

# Effect of breed and sward height on sheep performance and production per hectare during the spring and autumn in Northern Spain

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## Abstract

Effects of breed and sward surface height on ewe liveweight and body condition changes and on lamb liveweight gains during grazing in the spring and autumn were studied. The output per hectare in each season was also calculated.

A total of 112 Gallega ewes (35.6 kg live weight) and 204 Latxa ewes (47.5 kg live weight) with their lambs were used during the spring (March–June) to study the effect of five target sward heights (3.0, 4.5, 5.5, 6.5 and 8.0 cm) and the interaction with breed. In autumn (October–December) 155 Gallega and 126 Latxa ewes were used to study the effect of three target sward heights (4.0, 5.5 and 7.0 cm) and the interaction with breed. Each study was replicated twice.

A quadratic relationship was found between sward height and ewe liveweight and body condition changes and lamb liveweight gain during the spring grazing season, with the maximum individual performance being achieved at around a sward height of 6.0 cm. There were significant breed  $\times$  sward height treatment interactions for ewe liveweight and body condition changes, and lamb liveweight gains. Higher liveweight gains were achieved by Latxa ewes and lambs in swards taller than 6.5 cm but they also sustained higher liveweight losses in swards shorter than 4.5 cm. Nevertheless, a higher output (liveweight gains of ewes + lambs) per hectare for a given weaning date or age was achieved by the Gallega ewes. In autumn, the relationship between liveweight change and sward height was linear, with a breed–sward height interaction similar to that observed in the spring.

Sward surface heights of 4.0–4.5 cm and 4.5–5.0 cm were required to maintain live weight and body condition in spring and autumn respectively. Lamb and ewe liveweight gains per hectare decreased considerably in swards taller than 6.5 cm.

**Keywords:** ewes, lambs, grazing, live weight, carrying capacity

## Introduction

Genotype and nutrition are the two main factors affecting individual performance in any ruminant production system. In extensive grazing systems, intake is related to the available vegetation (Hodgson and Eadie, 1986) and to the characteristics of the ruminant utilizing that vegetation. Sward surface height has been considered as a good predictor of the grazing behaviour and intake of ruminants (Bircham and Hodgson, 1983; Orr *et al.*, 1990).

The interactions of sward surface height with herbage growth rate, intake and individual performance have been discussed by Maxwell and Treacher (1987). There is a considerable potential for influencing ruminant output, either in terms of stock-carrying capacity or in terms of liveweight gain, through the control of sward surface height (Maxwell *et al.*, 1994). These two parameters are, however, inversely related, as taller swards generally result in higher intakes but support fewer animals.

Responses in sheep performance to differences in sward height have been variable. Evidence that live-weight gains of suckling lambs increase as sward height increases from 3 to 6 cm was found by Penning (1986), Maxwell and Treacher (1987) and Orr *et al.* (1990). Also, Maxwell *et al.* (1994) observed that, provided the grazed sward height is controlled between 3.5 and 5.0 cm during lactation, and supplementation is offered when the sward height falls below 3.5 cm in early lactation and during the mating period, individual performance, measured in terms of reproductive rate and lamb growth rate, was within acceptable limits. The results obtained by Chestnutt (1992) indicated that performance of suckling lambs is sensitive to changes in sward heights substantially greater than 5 cm; live-weight gains of suckling lambs increased as sward height increased up to 9 cm in two of the three years studied. However, in only one year did ewes on a 7 cm sward gain significantly more live weight than those on a 5 cm sward. Above 7 cm there was no evidence of an effect of sward height on ewe liveweight gain.

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Ewe body size is also an important factor in production systems. Ewes with a greater body size have a higher intake capacity (Penning *et al.*, 1991), but at the same time also have higher maintenance requirements (Fitzhugh, 1978). Body size thus affects the stocking rate and consequently output per hectare.

There are important differences between breeds in milk production and growth potential. Milne *et al.* (1981) indicated that, although the liveweight gain of lambs and the reproductive performance of ewes can be influenced by controlling sward height and supplementary feed inputs, output per ewe will be affected by breed – an observation later confirmed by Maxwell *et al.* (1997).

Iason *et al.* (1994) observed that, in sheep, voluntary food intake was affected by a significant breed  $\times$  month interaction. These factors, and the way in which different breeds respond in terms of their behaviour and grazing ecology to variations in their physical and nutritional environments, are important in determining the suitability of genotypes to particular situations and for particular functions. Current knowledge of the determinants of bite weight suggests an interaction between sward structure and ruminant size. Differences in bite weight between ruminants of different size would be expected to be greater in swards of high herbage availability and high quality; as the sward becomes shorter and more sparse, the absolute difference between ruminants with small and large bite sizes would be expected to decrease (Demment *et al.*, 1995).

