BEEF SYSTEMS

A comparison of pasture and indoor finishing of spring-born Aberdeen Angus x Friesian and Belgian Blue x Friesian steers

The objectives of this study were (i) to compare Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers for growth and carcass traits, (ii) to compare these breed types on two finishing regimens for two periods, and (iii) to evaluate interactions between breed type, finishing regimen and duration of finishing.

Management of animals

Eighty (40 per breed type) beef x Holstein-Friesian calves, the progeny of 5 Aberdeen Angus, and 7 Belgian Blue, bulls were used in the study. The bulls were representative of those available through artificial insemination (AI) in Ireland and recommended for use in dairy herds. The calves were identified from AI records and purchased individually on dairy farms in spring, 2005. They remained on their farms of origin until they were 3 to 4 weeks old and were then transferred to Grange Beef Research Centre. Calves were penned individually and offered a total of 25 kg milk replacer for 56 days after arrival. Calf concentrates (750 g/kg coarsely rolled barley, 170 g/kg soya bean meal, 55 g/kg molasses, 25 g/kg mineral/vitamin premix) were offered up to a maximum of 2 kg per head daily, with hay available *ad libitum*. On June 8, all the calves were turned out to pasture where they grazed together ahead of yearling steers in a leader/follower rotational grazing system. Cattle concentrates (875 g/kg rolled barley, 65 g/kg soya bean meal, 45 g/kg molasses, 15 g/kg mineral/vitamin premix) were offered at 1 kg per head daily (group basis) for 4 weeks after turn-out. At 3, 8 and 13 weeks after turn-out, the calves were treated with ivermectin (Qualimec, Janssen Animal Health) by injection for the control of internal parasites. On September 21st the calves were castrated, and from then until housing on November 29th, they were group-fed 1 kg of cattle concentrates per head daily.

During the first winter, the animals were accommodated in a slatted floor shed where they were offered grass silage [chemical analysis (± s.d.): 209 (13.1) g/kg dry matter (DM), 162 (9.4) g/kg crude protein (CP) in the DM, 739 (24.1) g/kg *in vitro* DM digestibility, 75 (7.1) g NH_3N per kg total N, pH 4.0] *ad libitum* plus 1 kg cattle concentrates per head daily (group basis) until January 23rd when the concentrates were withdrawn. The animals were turned out to pasture for their second grazing season on March 29th and were managed together in a rotational grazing system until commencement of the finishing treatments.

Management during finishing

On August 1, the steers were assigned on descending live weight within breed type to 4 blocks of 10 animals each. From within blocks, pairs of animals were assigned at random to a pre-finishing slaughter group and to 4 finishing treatments in a 2 (finishing regimens) x 2 (finishing periods) factorial design. The pre-finishing group was slaughtered immediately and the data were used to estimate initial carcass weight and ribs joint composition of the finished animals. The four finishing treatments were: 1) pasture only for 94 days to slaughter on November 3rd (PE), 2) concentrates *ad libitum* (continuously available to appetite) indoors for 94 days to slaughter on November 3rd (CE), 3) pasture for 94 days followed by concentrates *ad libitum* indoors for 95 days to slaughter on February 6th (PL), and 4) concentrates *ad libitum* indoors for 189 days to slaughter on February 6th (CL). The finishing regimen with pasture to 94 days (after which the animals were either slaughtered or offered concentrates *ad libitum* to 189 days) is designated P (pasture), while that with concentrates to slaughter after either 94 or 189 days is designated C (concentrates). Slaughter after 94 days is designated E (early) while slaughter after 189 days is designated L (late). Thus, the 4 finishing treatments in the order listed are designated PE, CE, PL and CL.

The cattle in CE and CL were housed in pairs (blocks) in a slatted floor shed giving 8 replicates per breed type for feed intake measurement up to early slaughter. When the CE animals were slaughtered after 94 days, they were replaced in the shed by the PL animals that had been at pasture until then. This permitted the following comparisons of concentrate intake by breed type: (i) intake up to 94 days (for all 32 animals housed in this period) compared with intake from 95 to 189 days (for the 16 animals housed from the start), and (ii) intake from 95 to 189 days for animals previously at pasture compared with those previously on concentrates.

The pasture area used consisted of 5 equally sized paddocks that were grazed rotationally over 3 grazing cycles to a target post-grazing stubble height of 6 cm. Pre-and post-grazing sward heights, herbage yields (to 4.5 cm stubble height) and *in vitro* DMD values were measured for each paddock and grazing cycle. All the cattle were grazed together as a single group. Indoors, the animals were offered grass silage (above analysis) *ad libitum* initially and concentrates were increased gradually to *ad libitum* intake over a 4-week period. Concentrate intake was recorded daily as the weight difference between that offered and that uneaten 24 h later. Uneaten residues were discarded twice weekly. All animals on *ad libitum* concentrates were offered 1 kg/day silage DM to maintain rumen function.

Slaughter and carcass assessment

The animals were slaughtered in a commercial meat plant and the carcasses dressed according to standard procedures. The weight of perinephric plus retroperitoneal fat, cold carcass weight (hot weight x 0.98), carcass conformation and fat classes, and carcass measurements were recorded. After 48 h in the chill at 4°C, the right side of each carcass was quartered between the 5^{th} and 6^{th} ribs into a hind quarter without the flank and a fore quarter that included the flank. The hind quarter, also termed the pistola, was weighed and the ribs joint (ribs 6 to 10) was removed by cutting between the 10^{th} and 11^{th} ribs. *M. longissimus* area was measured at the 10^{th} rib. The ribs joint was weighed and separated into fat, *m. longissimus*, other muscle and bone (including *ligamentum nuchae*). Within breed type, the mean kill-out proportion of the pre-experimental slaughter group was used to estimate the initial carcass weight of the finished animals. Carcass gains were estimated as the difference between the initial and final carcass weights. Likewise, the mean ribs joint tissue proportions of the pre-experimental slaughter group were used within breed type to estimate the initial ribs joint tissue weights of the finished groups. This permitted estimation of the composition of the ribs joint weight gain during finishing.

Statistical analysis

Data were statistically analysed using the general linear model least squares procedures of the Statistical Analysis Systems Institute (SAS, 2002-2003). Live weights and gains up to the start of finishing were analysed for breed type effects only. The finishing data were analysed as a 2 (breed types) x 2 (finishing regimens) x 2 (slaughter times) factorial with terms for block, breed type, finishing regimen, slaughter time and the interactions of the latter three. Concentrate intake data were analysed as a 2 (breed types) x 2 (periods or backgrounds) factorial in two separate analyses. In the first analysis, concentrate intake from the start to 94 days was compared with that from 95 to 189 days. In the second analysis, concentrate intake from 95 to 189 days was compared for animals on pasture or indoors on concentrates up to 94 days. Pasture data were analysed for defoliation (pre- v. post-grazing) and grazing cycle effects. The data are presented as the breed type main effect means and the individual finishing regimen by slaughter time means. Where there were significant interactions with breed type, the means for the individual treatments are shown in footnotes.

Live weights and gains to start of finishing

Live weights and live weight gains from calf arrival to the start of finishing are shown in Table 1. There were no differences between the breed types in calf arrival or turn-out weights, but housing weight tended ($P<0.08$) to be heavier, and yearling turn-out and start of finishing weights were heavier (P<0.05), for BB. There was no significant difference between the breed types in live weight gain for any of the production phases to the start of finishing, but the BB values were always numerically higher. Accordingly, daily live weight gain from arrival to slaughter, together with slaughter and carcass weights per day from arrival were significantly higher for BB.

Table 1: Live weights and live weight gains for Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers from calf arrival to start of finishing

Live weights (kg) at:	AA	BB	s.e.[1]	Significance
Arrival (April 2)	63.9	66.1	1.22	NS
Calf turn-out (June 8)	105	108	2.2	NS
Housing (November 29)	226	235	3.0	P<0.08
Yearling turn-out (March 29)	292	306	4.4	*
Start of finishing (August 1)	426	442	4.9	*
Live weight gains (g/d) for:				
Arrival to calf turn-out	611	623	21.8	NS
Calf turn-out to housing	695	729	16.6	NS
Housing to yearling turn-out	552	594	26.6	NS
Yearling turn-out to start of finish	1075	1085	18.7	NS
Arrival to housing	671	700	13.2	NS
Arrival to slaughter	820	851	10.2	*
Per day from arrival (g)				
Slaughter weight	922	957	10.6	*
Carcass weight	476	511	6.1	***

[1]For n = 32; NS = not significant, * = p<0.05, ** = P<0.01, *** = P<0.001 in this and subsequent tables.

