Effects of the timing of weaning lambs and transferring from rangeland grazing to forage rape and aftermath grazing, with respect to lamb growth and development

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ABSTRACT

Experiments have shown that average daily gains (ADG) of lambs grazed on lowland mires declined at a rapid clip during the summer. Lambs grazed on highland range have, in general, greater carcass weights and dressing percentages at 4-5 months of age than lambs grazed on lowland mire, as their ADG is much greater during midsummer. However, some farms have no or limited access to highland range and the potential exists to graze green forage crops and aftermath already in August. In the present experiment, 3 groups of lambs were early-weaned and grazed on forage rape and fertilized aftermath starting at (on average) 86 days (group 3), 101 days (group 4) and 114 days (group 5) of age. Control groups were grazed with the ewes on highland range (group 1) and on homeland range at the Hestur sheep experimental farm (group 2). The early-weaned lambs had heavier carcass weights (16.0, 16.8, 18.6, 17.5 and 17.7 kg in groups 1-5 respectively), improved carcass conformation scores and higher dressing percentages (40.8, 42.7, 45.2, 43.3 and 44.2), even though there were only small differences in live weight. Weaning lambs and grazing them on forage rape and aftermath the last month of the summer grazing is beneficial over the traditional grazing on the highland range, with respect to weight, conformation and overall development of the carcass.

Keywords: carcass conformation, forage rape, growth, nutrition, sheep

YFIRLIT

Áhrif tímasetningar þess að venja lömb undan og færa þau af úthagabeit yfir á vetrarrepju- og háarbeit, með tilliti til vaxtar og þroska lamba

Tilraunir hafa sýnt að vaxtarhraði lamba á láglendismýri fellur jafnt og þétt yfir sumarið. Lömb á hálendisbeit hafa yfirleitt hærri fallþunga og betri kjötprósentu við 4-5 mánaða aldur, þar sem vaxtarhraði þeirra er hærri yfir hásumarið en hjá lömbum sem beitt er á láglendismýrar. Sum sauðfjárbú hafa þó takmarkaðan eða engan aðgang að hálendisbeit. Hinsvegar er sá möguleiki fyrir hendi að beita lömbum á grænfóður og há strax í ágúst. Þrír lambahópar voru vandir undan mæðrum sínum og beitt á vetrarrepju og há við 86 daga (hópur 3), 101 daga (hópur 4) og 114 daga (hópur 5) aldur. Einum viðmiðunarhóp var beitt á afrétt (hópur 1) og öðrum á heimaland á Hesti (hópur 2). Repjulömbin höfðu meiri fallþunga (16,0, 16,8, 18,6, 17,5 og 17,7 kg í hópum 1-5 í þessari röð), betri holdfyllingu og hærri kjötprósentu (40,8, 42,7, 45,2, 43,3 og 44,2) en úthagalömbin þó svo að lítill munur hafi verið á lífþunga. Lömbin sem voru vanin undan ánum og beitt á fóðurrepju og há síðustu vikurnar fyrir slátrun voru betur þroskuð með tilliti til fallþunga, holdfyllingar og heildarþroska skrokksins en þau lömb sem fengu hefðbundna meðferð.

INTRODUCTION

Most Icelandic sheep graze on the highlands during the summer. Some farms, however, especially in the South of Iceland, have no or limited access to a highland range and therefore they graze their sheep on lowland mire the whole summer (Bjarnadóttir et al. 2004). Experiments have shown that lambs grow better on highland range than on lowland mires (Gudmundsson & Thórhallsdóttir 1999, Gudmundsson 1988). Lambs grazed on highland range have, in general, greater carcass weight and dressing percentages at the age of 4-5 months than lambs grazed on lowland mire (Gudmundsson & Arnalds 1976-1980). One of the reasons for these differences is that the plants start to grow earlier in the spring on the lowland mire and therefore they also wilt earlier. In addition, plant species diversity is greater on the highland range than on the lowland mires. The vegetation of mires consists mostly of sedge and related plant species, whereas the highland range contains a combination of hill grasses, heath, mosses, sedge and shrubs. The digestibility of highland plants is similar or lower than for plants on lowland mire (Gudmundsson 1993). However, the composition of the digestible portion of the plant is different, which may explain higher herbage intake and better ADG of the lambs on highland range (Gudmundsson & Thórhallsdóttir 1999), along with more selective feeding. The chemical composition of the herbage in highland range is closer to legumes than grasses, as it contains more soluble carbohydrates and lignin and less cellulose and hemicellulose than herbage on lowland mire (Gudmundsson 1993).

