-matter intake (DMI) and digestible DMI (DDMI) were estimated on two occasions (during the first 2 weeks of July and September) in 1991 and 1992, using the modification of the n-alkane technique (Mayes *et al.*, 1986) made by Olivan and Osoro (1999). In 1991, on each occasion, twenty-eight ewes from each treatment (fourteen lactating and fourteen non-lactating ewes) and in 1992 fourteen non-lactating ewes from each treatment were dosed once daily between 08.00 and 11.00 h for 11 d with a paper pellet containing 45·1 ± 2·3 mg n-tetracontane (*C*24).
Faecal grab samples were collected from the rectum for the last 5 d of each dosing period. Intake was estimated using the C\textsubscript{32}/C\textsubscript{33} alkane pair, based on the whole-diet (from the estimated diet composition) and faecal concentrations of these alkanes and the C\textsubscript{32} dosing rate.

**Diet digestibility**

Diet digestibility was estimated from the calculated intake (based on the C\textsubscript{32}/C\textsubscript{33} alkane pair) and the calculated faecal output, estimated using the C\textsubscript{36} alkane as an external marker.

**Diet composition**

Samples of the three principal vegetation components (C. vulgaris, F. rubra + A. capillaris, and N. stricta) were collected by hand plucking, to simulate grazing, on four occasions during each dosing period. The proportions of the three vegetation components in the diet were calculated by a least-squares method which determines the combination of dietary components which best matches the observed pattern of faecal alkane concentrations, after an adjustment for incomplete faecal alkane recovery (Oliva˚n and Osoro, 1999).

**Statistical analysis**

Analyses of variance were carried out, using Genstat V (Lawes Agricultural Trust, 1984) to test the main effects of treatment, year and replicate and their interactions on ewe live weight and body condition score and changes in live weight and body condition score in the first half (period 1), second half (period 2) and for the whole grazing season. Because there were significant (\(P < 0.001\)) differences between years in the mean live weight and body condition of ewes at the beginning of the grazing season, both these variables were introduced in the model as a covariate.

The main effects of treatment, replicate, year and season (July and September) on herbage intake, diet digestibility and dietary composition (expressed as proportion of different components) of the ewes were analysed by analyses of variance. For 1991, the effect of lactational status was also included as a factor in the statistical model.

**Results**

**Sward height**

Mean sward surface heights of the grass community in each treatment for period 1 (20 June–9 August), period 2 (9 August–29 September) and for the whole grazing season in each of the 5 years, are presented in Table 2.

**Treatment**

Over the 5 years, there were significant (\(P < 0.05\)) differences in the mean sward height for the whole grazing season between treatments C\textsubscript{0:3} (3-6 cm) and C\textsubscript{0:7} (2-9 cm) (s.e.d. 0-26). The differences between treatments were less in period 2, when mean sward height in treatments C\textsubscript{0:3} and C\textsubscript{0:7} were 2-3 and 1-8 cm, respectively (s.e.d. 0-09; \(P < 0.001\)), while in period 1 they were 4-4 and 3-3 cm (s.e.d. 0-34; \(P < 0.001\)). This led to a significant (\(P < 0.01\)) interaction between...

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**Table 1** Number of animals and stocking rate on each replicate of the two treatments (C\textsubscript{0:3}, cover of 0-30 of C. vulgaris in total area and C\textsubscript{0:7}, cover of 0-70 of C. vulgaris in total area) in the experiment.

<table>
<thead>
<tr>
<th>Year</th>
<th>C\textsubscript{0:3}</th>
<th>C\textsubscript{0:7}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Replicate 1</td>
<td>Replicate 2</td>
</tr>
<tr>
<td>1990</td>
<td>37</td>
<td>74</td>
</tr>
<tr>
<td>1991</td>
<td>40 + 7*</td>
<td>94</td>
</tr>
<tr>
<td>1992</td>
<td>31 + 21\†</td>
<td>104</td>
</tr>
<tr>
<td>1993</td>
<td>18 + 21\†</td>
<td>78</td>
</tr>
<tr>
<td>1994</td>
<td>16 + 17\†</td>
<td>66</td>
</tr>
</tbody>
</table>

\* Lactating ewes in each replicate.
\† Non experimental dry ewes.