Pasture measurements

Mean pre-grazing and post-grazing sward heights and herbage DM yields were 12.4 (s.d. 2.01) and 5.5 (s.d. 0.59) cm, and 2.63 (s.d. 0.536) and 1.44 (s.d. 0.293) t/ha, respectively. Corresponding herbage DM and *in vitro* DM digestibility values were 177 (s.d. 31.3) and 226 (s.d. 34.3) g/kg, and 686 (s.d. 31.2) and 627 (s.d. 41.4) g/kg, respectively.

Slaughter and carcass traits

For the animals slaughtered pre-finishing, mean slaughter weights, carcass weights, ribs joint weights, and ribs joint fat, muscle and bone proportions were 417 and 442 (s.e. 3.7) kg, 202 and 229 (s.e 3.9) kg, 4.66 and 5.17 (s.e. 0.137) kg, and 83 and 61 (s.e. 6.8), 647 and 680 (s.e. 8.2) and 270 and 258 (s.e. 4.5) g/kg for AA and BB, respectively. Corresponding *m. longissimus* moisture, protein and lipid concentrations (g/kg) were 748 and 748 (s.e. 2.2), 223 and 228 (s.e. 1.3), and 16 and 10 (s.e. 1.9). Mean carcass conformation and fat classes for AA and BB were 2.00 and 2.50 (s.e. 0.13) and 2.25 and 1.50 (s.e. 0.17), respectively.

Live weights together with live weight and carcass weight gains during finishing are shown in Table 2. Live weights at the start of finishing and at the early and late slaughter times were significantly greater for BB than for AA, but live weight gains during finishing were not significantly different between the breed types. However, carcass weight gain per day was greater (P<0.01) for BB than for AA. Finishing regimen significantly affected all live weights (except at start of finishing), live weight gains and carcass weight gain, with all values higher for C than P, except live weight gain from early to late slaughter where the opposite was true. There was no significant effect of slaughter time other than on daily carcass weight gain which was higher (P<0.01) for late slaughter. There were finishing regimen by slaughter time interactions for live weight gain from start of finishing to slaughter and for carcass weight gain. These were due to the differences between P and C being greater for early than for late slaughter. When animals were retained to late slaughter, those previously on pasture exhibited compensatory growth when offered concentrates *ad libitum.* In contrast, those previously on concentrates *ad libitum* had lower live weight gains than earlier, probably as a consequence of their more advanced stage of fattening. There were no interactions involving breed type.

Slaughter weight, kill-out proportion, carcass weight and carcass conformation class were all significantly higher for BB than for AA, while carcass fat class was significantly lower (Table 3). Weight of perirenal plus retroperitoneal fat, and its proportion of carcass weight, were not affected by breed type. All slaughter traits had significantly (carcass conformation class P<0.06) higher values for late than for early slaughter. Compared with P, the C finishing regimen significantly increased slaughter weight, carcass weight, carcass fat class and perirenal plus retroperitoneal fat weight and proportion, but kill-out proportion and carcass conformation class were not affected. There were no interactions involving breed type, but interactions of finishing regimen and slaughter time did occur for slaughter weight and carcass fat class. Both were due to the difference between P and C being greater for early than for late slaughter (i.e. a difference in magnitude rather than in direction of effect).

Carcass measurements and *m. longissimus* area expressed both as absolute values and per kg carcass weight are shown in Table 4. Carcass length and depth did not differ between AA and BB, but leg length, width and thickness, together with *m. longissimus* area, were all significantly greater for BB. All measurements were significantly greater for late than for early slaughter, but the only significant effect of finishing regimen was for leg thickness which was greater for C. Per kg carcass weight, all linear measurements except leg thickness were significantly lower for BB than for AA, and *m. longissimus* area was significantly greater. On a per kg carcass weight basis also, all values were significantly lower for late than for early slaughter, and for the C compared with the P finishing regimen. There were no significant interactions between the experimental factors.

Concentrate intakes

Mean live weights and concentrate intakes for the period from start to early slaughter, compared with the period from early to late slaughter, for the animals on concentrates throughout are shown in Table 5. BB had a significantly greater mean live weight than AA both from start to early slaughter and from early to late slaughter. However, the two breed types had identical DM intakes resulting in intake per kg mean live weight being lower (P<0.08) for BB. As expected, mean live weight and DM intake were significantly higher in the period from early to late slaughter than in the period from start to early slaughter, but the difference in intake was proportionately less than the difference in mean live weight. As a result, intake per kg mean live weight was significantly lower in the period from early to late slaughter.

Mean live weights and intakes in the period from early to late slaughter for the animals previously on pasture compared with those previously on concentrates are shown in Table 6. Animals previously on concentrates were heavier and had higher intakes than those previously on pasture, but when scaled to mean live weight, intakes were similar. When account is taken of the fact that the animals previously on pasture required 3-4 weeks to adapt to *ad libitum* concentrate intake, whereas those previously on concentrates required no such adaptation period, then true *ad libitum* concentrate intake was actually higher for those previously on pasture (i.e. in the first 5 weeks after housing, mean intakes were 18.8 and 12.8 (s.e. 0.10) g/kg live weight for those previously on concentrates and these previously at pasture, respectively; corresponding intakes for the remainder of the period were 18.0 and 20.5 (s.e. 0.17) g/kg live weight).

Carcass and muscle composition

Compared with AA, BB had higher (P<0.001) proportions of pistola, ribs joint *m. longissimus* and total muscle, and had a lower (P<0.001) proportion of ribs joint fat (Table 7). There was no difference between the breeds in ribs joint bone proportion. Compared with C, the P finishing regimen resulted in a higher (P<0.001) proportion of side weight in the pistola. Ribs joint fat proportion was higher (P<0.001) and ribs joint total muscle and bone proportions were lower (P<0.001) for C than P. Likewise, ribs joint fat proportion was higher (P<0.001), and muscle and bone proportions were lower (P<0.001) for late than for early slaughter, but *m. longissimus* proportion was not affected. There was a breed type x slaughter time interaction for ribs joint fat proportion and a breed type x finishing regimen interaction for *m. longissimus* proportion. The interaction for the ribs joint fat proportion was due to a greater difference between the two slaughter times for AA than for BB, while the *m. longissimus* interaction was due to a greater difference between P and C for AA than BB. During finishing, AA had a higher (P<0.001) proportion of fat in the ribs joint weight gain than BB, while BB had a higher (P<0.001) proportion of muscle in the ribs joint weight gain than AA. There were no significant differences between the breed types in the proportion of bone in the ribs joint weight gain. The proportion of fat in the ribs joint weight gain was higher (P<0.001), and the proportion of muscle in the ribs joint weight gain was lower (P<0.001), for C than P, and for late than for early slaughter. There was an interaction between breed type and slaughter time for the proportion of fat in the ribs joint weight gain. This was due to the difference between the two slaughter times being greater for BB than for AA. There were breed type differences in *m. longissimus* chemical composition. Moisture, protein and ash concentrations were higher (P<0.001), and lipid concentration was lower (P<0.001), for BB than AA. Moisture concentration was also higher (P<0.001) and lipid concentration was lower (P<0.001) for P than C, and for early than for late slaughter. Protein concentration was lower for late than for early slaughter but was unaffected by finishing regimen. There were no significant interactions for *m. longissimus* chemical composition.

