

Effect of type of forage offered and breed on performance of crossbred suckler heifers and their calves

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Thirty Hereford-Ayrshire (HfAy) and 29 Limousine-Ayrshire (LiAy) spring-calving heifers in calf to a Aberdeen Angus (Ab) bull were used to study the effects of cow breed and winter diet on performance. The diets were either primarily based on hay (H, $\frac{2}{3}$ of dry matter (DM) intake, silage $\frac{1}{3}$) or silage (S, $\frac{2}{3}$ of DM intake, hay $\frac{1}{3}$). In addition, animals were offered 1.0 kg milled barley per head daily for two months prior to calving and 1.5 kg/day from calving until grazing commenced. Animals also had free access to barley straw.

During the indoor feeding period from 15 December to 1 June HfAy-heifers consumed slightly but not significantly more feed DM, metabolizable energy and AAT (amino acids absorbed from the small intestine) than LiAy-heifers on both diets. At the start of the experiment LiAy- and HfAy-heifers were 572 and 596 ($P < 0.05$) days of age, respectively. Corresponding ages at calving were 732 and 729 days. The type of forage feeding did not affect the rate of *pre partum* live weight gain (LWG). The calving difficulties observed were minor. Average milk production of HfAy-cows was higher ($P < 0.01$) than that of LiAy-cows. Calf LWG from birth to weaning was 1058 and 987 g/day for HfAy- and LiAy-progeny, respectively. Corresponding values for the progeny of cows fed S- and H-diets were 1009 and 1036 g/day. All HfAy-cows and 87.1% of LiAy-cows were successfully rebred to Charolais (Ch) sires.

Both S- and H-based diets were suitable for crossbred heifers. Although the energy intake was below Finnish recommendations on both diets, particularly *pre partum*, live weight of 488 kg for HfAy- and 476 kg for LiAy-heifers *pre partum* proved to be adequate. The incidence of calving difficulties was low.

Key words: beef heifers, calf performance, calving difficulty, feed requirement, milk production

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Introduction

Most Finnish beef is derived from dairy herds and approximately only six per cent originates from beef suckler herds. Continuous reduction in dairy cow numbers together with a growing consumer demand for quality beef has increased the need for specialized beef production and therefore, knowledge of feeding suckler heifers and cows.

It is known that feeding beef heifers from puberty to weaning of their first calf is a critical period. Under- or over-heifernutrition may have a major influence on calf birth weight, milk production, calf survival, and above all, resumption of oestrus activity (Field 1991). However, information on crossbred replacement beef heifer management under Finnish conditions, with relatively short grazing and long indoor feeding periods, is inadequate.

The purpose of the present experiment was to study the effect of forage type (grass silage vs. hay-based diet) on forage intake, live weight, live weight gain, calving difficulty, milk production and rebreeding of Hereford × Ayrshire (HfAy) and Limousine × Ayrshire (LiAy) heifers and calf performance. An additional aim of the experiment was also to examine the suitability of direct-cut grass silage in the prevailing cold indoor feeding conditions. Breed types were chosen based on calf availability from farms and the popularity of HfAy animals as crossbred suckler dams. Furthermore, Limousin was the most popular beef breed used during recent years for beef inseminations on dairy herds. Aberdeen Angus (Ab) was chosen as the maiden heifer sire.

Material and methods

Animals and experimental design

The experiment was carried out at Tohmajärvi research station located in eastern Finland (62°

14'N, 30°21'E). In December, the minimum temperatures recorded inside and outside the cowhouse were -19°C and -32°C, respectively (Figure 1). Thirty-two HfAy-heifers with an initial live weight (LW) on 14 December of 436 kg, and 32 LiAy-heifers with an initial LW of 393 kg, both breeds in calf to Ab, were used. The experiment commenced 15 December when HfAy- and LiAy-heifers averaged 596 and 572 days old, respectively. At calving both HfAy- and LiAy-heifers averaged 24 months of age, after which they are referred to as cows. Animals were allocated to four treatments according to their LW and predicted calving date according to a 2 × 2 factorial design. Factors were breed type (HfAy and LiAy) and diet (hay-based, H and silage-based, S). Animals were group-fed, eight animals per pen, two pens per treatment. The experiment was subdivided in two main parts, the indoor feeding period and the grazing period. During the indoor feeding period animals were housed in a barn with an area of 77 m²/group. Both straw and peat were used as bedding materials. Animals also had access to an outside exercise area of 108 m²/group.

