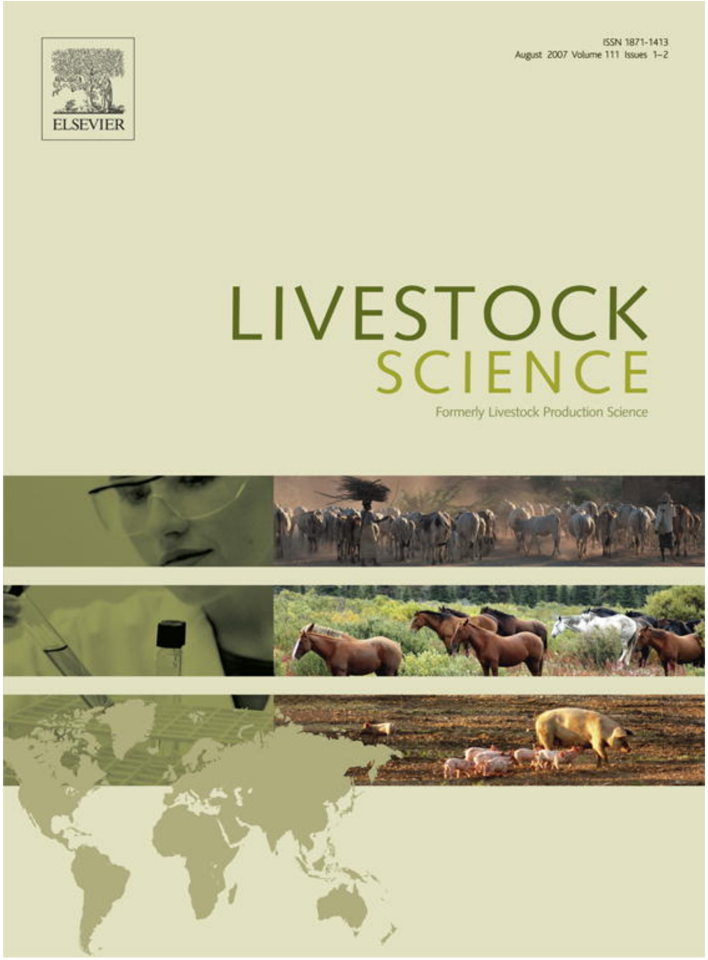
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Beef heifer production as affected by indoor feed intensity and slaughter age when grazing semi-natural grasslands in summer

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Abstract

Only limited knowledge exists on how to produce high-quality beef carcasses when the cattle also are grazing semi-natural grasslands for nature conservation purposes. The objectives of the two factorially-designed trials were to determine the effects of indoor feed intensity (low vs. high) and slaughter age (18 vs. 22 months) on performance and carcass quality of beef heifers, raised from weaning until slaughter and grazing semi-natural grasslands during growing seasons. In the first trial, 56 Charolais heifers were used of which 28 were fed only grass-clover silage *ad libitum* (low; CL), and another 28 heifers were fed 2.0 kg of grain daily in addition to the silage (high; CH). In the second trial, 28 Angus heifers were fed grass-clover silage at 80% *ad libitum* (low; AL), whereas another 28 heifers were fed silage *ad libitum* (high; AH). According to a national nature conservation score, the grazing pressure on the semi-natural grassland was classified as having been satisfactory to maintain the floristic diversity as no litter had been accumulated onto the sward. From weaning until slaughter, no difference in average daily gains (ADG) was found between the CH and the CL, whereas the AH had higher ADG than the AL (693 vs. 573 g, $P<0.001$). Heifers in both trials had higher carcass weights and more fat, Charolais heifers also had better conformation and Angus heifers had higher dressing percentage at 22 months than at 18 months of slaughter age ($P<0.05$). In conclusion, carcass traits in both trials were more affected by slaughter age than by feed intensity and desirable grazing effects were achieved on the pasture.

Keywords: Beef heifers; Feed intensity; Slaughter age; Semi-natural grasslands

1. Introduction

Semi-natural grasslands are important from many natural and cultural perspectives (Ihse and Norderhaug, 1995). For example, they contain many endangered plant and animal species (Gärdenfors, 2000). A prerequisite for maintaining the values of the grasslands is a continued grazing management. Unfortunately, large acreages of semi-natural grasslands in Sweden have been abandoned during the last decades. In some regions, only about 10% of these are managed compared to 50 years ago (Mejersjö and Kronqvist, 2000). Today, 13% of the remaining 270,000 hectares (ha) of valuable grasslands are threatened by reduced land management and a continuing decrease in grazing livestock is forecasted (Kumm, 2003; Persson, 2005a). The scarcity of grazers is a natural outcome of the decline in Swedish animal production in general. In addition, if only beef production aspects are taken into account, intensive indoor production is more profitable than extensive rearing on pasture (Lewis et al., 1990; Kumm, 2006).

To promote grazing of semi-natural grasslands, farmers can receive environmental monetary support

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for commitments to maintain grazing animals on these areas (Official Statistics of Sweden, 2006). These stewardships have made extensive beef production on pasture instead of indoor rearing more economically interesting for the producers. The main prerequisite to receive the environmental support is a sward height at the end of the growing season short enough to ensure no litter is accumulated onto the sward (Swedish Board of Agricultural, 2004).

Young bulls reared in intensive indoor production dominate the Swedish national supply for slaughter. The supply is distributed irregularly throughout the year, with a surplus in late autumn and a deficiency in early spring and summer, whereas the demand is constant all through the year. To finish heifers of beef breeds instead of slaughtering them as fattening calves, which used to be the practise, is a possible solution to even out the supply of beef throughout the year. Heifers have lower weight gain capacities than bulls and steers and they should be fed relatively extensively to avoid excessive fatness at low liveweights (McMillin et al., 1990; Steen and Kilpatrick, 1995; McCaughey et al., 1999). When finishing on pasture, heifers have more marbling and a more desirable colour in rib eye than steers (McCaughey et al., 1999). In 2005, there were 177,000 suckler cows in Sweden (Official Statistics of Sweden, 2006). If 50% of the heifer calves born of these cows were raised as finishing heifers using semi-natural grasslands, they could graze 20,000 to 40,000 ha of grasslands depending on herbage mass. Consequently, finishing of beef heifers in production systems including grazing of semi-natural grasslands may result in an even supply of bovine carcasses, management of valuable pastures and greater profitability for the farmers.

As in other European countries, the European Union Carcass Classification Schemes EUROP, modified to the Swedish system using 15 classes (SJVFS, 1998; Commission of the European Communities, 2005), establishes the quality of Swedish carcasses. The EUROP classes can be transformed to numerical figures for conformation score (1 = P−, poorest, and 15 = E+, best) and fatness (1 = 1−, leanest, and 15 = 5+, fattest). The classification reflects the values of the carcasses for the industry and forms the basis of the payment to the farmer. In Sweden at this time, full payment is received for carcasses from 250 to 400 kg, conformation ≥ 7 and fatness from 6 to 10. Only one-third of Swedish beef heifers achieve all these criteria, mainly because carcasses are too fat and too small (Helena Stenberg, pers. comm.). A high dressing percentage and great amounts of valuable retail cuts are of economical interests for the farmer and the industry, respectively.