Numerous experiments in Iceland have shown that lambs grazed on green forage crops and/or fertilized aftermath have heavier carcasses, better carcass conformation score and higher dressing percentages, with minimal increases in subcutaneous fat than lambs grazed on rangeland until slaughter (Pálsson & Sveinsson 1952, Pálsson 1957, Pálsson & Gunnarsson 1961, Guðmundsson & Dýrmundsson 1989, Thorgeirsson et al. 1990). Of the green forage crops tested, forage rape (*Brassica napus* L.) has been shown to be most suitable for finishing lambs (Fitzgerald & Black 1984, Guðmundsson & Dýrmundsson 1989, Thorgeirsson et al. 1990), as its digestibility and protein levels are high (Armstrong et al. 1993). The aftermath and green forage grazing usually occur in September and the beginning of October, after the sheep have been gathered from the highland range and the lowland pastures in the beginning of September. However, due to the low ADG in late summer, especially on the lowland mires and rangelands, it is interesting to examine the various aspects of grazing the lambs on green forage crops and aftermath in August. Due to the additional costs associated with this type of system, the effects on carcass weight and quality need to be determined to assess the economic impact of using this management system.

The growth of lambs occurs in waves, beginning cranially and running caudally and from distal limbs towards the torso. Of the main parts of the body the nervous system will mature first and then bone, muscle and fat (Pálsson 1955). The chemical composition of the body changes when the proportion of muscle development declines and proportion of fat development increases (Owens et al. 1995). It is important to supply growing lambs with high energy and protein feed before their potential for muscle development declines to maximize lean meat production. In young lambs, the ewe's milk provides the only nutrition for the lamb. After a few weeks, the lamb starts to seek additional nutrition from herbage that becomes its main nutrition source later in the growing period. As the importance of the mother's milk declines, it becomes possible to manipulate the lamb's growth with nutritious herbage. Thus, it is essential to know how weaning and subsequent grazing on green forage crops would affect the lambs depending on their age at weaning.

In an earlier experiment (Ólafsdóttir 2003), lambs were grazed on four different species of green forage crops with or without their mothers (early-weaned) from 27 July until slaughtered at 4 October. The control group was grazed on mountain rangeland until weaning in the middle of September and then grazed on fertilized aftermath until slaughtered on 4 October (i.e. a traditional grazing method). The early-weaned lambs had lower ADG than the other lambs grazing with their mothers on the forage crop. Their body composition was also less developed, as their carcass weight, conformation and fat score was lower than for the lambs that grazed with their mothers. These results suggested that the lambs were probably weaned too early (on average 77 days old). Therefore the present experiment was conducted to explore in greater detail the effects of weaning age of lambs and grazing system on lamb growth and development. Grazing experiments involve both vegetation and animal factor, but often only one of them has to be emphasized because of time shortage and funding. In this experiment more emphasis was laid on the animal factor to look at effects of different grazing systems on lamb growth and development. Thus, the amount of herbage ingested by the lambs or its nutritive value was not measured.

MATERIALS AND METHODS

The present experiment took place on the Hestur sheep experimental farm of the Agricultural University of Iceland during late summer 2003.

Animals

The native Icelandic ewes were between two and six years of age and were all raising twin lambs (Table 1). The ewes were allocated to five treatment groups, each with ten ewes, with ewes in all groups having a similar age distribution and index for mothering ability.

- *Group 1*. Control group, traditional grazing system. Ewes and lambs were grazed in the highlands from 28 June until 15 September. On 15 September, the lambs were weaned and grazed on fertilized aftermath until slaughtered. Average age at weaning was 130 days.
- *Group 2*. Ewes and lambs were grazed on rangeland at Hestur from 28 June until 15 September. On 15 September, the lambs were weaned and grazed on fertilized aftermath until slaughtered. Average age at weaning was 130 days.