Feeding and feed sampling

Animals were fed once a day in the morning. The amount of feed offered and refused was recorded for each group daily. The quantity of forage offered daily was restricted. Hay and silage were given to heifers fed S- and H-diets according to their initial LW and Finnish recommendations (Ojala 1987) which are based on feeding recommendations for dairy cows and heifers given by Salo et al. (1982). On the H-diet the proportion of total forage dry matter (DM) intake was designed to be 2/3 of hay and 1/3 silage. The reverse applied for the S-diet. *Pre partum* and *post partum* feeding regimens involved increasing the amount of silage two months before the estimated calving date and after calving. Barley straw was fed *ad libitum* to all groups. Milled barley was offered individually to heifers at 1.0 kg/d, two months *pre partum* and 1.5

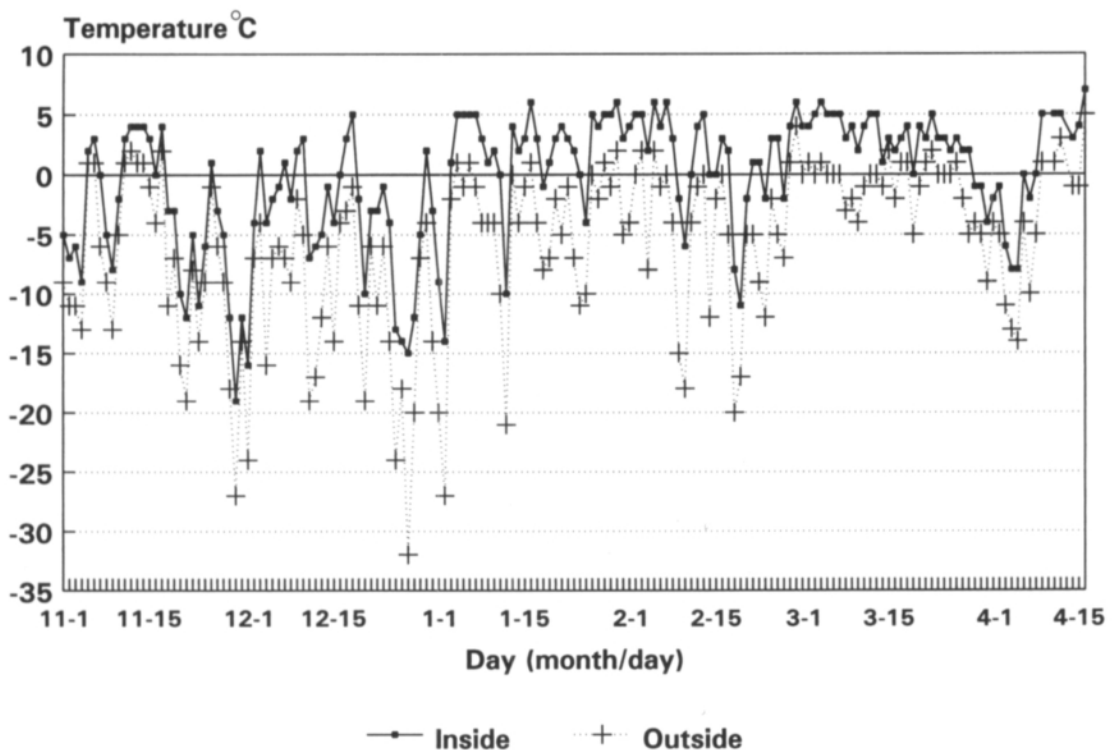


Fig. 1. Daily temperature (°C) inside and outside the barn during indoor feeding.

kg/d from calving to the start of the grazing season by retaining animals in the feed alley. During the indoor feeding period 150 g/day of mineral mixture rich in magnesium (Viher-Terki) and 50 g/week of vitamin mixture (Deb-Karja-Vitan) was given to the heifers. Heifers had free access to water and a salt lick.

Meadow fescue-timothy (*Festuca pratensis-Phleum pratense*) hay was harvested during the first two weeks of July, dried in the swath and baled into small and round bales. Direct-cut grass silage was made using a flail harvester from the same meadow fescue-timothy fields in August and ensiled in three bunker silos using a formic acid based additive (AIV II; 800 g formic acid/kg, 20 g orthophosphoric acid/kg), applied at 4–5 l/t of grass. Field-dried barley straw was baled into small bales. Barley was harvested conventionally and dried in a hot-air drier.

The grazing season commenced on 1 June. Seventeen heifers calving in June were kept inside and started grazing after calving. The continuous grazing area allocated for cows was about 30 hectares. Cows had free access to water and a mineral mixture rich in magnesium. As a result of drought in July, August and September cows on pasture were fed during this period of 8 weeks about 2 kg hay/animal/day. The grazing season ended on 24 August and calves were weaned on either 30 September or 21 October.

During the indoor period feed samples for chemical analyses were taken at every feeding and were pooled over a four week period. Calculated energy values of hay, grass silage, barley straw and barley are based on determined chemical composition and using average digestibility coefficients reported by Tuori et al. (1996). Silage DM content was determined by

oven drying at 105°C for 24 hours and was corrected for volatile losses (volatile fatty acids, ammonia, lactic acid) according to Huida et al. (1986). Fresh silage samples were analysed for pH, water soluble carbohydrates according to Somogyi (1945) with modifications of Salo (1965), lactic acid (Barker and Summerson 1941), volatile fatty acids (Huida 1973), ammonia nitrogen (N) (McCullough 1967) and soluble and total nitrogen N by the Kjeldahl method. Metabolizable energy (ME) values of feeds were calculated according to MAFF (1975, 1984). Amino acids absorbed in the small intestine (AAT) and protein balance in the rumen (PBV) were calculated according to Tuori et al. (1996).