The nutritive value of autumn pastures to ruminants is lower than that of spring pastures (Reed, 1978). As a consequence, liveweight gains in autumn are generally lower than in spring (Marsh, 1975), even when the digestibility of the pastures is similar. As a consequence, higher sward heights are recommended for autumn grazing (Maxwell and Treacher, 1987). Studies by Burnham *et al.* (1994) suggested, however, that in the autumn, grazing perennial ryegrass-white clover pastures, maximum herbage intake and ewe performance can be obtained at a sward height of about 4 cm.

The objective of the present work was to study the responses in liveweight changes and production per hectare of two breeds of sheep (Gallega and Latxa) of contrasting body size, when they grazed during spring and autumn on perennial ryegrass-white clover pastures at different sward heights.

## Materials and methods

### Experimental site

The experiment was conducted at La Mata Research Farm (Grado) located at 50 m.a.s.l. in Asturias, northern Spain (latitude 43°22'N, longitude 6°03'W). The sward was a pasture sown in November 1991 with a mixture of

20 kg ha<sup>-1</sup> perennial ryegrass (*Lolium perenne* L. cv Phoenix) seed plus 3 kg ha<sup>-1</sup> white clover (*Trifolium repens* L. cv Huia) seed and received an application of 40 kg N, 90 kg P<sub>2</sub>O<sub>5</sub> and 60 kg K<sub>2</sub>O ha<sup>-1</sup> in January 1992. The nitrogen application (40 kg ha<sup>-1</sup>) was repeated every six weeks during the spring grazing period and twice during the autumn grazing period.

### Treatments

The experimental site was divided into 0.5 ha plots to establish the following experimental design.

#### Spring grazing

A factorial design comprising two replicates of the two sheep breeds (Latxa and Gallega) and five target sward surface heights (3.0, 4.5, 5.5, 6.5 and 8.0 cm).

#### Autumn grazing

A factorial design comprising two replicates of the two sheep breeds (Latxa and Gallega) and three target sward surface heights (4.0, 5.5 and 7.0 cm), plus a further treatment with only Gallega ewes grazing a 8.0 cm sward, there being insufficient Latxa ewes to complete an orthogonal design.

### Animals and management

A total of 112 Gallega ewes (average live weight 35.6 kg; s.e. 1.05) and 204 Latxa ewes (average live weight 47.5 kg; s.e. 0.72) with their lambs were used in the spring grazing treatments; 155 Gallega ewes and 126 Latxa ewes were used in the autumn.

All ewes had lambed during January–February and were turned-out at the beginning of March, grazing with their single lambs until weaning in the middle of June. The autumn grazing season extended from September to December. Ewes and their lambs were allocated in groups according to lamb age and live weight of ewes and lambs.

The experimental groups of each breed grazed continuously throughout the experimental periods (spring and autumn). Non-experimental ewes plus lambs were added to or removed from the plots throughout the experiment to control sward heights, but were not necessary in the autumn.

### Measurements

#### Pastures

Sward surface height (cm), defined as the unextended height of grass and white clover leaf, was estimated twice

weekly with the HFRO swardstick (Barthram, 1986), taking forty measurements at random in each plot.

#### *Live weight and body condition*

Ewe and lamb live weights were recorded at the beginning (one week after turn-out) and end of each experimental grazing season and every three weeks during the experiment. Body condition score was assessed to the nearest 0.25 on the 0–5 scale of Russel *et al.* (1969) by the same operator at the time of recording live weight.

#### *Average stocking rate*

The average stocking rate was calculated from the number of ewe plus lamb grazing days from turn-out to weaning (spring grazing period) or the number of ewe grazing days from the start to the end of grazing (autumn grazing period) divided by the number of days in the relevant period.

#### *Animal production per hectare*

Production per hectare during the experimental periods (spring and autumn) was calculated, taking account of average stocking rate and individual liveweight changes of ewes and lambs.

### **Statistical analysis**

The liveweight changes of ewes and lambs during the spring grazing were calculated for two different periods: period 1 from turn-out (March) to the beginning of May and period 2 from the beginning of May to weaning (middle of June), as well as overall (March–June).

Relationships between the actual sward surface height, liveweight change, carrying capacity and production per hectare in spring and autumn were studied by the best-fit regression using SPSS (1989). Plot data from each treatment and replicate were used for the regression analysis.

During the spring grazing season most of the lambs on one of the plots containing Gallega ewes on a 4 cm sward were killed by foxes. The results from the sheep on this plot have therefore been omitted.