Table 1. Mean values for live weight (LW), ultrasound scanning and average daily gain (ADG in g LW d^{-1}) from birth until the start of the experiment on 28 June. Depth of *l. dorsi* and subcutaneous fat is in mm, and shape of muscle assessed on a scale of 1-5.

Treatment groups	Number of lambs	Males	Females	LW in kg	Ultrasound scanning			ADG from birth, g LW day^{-1}
					l. dorsi	Fat	Shape	
Highland range (1)	16	11	5	17.7	19.8	1.23	3.93	297
Range land (2)	16	6	10	18.6	19.6	1.39	3.78	312
Weaned 6/8 (3)	17	5	12	17.9	20.4	1.38	3.76	300
Weaned 20/8 (4)	19	13	6	18.1	20.5	1.36	3.67	303
Weaned 3/9 (5)	22	13	9	17.7	19.4	1.25	3.22	296

- *Groups 3-5*. Ewes and lambs were grazed on rangeland at Hestur from 28 June until 6 August (group 3), 20 August (group 4) and 3 September (group 5). The lambs then were weaned and grazed on forage rape and fertilized aftermath until slaughtered. Average age at weaning was 86 days, 101 days and 114 days in groups 3 to 5 respectively.

The ewes lambed indoors and the mean lambing date was 11 May. After lambing, the ewes and lambs were kept inside for approximately 10 days. Ewes and lambs then were placed on cultivated grass pasture. The ewes were fed hay *ad lib* and 300 g d^{-1} per ewe of concentrate (1.14 FE_m, 500 g CP, 200 g AAT and 168 g PBV per kg DM) while indoors and during the first 2 weeks on the grass pasture. All ewes and lambs grazed on rangeland at Hestur from 1 to 28 June. On 28 June all lambs received 1 ml $lamb^{-1}$ of the anthelmintic Zerofen. The ewes received 5 ml ewe^{-1} of the anthelmintic Panacur at the end of April.

All lambs were weighed at birth (initial live weight; ILW) and on 28 June when ewes and lambs in group 1 were moved to mountain pasture. Lambs in groups 2-5 were weighed every other week from 6 August until slaughtered. Lambs in groups 1 and 2 were not weighed at weaning (15 September). All lambs were weighed before slaughter. Ultrasound scanning was conducted to determine the depth of the *longissimus dorsi* (*l. dorsi*) muscle, subcutaneous fat thickness over the *l. dorsi*, and *l. dorsi* shape was measured over the 3rd sacral vertebrae in all groups on 28 June and 30 September. Ultrasound measurements also were taken in groups 2-5 on 6 August and 3 September. The shape of the *l. dorsi* muscle was evaluated by a subjective score on the scale 1-5, where score 1 represents a narrow, triangular muscle shape and score 5 a wide and even shape of the muscle (Thorsteinsson 1995). Table 1 describes the conditions of the lambs at the start of the experiment.

Some of the experimental ewes and lambs did not show up when the sheep were rounded up from the rangeland at Hestur on 28 June, resulting in a variable number of lambs among groups from the beginning of the experiment (Table 1). Two lambs in group 3 and one in group 4 became sick in August and one lamb from group 3 died in the beginning of September, leaving 17 and 19 lambs in group 3 and 4, respectively. A few lambs were kept for breeding (1 from group 3, 2 from group 4 and 2 from group 5) and are therefore not included in the slaughter data.

Grazing

The highland range is 290-400 m above sea level (a.s.l.), with an area of 190 km^2, and it is grazed by about 4500 sheep from the end of June until the middle of September. The vegetation of the highland range is made up of alpine moss heath with grasses (example *Festuca spp*. and *Kobresia myosuroides* (Vill.) Fiori) and ling (example *Empetrum nigrum* L. and *Calluna vulgaris* (L.) Hull.), 42.3%, and bog grown with, for example, *Carex spp*. and *Equisetum spp*., 16.2%. The rest of the highland range is desert and bare mountains with little or no vegetative coat. The rangeland at the Hestur experimental farm is at 200 m a.s.l., on average, consisting of approximately 500 ha, and it was grazed by 70 twin lamb ewes. The main vegetation is alpine moss heath with grasses (example *Festuca spp*. and *Kobresia myosuroides*) and ling (example *Empetrum nigrum* and *Calluna vulgaris*). Around one third is mire with species like *Carex spp*. and shrub area with birch (*Betula pubescens* Ehrh.).

