Effect of sward height and vertical distribution of clover on performance of cashmere goats in autumn

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Abstract

To investigate the effect of sward height on liveweight change in goats grazing grass/white clover swards, an experiment was conducted from mid-August to mid-November with groups of non-lactating female cashmere goats that continuously grazed perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) swards. Three replicated different sward height treatments – 10–8 cm (high), 7–5 cm (medium) and 5–3 cm (low) – were used to examine the effects on the competitive ability of grass and clover components within the sward canopy and their effect on liveweight. The pasture after grazing by goats had relatively higher ryegrass leaf (+0.26, high; +0.32, medium; and +0.18, low) and lower dead ryegrass proportions (–0.28, high; –0.23, medium; and –0.18, low) than at the beginning of the experiment, whereas the white clover fraction in the sward remained constant (+0.04, high; –0.02, medium; and +0.03, low). Higher proportions of the white clover leaf lamina and petiole were found near the top of the sward canopy and were negatively correlated with the rate of liveweight gain by goats ($P < 0.05$). Goats gained 50.2 g Live weight (LW) d^{-1} on the tallest treatment (high) but lost 0.01 and 42.3 g LW d^{-1} on the medium and low sward height treatments respectively (s.e.d. 13.21, $P < 0.001$). Liveweight changes that occurred between sampling periods were also correlated ($R^2 = 0.858$, $P < 0.001$) with changes in the mean sward height and proportion of white clover lamina–petiole at the sward surface in relation to the proportion found within the whole sward. These

results suggest that goat liveweight gains would be increased if another species was introduced to reduce the white clover proportion in the surface horizon.

Introduction

A revival of interest in Europe in low-input grazing systems has recently favoured the introduction of fibre-producing goats to different pastoral resources of northern Spain (Osoro and Martinez, 1995) as an option in managing sward composition and diversifying animal production. However, the management of cashmere-producing goats to achieve acceptable levels of production on grass/clover swards is constrained by the much greater herbage allowances needed to meet the requirements of goats than sheep (Merchant and Riach, 1994). The seasonal breeding calendar for farmed cashmere goats after kidding in early spring is for the does to be mated at the beginning of autumn. Consequently, a negative energy balance in autumn could affect the future growth rate and reproductive efficiency of these goats. This therefore suggests that for goats sward heights are kept tall after the summer drought to improve their performance, although this may also bring deleterious effects on the amount of dead matter in the sward.

Under some circumstances sward characteristics may, however, override the influences exerted by height. Demment and Laca (1993) have argued that herbage mass itself does not affect animal performance as much as the spatial arrangement of its components. In addition, Milne *et al.* (1982) showed that sheep respond to sward conditions in the grazed stratum rather than to average conditions in the whole sward. Although research performed by Clark *et al.* (1984), McGregor (1985) and Lambert *et al.* (1987) reported increases in the white clover content in grass/white clover pastures grazed by goats or sheep and goats, other experiments (Radcliffe and Francis, 1988; Townsend and Radcliffe, 1990; del Pozo and

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Wright, 1995) have examined the effect of increased clover on the performance of sheep but with little attention to that of goats. In particular, the possibility that goat performance could not only be influenced by the amount of leafy material or the proportions of live grass and clover in the swards but also by their distribution within the pasture has not yet been fully assessed. Several authors, such as Hughes *et al.* (1984), Nicol and Collins (1990) and Stevens *et al.* (1992b; 1993), have shown increases in goat performance as the legume content of the sward increases, but these could be of limited value in different environmental conditions.

Furthermore, a restricted white clover growing season implies that the clover enhancement in the sward by goat grazing could disappear with the onset of the autumn rains and decreased temperatures (Barthram *et al.*, 1992). Therefore, the vertical and horizontal distribution of clover and grass in the sward could differ during the grazing cycle and with different sward management criteria. When cashmere goats are used also for meat production (Glimp, 1995), the importance of these physical sward arrangements on liveweight performance needs to be examined. The aim of this experiment was to examine the effect of sward height and clover content on liveweight change of cashmere goats grazing ryegrass/white clover swards from mid-summer to mid-autumn, so that appropriate guidelines for the use of fibre-producing goats may be determined.