## **Results**

### **Spring grazing**

#### *Ewe liveweight and body condition changes*

**Sward height.** Sward height had a highly significant ( $P < 0.001$ ) effect on ewe liveweight change (Table 1).

The highest gains ( $50\text{--}60\text{ g day}^{-1}$ ) were achieved when the mean sward height was around 6 cm. At higher sward heights liveweight gains of ewes decreased. A sward height of about 4.5 cm was required to maintain the live weight of lactating ewes. With a sward height of only 3.3 cm ewes lost  $35\text{--}50\text{ g d}^{-1}$ . The relationship between liveweight change ( $y_{\text{ELWG}}$ ;  $\text{g d}^{-1}$ ) and sward height ( $x$ ; cm) for the range of sward heights studied (3.2–8.1 cm) was quadratic and given by the following regression:

$$y_{\text{ELWG}} = 106 (\pm 14.6)x - 8 (\pm 1.3)x^2 \\ - 302 (\pm 37.8) \quad \text{s.e. } 14.1, \quad r^2 = 0.86, \\ P < 0.001, \quad n = 19$$

Changes in body condition ( $y_{\text{BCS}}$ ) were closely correlated ( $r = 0.87$ ) with changes in live weight and therefore related to sward height according to the following regression:

$$y_{\text{BCS}} = 0.7 (\pm 0.14)x - 0.05 (\pm 0.013)x^2 \\ - 2.1 (\pm 0.37) \quad \text{s.e. } 0.14, \quad r^2 = 0.78, \\ P < 0.001, \quad n = 19$$

**Breed.** There were significant differences between breeds in liveweight and body condition changes according to sward height (Table 1). Latxa ewes, with a larger body size, achieved higher daily liveweight gains than Gallega ewes when the actual sward height was greater than 6.0 cm. Gallega ewes, however, lost less live weight and body condition when the actual sward height was lower than 4.0 cm. There was thus a significant ( $P < 0.01$ ) interaction between breed and sward height.

The relationships between the sward heights studied and liveweight (Figure 1) and body condition changes in each breed were also quadratic and are given by the following regressions:

Latxa:

$$y_{\text{ELWG}} = 116 (\pm 21.4)x - 9 (\pm 2.0)x^2 \\ - 342 (\pm 55.6) \quad \text{s.e. } 12.8, \quad r^2 = 0.91, \\ P < 0.001, \quad n = 10$$

$$y_{\text{BCS}} = 0.6 (\pm 0.23)x - 0.04 (\pm 0.021)x^2 \\ - 1.9 (\pm 0.61) \quad \text{s.e. } 0.14, \quad r^2 = 0.70, \\ P < 0.01, \quad n = 10$$

Gallega:

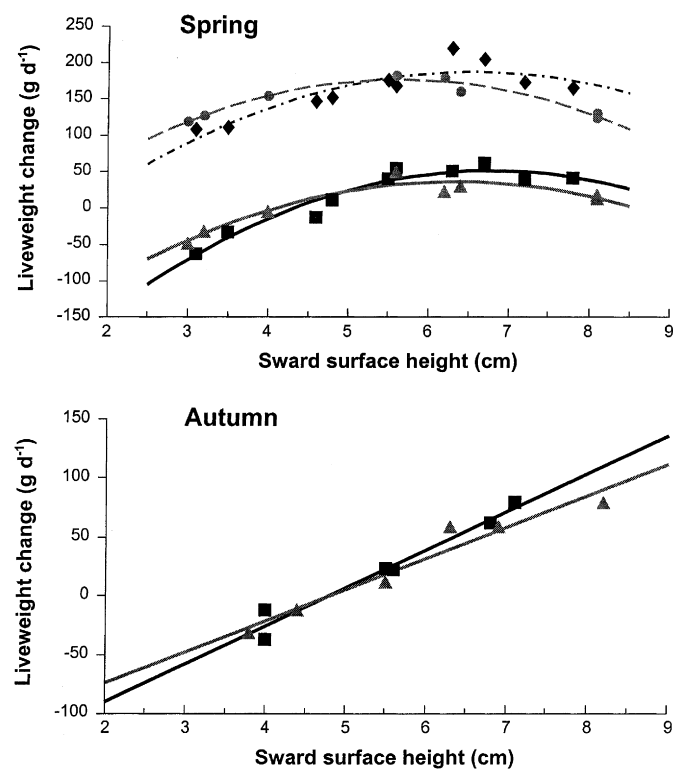
$$y_{\text{ELWG}} = 91 (\pm 15.2)x - 7 (\pm 1.4)x^2 \\ - 253 (\pm 38.7) \quad \text{s.e. } 10.6, \quad r^2 = 0.89, \\ P < 0.001, \quad n = 9$$

$$y_{\text{BCS}} = 0.8 (\pm 0.24)x - 0.06 (\pm 0.021)x^2 \\ - 2.3 (\pm 0.60) \quad \text{s.e. } 0.16, \quad r^2 = 0.78, \\ P < 0.01, \quad n = 9$$