The forage rape (*Brassica napus*) was sown in a 1.2 ha field on 29 May at the sowing rate of 8 kg of seed per ha and 600 kg ha^{-1} of N-P-K 16-6.6-10 fertilizer was spread over the field. On 6 August the forage rape was ready for grazing. The grass pasture was 3 ha in size. It was cut on 10 July and then fertilized again with 150 kg ha^{-1} of N-P-K 20-5.2-6.6 % prior to grazing. It was grown with timothy grass (*Phleum pratense* L.) and meadow grass (*Poa pratensis* L.). The forage rape field and the grass pasture adjoined and were grazed continuously. The lambs were not monitored to see when they were grazing the forage rape or the grass pasture.

Slaughtering

All lambs were slaughtered on 3 October at the same commercial abattoir. Hot carcass weight was recorded and carcasses were assessed for conformation and fatness using the EUROP carcass classifying system (MLC 1993). Conformation and fat score were converted to numerical values representing a 15-point scale (Lewis et al. 1996), for analysis, as seen in Table 2. Dressing percentage was calculated as: hot carcass weight/pre-slaughter live weight x 100.

Table 2. Numerical values for carcass conformation and fat score.

Conformation		Fat	
Class	**Value**	**Class**	**Value**
E	14	5	14
U	11	4	11
R	8	3+	9
O	5	3	8
P	2	2	5
		1	2

The carcasses were chilled at 4°C with a low air speed for 24 hours. Fat thickness on the 12th rib (J) was measured and recorded on cold carcasses. The external measurements, length of tibia (T), depth of crutch (F), thorax depth (Th) and thorax width (W) were measured. Conformation of shoulder and leg was scored on a scale of 1-5 (Pálsson 1939).

Data analysis

The data were subjected to analysis of variance with covariates to examine the effect of grazing group (treatment), sex of lambs and possible interactions. The data were analyzed using the General Analysis of Variance (ANOVA) procedure in Genstat Version 7.1 (Laws Agricultural Trust 2003). Treatment and sex differences were tested for significance at the 0.05 probability level, based on the least significant difference (LSD) method (Snedecor 1980). Age, in days from birth, and initial live weight (ILW) were used as covariates in the model for all analyses except for average daily gain (ADG). The model used was:

$$Y_{ijk} = \alpha_i + \gamma_j + \alpha\gamma_{ij} + \beta_{x(ij)} + \varepsilon_{ijk}$$

Where Y_{ij} is the record of the kth animal assigned to the ith treatment (grazing group), α_i is the effect associated with the ith treatment, γ_j is the effect associated with the jth sex, $\alpha\gamma_{ij}$ is the interaction between treatment and sex, $\beta_{x(ij)}$ is the linear regression on covariates and ε_{ijk} is the residual effect. If no significant interactions were found they were not included in the model. Where significant interactions were found, the unstructured treatment option in ANOVA was used. Then the treatment groups were combined into 2 groups, rangeland (groups 1 & 2) and early weaned (groups 3-5), because of variation in number of female and male lambs among groups.

RESULTS

Age and ILW had significant effects ($P < 0.05$) on all live weight (LW) measurements, as expected. Male lambs were significantly heavier than female lambs ($P < 0.001$) at all weighings. At the last weighing (30 Sept.), the mean LW of male and female lambs were 41.9 kg and 38.2 kg, respectively. Significant differences in LW were found among treatment groups 2-5 ($P < 0.01$) on 20 August and 3 September, but those differences were not present at the end of the experiment (Table 3). Significant interactions upon live weight were found between treatment and sex at the end of the treatment period ($P = 0.013$), when the differences between sexes were smaller in the rangeland groups (groups 1 & 2; 38.6 vs. 40.5 kg for female and male lambs, respectively) as compared to the early weaned groups (groups 3-5; 38.3 vs. 42.3 kg).