There is limited recent published research on raising beef heifers, especially when grazing semi-natural grasslands in summer. Consequently, there is a need for more research investigating the possibilities to produce marketable carcasses from beef heifers that have grazed semi-natural grasslands. The objective of this study was to evaluate alternative production systems differing in indoor feed intensity and slaughter age of Charolais and Angus heifers to produce high-quality, market-oriented carcasses when the animals graze semi-natural grasslands in summer for nature conservation purposes.

2. Materials and methods

2.1. Experimental design

The study, that was conducted at Götala Research Station, The Swedish University of Agricultural Sciences, Skara, in southwestern Sweden (long 13°21′E, lat 58°42′N; elevation 150 m), included two trials with two different beef breeds, where heifers were raised from weaning until slaughter. Trial 1 started in November 2000 and trial 2 started in November 2001. Both trials had a 2 × 2 factorial design with two feed intensities during indoor periods (low and high) and two slaughter ages (18 and 22 months) each. For all animals, one indoor period followed by a grazing period was included in the study. Heifers slaughtered at 18 months of age were slaughtered directly after the grazing period, whereas heifers at 22 months of slaughter age were kept for another indoor period. Times of slaughter were chosen to respond to the demand of the beef market. As the trials were not conducted simultaneously, no comparisons between breeds could be made.

2.2. Animals

Weaned heifer calves, bought from commercial suckler herds, were 8 months of age at the initiation of the trials. The heifers were fed 2.0 kg of grain daily and grass-clover silage *ad libitum* indoors at Götala Research Station during two weeks prior to the start of the trials. Trial 1 included 56 heifers with at least 75% Charolais breed and trial 2 included 56 heifers with at least 75% Angus breed. Charolais heifers had an average initial liveweight of 291 (SD 35) kg and Angus heifers had an average initial liveweight of 203 (SD 38) kg. During indoor periods, heifers of each breed were housed in eight pens with two pens per treatment combination of feed intensity and slaughter age. One Charolais heifer and five Angus heifers were excluded from the study at time of turn-out to pasture; one because of disease, two because of pregnancy and three because of aggressive temperament.

2.3. Diets during indoor periods

In trial 1, half of the Charolais heifers were fed grass-clover silage (Table 1) *ad libitum*, defined as the intake at >5% orts, combined with 2.0 kg of mixed grain containing 65% oats and 35% barley [853 g dry matter (DM) kg^{-1}, 12.3 MJ metabolizable energy (ME), 109 g crude protein (CP), 304 g neutral detergent fibre (NDF), 45 g crude fat, 503 g starch and 28 g ash kg DM^{-1}] per heifer and day (high-feed intensity). The other half of the heifers were fed grass-clover silage *ad libitum* only (low-feed intensity) during the indoor periods. In trial 2, half of the Angus heifers were fed grass-clover silage (Table 1) *ad libitum* only (high-feed intensity) and the other half of the heifers were fed grass-clover silage 80% *ad libitum* (low-feed intensity), defined as 80% of intake for high-intensity heifers at the same liveweight.

Grass-clover herbage containing 90 to 95% grass (*Lolium perenne, Festuca pratensis* and *Pleum pratense*) and 5 to 10% clover (*Trifolium repens* and *Trifolium pratense*) was wilted to about 25% DM and an acidic additive containing formic acid, propionic acid and ammonium was used at 4 l/tonne herbage (Promyr™, Perstorp Inc., Perstorp, Sweden). Herbage harvested each year was ensiled for at least four months in bunker silos before feed out. Heifers were fed once a day. Orts were weighed and disposed of three times a week for each pen and average feed consumption per pen was calculated weekly. Silage samples for analysis of nutrient content were taken daily and composited to one sample per month, whereas silage samples for analysis of fermentation quality were taken weekly and composited to one sample per silo. Grain samples were collected weekly and composited to one sample every second month for analysis of nutrient content.

2.4. Grazing periods

During the two grazing periods, in 2001 for trial 1 (from April 17 to October 1) and in 2002 for trial 2 (from May 2 to October 10), all heifers were kept together in one group on semi-natural grasslands (Fig. 1). The heifers in trial 1 were fed grass-clover silage during the first two weeks on pasture, whereas the heifers in trial 2 were fed silage during the last two weeks on pasture. The heifers were rotated among 38 ha of pasture divided into five paddocks. Every grazing interval for each paddock lasted for one to two weeks, depending on herbage supply. Each paddock was grazed three or four times per grazing period.

A description and inventory of plant species in the pasture was conducted before initiating the study. The moisture gradients of the pasture were 20% dry, 60% mesic and 20% wet areas in mainly open *Deschampsia cespitosa/Agrostis capillaris/Festuca ovina* meadows (70%) including areas of mixed deciduous tree pasture (20%) and small areas of sedges, rushes, reed and tall herb grasslands. Tree species consisted of *Betula spp.* and *Quercus robur* in dry and mesic areas, and *Alnus glutinosa*

Table 1
Chemical composition [mean, standard deviation (SD) and number of samples (*n*)] of grass-clover silage fed to Charolais and Angus heifers during indoor period 1 (IP 1; 2000/01 for Charolais and 2001/02 for Angus) and indoor period 2 (IP 2; 2001/02 for Charolais and 2002/03 for Angus), respectively

	Charolais						Angus					
	IP 1			IP 2			IP 1			IP 2		
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*N*
Dry matter, g kg^{-1}	273	29	32	229	20	18	260	40	32	247	16	21
ME[a], MJ kg DM^{-1}	11.1	0.2	5	10.6	0.1	4	10.2	0.4	6	9.5	1.3	5
CP[b], g kg DM^{-1}	142	12	5	136	11	4	148	9	6	151	15	5
NDF[c], g kg DM^{-1}	497	70	5	558	22	4	540	25	6	549	25	5
Ash, g kg DM^{-1}	83	3	5	89	9	4	89	6	6	92	12	5
pH	4.2	0.1	3	4.0	0.1	2	3.7	14	3	4.3	5	2
Reducing sugar, g kg^{-1} DM	61	38	3	<23	19	2	<20	13	3	8	26	2
Lactic acid, g kg^{-1} DM	83	11	3	104	19	2	109	13	3	111	14	2
Acetic acid, g kg^{-1} DM	31	16	3	35	10	2	29	0.2	3	36	0.0	2
Butyric acid, g kg^{-1} DM	<1.3	0.9	3	<1.1	0.1	2	<1.4	11	3	<0.8	0.2	2
Ethanol, g kg^{-1} DM	18	9.8	3	15	10	2	11	8.6	3	6.8	14	2

[a] ME = metabolizable energy.
[b] CP = crude protein.
[c] NDF = neutral detergent fibre.