**Table 1** Effects of the sward surface height on the changes in live weight (LW) and body condition (BC) of Latxa and Gallega ewes and on the liveweight gains of their lambs during the spring grazing season.

Breed	Latxa					Gallega				
Sward height (cm)										
Target	3.0	4.5	5.5	6.5	8.0	3.0	4.5	5.5	6.5	8.0
Period 1	3.6	5.2	5.4	6.6	7.4	3.6	3.8	5.5	6.1	8.2
Period 2	2.7	4.0	5.6	6.5	8.0	2.7	4.4	5.7	6.8	8.0
Overall	3.3	4.7	5.5	6.5	7.6	3.2	4.0	5.6	6.4	8.1
At turn-out										
No. of animals	42	55	42	38	27	18	17	14	47	16
Ewe LW (kg)	46.7	47.7	45.4	49.8	46.9	34.1	34.5	37.1	36.0	38.3
Ewe BC	2.7	2.6	2.6	2.6	2.5	2.7	2.7	2.7	2.6	2.6
Lamb LW (kg)	14.0	13.9	13.6	10.6	13.3	10.2	9.2	9.5	9.2	12.8
Ewe LW changes ( $\text{g d}^{-1}$ )										
Period 1	-96	-3	18	64	49	-48	-33	52	35	41
Period 2	12	6	85	46	22	-2	38	48	15	-33
Overall	-51	-1	45	56	40	-35	-5	50	29	16
Ewe BC changes (units)										
Overall	-0.33	-0.09	0.15	0.27	0.11	-0.44	-0.03	0.36	0.15	0.20
Lamb LW gains ( $\text{g d}^{-1}$ )										
Period 1	120	164	185	224	208	137	159	178	185	178
Period 2	88	118	165	195	89	100	147	188	120	30
Overall	109	149	173	213	168	126	154	182	162	127

Period 1: 1 March to 1 May; Period 2: 2 May to 19 June; Overall: 1 March to 19 June.

**Figure 1** The effect of sward surface height on daily liveweight changes in two breeds of sheep (Gallega and Latxa) grazing perennial ryegrass-white clover pastures during spring and autumn. —■— Latxa ewes; - -◆- - Latxa lambs; —▲— Gallega ewes; - -●- - Gallega lambs.

**Table 2** Stocking rate and sheep production during the spring grazing season according to sward height and sheep breed.

Breed	Latxa					Gallega				
Sward height (cm)										
Target	3.0	4.5	5.5	6.5	8.0	3.0	4.5	5.5	6.5	8.0
Actual	3.3	4.7	5.5	6.5	7.6	3.2	4.0	5.6	6.4	8.1
Stocking rate (ewes with lambs ha <sup>-1</sup> )	38	30	25	23	23	37	37	30	28	23
Live weight (kg ha <sup>-1</sup> )										
Ewes: start	1745	1431	1135	1145	1079	1262	1276	1113	1008	881
Lambs: start	532	417	340	297	306	377	340	285	258	294
Lambs: finish	916	828	763	738	630	799	873	879	686	538
Liveweight change (kg ha <sup>-1</sup> d <sup>-1</sup> )										
Ewes	-1.94	-0.03	1.13	1.29	0.92	-1.30	-0.19	1.50	0.81	0.30
Lambs	4.14	4.47	4.33	4.90	3.86	4.66	5.70	5.46	4.54	2.92
Total	2.20	4.44	5.46	6.19	4.78	3.36	5.51	6.96	5.35	3.22

### Lamb liveweight gains

**Sward height.** Lamb liveweight gains were significantly ( $P < 0.001$ ) affected by sward height (Table 1). The greatest liveweight gains occurred in pastures with sward heights around 6.0 cm, with a clear reduction in gains when the sward height was greater than 7.0 cm or less than 5.0 cm. The quadratic relationship between lamb liveweight gain ( $y_{LLWG}$ ; g d<sup>-1</sup>) and sward height is given by the following regression:

$$y_{LLWG} = 104 (\pm 18.7)x - 9 (\pm 1.7)x^2 - 129 (\pm 48.6) \quad \text{s.e. } 18.1, r^2 = 0.67, \\ P < 0.001, n = 19$$