Material and methods

Experimental management

The experiment was conducted at La Mata Research Farm (Grado) located at 50 m a.s.l., Asturias, northern Spain, in 1995. The sward was sown in November 1991 with a mixture of 20 kg ha⁻¹ perennial ryegrass (*Lolium perenne* L. cv. Phoenix) plus 3 kg ha⁻¹ white clover (*Trifolium repens* L. cv. Huia) and received an application of 40 kg ha⁻¹ N, 100 kg ha⁻¹ P₂O₅ and 80 kg ha⁻¹ K₂O on 25 January 1995. Before the experiment started, the experimental area was grazed to a mean height of 8 cm by ewes and does, and their offspring, to prevent seed-head development in summer.

After all stock were removed, six paddocks of 0.7 ha were established and continuously grazed from 17 August to 14 November with groups of dry does from a herd of 73 cashmere goats of mixed age [29.2 ± 0.29 kg live weight (LW)]. The experimental groups were stratified for genotype and age, and

allocated randomly to six paddocks in which mean sward heights were initially 10 (high), 7 (medium) and 5 cm (low) and then grazed until paddocks had sward heights of 8, 5 and 3 cm, respectively, at the end of the experiment. Each treatment was replicated. Each group grazed on the same paddock continuously throughout the experimental period and was run together with a single buck for mating purposes. The goats were regularly drenched with Netobimin (20 mg kg⁻¹ LW) to control gastrointestinal parasites.

Measurements

Meteorological data. Daily air temperature and total rainfall were recorded at the experimental site.

Pasture. Pasture surface height (cm), defined as the unextended height of grass and white clover leaf, was estimated weekly with an HFRO sward stick (Barthram, 1986) taking forty readings at random in each paddock. Frequency and distributions of sward heights were fitted for each treatment according to Gibb and Ridout (1986; 1988) to estimate the proportion of the shorter ('frequently') and the taller ('infrequently') grazed populations.

The relative abundance of the different herbage components within the sward canopy was recorded in each paddock at the beginning (17 August, d0), at the end of the experiment (14 November, d89), and whenever experimental animals were weighed (19 September, d33 and 10 October, d54), by using an inclined (32.5°) point quadrat apparatus (Grant, 1993) at twenty-five randomly selected points. As the point quadrat needle passed through the sward, each herbage contact height was noted after ground zero correction and classified using the following morphological units: perennial ryegrass (leaf, pseudostem, flower-stem or dead), white clover (lamina, petiole, stolon, flower or dead), other species and herbaceous weeds. In addition, 100 100-point estimates were made randomly across each paddock on a 'first hit' basis to describe sward surface composition.

Following Barthram and Grant (1994), the ratio of the total grass leaf, grass stem (pseudostem plus flower-stem), clover lamina-petiole or dead matter proportions on the sward surface, divided by their respective proportions in the whole sward, were calculated at each sampling period to examine the relative changes in their vertical distribution.

Animals. Liveweight changes were monitored by weighing individual animals on the same day as

sward composition was determined. Simultaneously, body condition was measured by the same operator according to a scoring scale from 0 to 5 used for goats by Russel (1990).

Statistical analysis

All analysis of variance and regression analyses were conducted using Genstat 5.2 (Lawes Agricultural Trust, 1990), stating in each measurement period their corresponding standard errors of difference of means (s.e.d.). Paddock was treated as a blocking factor and sward height was considered as the treatment factor. Effects of age, initial live weight and body condition score of goats were used as covariates but did not show any significant effects. When vegetation data were analysed, frequency of herbage contacts were transformed by $\log_{10} + 1$ before analysis but only back-transformed values, expressed as proportions, are included in the text. A Pearson's chi-square test (χ^2) was used to describe the pattern of height distribution across treatments by comparing the proportion of measurements falling above 2 cm of the mean sward height.