Fig. 1. Semi-natural grasslands at Götala Research Station.

in wet areas. Field layer in dry areas consisted of grass (*Festuca ovina, Deschampsia flexuosa, Nardus stricta)* and various herb species dominated by *Lathyrus linifolius, Galium verum, Galium boreale* and *Hieracium pilosella* but also, for example, *Veronica officinalis, Lotus carniculatus, Fragaria vesca, Saxifraga granulata*, *Plantago lanceolata, Hypericum maculatum, Leucanthemum vulgare, Thymus serpyllum, Lychnis viscaria* and *Antennaria dioica.* Mesic areas were dominated by the grasses *Festuca rubra* and *D. cespitosa* but also contained the grasses *A. capillaris* and *N. stricta* as well as the herbs *Ranunculus acris*, *Veronica chamaedrys*, *Ajuga pyramidalis*, *Succisa pratensis*, *Arnica montana*, *Scorzonera humilis* and others. Field layer in wet areas consisted of the grasses *D. cespitosa* and *Glyceria fluitans*, the rushes/sedges *Juncus effusus* and *Carex* species (*C. nigra*, *C. panicea, C. rostrata* and *C. vesicaria*) and a few herb species, mainly *Filipendula ulmaria* and *Ranunculus repens*, but also *Cardamine pratensis* and *Gerum rivale*.

At the end of each grazing period, the sward heights were visually judged to be short enough to ensure that no litter had been accumulated onto the sward (Swedish Board of Agriculture, 2004). Inspections of the paddocks were conducted according to a national inspection protocol, which was extended from three to five classes to accommodate management status (excellent, satisfactory, moderate, weak or ungrazed; Persson, 2005b).

Sward height measurements and herbage sampling were performed each time heifers changed paddocks, both in the grazed paddock and in the ungrazed paddock to be grazed. A procedure for sward height measurements and herbage sampling was established by mapping out a path to follow passing through all parts of the paddocks. The path followed the shape of a W in each paddock, as recommended by Frame (1993). Sward height measurements were taken with a rising plate meter (0.3 × 0.3 m with a weight of 430 g) with 45 to 60 recordings in each paddock. Samples for chemical composition of the pasture were taken at every fifth sward height recording. Samples were picked manually, trying to imitate the choice and bite of the animals, taking approximately 25 "bites" within a circle with a diameter of approximately 3 m. When a sampling spot contained pasture that seemed to be rejected by the animals, for example *F. ulmaria*, the spot was left unsampled. Herbage samples were composited to one sample per paddock before and after each grazing interval.

In 2001, the total precipitation was higher than normal in May (64 mm), low in June (23 mm), high in July (96 mm), and normal during late summer and autumn (56, 63, and 67 mm in August, September and October, respectively). In 2002, the precipitation was higher than normal in early summer (78, 99, 83 mm in May, June and July, respectively), low in late summer (10 and 9 mm for August and September, respectively), and high in October (123 mm). Average temperatures were normal during both years (12.4 vs. 12.8 °C from May to October in 2001 and 2002, respectively).

2.5. Chemical analysis

Silage, grain and pasture samples were analysed for concentrations of DM, ash, CP, NDF and organic matter digestibility. The DM concentrations of silage and pasture were determined at 60 °C and 105 °C, respectively, for 24 h, whereas ash was determined at 550 °C for 5 h. The CP was determined in a Tecator Kjeltec Auto Sampler 1035 Analyzer (Tecator Inc., Höganäs, Sweden). Concentrations of NDF in silage and pasture were determined according to Goering and Van Soest (1970) and NDF in grain was determined according to Van Soest et al. (1991). The ME concentrations of silage and pasture were calculated from *in vitro* organic matter digestibility (Lindgren, 1979), and the ME of grain was calculated according to Axelsson (1941). Concentrations of starch and crude fat were determined in grain (Åman and Hesselman, 1984; Commission of the European Communities, 1998). In addition, silage samples were analysed for pH and concentrations of reducing sugars (Ekelund, 1966), organic acids and ethanol (Andersson and Hedlund, 1983).

2.6. Animal weights and carcass measurements

Heifers in both trials were weighed every two weeks until the day of slaughter and their feed intake in proportion to their liveweights were calculated. Heifers' daily liveweight gains during separate indoor and grazing periods were calculated from the first and last weighing of each period. The weight gains from weaning to slaughter were calculated from the first and last weighing. Half of the heifers in both trials were slaughtered at the end of the grazing period at 18 months of age, averaging 551 and 572 days of age for trial 1 and 2, respectively. The remaining heifers were slaughtered after an additional indoor finishing period at 22 months of age, averaging 675 and 693 days of age for trial 1 and 2, respectively. The heifers were slaughtered within one hour at a commercial abattoir after departure from Götala Research Station. Conformation and fatness were graded according to the EUROP schemes modified to the Swedish system in which 15 classes are used (SJVFS, 1998; Commission of the European Communities, 2005). The EUROP classes were transformed to numerical figures for conformation score (1 = P−, poorest, and 15 = E+, best) and fatness (1 = 1−, leanest, and 15 = 5+, fattest). Cold carcass weight (0.98 × hot carcass weight) was registered and the total kidney knob and channel fat (KKCF) was weighed. When the carcasses were commercially handled, the fore and hind quarters were separated between the 10th and 11th rib where marbling was determined visually in *musculus* (*m.*) *longissimus dorsi* on a scale from 1 (lean) to 5 (well marbled). The right hind quarter from each heifer was weighed and then the trim fat and bones of it. Trim fat was defined as subcutaneous and intermuscular fat deposits separable with a knife in a standardized cutting up procedure. Bones were weighed together with closely bound connective tissue capsules and without extra trimming of the bones. The seven most valuable retail cuts in the hind quarter, including strip loin (*m. longissimus dorsi*), fillet (*m. psoas major*), topside (*m. semimembranosus*), outside round (*m. biceps femoris*), eye of round (*m. semitendinosus*), top rump (*m. quadriceps femoris*), and rump steak (*m. gluteus medius*), were weighed. Remaining parts of the hind quarter consisted of a mixture of lean meat and fat and were not weighed. Dressing percentage, percentage of the hind quarter of the side, as well as percentage of retail cuts, trim fat and bone of the hind quarter were calculated.

2.7. Statistical analysis

Data from the two trials were analysed separately. Two different statistical models were used for each trial, as the feed intake and feed conversion data were recorded as the average for seven animals in each pen, whereas weight gain and carcass traits were recorded for the individual animal nested within pen.

Feed intake and feed conversion data were analysed with the GLM procedure of SAS (2001) using the model:

$$y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk}$$

Weight gain and carcass traits were analysed with the Mixed procedure of SAS (2001) using the model:

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + c_{ijk} + e_{ijkl}$$

where: α_i is the fixed effect of feed intensity, β_j is the fixed effect of slaughter age, $\alpha\beta_{ij}$ is the interaction between feed intensity and slaughter age, c_{ijk} is the random effect of pen, and e_{ijk} and e_{ijkl} are the error terms.