**Breed.** As was observed in relation to the ewes, Latxa lambs had higher daily liveweight gains than Gallega lambs as sward height increased from 3.0 cm to 8.0 cm (Figure 1) with a significant interaction ( $P < 0.001$ ) between sward height and breed. The relationships between lamb liveweight gain and sward height were again quadratic:

Latxa:

$$y_{LLWG} = 101 (\pm 29.9)x - 8 (\pm 2.7)x^2 - 144 (\pm 77.5) \quad \text{s.e. } 17.9, r^2 = 0.75, \\ P < 0.01, n = 10$$

Gallega:

$$y_{LLWG} = 93 (\pm 9.3)x - 8 (\pm 0.8)x^2 - 86 (\pm 23.7) \quad \text{s.e. } 6.5, r^2 = 0.93, P < 0.001, n = 9$$

### Carrying capacity

**Sward height.** The carrying capacity of ewes and lambs from turn-out (March) to weaning (June) was negat-

ively correlated with the sward height. Carrying capacity of ewes and lambs ( $y_{CC}$ ; kg LW ha<sup>-1</sup>) decreased linearly as sward height increased:

$$y_{CC} = -148 (\pm 41.1)x + 2363 (\pm 235.0) \quad \text{s.e. } 209.5, r^2 = 0.57, P < 0.01, n = 19$$

**Breed.** The stocking rate of ewes with lambs of the Latxa breed was 1.52 times higher on pastures with a sward height of 3.3 cm than on those with a 5.5 cm sward height (Table 2). A small decrease in stocking rate was, however, observed when sward height increased from 5.5 cm to 7.6 cm. In the Gallega breed stocking rate of ewes with lambs for similar values of sward height (3.2–5.6 cm) was only 1.23 times higher on the shorter pasture, but a similar reduction (0.30) in stocking rate was observed when sward height increased from 5.6 cm to 8.1 cm. Significant quadratic and linear regressions for the Latxa and Gallega breeds, respectively, were obtained between carrying capacity of ewes and lambs and sward height:

Latxa:

$$y_{CC} = -831 (\pm 215.5)x + 57 (\pm 19.6)x^2 + 4418 (\pm 516.0) \quad \text{s.e. } 88.7, r^2 = 0.94, \\ P < 0.02, n = 10$$

Gallega:

$$y_{CC} = -104 (\pm 11.8)x + 1988 (\pm 67.5) \quad \text{s.e. } 45.8, r^2 = 0.95, P < 0.003, n = 9$$

### Productivity per hectare

The liveweight changes per day and per hectare during the spring grazing season were related to the individual liveweight changes of ewes and lambs and the stocking rate. Thus the higher gains per hectare in

the Gallega breed occurred on pastures with a sward height of 5.6 cm compared with 6.5 cm in the Latxa breed (Table 2). Small differences were observed between sward heights in the effect on lamb live-weight gain per hectare, except for the higher sward height treatments (7.6 cm and 8.1 cm) in which not only the carrying capacity, but also the individual lamb liveweight gains, decreased. Thus the differences in total daily liveweight gain per hectare between treatments occurred mainly as consequence of the differences in ewe liveweight changes. These ranged from  $-1.94 \text{ kg LW ha}^{-1} \text{ d}^{-1}$  (sward height of 3.3 cm) to  $1.29 \text{ kg LW ha}^{-1} \text{ d}^{-1}$  (sward height of 6.5 cm) in Latxa ewes and from  $-1.30 \text{ kg LW ha}^{-1} \text{ d}^{-1}$  (sward height of 3.2 cm) to  $1.50 \text{ kg LW ha}^{-1} \text{ d}^{-1}$  (sward height of 5.6 cm) in Gallega ewes.

Total liveweight gains per hectare in the Gallega breed on pastures with a sward height of 5.6 cm ( $6.96 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ ) were twice those of animals managed on pastures with sward heights of 3.2 cm and 8.1 cm ( $3.36$  and  $3.22 \text{ kg LW ha}^{-1} \text{ d}^{-1}$  respectively). The differences in liveweight production of sheep on pastures with sward heights between 4.0 cm and 6.4 cm were less than  $1.6 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ . Similarly, in Latxa sheep the liveweight gains per hectare were almost three times greater on pastures with a sward height of 6.5 cm ( $6.2 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ ) than in those on pastures with a sward height of 3.3 cm ( $2.2 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ ). The differences in liveweight production of the animals on pastures with sward heights between 4.7 cm and 7.6 cm were less than  $1.8 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ . Thus in the conditions of this study, under optimum sward heights, the smaller Gallega breed has a superior liveweight performance (live weight of ewes + lambs) ( $6.96 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ ) than the larger Latxa breed ( $6.19 \text{ kg LW ha}^{-1} \text{ d}^{-1}$ ) at sward height of 6.5 cm.