Multiple linear regressions were calculated by stepwise regression to produce the simplest model that accounted for as much as possible of the significant variation in liveweight changes that occurred in goats between sampling dates. Mean sward surface height and sward changes in proportions and in ratios of white clover lamina-petiole, ryegrass leaf, ryegrass stem and dead matter were considered as potential explanatory variables.

Results

Weather

The mean annual precipitation was 976.9 mm (57 mm below a 25-year average) and was greatest during the experiment in the d33–d54 interval (105.3 mm), with 22.4°C and 11.7°C being the mean maximum and minimum temperatures. However, the mean amount of rainfall for the d0–d33 and d54–d89 intervals (16.4 and 51.7 mm respectively) provided periods with below-average rainfall accompanied with above-average mean maximum (24.2°C and 19.9°C respectively) and minimum (15.2°C and 8.3°C respectively) temperatures.

Pasture composition

Mean sward surface heights across treatments were

Table 1. Mean sward surface height (cm) between sampling periods and the proportion of sward height measurements falling above 2 cm of the mean height across the different treatments

Interval	Sward height treatment			s.e.d.
	10–8 cm	7–5 cm	5–3 cm	
d0–d33 (<i>n</i> = 5)	9.6	6.8	4.8	0.411
d33–d54 (<i>n</i> = 3)	8.5	6.2	4.1	0.572
d54–d89 (<i>n</i> = 6)	8.2	5.5	4.0	0.395
Sward height proportion (<i>n</i> = 560)	0.08	0.06	0.03	0.011

successfully maintained within the range of target heights over the whole grazing season (Table 1). The target sward surface heights were reduced steadily from 10.1, 7.2 and 5.1 cm height (s.e.d. 0.301) at the beginning (d0) to 7.9, 5.1 and 3.0 cm height (s.e.d. 0.321) at the end of the experiment (d89) in the high, medium and low height treatments respectively.

The distribution of sward surface heights between treatments (Table 1) indicated that paddocks grazed at higher sward heights (high height treatment) did not have a more significantly skewed distribution than paddocks grazed at lower heights (medium and low height treatments) over the whole experimental period ($\chi^2 = 3.21$; d.f. = 2). No double normal distribution of sward heights was found across treatments.

Figure 1 illustrates the sward profiles of the different height treatments determined across the whole sward at each sampling period. These were obtained by plotting for ryegrass (leaf, stem and dead) and white clover (lamina-petiole and dead) components their point-quadrat contacts per 100 loci in each 1 cm horizon of the sward within the twenty-five points measured per paddock (see Forbes, 1982). Table 2 shows the composition of the clover lamina-petiole component present in the whole sward and at the sward surface and their ratios at each sampling period.

At the start of the experiment, there were no significant differences across sward height treatments in the proportions of the botanical components in the whole sward and in the sward surface respectively: ryegrass leaf [0.23, high; 0.24, medium; and 0.31, low (s.e.d. 0.049) and 0.57, high, 0.55; medium and 0.60, low (s.e.d. 0.065)]; dead ryegrass [0.33, high; 0.30, medium; and 0.31, low (s.e.d. 0.034) and (0.13, high; 0.12, medium; 0.15, low (s.e.d. 0.022)]; live clover [0.16, high; 0.18, medium; 0.14, low (s.e.d. 0.010) and 0.17, high; 0.20, medium; and

Figure 1. The vertical distribution of ryegrass leaf, stem (pseudostem + flower-stem) and dead, plus clover lamina-petiole and dead components in the swards grazed by goats at 10–8 cm (high), 7–5 cm (medium) and 5–3 cm (low) sward height treatments as measured by point-quadrat at each sampling date. Data are expressed as number of hits per 100 loci in each 1 cm of the whole sward for twenty-five points per paddock (▧ ryegrass leaf; ▨ ryegrass stem; ▩ dead ryegrass; ▪ dead clover; ■ white clover lamina-petiole)

0.14, low (s.e.d. 0.012)]; dead clover [0.02, high; 0.03, medium; and 0.01, low (s.e.d. 0.009) and 0.03, high; 0.01, medium; and 0.01, low (s.e.d. 0.011)]. However, on the low height treatment there was a significantly lower proportion of clover flower

present in the whole sward (0.06, high; 0.05, medium; 0.01, low; s.e.d. 0.007, $P < 0.001$) when compared with that present at the sward surface. This was also the case for ryegrass flower-stem material (0.11, high; 0.10, medium; 0.04, low; s.e.d.