Feed intake data were analysed separately for each indoor period and averaged over the two indoor periods. Weight gain data were analysed for each indoor and grazing period, and averaged over the period from weaning until slaughter. Two replicates were made per treatment for feed intake data and 14 replicates per treatment for the weight gain and carcass

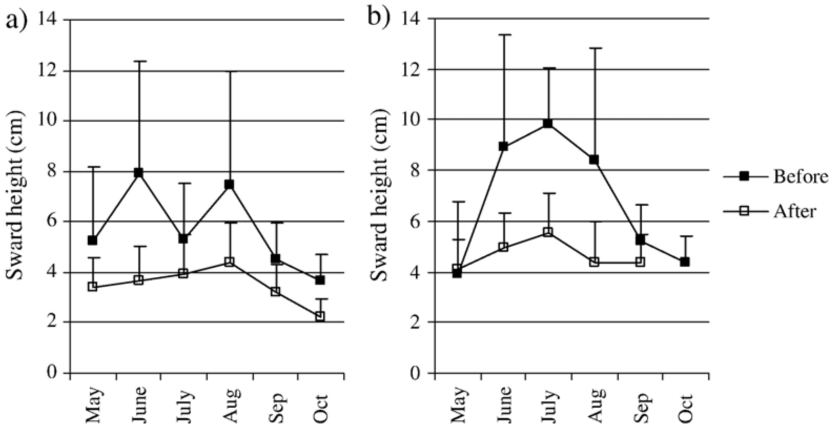

Fig. 2. Sward heights before and after grazing in *Deschampsia cespitosa*-domainated semi-natural grasslands grazed from May until October in a rotational grazing system by a) Charolais heifers in 2001 and by b) Angus heifers in 2002, mean over 45 to 60 recordings and error bars show standard deviations.

trait data. Differences among treatment means were significant at $P<0.05$ with a tendency to significance at $0.05<P<0.10$.

3. Results

3.1. Pasture

Averaged over the grazing periods, the stocking rates were 690 and 475 kg liveweight ha^{-1} and the sward heights were 4.7 and 6.0 cm in trial 1 and 2, respectively (Fig. 2). The average concentrations of ME, CP and NDF in the herbage were 9.7, 156 and 550 g kg^{-1} DM in trial 1 and 9.2, 129 and 570 kg^{-1} DM in trial 2 (Fig. 3). At the end of the grazing periods, the average sward heights were 2 and 4 cm in trial 1 and 2, respectively (Fig. 2). The sward heights were visually classified as being short enough to prevent litter accumulation, especially in trial 1. This classification indicated that the grazing management was satisfactory (82% of the pasture; Swedish Board of Agriculture, 2004) to excellent (18% of the pasture) in trial 1 and it was classified as having been satisfactory (45% of the pasture) to moderate (55% of the pasture) in trial 2.

3.2. Charolais heifers

No interactions between feed intensity and slaughter age were found regarding the variables studied for the Charolais heifers in trial 1. Charolais heifers at high-feed intensity had higher daily DM and ME intakes than heifers at low-feed intensity during indoor periods 1 and 2 (Table 2). The daily NDF intake was 0.86 and 0.84%

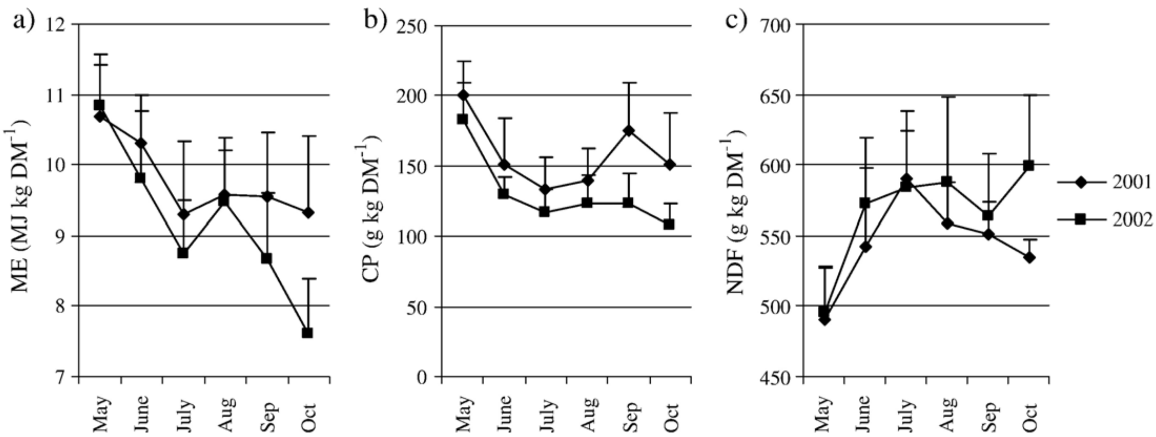

Fig. 3. Concentration of a) metabolizable energy (ME), b) crude protein (CP) and c) neutral detergent fibre (NDF) in herbage from *Deschampsia cespitosa*-dominated semi-natural grassland grazed rotationally from May until October by Charolais and Angus heifers in 2001 and 2002; mean and standard deviation of samples taken before and after each grazing interval (1 to 2 weeks long).

of liveweight for heifers at low- and high-feed intensity, respectively, when averaged over indoor periods 1 and 2 ($P=0.036$). Heifers at high-feed intensity gained 15% more weight per day than heifers at low-feed intensity during indoor period 1, whereas no differences were found in weight gains between the two indoor feed intensities during the grazing period and indoor period 2 (Table 2, Fig. 4). Averaged over indoor periods, heifers slaughtered at 18 months of age converted their feed to gain more efficiently than heifers slaughtered at 22 months of age (73.1 vs. 85.2 MJ ME kg^{-1} gain, $P=0.012$), whereas no effect of feed intensity on feed conversion was found (Table 2).

Carcass traits were more affected by slaughter age than by feed intensity (Table 2). Heifers slaughtered at 22 months of age were assessed as having higher conformation and fatness than heifers slaughtered at 18 months of age. Percentages of retail cuts and bone in the hind quarters were lower in heifers slaughtered at 22 months than in the heifers slaughtered at 18 months, whereas the percentage of trim fat was higher in the older animals (Table 2). However, the actual weights of retail cuts were higher in heifers slaughtered at 22 than at 18 month of age (33.7 vs. 28.2 kg; $P<0.001$). Percentages of retail cuts were lower in the heifers at high-feed intensity than in the heifers at low-feed intensity.