Average daily gain (ADG) from birth until 30 September was similar among treatment groups, although some differences were evident when the growth curve was divided into shorter periods (Table 4). Male lambs grew

Table 3. Mean values of live weight (kg LW) by treatment groups, adjusted for effects of sex and age of lambs.

Treatment groups	Date				
	6 Aug	20 Aug	3 Sept	18 Sept	30 Sept
Highland range (1)	-	-	-	-	39.5
Range land (2)	29.1	32.3[ab]	35.9[b]	38.9	39.8
Weaned 6/8 (3)	28.2	31.2[ab]	33.9[a]	38.6	40.8
Weaned 20/8 (4)	29.0	32.4[b]	33.7[a]	38.0	40.7
Weaned 3/9 (5)	27.9	30.9[a]	34.8[ab]	37.2	40.0

[a,b] values with a different superscript within a column are statistically different (P<0.05).

faster than female lambs for the whole experimental period ($P < 0.05$), 269.9 g d^{-1} and 238.9 g d^{-1} respectively. Significant interactions upon ADG were found between treatment and sex for the whole experimental period ($P = 0.036$). In the rangeland groups (groups 1 & 2), the ADG of male lambs was 257.7 g d^{-1} and female lambs 242.6 g d^{-1}, and in the early weaned groups (groups 3-5), the ADG of males was 274.0 g d^{-1} and females 239.8 g d^{-1}.

Age of lambs had a significant effect ($P < 0.05$) on the thickness of the loin muscle (*l. dorsi*) and the subcutaneous fat thickness over the loin muscle at all times of measure. Lambs in group 3 had significantly thicker loin muscles than groups 2, 4 and 5 on 3 September ($P < 0.05$; Table 5). At the last measurement (30 Sept.), all the early weaned groups (3, 4, 5) had significantly thicker loin muscles than the control groups (1 & 2; $P < 0.001$). Group 3 had the thickest subcutaneous fat over the loin muscle measured on 3 and 30 September and also the best shape of the loin muscle on 3 September. At the end of the experiment there were no significant differences in muscle shape between the treatment groups. Sex of lambs did not affect the ultrasound measurements but significant interactions upon thickness of the loin muscle were found between treatment and sex on 30 September ($P = 0.035$). In the rangeland groups loin muscle thickness was 26.9 mm in male lambs and 27.5 mm in females, whereas in the early weaned groups muscle thickness was 30.1 mm in males and 30.5 mm in females.

When adjusted for age and ILW the carcass weights differed significantly between groups (3>5> 4> 2> 1; Table 6). Lambs in the control group (1) had the lowest numerical carcass conformation score, even though it was not

Table 4. Mean values of average daily gain (g LW d^{-1}) for different time periods by treatments, adjusted for effects of sex and age of lambs.

Treatment groups	Time					
	28 Jun - 6 Aug	6 Aug - 20 Aug	20 Aug - 3 Sept	3 Sept - 18 Sept	18 Sept - 30 Sept	Birth - 30 Sept
Highland range (1)	-	-	-	-	-	251
Range land (2)	267[ab]	228	254[c]	200[a]	31[a]	250
Weaned 6/8 (3)	257[ab]	219	193[b]	318[b]	181[b]	261
Weaned 20/8 (4)	277[b]	244	90[a]	291[b]	215[b]	261
Weaned 3/9 (5)	253[a]	218	276[c]	161[a]	217[b]	253

[a,b,c] values with a different superscript within a column are statistically different (P<0.05).

Table 5. Mean values of measurements of ultrasound scanning by treatment, adjusted for effects of sex and age of lambs. Depth of *l. dorsi* and subcutaneous fat is in mm, and shape of muscle assessed on a scale of 1-5.