50.7 ± 1.7 mg n-dotriacontane (C\textsubscript{32}) and 50.3 ± 1.9 mg n-hexatriacontane (C\textsubscript{36}). Faecal grab samples were collected from the rectum for the last 5 d of each dosing period. Intake was estimated using the C\textsubscript{32}/C\textsubscript{33} alkane pair, based on the whole-diet (from the estimated diet composition) and faecal concentrations of these alkanes and the C\textsubscript{32} dosing rate.
See Table 1 for treatment abbreviations. There were no significant differences in mean grass height between replicates.

**Year**

There were highly significant \((P < 0.001)\) differences between years in the mean grass height for whole grazing season, ranging from 4.2 cm in 1990 to 2.6 cm in 1992, but the interaction between treatment and year was not significant. The interaction between year and period was significant \((P < 0.01)\).

**Liveweight changes**

**Treatment**

There were no significant differences between replicates of the same treatment, in any of the analyses.

Liveweight changes of dry ewes were significantly \((P < 0.001)\) affected by *Calluna vulgaris* cover in both periods and over the whole grazing season (Table 3). In period 1, all ewes gained live weight, but liveweight gains were higher on treatment C0.3. In period 2, while ewes on treatment C0.3 maintained live weight, those on treatment C0.7 lost live weight. Over the whole grazing season, ewes on both treatments increased in live weight, although at the end of the grazing season the live weight of ewes on the C0.3 treatment was significantly \((P < 0.001)\) greater as a consequence of the differences in liveweight changes. Changes in body condition score were related to the changes in live weight, with greater increases in body condition score on treatment C0.3.

Liveweight changes of lactating ewes were also significantly \((P < 0.001)\) affected by treatment in period 1 (Table 4), being 35 g d\(^{-1}\) on treatment C0.3 and –20 g d\(^{-1}\) on treatment C0.7. However, during period 2, all the ewes lost live weight and, although the difference was not significant, those on the C0.7 treatment tended to lose more live weight. Lamb liveweight gains were significantly higher on treatment C0.3 during period 1 (99 g vs. 80 g d\(^{-1}\); s.e.d. 7.6; \(P < 0.05\)) and period 2 (11 vs. –19 g d\(^{-1}\); s.e.d. 6.3; \(P < 0.001\)), with the lamb liveweight gains for the overall grazing season being 58 and 39 g d\(^{-1}\) on the C0.3 and C0.7 treatments respectively (s.e.d. 5.2; \(P < 0.001\)).

**Year**

Ewe liveweight gains over the whole grazing season increased significantly \((P < 0.001)\) from year to year, increasing from 27 g d\(^{-1}\) in the first year to 70 g d\(^{-1}\) in the fifth year on treatment C0.3 and from 15 to 40 g d\(^{-1}\) on treatment C0.7.

In general, changes in body condition score reflected changes in live weight, although in the first year the increase in body condition score was greater relative to liveweight gains, possibly because of the significant lower body condition of the ewes at the beginning of the grazing season in that year. The correlation of body condition score at the beginning of the grazing season with body condition score change was –0.34 (s.e.d. 0.036; \(P < 0.001\)).

**Lactational status**

There were no significant differences in ewe liveweight changes in either period as a consequence of lactational status of the ewes, although in period 1 there was a tendency \((P < 0.1)\) for the lactating ewes to have lower liveweight gains. Body condition score showed a similar pattern to that of liveweight changes (Table 4).

**Dry-matter intake and digestibility**

**Treatment**

Overall daily DMI by non-lactating ewes (1991 and 1992) was not significantly different between treatments (Table 5). However, the dry-matter digestibility was significantly \((P < 0.05)\) higher on treatment C0.3 (0.59) than on treatment C0.7 (0.56; s.e.d. 0.012).
Table 3 Effect of treatments ($C_0$ or $C_7$) on live weight and body condition of dry ewes.