It is concluded that BB grew faster than AA, resulting in 4% greater slaughter weight. Due to a higher kill-out proportion, carcass weight was 7% greater for BB. When account is taken of their higher ribs joint muscle proportion, estimated muscle production was 18% greater for BB. Scaled for mean live weight, feed intake was 3-4% lower for BB. For AA, carcass fat class exceeded 3, and *m. longissimus* lipid concentration exceeded 25 g/kg, at carcass weights above 270 kg. At carcass weights above 330 kg, AA carcass fat class exceeded 4 and *m. longissimus* lipid concentration exceeded 45 g/kg. In contrast, BB did not reach carcass fat class 3 or a *m. longissimus* lipid concentration of 25 g/kg until carcass weight exceeded 300 kg. During the autumn grazing period, the live weight and carcass weight gains on pasture were less than half those on concentrates, and up to the early slaughter date, the conversion ratio of concentrate DM to carcass weight gain was 10.8:1. At the early slaughter date, neither breed type produced acceptably finished carcasses (fat class 3) on pasture only, but both breed types produced acceptably finished carcasses on *ad libitum* concentrates. At the late slaughter date, the AA carcasses, finished on pasture followed by concentrates, were acceptably finished, while those finished on concentrates throughout were over fat. The opposite was true for BB, in that the animals finished on pasture followed by concentrates did not have acceptable fat cover, whereas those finished on concentrates throughout did. The implications of these findings are that spring-born, early maturing beef breed x dairy steers can be finished for slaughter in the late autumn/early winter of their second year at a carcass weight of 270 kg upwards following a 2-3 month feeding period on *ad libitum* concentrates. Even though late maturing breed types have heavier carcasses at the same age, they require a longer period of concentrate feeding to produce acceptably finished carcasses. This period must be extended further when the animals undergo a period of slower growth on autumn pasture before concentrate feeding commences.

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Table 2: Live weights, live weight gains and carcass gain of Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers subjected to pasture (P) or concentrate (C) based finishing (F) regimens and slaughtered (S) early (E, 94 days) or late (L, 189 days)

	Breed type (B)		Finishing (F) x Slaughter (S)				Significance[1]				
Live weight (kg) at:	AA	BB	PE	CE	PL	CL	s.e.[2]	B[3]	F[4]	S[5]	I[6]
Start of finishing	426	442	434	431	437	434	4.9	*	NS	NS	NS
Early slaughter	528	551	501	576	501	581	5.6	**	***	NS	NS
Late slaughter	632	652	-	-	626	658	6.1	*	***	-	NS
Live weight gain (g/day) for:											
Start to early slaughter	1085	1162	714	1539	678	1564	32.5	NS	***	NS	NS
Early to late slaughter	1076	1054	-	-	1317	813	44.8	NS	***	-	NS
Start to slaughter	1081	1126	714	1539	999	1186	22.6	NS	***	NS	FxS*
Carcass gain (g/day)[7]	644	724	416	901	645	774	17.4	**	***	*	FxS*

[1]Of main effects and interactions; [2]For Breed type main effect (n = 32), multiply by √2 (1.414) for Finishing x Slaughter group; [3]Main effect of Breed type; [4]Main effect of Finishing regimen; [5]Main effect of Slaughter date; [6]Interaction. There was no interaction involving Breed type; [7]Calculated from the pre-experimental slaughter group kill-out proportions of 485 and 520 g/kg for AA and BB, respectively.

Table 3: Slaughter traits of Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers subjected to pasture (P) or concentrate (C) based finishing (F) regimens and slaughtered (S) early (E, 94 days) or late (L, 189 days)

	Breed type (B)		Finishing (F) x Slaughter (S)				Significance				
	AA	BB	PE	CE	PL	CL	s.e.	B	F	S	I
Slaughter weight (kg)	579	601	501	576	626	658	6.8	*	***	***	FxS*
Kill-out (g/kg)	515	534	502	514	537	545	2.4	**	NS	***	NS
Carcass weight (kg)	300	322	252	296	336	359	3.9	***	***	***	NS
Carcass conformation class[1]	2.56	3.03	2.50	2.94	2.88	2.88	0.083	***	NS	P<0.06	NS
Carcass fat class[2]	3.57	2.67	2.00	3.48	3.11	3.90	0.078	***	***	***	FxS**
Perirenal + retroperitoneal fat (kg)	8.6	8.5	4.2	7.6	9.7	12.6	0.31	NS	***	***	NS
Perirenal + retroperitoneal fat (g/kg)[3]	27.7	25.6	16.9	25.6	29.0	35.1	0.89	NS	***	***	NS

[1]EU Beef Carcass Classification Scheme: scale 1 (poorest = P) to 5 (best = E); [2]EU Beef Carcass Classification Scheme: scale 1 (leanest) to 5 (fattest); [3]Of carcass. There was no interaction involving Breed type. See Table 2 footnotes.

Table 4: Carcass and *m. longissimus* area measurements for Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers subjected to pasture (P) or concentrate (C) based finishing (F) regimens and slaughtered (S) early (E, 94 days) or late (L, 189 days)

	Breed type (B)		Finishing (F) x Slaughter (S)				Significance			
	AA	BB	PE	CE	PL	CL	s.e.	B	F	S
Carcass measurements (cm)										
Carcass length	133.4	133.9	130.2	131.5	136.4	136.5	0.485	NS	NS	***
Carcass depth	47.3	47.4	46.4	46.3	48.4	48.3	0.250	NS	NS	***
Leg length	74.2	75.4	73.6	73.3	76.1	76.3	0.305	**	NS	***
Leg width	43.4	44.5	42.4	43.6	44.8	45.0	0.262	**	P<0.07	***
Leg thickness	25.9	27.8	25.2	26.5	27.6	28.3	0.221	***	**	***
M. longissimus area (cm^2)	60.4	77.2	58.2	59.2	78.7	79.0	1.59	***	NS	***
Per kg carcass (cm)										
Carcass length	0.454	0.424	0.520	0.446	0.407	0.383	0.004	***	***	***
Carcass depth	0.161	0.150	0.186	0.157	0.145	0.135	0.0017	***	***	***
Leg length	0.253	0.239	0.294	0.249	0.227	0.214	0.0025	**	***	***
Leg width	0.148	0.141	0.169	0.148	0.134	0.126	0.0015	**	***	***
Leg thickness	0.088	0.088	0.100	0.090	0.082	0.079	0.0007	NS	***	***
M. longissimus area (cm^2)	0.202	0.240	0.230	0.200	0.234	0.220	0.0046	***	*	**

There were no significant interactions. See Table 2 footnotes.

Table 5: Concentrate dry matter intakes of Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers from start to early slaughter and from early to late slaughter

	Breed type (B)			Slaughter interval (S)			Significance	
	AA	BB	s.e.[1]	Start to early	Early to late	s.e.[2]	B[3]	S[4]
Mean live weight (kg)	555	576	7.0	514	617	5.7	*	***
Mean intake (kg/day)	10.5	10.5	0.08	9.7	11.3	0.06	NS	***
Mean intake (g/kg LW)	18.9	18.3	0.24	19.0	18.2	0.20	P<0.08	*

[1]For Breed type pairs (n = 12); [2]For Start to early slaughter (n = 16), multiply by 1.414 for Early to late slaughter (n = 8);
[3]Breed type effect; [4]Slaughter interval effect. LW = live weight. There was no Breed type x Slaughter interval interaction.

Table 6: Concentrate dry matter intakes of Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers previously at pasture or on *ad libitum* concentrates indoors

	Breed type (B)		Previous diet (D)		Significance		
	AA	BB	Pasture	Concentrates	s.e.[1]	B[2]	D[3]
Mean live weight (kg)	577	600	560	617	2.8	***	***
Mean intake (kg/day)	10.7	10.7	10.2	11.3	0.06	NS	***
Mean intake (g/kg LW)	18.6	17.8	18.2	18.2	0.15	**	NS

[1]For Breed type and Previous diet (n = 8); [2]Breed type effect; [3]Previous diet effect. LW = live weight. There was no Breed type x Previous diet interaction.