Treatment groups	Date of measurement								
	6 Aug			3 Sept			30 Sept		
	l. dorsi	Fat	Shape score	*l. dorsi*	Fat	Shape score	*l. dorsi*	Fat	Shape score
Highland range (1)	-	-	-	-	-	-	27.0^{a}	2.91^{a}	3.79
Range land (2)	23.9	2.00^{ab}	3.34	24.9^{a}	2.64^{b}	3.19^{a}	27.4^{a}	3.15^{a}	3.79
Weaned 6/8 (3)	24.1	2.16^{b}	3.39	27.6^{b}	2.70^{b}	3.77^{b}	30.6^{b}	3.82^{b}	3.61
Weaned 20/8 (4)	24.2	2.02^{ab}	3.55	26.0^{a}	2.46^{ab}	3.21^{a}	30.0^{b}	3.17^{a}	3.68
Weaned 3/9 (5)	23.8	1.79^{a}	3.11	25.4^{a}	2.16^{a}	3.36^{ab}	30.2^{b}	2.97^{a}	3.93

^{a,b} values with a different superscript within a column are statistically different (P<0.05).

Table 6. Mean values by treatment groups of carcass weight, conformation and fat score according to the EUROP system, and carcass external measurements. Adjusted for effects of sex and age of lambs.

	Treatment groups[1]				
	1	2	3	4	5
Number of lambs slaughtered	16	16	16	17	20
Carcass weight, kg	16.0^{a}	16.8^{ab}	18.6^{c}	17.5^{b}	17.7^{bc}
Carcass conformation score[2]	8.28^{a}	9.74^{bc}	10.9^{c}	8.84^{ab}	10.4^{c}
Fat score	6.83^{a}	7.31^{a}	8.24^{b}	7.84^{ab}	7.63^{ab}
Rib fat thickness (J-cold), mm	8.13^{a}	9.41^{ab}	12.2^{c}	9.88^{b}	10.3^{b}
Dressing out percentage, %	40.8^{a}	42.7^{b}	45.2^{d}	43.3^{bc}	44.2^{cd}
Shoulder score (1-5)	3.67^{a}	3.98^{ab}	4.66^{c}	4.01^{b}	4.21^{b}
Leg score (1-5)	3.66^{a}	3.92^{ab}	4.35^{c}	3.81^{a}	4.22^{bc}
Leg length (F), mm	236^{a}	232^{ab}	227^{b}	237^{a}	231^{ab}
Length of tibia (T), mm	187^{ab}	186^{b}	185^{b}	191^{a}	187^{ab}
Muscle thickness of leg (F-T)	48.8^{a}	45.8^{abc}	41.6^{c}	46.5^{ab}	43.3^{bc}
Thorax width (W), mm	169^{a}	175^{b}	186^{c}	176^{b}	177^{b}
Thorax depth (Th), mm	265^{ab}	262^{b}	264^{ab}	268^{a}	265^{ab}
W/Th ratio	0.64^{a}	0.67^{b}	0.71^{c}	0.66^{b}	0.67^{b}

^{a,b,c} values with a different superscript within a row are statistically different (P<0.05).

[1]Treatment groups; 1 = Highland range, 2 = rangeland, 3= weaned 6/8, 4 = weaned 20/8, 5 = weaned 3/9.

[2]Numerical values defined in Table 2.

significantly different from group 4. Group 3 had the greatest side fat thickness on the 12th rib, but did not receive a significantly higher fat score than the other early weaned groups. The dressing percentage was lowest for the control group (1) (Table 6). Conformation scores for the shoulder and the leg were greatest for group 3 but the leg score was not significantly different between groups 3 and 5. Carcasses of lambs in group 3 had, in most cases, the best external measurements (Table 6). Male carcasses were significantly heavier than females, 18.0 kg and 16.5 kg respectively. Other carcass measurements generally did not differ between males and females. A significant interaction occurred between treatment and sex (P = 0.01) for carcass weight. In the rangeland groups, the mean carcass weight of male and female lambs was 16.9 kg and 15.6 kg, respectively, whereas in the early weaned groups the mean carcass weight for males and females was 18.4 kg and 17.3 kg, respectively.

DISCUSSION

The lambs in groups 3-5 did not seem to suffer from early weaning as they showed a similar ADG over the whole experimental period and attained a similar final live weight (FLW) as the lambs weaned at the traditional middle of September (groups 1, 2). Furthermore, the earlier weaned lambs had a higher dressing percentage and carcass weight than the lambs in groups 1 (especially) and 2. This suggests that the substitution of the ewe's milk and rangeland grazing with the more nutritious grazing of forage rape and fertilized aftermath was positive for the lambs even if they were early-weaned at 86 days of age (group 3). In this experiment, the lambs were older at weaning than in the experiment conducted by Ólafsdóttir (2003), where weaning at 77 days into a similar grazing system resulted in worse developed carcasses than in the early-weaned lambs in this experiment.