#### *Lamb live weight weaned per hectare*

The live weight of weaned lamb per hectare decreased as sward height increased. This was a consequence of the greater effect of sward height on stocking rate than on lamb liveweight gain. The relationship between the live weight of lamb weaned per hectare ( $y_{LLW}$ ; kg) and actual sward surface height was found for each breed to be the following:

Latxa:

$$y_{LLW} = -64 (\pm 5.5)x + 1127 (\pm 31.3) \quad \text{s.e. } 18.1, \\ r^2 = 0.97, P < 0.001, n = 10$$

Gallega:

$$y_{LLW} = -384 (\pm 52.7)x - 38 (\pm 4.6)x^2 \\ - 41 (\pm 138.2) \quad \text{s.e. } 26.7, r^2 = 0.98, \\ P < 0.05, n = 9$$

## **Autumn grazing**

### *Liveweight and body condition changes*

**Sward height.** On the autumn pastures sward height had a linear effect on ewe liveweight and body condition changes within the range of sward heights studied (4.0–8.2 cm). The non-lactating ewes were able to maintain live weight and body condition when the mean sward height was around 4.5 cm (Table 3). On the shorter pastures (4.0 cm) ewes lost live weight ( $10\text{--}25 \text{ g d}^{-1}$ ) and body condition, while on pastures with a 7.0-cm sward height the rate of liveweight gain was  $60\text{--}70 \text{ g d}^{-1}$ .

The relationship between mean sward heights and changes in ewe live weight and body condition (units) during the autumn grazing are shown by the following linear regressions:

$$y_{ELWG} = 29 (\pm 2.3)x - 137 (\pm 13.4) \quad \text{s.e. } 10.9, \\ r^2 = 0.93, P < 0.001, n = 13$$

$$y_{BCS} = 0.12 (\pm 0.017)x - 0.6 (\pm 0.10) \quad \text{s.e. } 0.08, \\ r^2 = 0.82, P < 0.001, n = 13$$

**Breed.** There were significant differences between the breeds in the liveweight and body condition responses to differences in sward height. In both breeds the response was linear. On short swards (4.0 cm) Gallega ewes had lower liveweight losses ( $-11 \text{ g d}^{-1}$ ) than Latxa ewes ( $-24 \text{ g d}^{-1}$ ). However, on the taller swards (7.0 cm) Latxa ewes achieved higher individual liveweight gains ( $72 \text{ g d}^{-1}$ ) than Gallega ewes ( $59 \text{ g d}^{-1}$ ) (Table 3). This interaction between breed and sward height is shown clearly in the following regressions (Figure 1):

Latxa:

$$y_{ELWG} = 32 (\pm 3.2)x - 155 (\pm 18.0) \\ \text{s.e. } 9.5, r^2 = 0.95, P < 0.001, n = 6$$

$$y_{BCS} = 0.13 (\pm 0.039)x - 0.7 (\pm 0.22) \\ \text{s.e. } 0.11, r^2 = 0.67, P < 0.03, n = 6$$

Gallega:

$$y_{ELWG} = 26 (\pm 3.3)x - 127 (\pm 19.8) \\ \text{s.e. } 11.9, r^2 = 0.93, P < 0.001, n = 7$$

$$y_{BCS} = 0.12 (\pm 0.014)x - 0.6 (\pm 0.08) \\ \text{s.e. } 0.05, r^2 = 0.93, P < 0.001, n = 7$$

### *Carrying capacity*

**Sward height.** The number of ewes carried per hectare at a sward height of 4.0 cm (42 for the Latxa breed and

**Table 3.** Effect of sward surface height during the autumn grazing season on the carrying capacity and daily liveweight changes per ewe and per hectare of two sheep breeds of different body size:

Breed	Latxa			Gallega			
Sward height (cm)							
Target	4.0	5.5	7.0	4.0	5.5	7.0	8.0
Actual	4.0	5.6	7.0	4.1	5.9	6.9	8.2
Stocking rate (ewes ha <sup>-1</sup> )	47	28	20	62	36	32	26
Live weight (kg)†	48.9	50.1	49.2	36.2	36.2	31.9	37.5
Body condition†	2.66	2.67	2.63	2.76	2.77	2.63	2.89
Liveweight changes:							
g ewe <sup>-1</sup> d <sup>-1</sup>	-24	23	72	-11	37	59	80
kg ha <sup>-1</sup> d <sup>-1</sup>	-1.13	0.64	1.44	-0.68	1.33	1.89	2.08
Carrying capacity (kg ha <sup>-1</sup> )	2298	1403	984	2244	1303	1021	975

†At the beginning of autumn grazing (September).