Table 7: Pistola proportion, ribs joint composition, composition of ribs joint gain and *m. longissimus* chemical composition for Aberdeen Angus x Holstein-Friesian (AA) and Belgian Blue x Holstein-Friesian (BB) steers subjected to pasture (P) or concentrate (C) based finishing (F) regimens and slaughtered (S) early (E, 94 days) or late (L, 184 days)

	Breed type (B)		Finishing (F) x Slaughter (S)				Significance				
	AA	BB	PE	CE	PL	CL	s.e.	B	F	S	I
Pistola (g/kg side)	405	425	-[1]	-[1]	423	407	2.4	***	***	-	NS
Ribs joint weight (kg)	7.36	7.71	5.81	6.81	8.45	9.07	0.116	*	***	***	NS
Ribs joint composition (g/kg)											
Fat	181	121	76	165	154	210	4.2	***	***	***	BxS*[2]
M. longissimus	207	230	224	211	227	213	3.1	***	**	NS	BxF*[3]
Total muscle	605	666	676	620	642	603	4.5	***	***	***	NS
Bone	214	213	248	215	204	188	2.5	NS	***	***	NS
Composition of ribs joint gain (g/kg)											
Fat	378	165	41	373	277	395	13.9	***	***	***	BxS*[4], BxF[5]
Muscle	524	758	837	555	636	538	14.0	***	***	***	NS
Bone	98	77	124	73	87	67	9.3	NS	NS	NS	NS
M. longissimus chemical composition (g/kg)											
Moisture	726	737	748	730	734	714	2.0	***	***	***	NS
Protein	220	228	225	226	224	221	0.9	***	NS	**	NS
Lipid	42	25	13	34	32	55	2.5	***	***	***	NS
Ash	12	14	14	13	13	12	0.3	***	*	NS	NS

[1]Recorded for late slaughter only; [2]Values of 142, 220, 99 and 144 (s.e. 6.0) for AAE, AAL, BBE and BBL, respectively; [3]Values of 219, 194, 232 and 229 (s.e. 4.4) for AAP, AAC, BBP and BBC, respectively; [4]Values of 328, 429, 86 and 244 (s.e. 19.6) for AAE, AAL, BBE and BBL, respectively; [5]Values of 300, 456, 18 and 312 (s.e. 19.6) for AAP, AAC BBP and BBC, respectively. See Table 2 footnotes.

Effects of breed type, silage harvest date and pattern of offering concentrates on feed intake pattern, feeding behaviour, and on blood metabolites of finishing steers

The objective of this study was to examine the effects, and in particular the interactions, of breed type, grass silage harvest date and pattern of offering concentrates on feed intake pattern, feeding behaviour and blood metabolites of finishing steers.

Animals and management

The animals comprised of 64 (32 Friesians and 32 beef crosses) finishing steers in a 2 (breed types) x 2 (silages- early- or late-cut) x 2 (finishing systems- flat rate or varied feeding pattern of offering concentrates) factorial arrangement of treatments. The flat rate feeding pattern was 5 kg concentrates per head daily with grass silage *ad libitum* to slaughter. The varied feeding pattern was silage only for 79 days after which the animals were adjusted to concentrates *ad libitum* plus 1 kg silage dry matter (DM) per head daily to slaughter. The animals were accommodated in two slatted floor sheds. One shed accommodated 56 animals in 8 pens fitted with Calan-Broadbent doors for individual feeding, and these were the animals used in the present study. The early-cut silage was made from a perennial ryegrass (*Lolium perenne*) sward harvested on 19^{th} May, 2004, and the late-cut silage was made from a similar sward harvested on 9^{th} June.

Feed intake pattern, feeding behaviour and blood metabolites were evaluated on two occasions, early in the study (Day 51 for feed intake, Day 37 for behaviour and Day 30 for blood metabolites) when animals on the varied feeding pattern were on silage only (S), and later, (Day 121 for feed intake, Day 128 for behaviour and Day 135 for blood metabolites) when they were on concentrates *ad libitum* (C). Feed intake pattern was recorded over a 24 h period by weighing the feed boxes every 20 min for the first 2 h post-feeding, then every hour for the next 2 h and every 2 h thereafter to 12 h with a final weight at 24 h. Feeding behaviour, namely eating and ruminating were visually recorded every 15 min for 24 h. Blood samples were obtained by jugular venipuncture immediately before feeding, and at 2, 6, 10 and 24 h after feeding using separate vacutainers containing lithium heparin and sodium fluoride as anticoagulants. Samples were assayed for plasma glucose, β-hydroxybutyrate and urea.

Data for feed intake, behaviour and blood metabolites study were analysed according to the 2 x 2 x 2 x 2 factorial randomised complete block design using the PROC GLM procedure in Statistical Analysis Systems (SAS, 2002-2003) with terms for block, breed type, silage harvest date, concentrate feeding pattern and sampling day. Sampling day was treated as a factor to permit comparison for the animals on the varied feeding treatment in the early part of the finishing period when they were on S with later in the finishing period when they were on C. In that context, the interaction of feeding pattern x sampling day is particularly relevant. The data are presented as the main effect means with the significance of the factors and interactions indicated. Where interactions occurred, the individual treatment values are shown in table footnotes. In the behaviour analysis, animal was the experimental unit and the data are presented as the proportion of time animals were observed eating and ruminating and the total proportion of time observed eating and ruminating. Feed intake pattern over 24 h was analysed using a repeated measures design using PROC MIXED in SAS (2002-2003).

Feed intake pattern and feeding behaviour

Results for 24 h feed intakes are shown in Table 8. Friesians had a higher ($P<0.01$) total DM intake, than the beef crosses. Silage harvest date had no significant effect on total DM intake but animals on the varied feeding pattern consumed more ($P<0.001$) total DM than those on the flat rate feeding treatment. Total DM intake was higher ($P<0.001$) for C than for S. There was a feeding pattern x day of measurement interaction for total DM intake such that animals on the flat rate of feeding had higher total DM intakes than those on the varied feeding pattern for S, whereas the opposite occurred for C.

The pattern of DM intake over 24 h for animals on the flat rate and varied feeding treatments for S and C are presented in Figure 1. As neither breed type nor silage harvest date had an effect on pattern of intake, only the effects of concentrate feeding pattern are reported. Likewise, as animals on the flat rate feeding treatment had a similar feed intake pattern on both sampling days, only the mean values are presented graphically. In contrast, animals on the varied feeding treatment had different intake patterns for S and C, hence both are presented. Compared with flat rate feeding, animals offered concentrates *ad libitum* (C) had higher intakes in the first than in any subsequent 20 min period of the first 2 h and consumed 0.39 of their total 24 h intake in that time, compared with 0.28 for flat rate feeding. For the subsequent 4 h post-feeding, both these groups consumed relatively little feed. Then feed intake increased again to 10 h, by which time C and the flat rate feeding treatment groups had consumed 0.81 and 0.90 of their total daily intake, respectively. Compared with these two groups, animals on silage only (S) displayed a more constant rate of intake consuming only 0.11 of their total 24 h intake in the first 20 min. By 4 h and 10 h they had consumed 0.44 and 0.79 of their total daily intake, respectively. Feed intake was low overnight for all treatments (0.14 of total DM consumed from 12 to 24 h).

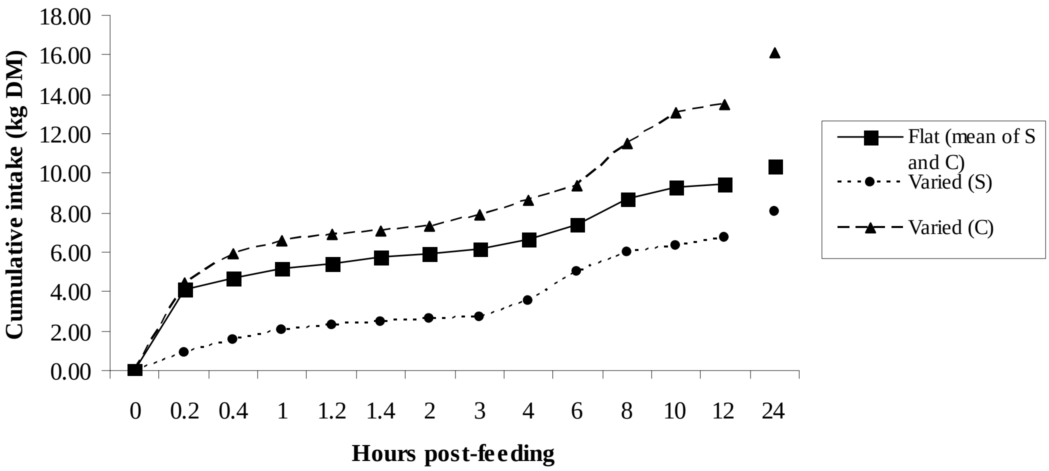

Figure 1. Cumulative total intake (kg DM) for 24 h after feeding.