Table 2. Effect of sward height treatment on the proportion of clover lamina/petiole in the whole sward and at the sward surface and on the sward surface/whole sward ratio

	Period	Sward height treatment			s.e.d.	Significance
		10–8 cm	7–5 cm	5–3 cm		
Whole sward	d0	0.09	0.11	0.10	0.018	NS
	d33	0.08	0.12	0.12	0.022	NS
	d54	0.13	0.17	0.20	0.020	NS
	d89	0.13	0.09	0.13	0.027	NS
Sward surface	d0	0.12	0.16	0.12	0.021	NS
	d33	0.20	0.24	0.20	0.029	NS
	d54	0.25	0.30	0.31	0.033	*
	d89	0.15	0.15	0.23	0.027	**
Sward surface/whole sward/ratio	d0	1.33	1.45	1.20	0.053	NS
	d33	2.50	2.00	1.67	0.048	*
	d54	1.92	1.76	1.55	0.073	NS
	d89	1.15	1.67	1.77	0.068	*

NS, not significant; * $P < 0.05$; ** $P < 0.01$.

0.020, $P < 0.05$), although this difference disappeared by the d54 sampling date. Throughout the experiment, live perennial ryegrass (leaf plus pseudostem plus flower-stem) was the dominant proportion in all of the sward height treatments with its leaf component making the highest contribution.

Although the leaf proportion increased from the first sampling date, that increase was higher in the whole sward than on the sward surface, decreasing from ratios of 2.48, 2.29 and 1.94 (s.e.d. 0.083) at d0 to ratios of 1.33, 1.30 and 1.08 ratios (s.e.d. 0.094) at d89 in the high, medium and low height treatments respectively. In contrast to leaf material, pseudostem and flower-stem proportions were present in lower proportions within the swards (always below 0.10), with ratios of 0.44, 0.53 and 0.56 (s.e.d. 0.0058) in the high, medium and low treatments, respectively, at d0 and decreased as the experiment progressed, particularly in the top layers of the sward, to reach values of 0.21, 0.17 and 0.40 for the ratios (s.e.d. 0.0049) in the high, medium and low treatments, respectively, at d89. By the end of the experiment, there were no significant differences between sward height treatments in the proportion of ryegrass stem across the whole sward, although there were lower leaf (0.53 vs. 0.65 and 0.73; s.e.d. 0.047, $P < 0.05$) and higher pseudostem (0.04 vs. 0.01 and 0.01, s.e.d. 0.019, $P < 0.05$) proportions at the sward surface in the low height treatment compared with the high and medium height treatments respectively.

The proportion of live white clover increased after the treatments were imposed and reached maximum values by d54, either in the whole sward ($P < 0.05$) or on the sward surface ($P < 0.001$). As

seen in Table 2, the average proportion of clover lamina and petiole during the experiment was higher in the sward surface layer than in the whole sward ($P < 0.001$), although by d89 the ratio in the high height treatment diminished to 1.15.