<table>
<thead>
<tr>
<th>Year</th>
<th>$C_0$</th>
<th>$C_7$</th>
<th>Mean</th>
<th>s.e.d.</th>
<th>Treatment</th>
<th>Year</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>29.5</td>
<td>29.6</td>
<td>31.7</td>
<td>1.25</td>
<td>NS</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>1991</td>
<td>30.4</td>
<td>31.7</td>
<td>30.9</td>
<td>0.063</td>
<td>NS</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>1992</td>
<td>33.0</td>
<td>31.7</td>
<td>32.7</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>1993</td>
<td>35.4</td>
<td>32.7</td>
<td>37.0</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>1994</td>
<td>31.0</td>
<td>36.7</td>
<td>31.0</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

Liveweight change (g d$^{-1}$)

<table>
<thead>
<tr>
<th>Year</th>
<th>$C_0$</th>
<th>$C_7$</th>
<th>Mean</th>
<th>s.e.d.</th>
<th>Treatment</th>
<th>Year</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>37</td>
<td>27</td>
<td>27</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>1991</td>
<td>67</td>
<td>10</td>
<td>26</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>1992</td>
<td>93</td>
<td>10</td>
<td>70</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>1993</td>
<td>59</td>
<td>33</td>
<td>33</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>1994</td>
<td>86</td>
<td>24</td>
<td>40</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

Body condition change

<table>
<thead>
<tr>
<th>Year</th>
<th>$C_0$</th>
<th>$C_7$</th>
<th>Mean</th>
<th>s.e.d.</th>
<th>Treatment</th>
<th>Year</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.46</td>
<td>0.44</td>
<td>0.43</td>
<td>0.01</td>
<td>***</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>1991</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
<td>0.01</td>
<td>***</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>1992</td>
<td>0.26</td>
<td>0.01</td>
<td>0.26</td>
<td>0.01</td>
<td>***</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>1993</td>
<td>0.30</td>
<td>0.24</td>
<td>0.30</td>
<td>0.01</td>
<td>***</td>
<td>***</td>
<td>NS</td>
</tr>
<tr>
<td>1994</td>
<td>0.33</td>
<td>0.24</td>
<td>0.33</td>
<td>0.01</td>
<td>***</td>
<td>***</td>
<td>NS</td>
</tr>
</tbody>
</table>

At the beginning of season:

- Live weight (kg)
- Body condition score

At the end of season:

- Live weight (kg)
- Body condition score

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$^*$s.e.d. of the overall means.

NS, not significant; **$P < 0.01$; ***$P < 0.001$.

See Table 1 for treatment abbreviations.
DDMI was significantly \((P < 0.05)\) higher in non-lactating ewes on the \(C_0\) treatment (314 g d\(^{-1}\)) than in those on \(C_7\) treatment (281 g d\(^{-1}\); s.e.d. 15 g d\(^{-1}\)).

**Season**

The difference in daily DMI between July and September was not significant, but because the dry-matter digestibility of the diet was significantly \((P < 0.001)\) higher in July (0.64) than in September (0.51; s.e.d. 0.012), daily DDMI (323 vs. 272 g d\(^{-1}\)) and DDMI per metabolic live weight (26 vs. 21 g d\(^{-1}\) kg LW\(^{-0.75}\)) were significantly \((P < 0.001)\) higher in July than in September.

**Year**

There were no differences between years in daily DMI and in daily DDMI of non-lactating ewes. However, dry-matter digestibility (0.56 vs. 0.59; s.e.d. 0.012) and DDMI per metabolic weight (23 vs. 26 g d\(^{-1}\) kg LW\(^{-0.75}\); s.e.d. 1.19) were significantly \((P < 0.01)\) lower in 1991 than in 1992.

**Interactions**

Significant \((P < 0.01)\) interactions between treatment and season in dry-matter digestibility and daily DDMI per metabolic weight were observed (Table 5). There were no significant interactions between treatments and year for any of the intake variables and only dry-matter digestibility showed an interaction between season and year \((P < 0.05)\).