Live-weight

Animals were weighed at the beginning of the experiment, 1–7 days *pre partum*, within 48 hours after parturition and at the beginning and end of the grazing season. All information from five heifers was omitted from the final data because of deaths and abortions. Calves were weighed immediately after birth, at 100 days of age and at weaning. The results of two calves were omitted from the final data because of removal of their dams from the experiment.

Calving difficulties

All calvings were monitored and assistance was given if calving was prolonged. The character of the calving was recorded using a classification scale: easy calving with no assistance (1), calving with a slight assistance (2) and difficult calving (3).

Milk production

Milk production of 16 cows, four cows per treatment, was measured using the calf-suckling technique. The cow and her calf were removed from

the main group at 1500 hours, and the calf was separated from the dam until 700 hours the following morning. In the morning the calf was weighed and then allowed to suckle after which the calf was reweighed. After suckling the calf was separated from the dam. At 1500 hours this procedure was repeated. The sum of both changes in calf live weight was used as an estimate of dam milk production. Milk yield was measured on days 10, 50, 95 and 145 of lactation. Data of one HfAy-cow fed the H-diet was deleted due to incomplete pre-calving feed intake records.

Rebreeding

At pasture an oestrus synchronisation procedure was carried out using PRID (Progesterone Releasing Intravaginal Device) on all cows. HfAy- and LiAy-cows were subdivided into three groups according to calving date. After the removal of PRID-coils, cows were inseminated using double fixed time artificial insemination (A.I.) with Charolais-semen. A Charolais-bull ran with the cows from 24 July to 29 September.

Statistical analysis

The GLM procedure of the Statistical Analysis System (SAS 1989) was used for analysis of variance. Animals were in pens, eight animals per pen, two pens per treatment. Pen was used as an experimental unit (Gill 1989). The mean of the pen was used when interpreting feed intake data, while for other traits individual cow data was used.

Data for heifers was analysed according to the following model

$$y_{ijkl} = \mu + b_i + d_j + bd_{ij} + p_k(bd_{ij}) + \epsilon_{ijkl}$$

where y_{ijkl} is the response variable, μ is the general mean, b_i is the breed, d_j is the diet, bd_{ij} is their interaction, p_k is a random effect due to the pen within treatment and ϵ_{ijkl} is the random error term. In the analysis, the $p_k(bd_{ij})$ term with four

Table 1. Duration of feeding periods and age of heifers at calving (days).

Breed Diet	Hereford x Ayrshire		Limousin x Ayrshire ³		SEM ²	Statistical significance ¹		
	Silage	Hay	Silage	Hay		Breed	Diet	Interaction
Number of animals	15	15	13	16				
Age at start of experiment	606	586	580	565	7.8	*	o	NS
Experiment start to calving	134	133	160	160	16.4	NS	NS	NS
Age at calving	740	719	740	725	14.7	NS	NS	NS
From calving to the start of grazing (n) ⁵	41 (12)	35 (14)	28 (6)	16 (9)	11.6 ⁴	NS	NS	NS

¹ o P<0.10; * P<0.05; ** P<0.01; *** P<0.001; NS not significant.

² SEM = Standard Error of the Mean.

³ Means were based on 13 (LiAy-Silage) or 16 (LiAy-Hay) rather than 15 observations. SEM given should be multiplied by 1.08 (LiAy-Silage) or 0.97 (LiAy-Hay) when making comparisons with other mean values.

⁴ SEM given should be multiplied by 1.10 (HfAy-Silage), 1.32 (LiAy-Hay) or 1.53 (LiAy-Silage) when making comparisons with the mean value of HfAy-Hay.

⁵ Number calved at the start of grazing.

degrees of freedom has been used as an error term.

Data for calves was analysed with the same model with the exception that the effect of sex (s_m) and interactions between sex and breed, sex and diet, and sex, breed and diet were included. In this analysis, the $p_k(bds_{ijm})$ term with eight degrees of freedom has been used as an error term. Calf birth date was used as a covariate in the analysis of variance when interpreting calf performance data. Standard error of estimate (SEE) was used to interpret calf data due to variable number of observations per treatment.

Results

General results

At the start of the experiment LiAy-heifers were younger (P<0.05) than HfAy-heifers (Table 1). In addition, heifers on the H-diet tended (P<0.10)

to be younger than those on the S-diet. One LiAy-heifer was observed to be open during the indoor feeding period and one HfAy-cow was slaughtered as a result of injury at calving. One LiAy-cow died of septicaemia during the grazing season and another LiAy-heifer aborted. Otherwise the health of heifers was good.

Chemical composition of feeds and feed intake

Average chemical composition and feed values of experimental feeds are given in Table 2. Silage was of good fermentation quality with a low pH and low concentration of ammonia N.

Average daily intakes of DM, ME, AAT and PBV during the indoor feeding period are summarised in Table 3. HfAy-heifers consumed numerically more (P>0.10) DM, ME and AAT than LiAy-heifers during the indoor feeding period on both diets. No significant differences were observed in DM and AAT intakes between feeding types but ME intake tended (P<0.10) to be low-

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Table 2. Chemical composition and feed value of experimental feeds.