In contrast to the clover lamina–petiole ratios, dead matter ratios were below 1.0, indicating that the proportion of total dead matter on the sward surface was less than in the whole sward. Average ratios were 0.58, 0.46 and 0.68 ratios in the high, medium and low height treatments respectively (s.e.d. 0.052), although the high and low height treatment ratios increased to 0.75 and 1.13, respectively, by the end of the experiment. Similarly, dead ryegrass material decreased from the beginning of the experiment ($P < 0.001$) and resulted, by the end of the experiment, in higher proportions in the whole sward (0.13 vs. 0.05 and 0.07; s.e.d. 0.036; $P < 0.05$) and on the sward surface (0.17 vs. 0.07 and 0.04; s.e.d. 0.015, $P < 0.001$) in those paddocks grazed at the low height compared with those at the high and medium height treatments respectively. In comparison with dead ryegrass, the proportion of dead clover by the end of the experiment reached higher values than those for dead ryegrass at the high and medium height treatments but not for the low height treatment, either in the whole sward (0.15 and 0.09 vs. 0.03; s.e.d. 0.012, $P < 0.001$) or on the sward surface (0.08 and 0.05 vs. 0.01; s.e.d. 0.011, $P < 0.01$).

Animal production

Treatment means for LW and body condition changes are given in Table 3.

Table 3. Effect of sward surface height treatment on goat liveweight change and body condition score (means, pooled s.e.d. and *P*-values)

	Sward height treatment			s.e.d.	<i>P</i>
	10–8 cm	7–5 cm	5–3 cm		
Live weight (kg)					
d0	29.5	30.7	29.8	0.48	NS
d33	30.8	30.7	28.5	0.51	*
d54	33.1	30.9	27.7	0.50	*
d89	34.0	30.4	26.0	0.47	***
Liveweight change (g d ⁻¹)	50.24	-0.01	-42.30	13.213	***
Condition score (units)					
d0	2.25	2.20	2.28	0.051	NS
d33	2.61	2.42	2.12	0.047	*
d54	2.91	2.40	2.10	0.045	**
d89	3.05	2.29	1.92	0.060	***
Condition score change (units d ⁻¹)	0.009	0.001	-0.004	0.0011	***

NS, not significant; **P* < 0.05; ***P* < 0.01; ****P* < 0.001.

Over the 89 days of the experiment, goats gained 4.50 kg LW head⁻¹ on the high height treatment, whereas they lost 0.27 kg LW head⁻¹ on the medium height treatment and lost 3.76 kg LW head⁻¹ on the low height treatment. This was accompanied with body condition gains of 0.80 and 0.07 units head⁻¹ on the high and medium height treatments, respectively, and with a body condition loss of 0.36 units on the low height treatment (s.e.d. 0.079, *P* < 0.001). During the interval d54–d89, goats had higher liveweight losses on the medium and low height treatments (-11.6 and -51.3 g LW d⁻¹ respectively; s.e.d. 0.38) than for the remainder of the grazing period (3.1 and -38.2 g LW d⁻¹ respectively; s.e.d. 0.42), whereas the liveweight pattern on goats grazing at the high height treatment showed significant wide fluctuations during the whole experimental period (39.4, 109.5 and 25.7 g LW d⁻¹ in the d0–d33, d33–d54 and d54–d89 intervals respectively).

The liveweight gains of goats were negatively correlated with changes in clover lamina–petiole ratios ($R^2 = 0.544$, *P* < 0.05) but not with changes in dead matter ratios ($R^2 = 0.033$, NS). The multiple linear regression of liveweight gain (*y*, g LW d⁻¹) with the mean sward height (*P* < 0.001) between sampling dates (χ_1 cm) and the change in the ratio of the vertical distribution of the clover lamina–petiole component in the sward (*P* < 0.01) between sampling dates (χ_2) was significant ($R^2 = 0.858$, *P* < 0.001) and gave the following equation:

$$y = -120.4 (\pm 14.10) + 19.4 (\pm 2.04) \chi_1 - 23.3 (\pm 6.93) \chi_2$$

Discussion

Sward characteristics

Patch grazing, a characteristic of cattle (Gibb and Ridout, 1986; 1988) and sheep (Clark *et al.*, 1984) behaviour, was absent in the present trial. In their paper, Gibb and Ridout (1988) showed that analysis and interpretation based on the mean sward height may be imprecise, as swards grazed by steers typically become heterogeneous in height, showing a double normal height distribution that represented 'frequently' and 'infrequently' grazed areas. However, in the current experiment the defoliation by goats produced a high degree of sward height uniformity in the vegetation canopy in all of the treatment paddocks and consequently there was a low proportion of lightly grazed areas recorded over the whole experimental period. Several papers (Hughes *et al.*, 1984; McCall and Lambert, 1987; Nicol and Collins, 1990; Gong *et al.*, 1993; Betteridge *et al.*, 1994) report that goats seem to defoliate pastures from the top downwards in successive layers and hardly penetrate into the basal horizon. Such grazing behaviour would be in accordance with a report of goat's predisposition to browse taller patches of the sward as found by D. A. Clark, J. Hodgson, A. Illios, T. Hughes, E. Robertson and D. Elston (unpublished) and cited by Illios and Gordon (1993). Evidence in this experiment for goat browsing activity being concentrated in the upper layers of the sward came from the decreased proportion of dead and ryegrass flower-stem that occurred in the upper layers of the sward.

There was a continued increase in the proportion of white clover lamina-petiole at the sward surface from d0 to d54. As can be seen from the weather data, reasonable clover growth was still possible and the goats' non-preference for white clover probably enhanced it. Woledge *et al.* (1989) showed that clover at warm temperatures has a more active growth rate and is able to maintain a position high in the canopy compared with grass; clover predominance in the sward at this particular time might also have been favoured by its apparent non-consumption by goats. However, it could be that goats, as surface feeders, selected the tallest material first (d0–d33), exposing more growing clover at the surface that subsequently (d33–d54) was more grazed relative to the whole sward. Finally, the live clover proportion declined for all sward height treatments at the sward surface in the d54–d89 interval, probably as a result of the combination of reduced growth, senescence and defoliation. Therefore, whereas grass and white clover might establish a particular balance under different height managements, it is clear that this balance is dynamic within the experimental grazing season and could be influenced by goat grazing.

Furthermore, despite a wide range of sward heights in this study, there was no consistent effect of sward height on the proportion of live white clover in the sward, unlike that reported for sheep grazing (Orr *et al.*, 1990; Barthram *et al.*, 1992). The proportion of ryegrass material increased steadily from the top to the bottom of the sward profiles (Figure 1), whereas, conversely, the clover proportion was higher within the upper stratum than in the lower stratum. Sward height would only affect readily prehensible material to a limited extent in swards with high white clover contents. Thus, the 5–3 cm (low) height treatment had higher white clover proportions in the sward surface by the end of the experiment than the 10–8 cm (high) and 7–5 cm (medium) height treatments, probably as a result of reduced competition from ryegrass at low temperatures.

Because of non-preferential defoliation of clover in the whole sward, dead clover proportions progressively rose in all the sward height treatments; this was greatest on the high height treatment, and greater in the whole sward than in the surface. However, the reverse was the case for the appearance of dead ryegrass. Its proportional cover was greater in the base of the sward probably because of an interaction of low preference and inaccessibility, as previously reported for goats by Hughes *et al.*

(1984) and Casey *et al.* (1993). Goats kept the proportion of ryegrass in the sward in a vegetative state avoiding the build-up of seed heads and dead material, with the proportion of ryegrass stems (flower-stem plus pseudostem) and white clover flowers declining from the beginning of the experiment. The great capability of goats to control reproductive swards has also been reported by Clark *et al.* (1984), Clark and Lambert (1989), Domingue *et al.* (1991) and Gurung *et al.* (1994). Under similar local conditions, previous work by Martinez and Osoro (1995) has reported slow pasture growth rates in autumn at a time when decomposition is occurring after dry summer periods. Therefore, much of the seedhead growth and dead herbage, if not eaten by livestock, could subsequently die and decompose, thus inhibiting live ryegrass and white clover growth. However, the goats' laxer grazing in this experiment, i.e. the 10–8 cm (high) sward height treatment, seemed to minimize the impact of seasonal senescence on subsequent pasture performance. This suggests that goats could be managed on these swards in late season for cleaning up the most lignified and reproductive components.