**Lactational status**

Lactating ewes had significantly higher intakes in July than non-lactating ewes (598 vs. 495 g d\(^{-1}\); \(P < 0.001\)). Although the dry-matter digestibility of the diet was not significantly different, the DDMI was also significantly \((P < 0.001)\) higher in lactating (301 g d\(^{-1}\)) than in non-lactating ewes (257 g d\(^{-1}\)). In September, the difference in DMI between lactating and non-lactating ewes was less but lactating ewes still had a significantly higher \((P < 0.05)\) daily DMI (592 g d\(^{-1}\)) and daily DDMI per metabolic live weight (246 g d\(^{-1}\) kg LW\(^{-0.75}\); \(P < 0.001\)) than non-lactating ewes (514 g d\(^{-1}\) and 198 g d\(^{-1}\) kg LW\(^{-0.75}\)). There were no significant interactions between lactational status and treatment and season.

**Diet composition**

**Treatment**

Overall the proportion of *Calluna vulgaris* in the diet of dry ewes on treatment \(C_0\) (0.24) was higher than on treatment \(C_7\) (0.15; s.e.d. 0.013; \(P < 0.001\)). Likewise the proportion of *N. stricta* was higher in treatment \(C_7\) (0.18) than in \(C_0\) (0.11; s.e.d. 0.021; \(P < 0.001\)). As a consequence, the proportion of preferred grasses (*F. rubra* + *A. capillaris*) in the diet was lower on the \(C_7\) treatment (0.58 vs. 0.74; s.e.d. 0.023; \(P < 0.001\)).

**Season**

The proportions of *C. vulgaris* and *N. stricta* in the diet were higher \((P < 0.001)\) in September than in July and the proportion of preferred grasses (*F. rubra* + *A. capillaris*) was lower (0.49 vs. 0.83; s.e.d. 0.227; \(P < 0.001\)).

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**Table 4** Effect of treatment \((C_0\) or \(C_7\)) and lactational status on live weight and body condition of ewes (1991 only).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>(C_0)</th>
<th>(C_7)</th>
<th>s.e.d.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactating</td>
<td>Lactating</td>
<td>Dry</td>
<td>Lactating</td>
<td>Dry</td>
</tr>
<tr>
<td>At the beginning of season:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live weight (kg)</td>
<td>32.0</td>
<td>32.5</td>
<td>29.5</td>
<td>33.7</td>
</tr>
<tr>
<td>Body condition score</td>
<td>2.6</td>
<td>2.8</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Liveweight change (g d(^{-1}))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period 1</td>
<td>35</td>
<td>52</td>
<td>-20</td>
<td>1</td>
</tr>
<tr>
<td>Period 2</td>
<td>-41</td>
<td>-47</td>
<td>-67</td>
<td>-62</td>
</tr>
<tr>
<td>Total</td>
<td>-5</td>
<td>0</td>
<td>-45</td>
<td>-32</td>
</tr>
<tr>
<td>Body condition change</td>
<td>-0.05</td>
<td>-0.04</td>
<td>-0.27</td>
<td>-0.18</td>
</tr>
</tbody>
</table>

NS, not significant; ***\(P < 0.001\).

See Table 1 for treatment abbreviations.
Table 5 Effect of treatment (C0Æ or C0–7), period and year on intake and diet composition in non-lactating ewes.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1991</th>
<th>1992</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C0Æ</td>
<td>C0–7</td>
<td>C0Æ</td>
</tr>
<tr>
<td>DMI (g d⁻¹)</td>
<td>485</td>
<td>585</td>
<td>506</td>
</tr>
<tr>
<td>DDMI (g d⁻¹)</td>
<td>299</td>
<td>320</td>
<td>337</td>
</tr>
<tr>
<td>DDMI (g d⁻¹ kg LW⁻⁰·⁷³)</td>
<td>23.8</td>
<td>24.3</td>
<td>26.5</td>
</tr>
<tr>
<td>Digestibility of DM</td>
<td>0.62</td>
<td>0.53</td>
<td>0.66</td>
</tr>
<tr>
<td>Diet composition†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. vulgaris</td>
<td>0.13</td>
<td>0.15</td>
<td>0.04</td>
</tr>
<tr>
<td>Preferred grasses</td>
<td>0.87</td>
<td>0.58</td>
<td>0.87</td>
</tr>
<tr>
<td>N. stricta</td>
<td>0.00</td>
<td>0.27</td>
<td>0.09</td>
</tr>
</tbody>
</table>