	Silage	Hay	Barley straw	Barley
Number of samples	6	6	6	4
Chemical composition (g/kg)				
Dry matter (DM)	191	860	850	869
In DM,				
Ash	58	57	48	24
Crude protein	131	102	50	122
Ether extract	55	19	15	23
Crude fibre	314	363	457	54
Nitrogen free extract	442	459	430	777
Feed value,				
ME, MJ/kg DM	10.6	8.5	6.1	13.3
AAT, g/kg DM	79	75	57	104
PBV, g/kg DM	-3	-27	-46	-48

ME, metabolizable energy; ME/11.7 = feed unit, FU.

AAT, amino acids absorbed in the small intestine.

PBV, protein balance in the rumen.

In silage: pH 3.86; in DM (g/kg): lactic acid 53, acetic acid 18, sugar 29.

In total nitrogen (g/kg): ammonia N 40, soluble N 427.

er on the hay-based diet than on the silage-based diet. Protein balance in the rumen was also significantly (P<0.01) lower on the hay-based diet

than on the silage-based diet (-148 g PBV/day vs. -105 g PBV/day). Total ME intakes during the indoor feeding period averaged 72.1 MJ ME/

Table 3. Effect of diet and breed on daily intake of dry matter (DM), energy (metabolizable energy, ME), amino acids absorbed in the small intestine (AAT) and protein balance in the rumen (PBV) during indoor feeding.

Breed	Diet	Hereford x Ayrshire		Limousin x Ayrshire		SEM ²	Statistical significance ¹		
		Silage	Hay	Silage	Hay		Breed	Diet Interaction	
Number of groups		2	2	2	2				
Intake									
DM, kg	Silage	4.06	1.90	4.00	1.92	0.016	NS	***	o
	Hay	2.56	4.48	2.49	4.41	0.060	NS	***	NS
	Barley straw	0.03	0.05	0.01	0.03	0.010	o	NS	NS
	Barley	0.71	0.70	0.49	0.52	0.133	NS	NS	NS
	Total [*]	7.51	7.27	7.13	7.03	0.179	NS	NS	NS
ME, MJ	Total	74.3	67.7	69.9	64.8	2.12	NS	o	NS
AAT, g	Total	588	561	552	538	17.4	NS	NS	NS
PBV, g	Total	-111	-152	-99	-144	6.2	NS	**	NS

¹ o P<0.10; * P<0.05; ** P<0.01; *** P<0.001; NS not significant.

² SEM = Standard Error of the Mean.

^{*} Including mineral mixture, 150 g/day.

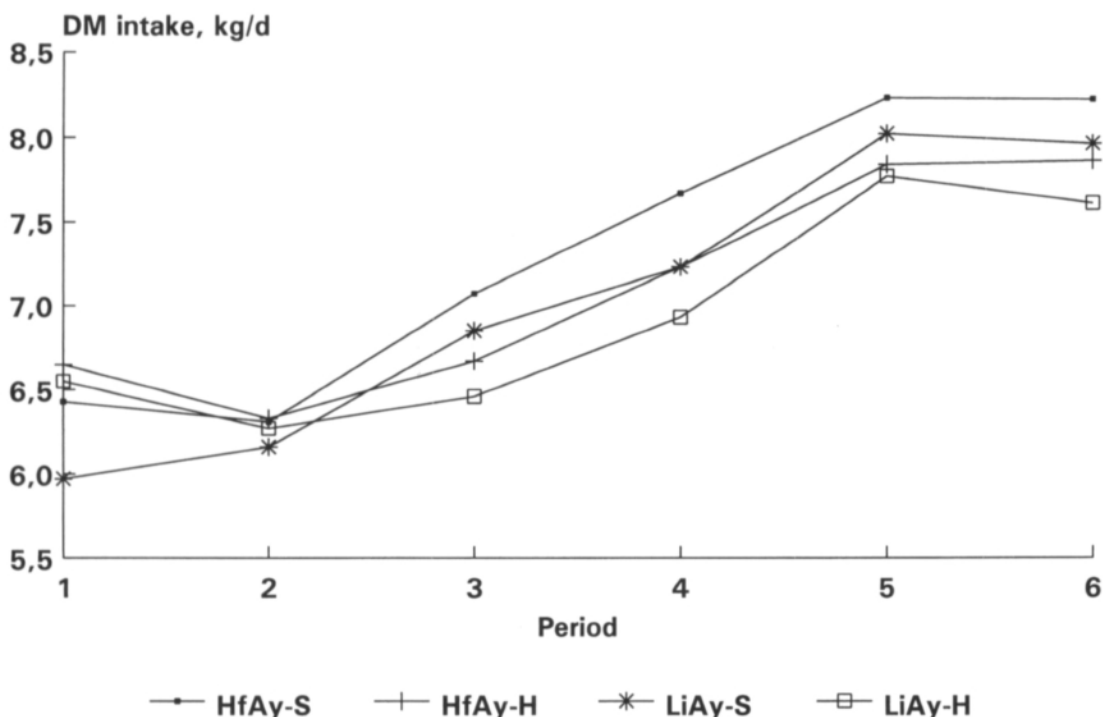


Fig. 2. Average daily intake of dry matter (DM) from experimental feeds on hay (H)- and silage (S)-based diets during indoor feeding.

day and 66.2 MJ ME/day on the silage and hay based diets, respectively. During the indoor period total ME intakes averaged 71.0 MJ ME/day and 67.4 MJ ME/day for HfAy- and LiAy-animals, respectively. Energy intake from barley was higher for HfAy- than LiAy-heifers due to earlier calving of the former and thus, a longer *post partum* period before the start of the grazing season. DM intake of experimental treatments during indoor feeding are shown in Figure 2.