Results for feeding behaviour are also shown in Table 8. Friesians spent a greater ($P<0.05$) proportion of time ruminating than the beef crosses. Animals on the late-cut silage spent a greater proportion of time eating ($P<0.01$) and ruminating ($P<0.001$) than animals on the early-cut silage. The proportion of time spent ruminating and the total proportion of time spent eating and ruminating was lower ($P<0.05$) for animals on the varied feeding treatment than those on the flat rate feeding treatment. The proportion of time spent eating and ruminating and thus, the combined total was higher ($P<0.001$) for S than C. There were feeding treatment x day of measurement interactions for the proportion of time spent eating and ruminating and for the combined total. This was due to the fact that while there was no difference between S and C for the flat rate feeding treatment, animals on the varied feeding treatment (S) spent a greater proportion of time eating and ruminating (so the total was also greater) and conversely for C.

Blood metabolites

Beef crosses had a higher ($P<0.05$) plasma glucose concentration and a higher ($P<0.01$) plasma urea concentration than Friesians (Table 8). Animals on the early-cut silage had higher (P<0.001) plasma glucose concentrations, higher (P<0.01) urea concentrations and lower (P<0.01) βHB concentrations than animals on the late-cut silage. Animals on the varied feeding treatment had higher (P<0.001) plasma glucose concentrations and lower (P<0.001) βHB concentrations than animals on the flat rate feeding treatment. Plasma glucose (P<0.001) and βHB (P<0.01) concentrations were higher for C than S. There were feeding treatment x day of measurement interactions for plasma glucose, βHB and urea concentrations. The glucose interaction was due to animals on the flat rate feeding treatment having a higher glucose concentration for S and a lower glucose concentration for C than animals on the varied feeding treatment. The βHB interaction was due to the difference between the feeding treatments being greater for S than for C, while the urea interaction was due to a lower value for the flat rate of feeding for S and a higher value for C.

It is concluded that the effects of the flat rate and varied feeding treatments were similar for both silage harvest dates and breed types. There were large differences in both total intake and pattern of intake between flat rate feeding (mix of silage and concentrates), S (silage) and C (concentrates). Total intake was higher and the proportion consumed in the first hour was higher for concentrates than for silage with intermediate values for a mix of silage and concentrates. Blood metabolites generally reflected feed energy intake.

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Table 8: Effects of breed type (B), silage harvest date (S), feeding pattern (F) and day of measurement (D) on feed intake, feeding behaviour and blood metabolites of finishing steers

	Breed type (B)		Silage harvest date (S)		Feeding pattern (F)		Day of measurement (D)		s.e.m.[5]	Significance				
	FR[1]	BC[2]	Early	Late	Flat	Varied	S[3]	C[4]		B	S	F	D	F x D
Total intake (kg DM)	11.81	10.64	11.21	11.25	10.40	12.06	9.09	13.37	0.251	**	NS	***	***	*** [6]
Proportion of time														
Eating	0.13	0.13	0.12	0.14	0.13	0.13	0.17	0.09	0.005	NS	**	NS	***	*** [7]
Ruminating	0.34	0.32	0.31	0.35	0.34	0.32	0.38	0.28	0.007	*	***	*	***	*** [8]
Total	0.47	0.45	0.43	0.49	0.47	0.45	0.55	0.37	0.008	NS	***	*	***	*** [9]
Blood metabolites (mmol/l)														
Glucose	3.88	3.97	4.03	3.81	3.84	4.00	3.61	4.23	0.031	*	***	***	***	***
βHB	0.38	0.40	0.37	0.41	0.42	0.36	0.37	0.41	0.009	NS	**	***	**	*** [11]
Urea	3.52	3.89	3.88	3.53	3.63	3.78	3.75	3.66	0.085	**	**	NS	NS	*** [12]

[1] FR = Friesians; [2] BC = Beef crosses.
[3] S = animals on varied feeding pattern were on silage only;
[4] C = animals on varied feeding pattern were on concentrates *ad libitum*.
[5] For n = 28.
[6] Values were 10.2 v 8.0 and 10.6 v 16.1 for Flat v Varied for S and C, respectively.
[7] Values were 0.15 v 0.19 and 0.12 v 0.06 for Flat v Varied for S and C, respectively.
[8] Values were 0.36 v 0.40 and 0.32 v 0.24 for Flat v Varied for S and C, respectively.
[9] Values were 0.51 v 0.59 and 0.41 v 0.30 for Flat v Varied for S and C, respectively.
[10] Values were 3.68 v 3.54 and 4.00 v 4.46 for Flat v Varied for S and C, respectively.
[11] Values were 0.43 v 0.32 and 0.42 v 0.40 for Flat v Varied for S and C, respectively.
[12] Values were 3.47 v 4.03 and 3.79 v 3.54 for Flat v Varied for S and C, respectively.

Trends in beef carcass classification

It is now timely to look at recent trends in beef carcass classification in view of the change to machine classification in 2004. As 2004 was the transition year, it is arguable if the results for that year should be considered manual or machine values. For the purposes of this evaluation, the 2004 results are considered manual but from the beginning of 2005 the results are considered to be machine values, even though it is likely that machines were not fully operational in all meat plants from that date. Mean steer and heifer carcass conformation and carcass fat classes for 2000 to 2007 inclusive are shown in Figure 2.

Conformation

Over the 8 year period there was a small improvement (0.04 for steers and 0.22 for heifers) in average conformation class. In the first 3 years of the decade, carcass conformation changed little for either gender. Then in 2003 and 2004, there was an increase in the better grades and a decrease in the poorer grades, with the effect being greater for heifers than steers (Figure 3). After 2004, there was a small deterioration in the better grades and a corresponding increase in the poorer grades. For the 3 years (2005 to 2007 inclusive) since the introduction of the machines the combined better grades (U + R) accounted for 51% of steer carcasses compared with 56% for the proceeding 3 years. The corresponding values for heifers were 61% v. 62%. Thus, while there was a slight reduction in the proportion of the better conformed steer carcasses since the introduction of machine classification, this needs to be put in context of the relatively large improvement in the preceding years. Interestingly, in the first two years of the decade there was a higher proportion of heifer than steer carcasses in the better conformation classes. In 2002 the proportions were equal for the two genders, but since then there has been a higher proportion of steer carcasses in the better conformation grades. It is often claimed that the proportion of best conformation (E and U) grade carcasses has declined since the advent of machines. There is no evidence for this. The mean proportion of E + U steer carcasses was 6.5% for the 3 years 2005 to 2007 inclusive compared with 6.4% for the previous 3 years (2002 to 2004 inclusive). The corresponding values for heifers were 5.8% and 6%. Differences between steers and heifers in mean carcass conformation were small but the heifer population would have had few pure dairy animals which have poorer conformation.

Fatness

Unlike conformation where any changes have been rather small, there have been relatively large changes in fat class since the beginning of the decade. However, it is unclear if any of this can be attributed to the move to machine classification. From 2000 to 2007, average fatness of steers and heifer decreased by 0.63 and 0.50 of a class, of which 0.43 and 0.37, respectively had occurred by 2004. In 2000, only 20% of steer carcasses were in fat classes 1 to 3 (Figure 4). This increased to 50% in 2004 and to 65% in 2007. The corresponding values for heifers were 18% in 2000, 40% in 2004 and 51% in 2007. There is little evidence that the fatness trends were influenced by the introduction of machines for either steers or heifers.

Cow and cattle numbers

There were declines of 5% and 7% in total cow (2.31 to 2.21m) and cattle (6.33 to 5.90m) numbers, respectively over the 8-year review period with a small increase in beef cows as a proportion of total cows (50.0 to 50.7%). While an increase in the proportion of beef cows should be positive for carcass conformation and leanness, the increase was so small that its difficult to attribute any of the carcass classification changes to it.