† Proportion of each component.
NS, not significant; *P < 0.05; **P < 0.01; ***P < 0.001.
DMI, dry-matter intake; DDMI, digestible dry-matter intake; see Table 1 for treatment abbreviations.

Discussion

The results show clear evidence of the effect of the proportion of C. vulgaris cover on grass height, diet composition and digestibility and on herbage intake, and therefore on liveweight changes and lactation performance. There was no significant effect of lactational status on diet composition, nor were there any significant interactions between lactational status, treatment and season.

There was no significant effect of lactational status on diet composition, nor were there any significant interactions between lactational status, treatment and season.

Interventions

Lactational status

There were significant (P < 0.01) interactions between treatments, seasons and years in the proportions of C. vulgaris in the diet. The interaction between season and year was also significant (P < 0.01) in year 2 (1992), but there was no difference in the proportion of C. vulgaris in the diet in 1991 (0.27 vs. 0.14, s.e.d. 0.003), and the proportion of N. stricta was lower (0.07 vs. 0.014, s.e.d. 0.002) in year 2 (1992) than in year 1 (1991).

The proportion of C. vulgaris in the diet was higher in 1992 than in 1991 (0.27 vs. 0.14, s.e.d. 0.003), and the proportion of N. stricta was lower (0.07 vs. 0.014, s.e.d. 0.002), but there was no difference in the proportion of (F. rubra + A. capillaris).
The daily DDMIs of the ewes grazing the grass-dominant (C0.3) treatment (9.4–11.7 g kg⁻¹ d⁻¹) were lower than the 22.6 g kg⁻¹ d⁻¹ of DOM observed by Hodgson et al. (1991) on Agrostis spp. communities grazed by Scottish Blackface ewes (56 kg LW). On the C. vulgaris-dominant (C0.7) treatment, however, DDMIs in period 2 (87–94 g kg⁻³ d⁻¹) were higher than those (47 g kg⁻¹ d⁻¹) of DOM found by Hodgson et al. (1991) on monospecific C. vulgaris moor and illustrate the low nutritive value of C. vulgaris noted by Milne et al. (1979).

The dry-matter digestibility of the diet in July (0.60–0.66) was slightly lower than the 0.69 observed for Agrostis–Festuca communities but much higher than the 0.41 estimated for C. vulgaris, by Hodgson et al. (1991). In September, the dry-matter digestibility of the diet in treatment C0.7 was only 0.43–0.48, but the mean sward height of the (F. rubra + A. capillaris) component was low at 1.8 cm.

The live-weight changes corroborate the observation of Maxwell et al. (1986) that to meet the energy and nitrogen requirements for maintenance of live weight, 0.50 of the diet would require to be derived from grass with a dry-matter digestibility of 0.70. In the present work, the proportion of grass in the diet was higher than 0.50 in both July and September although the dry-matter digestibility of the diet was lower than 0.70, especially in September. C. vulgaris as the sole component of the diet would not support the maintenance of live weight of the ewes (Milne, 1974). It is assumed that the ewes will increase their DMI by around 0.25 during lactation (Maxwell et al., 1986) and the difference in total DMI between lactating and non-lactating ewes in this study was 0.20 in July; in September the difference was lower because of the reduction in milk production.