Live weight of heifers

The initial LW of LiAy-heifers was lower ($P < 0.01$) than that of HfAy-heifers (Table 4). Despite a higher ($P < 0.01$) live weight gain (LWG) *pre partum* LW of LiAy-heifers tended ($P < 0.10$) to be lower than that of HfAy-heifers.

Also *pre partum* LW of heifers on the S-diet tended ($P < 0.10$) to be higher than that of heifers on the H-diet. No interactions between breed and feeding on *pre partum* LW were observed. At the end of the experimental grazing season LiAy-cows were still significantly ($P < 0.05$) lighter than HfAy-cows. Heifers overwintered on the S-diet continued to be numerically heavier at the end of the grazing season than those overwintered on the H-diet.

Age of heifers at calving and calving difficulties

Mean age at calving of both HfAy- and LiAy-heifers was 24 months. As a consequence of the younger age of LiAy-heifers at the start of the experiment, the period from the start to calving

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Table 4. Live weight (LW) and live weight gain (LWG) during indoor feeding and grazing.

Breed Diet	Hereford x Ayrshire		Limousin x Ayrshire [*]		SEM ²	Statistical significance ¹		
	Silage	Hay	Silage	Hay		Breed	Diet Interaction	
Number of animals	15	15	13	16				
LW, kg								
Initial, 15 December	449	423	390	396	7.1	**	NS	o
Pre partum	498	478	478	473	4.6	o	o	NS
Post partum	458	445	443	419	8.1	o	o	NS
At the beginning of grazing, 1 June	438	420	434	408	8.8	NS	o	NS
At the end of experimental grazing, 24 August	449	426	419	420	4.6	*	o	o
LWG, g/day								
From start to calving	357	407	554	480	25.8	**	NS	o
From calving to start of grazing	-584	-763	-434	-390	321.6	NS	NS	NS
During grazing	160	74	-220	165	71.3	NS	NS	*

¹ o P<0.10; * P<0.05; ** P<0.01; *** P<0.001; NS not significant.

² SEM = Standard Error of the Mean.

^{*} Means based on 13 (LiAy-Silage) or 16 (LiAy-Hay) rather than 15 observations. SEM given should be multiplied by 1.08 (LiAy-Silage) or 0.97 (LiAy-Hay) when making comparisons with other mean values.

was longer ($P>0.10$) for LiAy-heifers than for HfAy-heifers (Table 1). The calving period was 104 days. Eight calves (13%) were born in March, 15 (24%) in April, 22 (35%) in May and 18 (28%) in June. Two of the calves were dead at parturition, one died immediately after birth and one died accidentally.

A significant interaction ($P<0.01$) between breed and sex was observed for calving difficulty (Table 5). HfAy-heifers had more calving difficulties with male than female calves (1.50 vs. 1.06) while no differences were observed between sexes born to LiAy (1.34 vs. 1.32). Also a significant ($P<0.001$) interaction between diet and calf sex on calving difficulty was observed. Heifers on the S-diet had more calving difficulties when they had male than female calves (1.78 vs. 1.21) while heifers on the H-diet producing female calves had slightly more calving difficulties than those producing male calves (1.18 vs. 1.06).

Live weight of calves

There was no effect of breed on calf birth weight but diet and sex of calves tended ($P<0.10$) to have an effect on calf birth weight (Table 5). At 100 days of age, male calves were heavier ($P<0.01$) than females (150 kg vs. 137 kg). At weaning Ab x HfAy calves were numerically heavier (197 kg vs. 188 kg) but older ($P<0.05$) than Ab x LiAy calves (163 days vs. 141 days). The rate of LWG from birth to weaning of Ab x HfAy calves was numerically higher than that of Ab x LiAy calves (1058 g/day vs. 987 g/day). The rate of LWG from birth to weaning of male calves was higher ($P<0.05$) than that of female calves (1078 g/day vs. 968 g/day). The average weaning weight, (i.e. 151-day weight), was higher ($P<0.05$) for male than female calves (198 kg vs. 179 kg). No interactions between breed, type of feeding and sex on calf weight, age or rate of LWG were observed.

Table 5. Effect of type of feeding, breed and sex on calving difficulty and calf performance.

Breed Diet Sex	Aberdeen Angus x HfAy				Aberdeen Angus x LiAy				Statistical significance ¹			
	Silage		Hay		Silage		Hay		SEE ²	Breed	Diet	Sex
	Male	Female	Male	Female	Male	Female	Male	Female				
Number of animals	12*	4	8	7	9*	5	7	9*				
Calving difficulty ^{3,4}	2.00	1.00	1.00	1.13	1.55	1.42	1.13	1.23	0.186	NS	***	**
Live weight, kg												
At birth	40.8	37.7	36.4	34.3	36.8	36.5	38.1	34.6	3.98	NS	o	o
100-day	153	143	151	138	143	136	152	132	12.9	NS	NS	**
At weaning	205	194	198	192	188	181	199	184	22.3	NS	NS	NS
151-day ⁵	201	189	202	185	189	167	199	175	26.4	NS	NS	*
Weaning age (days)	156	173	154	169	140	138	138	147	30.9	*	NS	NS
Live weight gain from birth to weaning (g/day)	1093	1021	1110	1010	1025	899	1083	944	152.0	NS	NS	*

¹ o P<0.10; * P<0.05; ** P<0.01; *** P<0.001; NS not significant.