Grange Beef Research Centre

Live exports

Other than 2000 when they were highest (18%) and 2001 when they were lowest (5%), live exports as a proportion of total cattle disposals ranged from 7% to 12%. As live exported animals are predominately < 6 months of age the effects on carcass grades should be evident about two years later. Thus, the high live exports in 2000 (assuming they were predominantly suckled weanlings) should have had an adverse effect on carcass grades in 2002 (all else being equal) but this was not so. Neither was there any great evidence of an improvement in carcass grades in 2003 following the low proportion of live exports in 2001. From the data available therefore, it is not possible to attribute the observed national carcass classification trends to the effects of between year differences in live exports.

Breed composition

Since there are differences between breed types in carcass classification values, trends over time in carcass classification could be attributable to changes in breed composition. Generally, there has been little change in breed composition during the review period. The proportions of the national calf crop sired by dairy, early maturing beef breeds and late maturing beef breeds (Figure 5) were identical for 2000 and 2006 (last year for which data are published). In between, the proportion of late maturing beef sired calves was quite consistent but in the early years of the decade, the proportion of dairy calves increased while that of early maturing beef calves decreased. Thus, the 2003 and 2004 calf crops had more dairy and fewer early maturing beef calves than earlier or later years. This might explain the slightly poorer carcass conformation in 2005 and 2006 but if so, some increase in fat class would also be expected and this was not observed.

Carcass weight

Changes in carcass weight would be expected to affect carcass classification because conformation improves and fatness increases with increasing weight, all else being equal. From 2000 to 2004 carcass weight remained fairly constant (Figure 6) but it has since increased for both steers (20 kg) and heifers (19 kg). This should have led to better carcass conformation and a higher carcass fat class in the last 3 years. As indicated already, this was not observed and both carcass conformation and fat class of both steers and heifers remained essentially constant over this time.

In summary, over the 8-year period 2000 to 2007, carcass conformation of steers improved slightly to 2003 and then declined slightly with the result that it was little different in 2007 to what is was in 2000. Heifer conformation followed a similar trend but the changes were somewhat greater with the result that in 2007 carcass conformation was 0.22 of a class better than in 2000. Carcass fat class decreased consistently over 8 years and was 0.63 (steers) and 0.50 (heifers) of a class lower in 2007 than in 2000. There did not appear to by any relationship between carcass classification values and the proportions of beef and dairy cows, the level of live exports, the breed composition of the cattle population or mean carcass weight. There was also little evidence of any effect of the change from visual to machine classification.

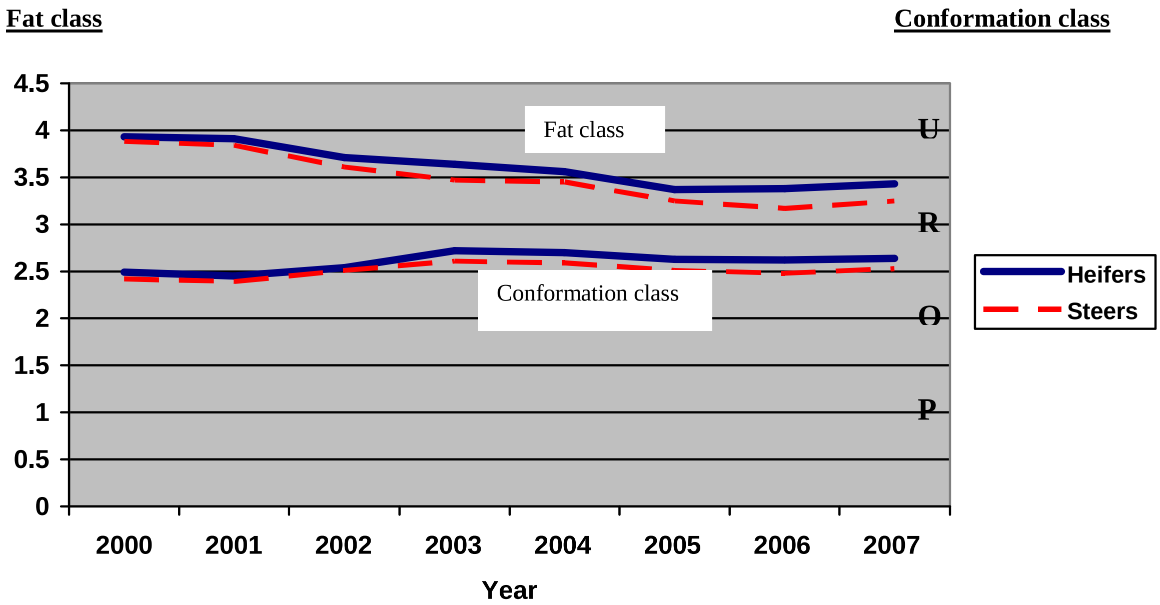

Figure 2. Mean carcass conformation and carcass fat classes for steers and heifers (2000-2007).

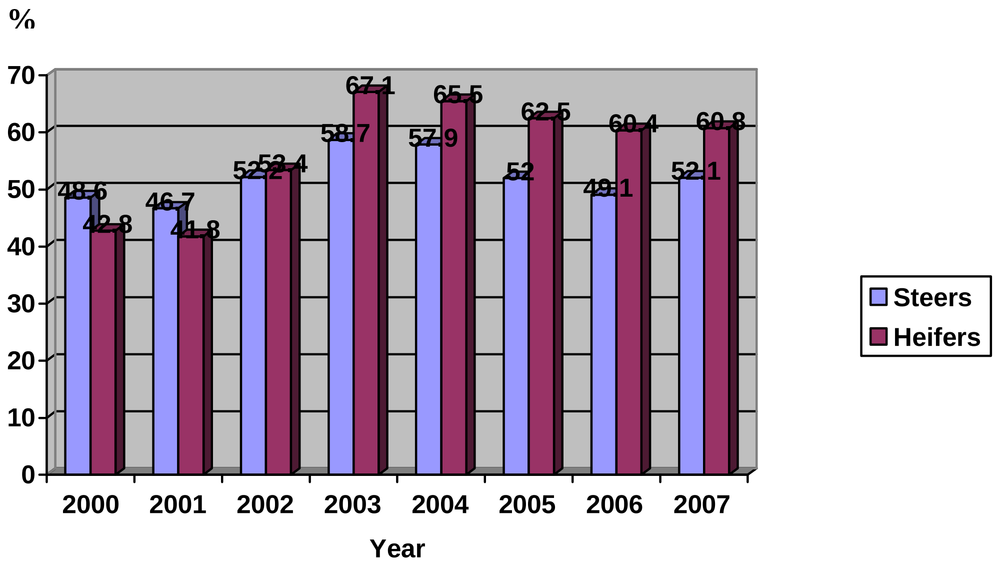

Figure 3. Proportions of carcasses in the better conformation classes (U + R) for steers and heifers (2000- 2007).

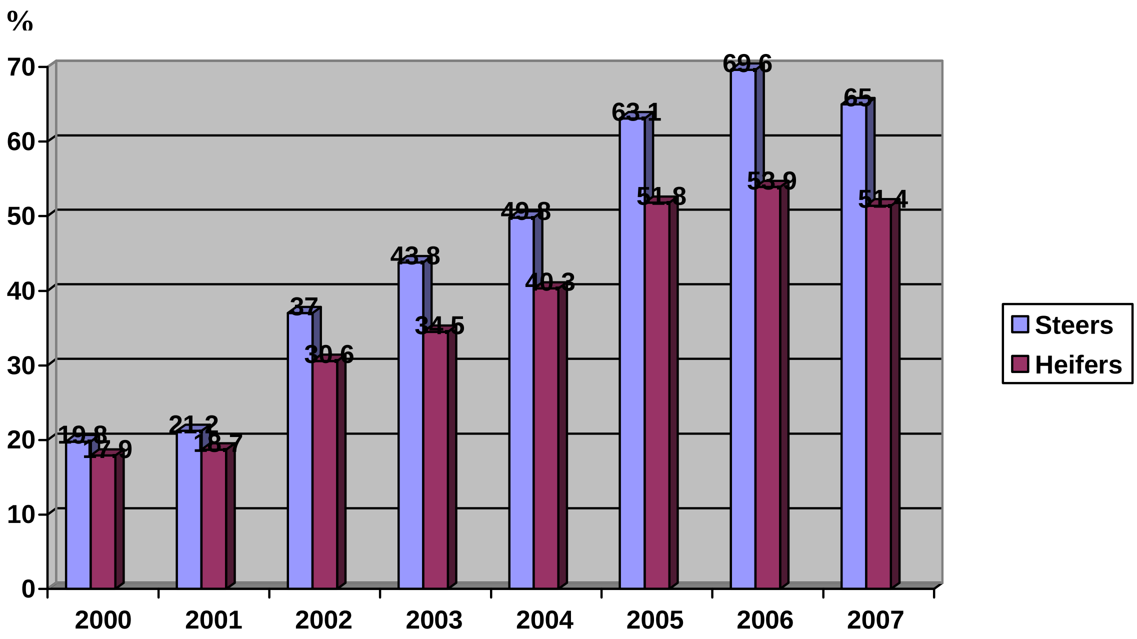

Figure 4. Proportions of carcasses in the lower fat classes (1 + 2 + 3) for steers and heifers (2000-2007).