It is not easy to explain more accurately botanical differences within the experimental sward without knowing more about the goat grazing process as it is possible that this affects pasture growth and decay. Further progress will require a detailed understanding of diet selection as well as pasture changes induced by goat grazing behaviour.

Animal production

In general, goat performance was reduced as the sward height decreased. Merchant and Riach (1994) recommended that lactating cashmere goats be maintained on swards at least at a sward height of 6 cm to obtain satisfactory levels of performance. Radcliffe *et al.* (1991) showed that rotational grazing increased the post-weaning performance of does when residual sward height increased from 5–8 cm to 6–11 cm. Collins and Nicol (1986) found that the intake rate of goats on a per kilogram liveweight basis fell rapidly when the herbage allowance ($\text{kg DM ha}^{-1} \text{d}^{-1}$) of a progressively defoliated sward was reduced. Therefore, the liveweight losses recorded in the current study under the lower sward height treatments may be considered normal for dry animals at the end of the grazing season.

However, although sward height had a dominant effect on goat performance, the spatial distribution

of white clover within the canopy also had a statistically significant effect. Liveweight gains were lower as the proportion of the clover lamina-petiole increased on the sward surface compared with that of the whole sward. Reports from more moist environments (Stevens *et al.*, 1993) have shown, in mixed swards of ryegrass with clover, that maximum benefits on goat liveweight performance occur when 40% of the sward contained clover and herbs. However, Stevens *et al.* (1992a) reported liveweight gains of only 41% compared with those achieved during spring for goats grazing prairie grass-white clover pastures. Furthermore, Stevens *et al.* (1992b) showed that angora-type goats reduced their liveweight gains when the proportion of white clover in the grazed stratum was greater than the red clover proportion. Thus, although a substantial presence of clover laminae on the sward surface seems to promote the intake of clover by sheep (Milne *et al.*, 1982) it might not necessarily occur in goats. Parsons *et al.* (1994) suggested that the energetic cost of foraging increases substantially as the horizontal or vertical availability of the desired plant species decreases. Therefore, the cost associated with selection by goats against the horizontal layer of live white clover near to the canopy surface might have been quite important and affected their liveweight gain.

However, it could be argued that higher goat performance was linked with high white clover intakes, as liveweight gains were higher when surface clover content relative to the whole sward was lower. In addition, it can be argued that the clover fraction was not significant as liveweight loss occurred when the allowance of ryegrass leaf in the sward was predominant. Therefore, the conclusions about the influence of the ratios of live clover on goat performance is less clear in this experiment than the relationships estimated between sward height and liveweight change. Complementary studies on diet selection, grazing location and intensity of utilization need to be performed to achieve a better understanding of the effect of sward clover composition on goat performance.

Implications

Because goats in this experiment seemed to be sensitive to decreasing sward height below 7–6 cm, it would be advisable not to stock them at lower sward heights on grass/clover swards in the autumn. The integration with other species of livestock, such as sheep, into these ryegrass/white clover swards may

be necessary to control increased white clover growth for the optimal management of goats.

Conclusions

Across all sward height treatments, goat grazing increased the proportion of ryegrass leaf and decreased the proportion of stem and dead matter in the whole sward and produced higher proportions of live clover on the sward surface than in the whole sward. Liveweight performance was higher in those swards that decreased in height from 10 cm to 8 cm than from 7 cm to 5 cm and from 5 cm to 3 cm in which they lost liveweight. As senescence rates were contained and the decline in the sward of live clover was deferred, it seems that autumn swards may be able to be managed with goats at taller heights than 7–5 cm. However, goats responded negatively to increasing clover content, in particular at the sward surface and, to achieve satisfactory individual animal performance for mating purposes, integration with other livestock species such as sheep, seems to be necessary. Therefore, the possible grazing advantages of the use of other species with goats during the late part of the season might represent a multispecies solution to the management of grass/clover swards.

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