62 for the Gallega breed) was more than twice those with a sward height of 7.0–8.2 cm (20 for the Latxa breed or 26 for the Gallega breed). The significant ( $P < 0.001$ ) regression of carrying capacity (kg LW ha<sup>-1</sup>) on sward height was:

$$y_{CC} = -1481 (\pm 39.9)x + 95 (\pm 3.3)x^2 \\ + 6710 (\pm 114.0) \quad \text{s.e. } 16.4, \quad r^2 = 0.999, \\ P < 0.001, \quad n = 13$$

**Breed.** The proportional increase in stocking rate as sward height decreased was similar in both breeds: in the Latxa from 20 to 47 ewes and in Gallega from 30 to 62 ewes. The carrying capacity (kg ha<sup>-1</sup>) for a given sward height was not significantly different between breeds (Table 3).

#### Productivity per hectare

**Sward height.** Sward height had a significant effect on ewe daily liveweight change per hectare. In those treatments with the taller swards, greater daily liveweight gains per hectare were achieved and a quadratic relationship was observed. Sward height had a greater effect than stocking rate on individual ewe performance.

**Breed.** Significant differences in productivity per hectare were noted between the two breeds for a given sward height. Gallega ewes had higher daily liveweight changes per hectare than did the Latxa ewes (Table 3).

## Discussion

The results of the present work, showing that maximum sheep performance is achieved on pastures with a sward height of around 6.0 cm, are in agreement with

those found by Orr *et al.* (1990). These authors suggested a sward surface height close to 6 cm for optimum sheep performance in perennial ryegrass-white clover swards grazed under continuous stocking. The quadratic responses obtained in spring grazing in the present study accord with the responses in intake and performance observed by several authors. Penning (1986) observed a curvilinear relationship between herbage intake in the first 12 weeks of lactation by Scottish Halfbred ewes suckling twins and sward heights maintained at 3, 6, 9 or 12 cm. This pattern was also found by Hodgson (1986), who observed steep increases in intake with increases in sward height up to 6 cm. Also, the results of liveweight changes in lactating ewes are in agreement with those found by Chestnutt (1992). He found that ewes lost live weight on pastures with a sward height of 3 cm, while at all other heights (5, 7 and 9 cm) there were generally small gains in live weight, averaging 42 g d<sup>-1</sup>. In the present work, for the sward heights between 5.5 and 8.1 cm, liveweight gains averaged 39 g d<sup>-1</sup>, with clear differences between breeds (Gallega: 32 g d<sup>-1</sup>, Latxa: 47 g d<sup>-1</sup>).

Mackie *et al.* (1988) recorded a response in lamb liveweight gain of 66 g d<sup>-1</sup> and increases in ewe live weight and condition score of 5 kg and 0.5 points, respectively, from a 1.2-cm difference in sward height. Similar effects were later noted by Vipond *et al.* (1993). The effect of the increase in sward height on lamb liveweight gains in the present study is smaller than that observed by the above-mentioned authors, probably because of the lower intake capacity and growth potential of the breeds used in the present experiment, as compared with the Mule ewes and their Suffolk-cross lambs used in those studies. The increases in ewe live weight were, however, similar at sward heights between 3 cm and 6 cm; ewe daily liveweight gains were 40–50 g d<sup>-1</sup> over the 110 d duration of the spring grazing season.

The higher liveweight gains of larger Latxa ewes on the taller swards is consistent with the observation that bite size and bite weight are related to the animal size (Demment *et al.*, 1995) and with the higher intake potential of larger animals (Illius, 1989). The relationship between liveweight change and sward surface height indicates that performance was more affected by herbage availability in the larger Latxa ewes than in the smaller Gallega ewes. The smaller breed had lower liveweight losses under conditions of low herbage availability. Similar responses were observed by Osoro *et al.* (1999) for the same breeds grazing a hill vegetation community of *Festuca-Agrostis-Calluna*. Clutton-Brock and Harvey (1983) noted that large genotypes may have greater intake limitations when grazing short swards.

In both grazing seasons (spring and autumn) ewes required a sward height of around 4.5 cm to maintain their live weight and body condition. In situations in which the sward height is lower, different management rules have been suggested (Milne *et al.*, 1986; Gunn *et al.*, 1992).