Table 2
Daily feed intake (LW = liveweight), average daily liveweight gain (ADG), feed conversion (FC), and carcass traits (KKCF = kidney knob and channel fat; CW = carcass weight; HQ = hind quarter) of Charolais heifers at low or high indoor feed intensity with slaughter at 18 or 22 months of age; standard error of the mean (SEM) and significance of the main effects of indoor feed intensity and slaughter age

	Indoor feed intensity		Slaughter age			*P*-value	
	Low	High	18 months	22 months	SEM	Feed	Age
Indoor period 1[a]							
Feed intake (kg of DM)	6.07	6.70	6.58	6.19	0.05	<0.001	0.004
Feed intake (% of LW)	1.72	1.84	1.84	1.72	0.01	<0.001	0.001
NDF intake (kg)	3.03	3.03	3.13	2.93	0.02	NS	0.004
ME intake (MJ)	67.4	79.1	73.9	72.5	0.7	<0.001	NS
ADG (g)	910	1045	1012	943	27	0.026	NS
FC (MJ ME kg^{-1} gain)	74.2	75.8	73.1	76.9	1.9	NS	NS
Grazing period[b]							
ADG (g)	479	418	466	431	40	NS	NS
Indoor period 2[c]							
Feed intake (kg of DM)	8.84	10.03	–	9.44	0.02	<0.001	–
Feed intake (% of LW)	1.61	1.75	–	1.68	0.00	<0.001	–
NDF intake (kg)	4.89	5.11	–	5.00	0.01	0.008	–
ME intake (MJ)	93.4	109.2	–	101.3	0.2	<0.001	–
ADG (g)	985	1168	–	1080	80	NS	–
FC (MJ ME kg^{-1} gain)	110.7	102.6	–	106.7	2.2	NS	–
From weaning to slaughter[b]							
ADG (g)	728	776	725	779	23	NS	NS
Slaughter[b]							
Carcass weight (kg)	284	297	256	324	4	0.098	<0.001
Dressing (%)	50.7	51.6	50.4	51.8	0.6	NS	NS
Conformation[d]	7.9	8.3	7.3	8.9	0.4	NS	0.035
Fatness[e]	7.3	8.3	5.9	9.6	0.4	NS	0.004
KKCF (% of CW)	3.2	3.8	1.9	3.1	0.2	NS	0.015
Cutting[b]							
Marbling[f]	1.1	1.1	1.1	1.1	0.1	NS	NS
HQ (% of CW)	53.5	53.8	53.9	53.5	0.3	NS	NS
Retail cuts (% of HQ)	40.6	39.0	40.7	38.9	0.4	0.044	0.027
Bone (% of HQ)	20.8	20.3	21.5	19.5	0.3	NS	0.014
Trim fat (% of HQ)	5.2	6.2	3.8	7.6	0.5	NS	0.005

NS = non-significant ($P>0.10$).
[a] 56 heifers.
[b] 55 heifers.
[c] 27 heifers.
[d] EUROP system: 9=R+, 8=R, 7=R−, 6=O+, 5=O.
[e] EUROP system: 10=4−, 9=3+, 8=3, 7=2+, 6=2, 5=2−.
[f] Visually determined in *longissimus dorsi* on a scale 1 = lean and 5 = well marbled.

3.3. Angus heifers

Because of the restricted feed intake in trial 2, Angus heifers at low-feed intensity had lower DM, NDF and ME intakes than heifers at high-feed intensity (Table 3). The daily NDF intake was 0.85 and 1.06% of liveweight for heifers at low- and high-feed intensity, respectively, when averaged over indoor period 1 and 2 ($P<0.001$). Angus heifers at high-feed intensity had 102 and 133% higher liveweight gain than heifers at low-feed intensity during indoor period 1 and 2, respectively. Contrary, heifers at low indoor feed intensity had 33% higher liveweight gains than heifers at high-feed intensity during the grazing period (Table 3, Fig. 4). Averaged over the total rearing period from weaning to slaughter, daily liveweight gain was 21% higher in heifers at high-feed intensity than in heifers at low-feed intensity (Table 3). Expressed as MJ per kg liveweight gain, heifers at high-feed intensity utilised their feed 30% more efficiently than heifers at low-feed intensity during indoor period 1, but there was no effect of feed intensity on feed conversion during indoor period 2. Averaged over indoor periods, feed

Table 3
Daily feed intake (LW = liveweight), average daily liveweight gain (ADG), feed conversion (FC), and carcass traits (KKCF = kidney knob and channel fat; CW = carcass weight; HQ = hind quarter) of Angus heifers at low- or high indoor feed intensity with slaughter at 18 or 22 months of age; standard error of the mean (SEM) and significance of the main effects of indoor feed intensity and slaughter age

	Indoor feed intensity		Slaughter age			*P*-value	
	Low	High	18 months	22 months	SEM	Feed	Age
Indoor period 1 [a]							
Feed intake (kg of DM)	3.69	5.22	4.36	4.55	0.05	<0.001	0.048
Feed intake (% of LW)	1.63	2.02	1.81	1.85	0.02	<0.001	NS
NDF intake (kg) [g]	1.98	2.79	2.34	2.44	0.03	<0.001	0.046
ME intake (MJ)	37.5	52.9	44.2	46.2	0.5	<0.001	0.046
ADG (g)	416	840	606	650	28	<0.001	NS
FC (MJ ME/kg^{-1} gain)	90.4	63.0	77.0	76.4	1.7	<0.001	NS
Grazing period [b]							
ADG (g)	798	600	686	713	32	0.013	NS
Indoor period 2 [c]							
Feed intake (kg of DM)	6.00	8.51	–	7.26	0.35	0.037	–
Feed intake (% of LW)	1.38	1.82	–	1.60	0.07	0.047	–
NDF intake (kg)	3.32	4.71	–	4.01	0.19	0.036	–
ME intake (MJ)	57.6	81.8	–	69.7	3.3	0.036	–
ADG (g)	261	608	–	430	75	0.082	–
FC (MJ ME/kg^{-1} gain)	228.7	136.2	–	182.4	31.2	NS	–
From weaning to slaughter [b]							
ADG (g)	573	693	645	621	15	0.005	NS
Slaughter [b]							
Carcass weight (kg)	207	233	196	244	5	0.020	0.002
Dressing (%)	48.7	50.0	47.5	51.1	0.5	NS	0.006
Conformation [d]	6.0	6.6	6.1	6.4	0.2	0.087	NS
Fatness [e, g]	8.7	8.7	7.2	10.2	0.4	NS	0.007
KKCF (% of CW)	2.4	2.9	2.2	3.2	0.2	NS	0.043
Cutting [b]							
Marbling [f]	1.4	1.9	1.3	1.9	0.2	0.048	0.064
HQ (% of CW)	53.3	53.2	52.9	53.6	0.5	NS	NS
Retail cuts (% of HQ)	39.4	38.5	40.4	37.4	0.6	NS	0.025
Bone (% of HQ)	20.8	19.6	21.1	19.4	0.7	NS	NS
Trim fat (% of HQ)	6.7	8.4	5.2	9.9	0.7	NS	0.009

NS = non-significant ($P>0.10$).
[a] 56 heifers.
[b] 51 heifers.
[c] 26 heifers.
[d] EUROP system: 7=R−, 6=O+.
[e] EUROP system: 11=4, 10=4−, 9=3+, 8=3, 7=3−.
[f] Visually determined in *longissimus dorsi* on a scale 1 = lean and 5 = well marbled.
[g] Interactions between feed intensity and slaughter age; $P=0.046$ for NDF and ME intakes, $P=0.039$ for fatness.