The growth of a lamb is a function of its genetic potential and the extent to which the environment allows this potential to be expressed. Nutrition is a large part of the environmental effects and thus it is important to supply growing lambs with enough nutritious feed to allow for adequate growth (Pálsson & Vergés 1952). Young lambs have a high growth potential and the greatest part of the postnatal tissue growth until puberty is muscle development. Protein is the main building material for muscles and the rate of protein gain in the lamb's tissues depends on protein synthesis and accretion, which are affected by the lamb's growth efficiency (Black 1983). The higher conformation and fat score and dressing percentage of the early weaned lambs (groups 3-5) compared to the control groups (1, 2), suggests that forage rape grazing supported carcass growth and development in a more efficient way than rangeland grazing and milk. However, no significant difference in FLW was detected, which may be partly explained by possible lower gut fill in the early weaned lambs. Brassica species are a highly digestible feed with high protein and energy content (Bláfeld 1976, Barry et al. 1981, Pálsson et al. 1981, Fitzgerald 1985, Armstrong et al. 1993). Leafy Brassicas have high organic matter digestibility (OMD). In an experiment by Armstrong et al. (1993) the OMD of the whole plant was 0.84 and the intake of the feeds was closely related to the OMD. They also detected a significant difference between leaf and stem OMD (0.84 for the leaf and 0.79 for the stem). This high OMD of Brassicas is a reflection of their low fibre content (Armstrong et al. 1993, Wilman et al. 1996), which makes them very desirable as grazing plants for finishing lambs. Chemical composition of herbage on highland range in Iceland was detected in an experiment by Gudmundsson (1988), who found that the average digestibility of the plants was 0.45 during the growing season. Therefore forage rape grazing following early weaning could be expected to support fast growth.

The present results indicate that live weight gain of lambs grazing forage rape does not always reflect carcass weight gain and conformation in lambs in that lambs can be gaining in empty-body weight even though their live weight gain is low. Results from Fitzgerald (1985) indicated that finishing lambs grazing rape (R) or autumn pasture (P) lost weight during the first 4 weeks of grazing, while lambs grazing rape with autumn pasture runback (RP) or given hay *ad lib* (RH) gained weight over that time period. The difference in ADG between the rape diets then disappeared during the next 9 weeks of grazing, whereas the ADG of the pasture grazed lambs was less over the entire time period. This difference is explained with gut fill changes, where the feeding of hay or pasture reduced the initial reduction in gut fill and thereby reduced the initial loss in live-weight. However, the performance of the R lambs in empty body-weight gain and carcass gain was similar as the RP and RH lambs after the first 4 weeks of grazing. Therefore, lamb performance on forage rape is better expressed as empty-body weight gain or carcass gain rather than live weight gain alone. These factors are, however, more complicated to measure because several lambs have to be slaughtered on different time points during the experiment.

Differences in ADG between treatment groups over the shorter time periods were evident. As expected, ADG decreased over the first two weeks after weaning in groups 3-5 when the lambs were adapting to the forage rape grazing. In the time period 20 August until 3 September, the ADG of lambs in group 3 and 4 was lower than expected as compared to previous results (Thorgeirsson et al. 1990). This could have been due to very wet weather during the last 2 weeks of August. The forage rape fields become muddy due to wet weather and therefore are not desirable for grazing (Bastiman & Rigby 1990). The low ADG during this period is likely due to both wet weather and low rumen fill, as the lambs reached adequate carcass weights by the end of the experiment. On the other hand lambs in group 4 did not have as desirable carcass conformation scores as the other lambs in groups 3 and 5, and the carcass fat was high in relation to carcass conformation.