² SEE = Standard Error of the Estimate.

³ 1; Easy, no assistance, 2; Slight assistance, 3; Difficult calving.

⁴ A significant interaction between breed and sex (p<0.01), diet and sex (p<0.001) and breed, diet and sex (p<0.01).

⁵ 151-day weight; average calf weaning age.

* n = 12 for calving difficulty and birth weight then n = 11

n = 9 for calving difficulty and birth weight then n = 8.

Milk production

There was no effect of diet on milk production (Table 6). Daily milk production of HfAy-cows was marginally higher at day 10 and day 95 of lactation and much higher (P<0.05) at day 50 and day 145 of lactation than that of LiAy-cows. Overall milk production of HfAy-cows was higher (P<0.01) than that of LiAy-cows (7.7 kg/day vs. 5.8 kg/day).

Conception rate

All HfAy-cows starting the grazing period were successfully bred while only 87.1% of LiAy-cows were recorded to be in calf during pregnancy testing conducted in the autumn. Type of feeding during the indoor period did not affect conception rate since 93.3% of cows on the S-diet and 93.5% of cows on the H-diet were pregnant. Overall, 50.8% of cows were in calf to A.I.,

Table 6. Effect of type of feeding and breed on milk production (kg/day) of crossbred suckler cows.

Breed Diet	Hereford x Ayrshire		Limousin x Ayrshire		SEM ²	Statistical significance ¹		
	Silage	Hay ^a	Silage	Hay		Breed	Diet	Interaction
Number of animals	4	3	4	4				
Day of lactation								
10	7.0	7.4	5.5	6.0	0.58	o	NS	NS
50	8.8	7.6	5.8	6.5	0.59	*	NS	NS
95	9.8	9.2	7.3	6.4	1.13	o	NS	NS
145	6.6	5.5	5.0	3.7	0.56	*	NS	NS
Mean	8.1	7.4	5.9	5.6	0.28	**	NS	NS

¹ o P<0.10; * P<0.05; ** P<0.01; *** P<0.001; NS not significant.

² SEM = Standard Error of the Mean, for ^a multiply by 1.22.

42.6% to natural service and 6.6% failed to become pregnant.

Discussion

Feed intake

Feed values of hay and silage were satisfactory. In a cold environment the intake of unwilted grass silage may be depressed due to freezing. In the present study feed intakes were good and there were no refusals of silage, hay or barley. Barley straw was available *ad libitum*, but intake was minimal. On the coldest days of winter, freezing of unwilted grass silage caused some minor problems when weighing and apportioning feed for treatment groups.

On the S-diet both breeds received more energy (ME MJ) than heifers on the H-diet during the experiment except from the start of the experiment to the beginning of *pre partum* feeding. At the onset of the experiment, DM intake was 1.50 kg/100 kg live weight for HfAy-heifers and 1.59 kg/100 kg live weight for LiAy-heifers.

In Finland there are no official feeding standards for replacement beef heifers, but recommendations based on feeding standards of dairy heifers and cows are available (Salo et al. 1982, Tuori et al. 1996). The calculated AAT intake before calving exceeded recommendations, but DM and energy intake were below Finnish recommendations, particularly for the H-diet just before and after calving. Although indoor energy intake in this experiment was below recommendations (5–15%) particularly *post partum*, it appeared to be sufficient since conception rates were good. DM intakes were also considerably lower than minimum limits recommended by Macartney and Moon (1974) and Field (1991). However, feeding levels on the S-diet were in good agreement with the recommendations reported by Drennan (1988).

Nutrition, especially energy intake, is the most critical factor influencing the interval from calving to first oestrus. Dunn et al. (1969) observed that the level of energy intake can markedly change reproductive performance in two-year-old heifers as the pregnancy rate 120 days after calving was directly related to post-calving energy intake. Nicol (1977) also reported that a low level of nutrition for 40 days post calving for two- and three-year-old Aberdeen Angus and Aberdeen Angus crosses resulted in a delay of seven days to first oestrus compared to animals on a higher feeding level. Intervals from calving to first oestrus were not recorded due to the synchronisation programme during the mating period and thus, the effect of diet, energy level and breed on the interval to first oestrus can not be clearly identified. However, conception rate was good for all cows.