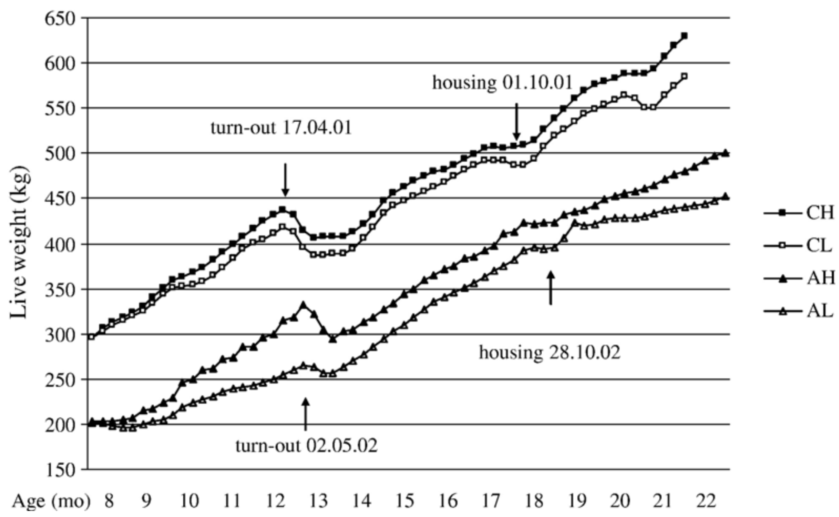

Fig. 4. Liveweight from weaning to slaughter in Charolais (C) and Angus (A) heifers at low (L) or high (H) indoor feed intensity with slaughter at 18 months (directly from pasture) or at 22 months of age; 56 heifers of each breed from weaning to turn-out, 55 Charolais and 51 Angus heifers from turn-out to housing/slaughter at 18 months of age, 27 Charolais and 26 Angus heifers from housing to slaughter at 22 months of age.

conversion was better in heifers at high-feed intensity than in heifers at low-feed intensity (76.3 vs. 112.9 MJ ME kg^{-1} gain, $P=0.005$) and it was better in heifers slaughtered at 18 months than in heifers slaughtered at 22 months of age (77.0 vs. 111.9 MJ ME kg^{-1} gain, $P=0.006$).

Carcass traits were more affected by slaughter age than by feed intensity (Table 3). Carcass weights were 24% higher when heifers were slaughtered at 22 months than at 18 months of age and 13% higher for heifers at high-feed intensity than at low-feed intensity. Heifers slaughtered at 22 months of age had higher dressing percentage and fatness score than heifers slaughtered at 18 months of age. There was an interaction between feed intensity and slaughter age in fatness ($P=0.039$). The high-feed intensity heifers were fatter when slaughtered at 22 months of age compared to those slaughtered at 18 months (score 11.0 vs. 6.3, $P<0.001$), whereas no differences in fatness was found between the two slaughter ages for heifers at low-feed intensity. No differences in conformation between slaughter ages of heifers were found. However, conformation tended to improve with the more intense feeding. The percentage of trim fat in the hind quarters was higher but the percentage of retail cuts was lower in heifers slaughtered at 22 months than in heifers slaughtered at 18 months of age (Table 3). However, the actual weights of the retail cuts were higher in heifers slaughtered at 22 than at 18 months of age (24.5 vs. 20.8 kg; $P=0.010$) and tended to be higher in heifers at high-feed compared to low-feed intensity (23.7 vs. 21.6 kg; $P=0.060$). Increasing feed intensity and slaughter age improved marbling (Table 3).

4. Discussion

Higher indoor dietary ME intakes in this study resulted in increased feed intakes, which is in agreement with earlier studies of beef heifers (Steen, 1995; Steen and Robson, 1995; Steinwidder et al., 1996). The generally low DM intake and liveweight gain in Angus heifers during indoor period 2 could be caused by the low nutritional quality of the silage (Tables 1 and 3; Huhtanen et al., 2003).

The differences in feed intensity were small, especially for the Charolais heifers, which only had a 14% lower daily ME intake when fed at low- compared to high-feed intensity, resulting in minor differences in weight gains and carcass traits between the two levels of feeding (Tables 2 and 3). For the Angus heifers, the difference in indoor ME intakes between the two levels of feeding was 29%. This resulted in 21% higher liveweight gains from weaning to slaughter accompanied by heavier carcasses with better conformation as well as more KKCF and marbling in heifers fed at high- compared to low-feed intensity. During indoor period 2, weight gains in Angus heifers varied greatly among individuals, resulting only in a tendency to differences in weight gains between heifers with a high- or low-feed intensity (Table 3). If there are large enough differences among feed intensities, an increased feed intensity generally results in higher liveweight gains accompanied by higher carcass weights, as well as higher conformation and fatness scores of the carcasses, but not if the differences are minimal (Aalhus et al., 1992; Steen, 1995; Steen and Kilpatrick, 1995; Steen and Robson, 1995; Steinwidder et al., 1996).

Increased slaughter ages have similar effects as increased diet concentrations on carcass traits (Aalhus et al., 1992; Hinks et al., 1999). In this study, increased slaughter age with accompanied higher carcass weight resulted in higher dressing percentages (Angus heifers only), conformation scores (Charolais heifers only), and fat deposits, which is in agreement with results from earlier studies (Steen and Kilpatrick, 1995; Hinks et al., 1999; Tables 2 and 3). Increased slaughter age and feed intensity (Charolais only) decreased the retail cuts expressed as percentages of hind quarter. However, the total amounts of retail cuts were greater, indicating higher values of the carcasses.

The proportion of liveweight gain from weaning to slaughter derived from pasture varied among the production systems studied (Tables 2 and 3). In Charolais heifers, averaged over feed intensities, 34 and 22% of the liveweight gains were gained on pasture when slaughtered at 18 and 22 months of age, respectively. In Angus heifers at high-feed intensity, 46% of the weight gains derived from pasture when slaughtered at 18 months and 34% of their gains derived from pasture when slaughtered at 22 months of age. Angus heifers at low-feed intensity gained as much as 67 and 62% of their liveweights on pasture when slaughtered at 18 and 22 months of age, respectively.

In all production systems studied, heifer liveweight decreased after turn-out to pasture (Fig. 4). The decrease was more pronounced for Angus heifers at the high indoor feed intensity than at the low-feed intensity, probably due to a larger rumen and intestinal fill and also a lower herbage intake on pasture by heifers previously fed at a high indoor feed intensity (Wright et al., 1986; Hinks et al., 1999). A daily decrease of 1 to 1.5 kg liveweight during the first two weeks at pasture is usual in cattle grazing semi-natural grasslands (Wright et al., 1986; Steen and Kilpatrick, 1998; Spörndly et al., 2000).