Some researchers have reported low growth rates of finishing lambs grazing Brassicas (Barry et al. 1981, Armstrong et al. 1993). These low growth rates can be related to secondary metabolites, S-methylcysteine sulphoxide (SMCO) and glucosinolates that are in greater amount in lamina than in other parts of the plant (Armstrong et al. 1993). The secondary metabolites of Brassicas have been shown to depress herbage intake, thus lowering ADG (Armstrong et al. 1993). In previous Icelandic experiments, this problem has not been evident (Bláfeld 1976) and it seems that the effects due to these metabolites in this study were also not great as the ADG of the early weaned lambs was high over the period of forage rape grazing.

Previous Icelandic experiments have reported an adequate stocking rate of 70-100 lambs ha^{-1} on forage rape (Eyþórsdóttir & Sveinbjörnsson 2001). In this experiment the stocking rate was from 15 lambs ha^{-1} the first two weeks on the forage rape up to 48 lambs ha^{-1} the last two weeks, excluding the aftermath. Therefore the forage rape was not overstocked and the risk of parasite infection should have been low. The stocking rate on the homeland range at Hestur was 0.14 two lamb ewes ha^{-1} the period 28 June until 6 August, which is light stocked. Then 20 lambs were removed every second week from 6 August. The weather the summer of 2003 was warm and vet, thus it was preferable for vegetation growth and more herbage was likely available for the sheep in the beginning of the summer. Weather like this is favourable for lamb meat production, as the lambs can be turned out earlier in the spring and the vegetation gets a good start at the onset of growth.

As stated in many reports (Pálsson & Sveinsson 1952, Pálsson & Gunnarsson 1961, Fitzgerald 1985, Pálsson et al. 1981, Thorgeirsson et al. 1990) grazing lambs on forage rape results in faster growth, and higher muscle/fat ratio than grazing on fertilized aftermath. Therefore, it is not surprising that loin muscle thickness was greatest in lambs in group 3 which had been grazing on the forage rape for the longest period (i.e. 4 weeks). From 3 until 30 September, the lambs in group 3 were gaining less muscle thickness than lambs in groups 4 and 5. This may be because lambs in group 3 reached a certain level of maturity resulting in decreased muscle deposition and increased fat deposition (Pálsson & Vergés 1952). Lambs in the control groups (1, 2) had thinner loin muscles but only slightly thinner subcutaneous fat over the loin muscle than the early weaned groups (3, 4, 5), suggesting that grazing forage rape by weaned lambs for the last 4-8 weeks of the summer grazing season has beneficial effects on muscle growth compared to rangeland grazing of un-weaned lambs in the same period.

The lambs in group 3 had the highest gain of subcutaneous fat over the loin muscle during the last 4 weeks of the experiment (Table 5). There is a positive correlation between the subcutaneous fat thickness over the loin muscle and fat thickness on the 12th rib of the carcass (Thorsteinsson & Eythórsdóttir 1998). Hence, with thicker subcutaneous fat over the loin muscle, a higher carcass fat score can be expected as the score is determined according to the fat thickness on the 12th rib. With this information, a more appropriate slaughter date for the lambs in group 3 would have been in the middle of September. Their carcass weight would have been lower (approximately 17.6 kg) assuming that the dressing percentage was the same as on 3 October. The carcasses also would have likely been leaner. Leaner meat has a higher demand by consumers and thus brings a higher price from the slaughterhouse.

Larger differences in FLW, ADG, final loin muscle thickness and carcass weight, were detected between sexes in the early weaned groups (3, 4, 5) than the control groups (1, 2). The male lambs seemed to benefit much more from the forage rape grazing than the female lambs. Male lambs have higher mature weight than female lambs and thus they have greater muscle growth at the same weight (Pálsson 1955). There is less energy in one kg of muscle than in one kg of fat and therefore more energy is needed to gain fat than muscle (Owens et al. 1995). Therefore, male lambs need less energy, but more protein, for growth and maintenance at the same live weight and ADG than do female lambs (Sveinbjörnsson & Ólafsson 1999). These differences between males and females, in combination with the shift in nutrient supply at weaning, probably explain why the male lambs gained more muscle on the forage rape than the female lambs.

It can be concluded from this experiment that weaning lambs and grazing them on forage rape and aftermath during the last weeks before slaughter, even from early August, is beneficial over the traditional grazing on the highland range, with respect to the weight, conformation and overall development of the carcass.

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