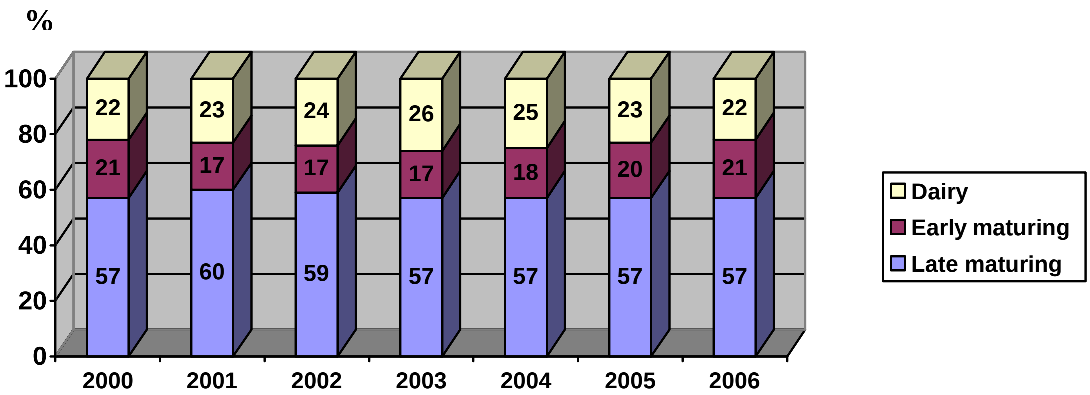

Figure 5. Proportions of late maturing, early maturing and dairy sired calves (2000-2006).

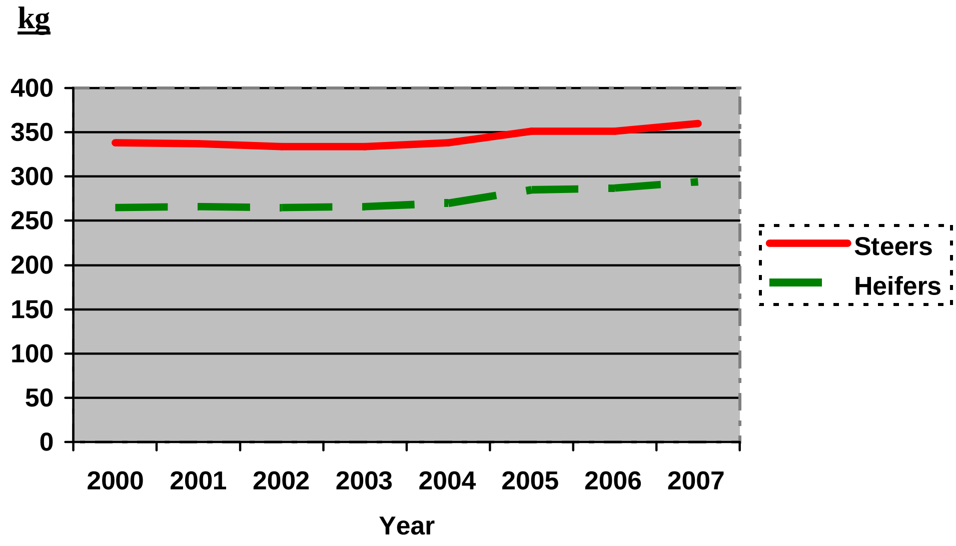

Figure 6. Mean carcass weights for steers and heifers (2000-2007).

Keane, M.G. *RMIS No. 5216*

Evaluation of genetic merit for growth rate in beef cattle: live weights, feed intake, body measurements, skeletal and muscular scores, and carcass characteristics

Animal selection

The overall objective of the present study was to evaluate the newly developed Irish beef EPD for growth rate (EPD_{CWT}) and to a lesser extent feed intake, under standard production conditions. The specific objectives were (i) to compare growth, feed intake and slaughter traits of progeny from two contrasting beef breeds selected for either high or low genetic merit for growth, and of two dairy strains of contrasting origin, (ii) to determine if genetic merit effects were consistent across two slaughter weights, and (iii) to elucidate interactions between genetic group and the production factors employed.

Male progeny of 23 beef sires of either high (H; 13 sires) or low (L; 10 sires) genetic merit for growth rate (EPD_{CWT}) were sourced from commercial Holstein-Friesian dairy herds in spring 2006. The beef sire breeds were Aberdeen Angus (AA; 10 sires) and Belgian Blue (BB; 13 sires). Sire selection was based on sire semen usage in 2005 (and therefore expected number of calves per sire in 2006), sire EPD_{CWT}, and reliability of sire EPD_{CWT} based on number of progeny in the national database with carcass weight records. AA and BB animals each account for 9% of the records in the common base against which beef sire EPDs are calculated. In addition to the beef breeds, male progeny from Friesian sires (FR; 7 sires) and Holstein sires (HO; 12 sires) were also sourced. FR sired calves were from FR dams while HO sired calves were from HO dams. Therefore, a total of six genetic groups (AAH, AAL, BBH, BBL, FR and HO) were employed in the study.

In total, 185 calves were sourced from 61 dairy herds and transferred to Grange Beef Research Centre at two to eight weeks of age (FR were later). After arrival, paternal verification of each animal was determined using 11 DNA-markers including the nine microsatellite markers recommended by the International Society of Animal Genetics. Only animals with a positive paternal test identification (n=177) were retained. Of these, seven calves were lost from the study due to mortality or ill-health, leaving 170 animals comprising 32 AAH, 24 AAL, 31 BBH, 27 BBL, 28 FR and 28 HO for which complete records were available. Median birth date for AAH, AAL, BBH, BBL, FR and HO were March 24th, March 8th, March 14th, March 12th, February 18th and March 7th, respectively. Corresponding arrival dates were May 4th, April 11th, April 14th, April 11th, July 5th and April 10th. The late arrival date of the FR calves was due to a disease incident on the farm where they were being assembled. They were retained and managed as a single cohort on this farm until a clear herd test permitted their transfer to the research herd.

The mean genetic merit for carcass traits of the sires, weighted by the number of progeny per sire, for the six genetic groups is summarised in Table 9. The individual EPD_{CWT} values ranged from -13 kg for the lowest ranked AA sire to 27 kg for the highest ranked BB sire. The mean difference between H and L in EPD_{CWT} across the two beef breeds was 15 kg. There were no difference between H and L in conformation (EPD_{CONF}) but L had a higher fat class (EPD_{FAT}) for AA. BB sires had higher EPD_{CWT} and EPD_{CONF} and lower EPD_{FAT} than AA sires. H and AA had higher EPDs for dry matter intake (DMI) (EPD_{DMI}) than L and BB, respectively. HO had, on average, a 9 kg superiority in EPD_{CWT} to FR. There was little difference between FR and HO in EPD_{DMI}, which was intermediate between the AA and BB values.

Table 9: Mean sire genetic merit, expressed as expected progeny difference for carcass weight (EPD_{CWT}), conformation class (EPD_{CONF}), fat class (EPD_{FAT}) and daily dry matter intake (EPD_{DMI}), weighted by number of progeny per sire, for the six genetic groups

	AA		BB		Dairy	
	H	L	H	L	FR	HO
EPD_{CWT} (kg)	3.4	-13.4	26.7	13.0	-8.1	0.9
Reliability EPD_{CWT} (%)	98	98	98	96	82	94
EPD_{CONF} (class)	0.61	0.68	2.64	2.32	-0.27	-0.65
EPD_{FAT} (class)	0.50	1.07	-1.08	-1.08	0.12	-0.15
EPD_{DMI} (kg)	0.23	0.06	-0.40	-0.68	-0.08	-0.01

Source: ICBF genetic evaluation (May, 2008).