When comparing liveweight gain in different production systems, the main issue rather is the gain during the entire grazing period. Average gains of the heifers on pasture in this study were lower than (Hinks et al., 1999; McCaughey et al., 1999) or similar to (Steinwidder et al., 1996; Hoving-Bolink et al., 1999) weight gains in heifers grazing cultivated grasslands in other studies. The diverging results may be due to varying conditions in the studies, as liveweight gain on pasture is affected by previous feed intensity as well as the quality and quantity of pasture herbage.

The relatively low average daily weight gain for Charolais heifers during the grazing period, compared to the weight gain during the indoor periods, could be due to the high gains during the previous indoor period (Table 2). On the other hand, the Angus heifers with a low liveweight gain during indoor period 1, had compensatory growth with high weight gains during the subsequent grazing period. In agreement with earlier studies, heifers of previously low indoor feed intensity retained about half of their lost weight gain on pasture (Wright et al., 1986, 1989; Hinks et al., 1999).

The nutrient concentration of herbage on the semi-natural grasslands was low, especially in late season, which is in agreement with Spörndly et al. (2000). Low liveweight gains in heifers in both trials during the last month on pasture, 100 g day^{-1}, affected the average weight gains during the entire grazing period.

However, the liveweight gains on pasture in this study were most probably restricted by the herbage mass rather than the nutrient concentrations. At the end of the grazing periods, the sward heights generally were low, especially in trial 1 (Fig. 2), which could be the main reason for the low weight gains in the autumn. In an earlier study of beef production on semi-natural grasslands (Spörndly et al., 2000), a sward height below 6 cm restricted the weight gain of the cattle. In trial 1 in our study, the stocking rate was 690 kg liveweight ha^{-1} resulting in a sward height at housing of 2 cm. According to the visual assessment at the end of the growing season, the grazing pressure had been higher than necessary to obtain nature conservation goals. In trial 2, the grazing intensity was low because of a low stocking rate (475 kg liveweight ha^{-1}) and high precipitation (260 mm from May to July). The grazing pressure resulted in a sward height of 4 cm at housing and was judged to have been excellent to satisfactory in half of the pasture.

Higher liveweight gains in the heifers could have been obtained by lower stocking rates in the autumn. However, there are not only beef production goals but also nature conservation goals when keeping cattle on semi-natural grasslands. Even if the optimal sward height for preserving biodiversity is debated (Götmark et al., 1998; Stenseke, 2004), a certain grazing pressure, is required to receive environmental support for grazing semi-natural grasslands in Sweden (Swedish Board of Agriculture, 2004). The defoliation ensures that no, for the flora, deleterious litter is accumulated onto the sward. Supplemental feeding on pasture or complementary grazing of aftermath could be alternatives to increase liveweight gain in grazing livestock, but is because of supposed risks for fertilization effects, often not allowed on Swedish valuable semi-natural grasslands (Swedish Board of Agriculture, 2004). Hence, there may be a risk for conflicting grazing pressure optimums when grazing grasslands dominated by low-nutrient vegetation such as *D. cespitosa*. In economically and ecologically sustainable production systems for growing beef cattle on semi-natural grasslands, this trade-off has to be properly balanced.

For Charolais heifers slaughtered at 18 and 22 months of age, 68 and 96% of the carcasses, respectively, were in the desirable carcass weight interval from 250 to 400 kg. In total, 93 and 65% of the Charolais heifers had desirable conformation (≥7) and fatness (6 to 10), respectively. Only 25% of the Angus heifers reached a carcass weight of 250 kg and only when slaughtered at 22 months of age. A desirable conformation was achieved in 39% of the Angus heifers, whereas 71% had desirable fatness. Averaged over both trials, the proportion of full-paid carcasses was doubled by a further indoor period with slaughter at 22 months instead of slaughter from pasture at 18 months of age. Therefore, a further indoor period may be necessary to obtain acceptable carcasses when the livestock are used for grazing semi-natural grasslands. In general, a decreased minimum carcass weight or increased maximum fatness for full payment would favour beef heifer production.

Beef production on semi-natural grasslands serves preservation of ecosystems, cultural heritage and recreation possibilities (Ihse and Norderhaug, 1995). If society is willing to pay for these public goods and compensate the farmers for the additional costs and the reduced incomes of this production system compared to indoor rearing, it is an interesting alternative (Hasund, 1998). Both from the producer's and society's viewpoint, it appears to be a more efficient strategy to combine preservational management of semi-natural grasslands for the public good at the same time as producing beef for the food market, instead of two unconnected approaches for the two objectives (Hasund, 1998).

5. Conclusion

In both trials, slaughter age had greater effects than indoor feed intensity on carcass traits but feed intensity had effects on feed intake and liveweight gain. Liveweight gains of the heifers were low on pasture, but the objective of grazing to conserve the biodiversity of semi-natural grasslands was achieved.

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References

Aalhus, J.L., Jones, S.D.M., Tong, A.K.W., Jeremiah, L.E., Robertson, W.M., Gibson, L.L., 1992. The combined effects of time on feed, electrical stimulation and aging on beef quality. Can. J. Anim. Sci. 72, 525–535.

Åman, P., Hesselman, K., 1984. Analysis of starch and other main constituents of cereal grains. Swed. J. Agric. Res. 14, 135–139.

Andersson, R., Hedlund, B., 1983. HPLC analysis of organic acids in lactic acid fermented vegetables. Z. Lebensm. Unters. Forsch. 176, 440–443.

Axelsson, J., 1941. Der Gerhalt des Futters an umsetzbarer Energie. Züchtungskunde 16, 337–347 (in German with English abstract).

Commission of the European Communities, 1998. Directive 1998/64/EC. Official Journal of The European Communities L257/14. Commission of the European Communities, Brussels, pp. 10–12.

Commission of the European Communities, 2005. Council Regulation determining the Community scale for the classification of carcasses of adult bovine animals. Council Regulation 2005/0171. Commission of the European Communities, Brussels. 13 pp.

Ekelund, S., 1966. Socker in redos. Report vol. 28. National Laboratory for Agricultural Chemistry, Uppsala, Sweden, pp. 67–71 (in Swedish).

Frame, J., 1993. Herbage mass. In: Davis, A., Baker, R.D., Grant, S.A., Laidlaw, A.S. (Eds.), Sward Measurement Handbook. British Grassland Society, Reading, UK, pp. 39–67.

Goering, H.K., Van Soest, P.J., 1970. Forage fiber analysis (apparatus, reagents, procedures and some applications). Agricultural Handbook vol. 379. Agriculture Research Service, United States Department of Agriculture, Washington, DC. 20 pp.