Live weight of cows

The higher LWG of LiAy-heifers may result from their younger age, larger size and later maturity which is typical for larger beef breeds such as the Limousin and Charolais. LWG of heifers *pre partum* was 382 g/day for HfAy-heifers and 517 g/day for LiAy-heifers and was thus, satisfactory when compared with recommendations given by Byers et al. (1987). The results observed in this experiment have to be compared with those observed with other Hereford- or Limousin-crosses because comparable to that used crosses in this experiment are not common elsewhere. The LW of heifers before calving was also satisfactory if compared to the results reported by Drennan (1987) with crossbred heifers although in contrast to the present study Limousin × Friesian-heifers were heavier than Hereford × Friesians before calving. In another experiment More O'Ferrall and Drennan (1989) reported that Hereford × Friesian first-calf heifers reached an average of 393 kg and Simmental × Friesian first-calf heifers reached an average of 422 kg at 32 months of age in autumn. However, in the present experiment HfAy- and LiAy-heifers reached 80

to 85% of expected mature LW at calving as recommended by Rittenhouse and Roath (1989).

Both the hay- and silage-based feeding systems were suitable for Hereford- and Limousin crosses in the current circumstances. During the grazing season LWG was quite poor for HfAy-cows previously on the H-diet in winter and for LiAy-cows offered the S-diet. The latter, in fact, lost LW. Negative LWG may reflect insufficient energy intake from grass due to drought during the grazing season. Additional feeding of hay appeared to be inadequate. On the other hand, the good conception rate of all cows reflects sufficient energy intake and condition from calving to the start of insemination and mating.

Calving difficulties

Generally, few severe calving difficulties were observed in this experiment although 29.5% of all calvings were assisted. Ease of calving probably reflects the sire genotype as was suggested by Roux et al. (1987), who used either Aberdeen Angus or Aubrac sires on Friesian or Charolais × Friesian heifers and by Harte (1987), who used Hereford × Friesian heifers and Aberdeen Angus bulls. Puntilla et al. (1985) reported that HfAy-heifers had marginally greater calving difficulties than LiAy-heifers calving to a Limousin sire. Male calves in the present experiment were heavier at birth than female calves (38.0 kg vs. 35.9 kg). It can be assumed that LW at calving was optimum for both HfAy- and LiAy-heifers to avoid dystocia which is in agreement with the findings by Bellows et al. (1971). Sinclair and Lowman (1990) observed that feeding level *pre partum* affected the birth weight of calves as Hereford-Friesian heifers in calf to a Simmental bull given only 50 MJ ME/day in the last 12 weeks of pregnancy gave birth to calves which were significantly ($p < 0.05$) lighter than those from heifers receiving 75 MJ ME/day. Keane et al. (1991) did not observe any effect of different feeding levels *pre partum* (41 days before calving cows were fed straw *ad libitum* plus 0.5 kg or 2.0 kg concentrates per head daily) on

calf birth weight or calving difficulties of cross-bred beef heifers.

Live weight of calves

The amount of milk is the most important factor affecting calf growth rate during the first three or four months, particularly for spring-born calves (Allen and Kilkenny 1984). In the present experiment the calf performance was affected only by sex. Although there was no difference in the calving age of heifers, LiAy-heifers calved significantly later in spring than HfAy-heifers. Lesmeister et al. (1973) observed that earlier born calves grew significantly faster from birth to weaning than calves born in later groups. Calves from LiAy-heifers were younger at the start of the grazing season which probably also affected their LWG. Pre-weaning gains (male calves 1078 g/day vs. female calves 968 g/day) measured in this experiment were, however, satisfactory when compared to pre-weaning gains of calves from Hereford × Friesian, Simmental × Friesian and Limousin × Friesian two-year-old dams reported by More O'Ferrall and Drennan (1989).

Milk production

The first lactation is probably the most important period in the life of a beef cow. Nutrient requirements of a heifer is greatest during this period because she has to maintain her body, nurse a calf, recover from calving, come into heat, rebreed, and continue to grow (Macartney and Moon 1974).

In the present experiment the type of feeding during the indoor period did not affect milk production, but there was a significant breed effect. It may be possible that the lower milk production which was measured for LiAy-heifers resulted from their later average birth date and, the later maturing of Limousin-crosses. However, milk production for both types of cows was satisfactory as judged from LWG of their calves.

The effect of breed on milk production is in agreement with the results observed by Jenkins and Ferrell (1992) and Jeffery et al. (1971). In contrast to the observations of Puntilla et al. (1985) HfAy-heifers produced more milk than LiAy-heifers. However, milk production of HfAy-heifers was in good agreement with those reported by Chigaru and Topps (1981) with Hereford x British Friesian heifers. In the present experiment the peak milk yield was observed 95 days after parturition. Somerville and Lowman (1980) observed a peak milk yield of 7.7 kg, 31 days *post partum* using the calf-suckling technique with Hereford x British Friesian heifers and 7.6 kg, 26 days *post partum* using the machine-milking technique with the same heifer type.

Milk production observed in this experiment with crossbred beef cows seems to be quite satisfactory when compared to milk production figures achieved with purebred Hereford-heifers (Johnsson and Obst 1984, Fleck et al. 1980) and other purebred adult beef cows reported by Andersen (1990). The main reason for good milk production was undoubtedly the effect of the Ayrshire breed although it can be assumed that Ayrshire dairy cows inseminated with beef semen would have a low production potential and are most likely to be the lowest producing animals in a dairy herd.