Maxwell and Treacher (1987) concluded that, in the late spring, pasture utilization and animal performance can be optimized if the sward surface height is kept between 4 cm and 6 cm. Nevertheless, Chestnutt (1992) found that for maximum lamb growth rate during the spring, the sward height should be at least 7 cm, although at this height large numbers of seed heads develop, causing deterioration of pasture quality. The lower daily liveweight gains observed in the second period of the spring grazing season in those treatments with higher sward heights are likely to be related to this decrease in pasture quality. Effects of varying sward height during the spring to determine the optimum compromise between animal performance and pasture quality require further research. The authors of the present work have observed this positive effect of varying heights from 5.5 cm to 7.0 cm during the spring (unpublished data). Vipond *et al.* (1993) concluded that the phenomenon of declining lamb performance in late lactation can be greatly reduced by the combined effects of a high white clover content and an increasing sward height. Vipond *et al.* (1997) demonstrated a rapid loss in white clover content under lax grazing and showed that the relationship between performance and sward height is also dependent on herbage density. They concluded that it was important for the persistence of white clover to maintain a sward surface height close to 5 cm; lax grazing at around 9 cm led to a rapid reduction in white clover content and the ingress of unsown species within one year.

The carrying capacity from turn-out (March) to weaning (June) was strongly affected by sward height. It was about 0.50 higher in pastures with a sward height

of 3.2 cm than in those with 7–8 cm swards; the relationship between sward height and carrying capacity was quadratic. Chestnutt (1992) found that almost twice the number of ewes could be carried on 3 cm compared with 9 cm swards. The greatest effect of height was at the shorter sward heights, with little difference between swards of 7 and 9 cm; the quadratic term was again significant. The stocking rates calculated by Chestnutt (1992) were 25.3, 19.3, 14.6, and 13.3 ewes ha<sup>-1</sup> (s.e. 0.60) at sward heights of 3, 5, 7 and 9 cm respectively. Similar effects of sward height on stocking rate were observed in the present work, although the number of ewes per hectare was different, with higher stocking rates under Spanish conditions (38 ewes ha<sup>-1</sup> on 3.3 cm swards to 23 ewes ha<sup>-1</sup> on 8.1 cm swards) at least partly because of the smaller size of the breeds used.

Calculated lamb live weights per hectare up to weaning in July decreased in both breeds, from 916 to 636 kg ha<sup>-1</sup> in Latxa breed and from 873 to 538 kg ha<sup>-1</sup> in the Gallega breed, as sward height increased from 3.3 cm to 7.6 cm and from 4.0 cm to 8.1 cm respectively. Very similar results were obtained by Chestnutt (1992), who found a decline in the live weight of lamb weaned per hectare from 808, 789, 628 to 584 kg ha<sup>-1</sup> as sward height increased from 3, 5, 7 to 9 cm respectively. The output of lamb per hectare is conditioned by the optimum carcass weight for marketing (8–12 kg) and is consequently affected by the efficiency of the breed with respect to body size and growth potential. Greeff *et al.* (1995) concluded that body size is an important factor determining the biological efficiency of lamb production and suggested that there is an optimum body size for each particular environment.

As regards liveweight gains in the autumn, Chestnutt (1992), working with weaned lambs, found that liveweight gain increased as sward height increased from 3 to 9 cm. The increases in liveweight gain were always greater on swards of between 3 and 5 cm (114 g) than on those between 7 and 9 cm (20 g); the quadratic term was again significant. In the present work, however, a linear regression between sward height (3.8–8.2 cm) and ewe liveweight change was observed.

The effect of sward height on live weight carried in autumn was considerable. In both breeds the live weight on 4 cm swards (2244–2298 kg ha<sup>-1</sup>) was more than twice that on 7.0 cm and 8.2 cm swards (984 and 975 kg ha<sup>-1</sup>). Chestnutt (1992) also found that the carrying capacity decreased with increases in sward height (2722, 1794, 1408 and 1208 kg LW ha<sup>-1</sup> d<sup>-1</sup> on swards of 3, 5, 7 and 9 cm respectively). Vipond *et al.* (1993) indicated that high stocking rates increase the fouling of the sward with excreta and treading damage. These harmful effects may influence herbage intake and



animal performance independently of the sward height effects.

In conclusion, significant interactions between breed and sward height on sheep liveweight gain have been observed, with the regressions containing significant quadratic terms in the spring and being linear in the autumn. Larger breeds have higher liveweight gains, but smaller breeds achieve greater productivity per hectare and at a lower sward surface height, for a given weaning weight of 25–30 kg.

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