The mean stocking rate applied from June to September over the 5 years (8.7 ewes ha⁻¹) in both treatments, was higher than those (four ewes ha⁻¹) suggested by Maxwell et al. (1986) for areas where the grass component produces 1800 kg DM ha⁻¹ year⁻¹, and much higher than the 0.20–0.70 ewes ha⁻¹ common for areas with predominantly C. vulgaris cover in Scotland under current farming practice. However, this stocking rate of 8.7 ewes ha⁻¹ is very similar to that suggested by Maxwell et al. (1986) for C. vulgaris communities with areas reseeded with grass species. They found that, if a C. vulgaris and grass mosaic is stocked between weaning and premating at a level to achieve utilization of heather of 0.30, then 8.75 ewes ha⁻¹ can be grazed on the area during a 90-d period and the ewes will gain live weight of around 50 g d⁻¹. The optimum stocking rate will be dependent on the area and dry-matter production of the grass species and level of heather utilized (Maxwell et al., 1986).

Milne and Grant (1978), working on vegetation with adjacent areas of C. vulgaris and reseeded grass, in order to achieve effective use of C. vulgaris without incurring unacceptable nutritional penalties to the grazing sheep, suggested that these objectives could be achieved where the ratio of grass to C. vulgaris by area was 0.30:0.70 and where herbage mass on the grass area was maintained at 1000–1500 kg DM ha⁻¹, although the balance is likely to vary with the time of year and the condition of C. vulgaris. In the present work, the ratio of grass to C. vulgaris cover was also 0.30:0.70 under treatment C0.7 and the average herbage mass on the grass area during the grazing season was higher than 1000–1500 kg DM ha⁻¹, according to the relationship between sward height and herbage mass for these pastures established by Celaya (1998). The non-lactating ewes maintained or increased live weight and body condition (average live-weight gains over five grazing seasons 12 g d⁻¹). However, in the second half of the grazing season, when the sward height on the grass area was lower than 2.5 cm, corresponding to a herbage mass lower than 1500 kg DM ha⁻¹, non-lactating ewes were not able to maintain their live weight when the ratio of grass to C. vulgaris was 0.30:0.70 and they lost 24 g d⁻¹. Under similar low (less than 1500 kg DM ha⁻¹) herbage masses, but where the ratio of grass to C. vulgaris cover was 0.70:0.30 (treatment C0.3), non-lactating ewes were able to maintain live weight (live-weight change 2 g d⁻¹) in spite of the low herbage mass.

The results of this work indicate that non-lactating ewes are able to maintain or increase live weight when sward height of the preferred grass species is higher than 2.5 cm, irrespective of whether C. vulgaris cover is 0.3 or 0.7 of the total area, although the liveweight gains are higher with higher grass cover. The increases in liveweight changes from year to year on both treatments are probably, at least in part, a consequence of the changes in vegetation, especially in the physiological status of C. vulgaris, which were observed by Celaya (1998) on this site. The nutritive value of the grass species and of C. vulgaris shoots increased during the experiment: crude protein content increased from 110 to 150 g kg⁻¹ DM in the grass species and from 70 to 90 g kg⁻¹ DM in C. vulgaris, while acid-detergent fibre content decreased from 380 to 340 g kg⁻¹ DM in the grass species and from 460 to 350 g kg⁻¹ DM in C. vulgaris. The proportion of green shoots and nutritive value of C. vulgaris is related to the level and season of utilization in previous years (Grant et al., 1978; 1982). The level of utilization is affected by the amount of grass available, and the ratio of grass to C. vulgaris, as was shown by Maxwell et al. (1986). This explains the differences in the present experiment between the C0.3 and C0.7 treatments in the level of liveweight change.
In conclusion, on hill vegetation communities in which the grass components (*Festuca, Agrostis* and *Nardus* spp.) cover at least 0.3 of the area and on which the *Festuca–Agrostis* component is maintained at a sward height of at least 2.5 cm, non-lactating ewes will increase their live weight and body condition. The magnitude of the increase will be influenced by the proportion of grass in the diet, which will be affected in turn by the species of grass available and their nutritive quality. However, ewes suckling lambs were not able to maintain live weight and body condition except when *C. vulgaris* cover was 0.3 and grass height higher than 3.5 cm.

These hill vegetation communities of northern Spain can be used in sheep production systems to complement the use of improved pastures. In particular they can be utilized during the non-lactating period (summer) to increase body condition before the beginning of the mating period in autumn.

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