Conception rate

It can be assumed, in spite of the negative LWG from calving to the start of the grazing season, that cows were at least in moderate condition at the start of the grazing season. The lower conception rate of LiAy heifers may reflect their slightly younger age and later maturity. Deutscher and Whiteman (1971) reported that under range conditions only 13% of Angus-Holstein crossbreds nursing heifers rebred compared to

63% of purebreds nursing Angus-heifers. This would indicate that nutritional requirements of better milking crossbreds are higher in order to ensure good reproductive performance. Van Niekerk et al. (1990) observed that winter and summer levels of nutrition only slightly affected conception rate of Simmental heifers.

Conclusions

Both H- and S-based diets used in this experiment seemed to be suitable for crossbred beef heifers during indoor feeding in a cold environment. Calculated ME and AAT intakes were lower on the H-diet than the S-diet but this did not cause any major performance differences. DM intake was below minimum recommendations on both diets. On the coldest days of the indoor feeding period, freezing of fresh grass silage caused minor technical problems. This may be avoided by using wilted grass silage, hay-based diets or increasing the amount of forages of lower nutritive value but higher DM content.

Calving difficulties observed in this experiment were minor which reflects the size of heifers being adequate at calving and suitable feeding level *pre partum*. In addition, use of an easy calving breed sire probably contributed to the low incidence of calving difficulties. Milk production of both crossbred heifer types was satisfactory as indicated by the growth rate of their calves. Although LWG of heifers before the grazing season and during the summer was not good it appeared to be sufficient to achieve a high conception rate. The reason for reduced conception rates in LiAy cows may be due to a later calving date than HfAy cows.

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SELOSTUS

Karkearehuruokinnan vaikutus risteytyshiehojen ja niiden vasikoiden kehitykseen sisäruokinta- ja laidunkaudella

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Tutkimuksessa selvitettiin heinävaltaisen (noin $\frac{2}{3}$ kuiva-aineen syönnistä heinää) ja säilörehuvaltaisen (noin $\frac{1}{3}$ kuiva-aineen syönnistä säilörehua) ruokinnan vaikutuksia Hereford- Ayrshire- (HfAy) ja Limousine-Ayrshire- (LiAy) risteytyshiehojen elopainon kehitykseen, poikimiseen, maidontuotantoon ja tiinehtymiseen. Lisäksi selvitettiin risteytyshiehojen Aberdeen Angus- (Ab) sonneista syntyneiden vasikoiden kehitystä syntymästä vieroitukseen.

Säilörehuruokinnalla olleet HfAy-hiehot saivat sisäruokintakaudella keskimäärin 74,3 MJ ME/pv ja LiAy-hiehot 69,9 MJ ME/pv ja heinävaltaisella ruokinnalla olleet vastaavasti 67,7 MJ ME/pv ja 64,8 MJ ME/pv. HfAy-hiehojen suurempaan kuiva-aineen syöntiin ja siten suurempaan energian saantiin lienee osittain vaikuttanut niiden LiAy-hiehoja hieman suurempi koko, aikaisempi täysikokoisuuden saavuttaminen ja siten ruuansulatuskanavan suurempi tilavuus.

Poikiessa HfAy- ja LiAy-hiehot olivat keskimäärin 24 kuukauden ikäisiä. Poikimiset onnistuivat hyvin, muutamia vaikeita poikimisia esiintyi ja 29,5%:ssa poikimisista tarvittiin hieman avustusta.

Kokeen alkaessa LiAy-hiehot olivat HfAy-hiehoja kevyempiä. LiAy-hiehojen elopaino lisääntyi poikimiseen mennessä enemmän kuin HfAy-hiehojen,

mutta laidunkauden päättyessä LiAy-eläimet olivat edelleen kevyempiä kuin HfAy-eläimet. Ruokinta ei vaikuttanut hiehojen elopainon kehitykseen.

Emän rotu tai ruokinta ei vaikuttanut vasikoiden kehitykseen. Syntymästä vieroitukseen Ab \times HfAy-sonnivasikat kasvoivat keskimäärin 1101 g/pv ja Ab \times LiAy-sonnivasikat 1054 g/pv, lehmävasikat vastaavasti 1015 ja 921 g/pv. Ab \times LiAy-vasikoiden hieman heikompaan kasvuun vaikutti ilmeisesti LiAy-emojen HfAy-emoja hieman myöhäisempi poikimisajankohhta. Vasikoiden keskimääräinen vieroitusikä oli 151 vuorokautta.

Sisäkauden ruokinta ei vaikuttanut emojen maidontuotantoon eikä tiinehtymiseen laidunkaudella. HfAy-emojen maidontuotanto oli keskimäärin LiAy-emojen maidontuotantoa parempi. Laidunkaudella kaikki HfAy-erot ja 87,1% LiAy-emoista tiinehtyivät.

Tutkimuksen perusteella heinä- ja säilörehuvaltaisen ruokinta soveltuu risteytyshiehojen sisäruokintakaudelle. Suositusten alle jäänyttä kuiva-aineen syöntiä voidaan lisätä lisäämällä dieettiin heinää tai olkea. Tämän kokeen perusteella Aberdeen Angusta voidaan suositella risteytyshiehojen ensimmäiseen poikimiseen.