Gärdenfors, U., 2000. The 2000 Red List of Swedish Species. Artdatabanken, Swedish University of Agricultural Sciences, Uppsala, Sweden. 397 pp. (in Swedish).

Götmark, F., Gunnarsson, B., Andrén, C., 1998. Artrikedom hos grupperna i relation till grad av hävd i ängs- och betesmark: en jämförelse. Biologisk mångfald i kulturlandskapet. Swedish Environmental Protection Agency, Erlanders, Stockholm, pp. 151–171 (in Swedish).

Hasund, K.P., 1998. Valuable landscapes and reliable estimates. In: Dabbert, S., Dubgaard, A., Slangen, L., Whitby, M. (Eds.), The Economics of Landscape and Wildlife Conservation. CAB International, Wallingford, UK, pp. 65–83.

Hinks, C.E., Hunter, E.A., Lowman, B.G., Scott, N.A., 1999. Effect of breed type, sex, method of rearing, winter nutrition and subsequent grazing treatment on lifetime performance and carcass composition in a 20-month beef system: carcass characteristics. Anim. Sci. 69, 465–472.

Hoving-Bolink, A.H., Hanekamp, W.J.A., Walstra, P., 1999. Effects of sire breed and husbandry system on carcass, meat and eating quality of Piemontese and Limousin crossbred bulls and heifers. Livest. Prod. Sci. 57, 273–278.

Huhtanen, P., Nousiainen, J.I., Khalili, H., Jaakkola, S., Heikkilä, T., 2003. Relationship between fermentation characteristics and milk production parameters: analyses of literature data. Livest. Prod. Sci. 81, 57–73.

Ihse, M., Norderhaug, A., 1995. Biological values of the Nordic cultural landscape: different perspectives. Int. J. Herit. Stud. 1, 156–170.

Kumm, K.-I., 2003. Sustainable management of Swedish seminatural pastures with high species diversity. J. Nat. Conserv. 11, 117–125.

Kumm, K.-I., 2006. Scenarios for profitable beef and lamb production. Report vol. 11. Dept. of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara, Sweden. 99 pp. (in Swedish with an English summary).

Lewis, J.M., Klopfenstein, T.J., Pfeiffer, G.A., Stock, R.A., 1990. An economic evaluation of the differences between intensive and extensive beef production system. J. Anim. Sci. 68, 2506–2516.

Lindgren, E., 1979. The nutritional value of roughages determined in vivo and by laboratory methods. Report vol. 45. Dept. of Animal Nutrition, Swedish University of Agricultural Sciences, Uppsala, Sweden. (in Swedish).

McCaughey, W.P., McAllister, T.A., Popp, J.D., Shelford, J.A., Cheng, K.-J., 1999. Carcass evaluation of cattle finished on alfalfa/grass pastures alone or supplemented with barley. Can. J. Anim. Sci. 79 (4), 545–548.

McMillin, K.D., Bidner, T.D., Hill, G.M., Coombs, D.F., Bagley, C.P., Knox, J.W., Loyacano, A.F., Oliver, W.M., Huffman, D.C., Wyatt, W.E., Saxton, A.M., 1990. Year-round production of beef using maximum levels of forages. III. Carcass evaluation. Appl. Agric. Res. 5 (4), 321–326.

Mejersjö, E.-M., Kronqvist, E., 2000. Miljöeffekter av EU:s jordbrukspolitik. Rapport från projektet CAP:s miljöeffekter 2001. Report no. 2000:21. Swedish Board of Agriculture, Swedish Environmental Protection Agency and National Heritage Board, Jönköping, Sweden, pp. 47–49, 69–96. (in Swedish with an English summary).

Official Statistics of Sweden, 2006. Yearbook of agricultural statistics 2006 including food statistics. SCB-Tryck, Örebro, Sweden, pp. 92, 135. (in Swedish).

Persson, K., 2005a. Ängs- och betesmarksinventeringen 2002–2004. Report no. 2005:1. Swedish Board of Agriculture, Jönköping, Sweden, pp. 47–49, 69–96. (in Swedish).

Persson, K., 2005b. Ängs-och betesmarksinventeringen — inventeringsmetod. Report vol. 2005:2. Swedish Board of Agriculture, Jönköping, Sweden, pp. 16–40 (in Swedish).

SAS, 2001. User's Guide. Release 8.02 Edition. SAS Institute Inc., Cary, NC, USA.

SJVFS 127, 1998. Directions of Classifications of Carcasses from the Swedish Board of Agriculture. Swedish Board of Agriculture, Jönköping. (in Swedish).

Spörndly, E., Olsson, I., Burstedt, E., 2000. Grazing by steers at different sward surface heights on extensive pastures: a study of weight gain and fat deposition. Acta Agric. Scand. Section A — Anim. Sci. 50, 184–192.

Steen, R.W.J., 1995. The effect of plane of nutrition and slaughter weight on growth and food efficiency in bulls, steers and heifter of three breeds. Livestock Prod. Sci. 42, 1–11.

Steen, R.W.J., Kilpatrick, D.J., 1995. Effects of plane of nutrition and slaughter weight on the carcass composition of serially slaughtered bulls, steers and heifers of 3 breed crosses. Livest. Prod. Sci. 43 (3), 205–213.

Steen, R.W.J., Kilpatrick, D.J., 1998. Effects of pasture grazing or storage feeding and concentrate input between 5.5 and 11 months of age on the performance and carcass composition of bulls and on subsequent growth and carcass composition at 620 kg live weight. Anim. Sci. 6, 129–141.

Steen, R.W., Robson, A.E., 1995. Effects of forage to concentrate ratio in the diet and protein intake on the performance and carcass composition of beef heifers. J. Agric. Sci. 125, 125–135.

Steinwidder, A., Gruber, L., Steinwender, R., Guggenberger, T., Greimel, M., Schauer, A., 1996. Influence of feeding intensity and slaughter weight on the fattening and slaughter performance of Simmental heifers. Bodenkultur 47 (1), 49–64.

Stenseke, M., 2004. Bönder och naturbetesmarker. Del 1: Bygdeperspektiv. Dept. of Human and Economic Geography, School of Economics and Commercial Law, Göteborg University, Sweden, p. 47 (in Swedish).

Swedish Board of Agriculture, 2004. Stöd för miljövänligt jordbruk 2004. EU-information från Jordbruksverket. The Swedish Board of Agriculture, Tabergs Tryckeri, Jönköping. 48 pp. (in Swedish).

Van Soest, P.J., Robertsson, J.B., Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccarides in relation to animal nutrition. J. Dairy Sci. 74, 3583–3597.

Wright, I.A., Russel, A.J.F., Hunter, E.A., 1986. The effect on winter food level on compensatory growth of weaned, suckled calves grazed at two sward heights. Anim. Prod. 43, 211–223.

Wright, I.A., Russel, A.J.F., Hunter, E.A., 1989. Compensatory growth in cattle grazing different vegetations types. Anim. Prod. 48, 43–50.