Management to start of finishing

Calves were reared indoors on milk replacer, concentrates and hay before being turned out to pasture based on age (mean age at turnout (except for FR) was 17 weeks). At pasture, they were offered up to 2 kg concentrate per head daily. Calves were treated with ivermectin at 3, 8 and 13 weeks post turn-out for the control of gastrointestinal parasites. All calves grazed together at pasture until housing on October 31st, having been castrated one month earlier. The mean duration of the 1st grazing season was 186 days.

During the 1st winter, individual DMI was recorded for 144 animals on two feed levels using a crossover design. The two feed levels were grass silage only and grass silage plus 3 kg concentrates/day. The animals were assigned to the feed levels on the basis of live weight at housing, genetic group and sire. Due to infrastructural constraints, feed intake measurement was conducted over two replicates with 72 animals per replicate. After a one-week acclimatisation period, DMI was measured on five days per week, over a seven-week period for both runs. Before commencing individual feeding, all animals were fed grass silage plus 1.5 kg concentrates/day. After the individual feeding period ended, animals fed grass silage only during individual feeding were fed grass silage plus 3 kg concentrates/day for a second seven-week period. Likewise, those animals that had been fed grass silage plus 3 kg concentrates/day during individual feeding were offered grass silage only afterwards. The objective was to feed all animals an average of 1.5 kg concentrates/day over the winter period (equivalent to a total of 250 kg concentrates over a 24-week winter period). Any animals not used for feed intake measurement (n=26) were fed grass silage plus 1.5 kg concentrates/day throughout the entire winter period.

The mean duration of this winter period was 169 days. On April 11 (n=98) and April 23 (n=72), animals were turned out to pasture for a 2nd grazing season with a mean length of 197 days.

Management during finishing period
On October 30th, at the end of the 2nd grazing season, all animals were housed in a slatted-floor shed and assigned to one of two mean slaughter weights (560 kg; Light and 620 kg; Heavy) balanced for age, live weight, genetic group and so far as possible, sire. On the basis of live weight/age, each of these groups was further subdivided into two subgroups based on live weight (backward and advanced) within genetic group and sire. (The rationale for this was that the backward animals required a further growing period before being placed on their finishing diet). The advanced Light and Heavy groups were immediately placed on a high energy finishing diet while the backward Light and Heavy groups were placed on a lower energy diet until January 22 when they were moved to the finishing diet. Thus, there were a total of four slaughter groups (advanced and backward Light and advanced and backward Heavy). The number of animals, mean slaughter weight and length of period on the finishing diet for the four groups were: 42, 571 kg and 91 days (advanced Light), 44, 633 kg and 175 days (advanced Heavy), 44, 556 kg and 71 days (backward Light), and 40, 613 kg and 141 days (backward Heavy).

The finishing diet consisted of a total mixed ration with a grass-silage:concentrate ratio of 30:70 on a dry matter (DM) basis. The concentrate was a coarse mix of 875g/kg rolled barley, 60g/kg soyabean meal, 50g/kg molasses plus 15g/kg vitamin/mineral premix. DMI was recorded daily using the Calan-Broadbent system and refusals were discarded twice weekly. The backward Light and Heavy groups were fed a diet consisting of grass silage *ad libitum* plus 1.5 kg concentrates/day from housing until moving to their finishing diet on January 22nd.

Skeletal and muscular scores and ultrasound measurements
All animals were weighed monthly throughout life. To provide a more objective description of animal morphology, linear body measurements were recorded on all animals on four separate occasions throughout life (end of 1st grazing season, end of 1st winter, end of 2nd grazing season and before slaughter). The measurements taken were: withers height, chest girth, back length, chest depth and pelvic width. A digital callipers was used to record height at withers, chest depth and width of pelvis, and a metal tape was used to measure chest girth and length of back. These measurements were expressed relative to live weight on the day of measurement.

Animals were linear scored at nine months of age and at slaughter by a trained ICBF assessor. Skeletal scores on a scale 1 (short/narrow) to 10 (long/wide) were taken at three locations (height at withers, length of back and width at hips). Muscular scores were assigned on a scale of 1 (hollow, poorly muscled) to 15 (wide, thick muscled) at four locations on the body (width behind withers, loin development, development of hind quarter and hindquarter width). The three skeletal scores were averaged to give a single skeletal score per animal. Likewise, a single muscular score was computed for each animal.

At the time of linear scoring, each animal was ultrasonically scanned to obtain *m. longissimus* depth and fat depth using a Dynamic Imaging Ultrasound Scanner (model - Concept/MCV, with

3.5 MHz head). Scanning was carried out on the right side. *M. longissimus* depth was measured at the 3rd lumbar vertebra, where muscle depth is greatest. Measurement was from the bottom of the backfat layer to the top of the bone. Four fat depth measurements were taken at the 13th rib and a further three at the 3rd lumbar vertebra. Fat depth was calculated as the mean of all the values recorded.

Live weight gain per day was calculated from the slope of a linear regression of live weight on age for each period (1st grazing season, 1st winter, 2nd grazing season, and finishing period).

Slaughter and carcass assessment
Animals were weighed on two consecutive days immediately prior to slaughter and the weights averaged to give the mean final live weight. The steers were transported approximately 130 km to Meadow Meats commercial slaughter plant at Rathdowney, Co. Laois. They were slaughtered according to standard procedures within fours hours of removal from Grange Beef Research Centre. After slaughter, cold carcass weight (hot carcass weight x 0.98) was recorded. Kill-out proportion was calculated as the proportion of cold carcass weight in the final live weight. Carcass conformation and fat classes were recorded mechanically, on a continuous 15 point scale, using a Video Imaging Analysis (VIA) carcass classification system (VBS2000, E+V, Germany).

Feed analysis
Silage samples were taken three times weekly during the intake periods. Silage was sampled in duplicate; one sample was dried at 40°C for 48h. DM was recorded immediately and samples were milled and composited weekly for chemical analysis (*in vitro* DM digestibility (DMD), crude protein, ash, neutral detergent fibre (NDF) and acid detergent fibre (ADF)). The other sample was stored at -20°C for subsequent measurement of pH and ammonia nitrogen (NH_3N). This sample was allowed to thaw for 48h and was then squeezed to obtain a sample of silage juice for the pH and NH_3N measurement. Concentrate samples were taken once weekly, dried and milled similar to the silage samples. These subsequently underwent chemical analysis (*in vitro* DMD, crude protein, ash, NDF and ADF). Net energy (NE) for feeds in the 1st winter (Unit Fourragere Lait (UFL)) and 2nd winter (Unit Fourragere Viande (UFV)) were estimated using the French net energy (NE) system, modified for Irish conditions. Chemical composition and NE values of the feeds for both 1st and 2nd winter intake periods are shown in Table 10.

Table 10: Mean (SD) chemical composition of feeds offered in the 1st and 2nd winter periods

	1st winter		2nd winter	
	Silage	Concentrate	Silage	Concentrate
Dry matter (DM) (g/kg)	258 (25.8)	804 (12.0)	231 (19.7)	827 (12.6)
Dry matter digestibility[a] (g/kg)	675 (37.5)	772 (89.1)	729 (63.4)	846 (40.8)
pH	4 (0.1)	-	4 (0.1)	-
Ammonia N (mg/100 ml)	81 (19.1)	-	76 (10.6)	-
Composition of DM (g/kg)				
Crude protein	143 (6.4)	127 (5.0)	149 (8.4)	135 (6.1)
Ash	91 (7.9)	36 (4.8)	84 (8.8)	39 (5.0)
Neutral detergent fibre	599 (10.4)	149 (8.0)	530 (27.4)	146 (16.6)
Acid detergent fibre	375 (15.5)	48 (4.0)	333 (19.6)	53 (7.3)
Net energy (UFL/UFV[b]/kg DM)[c]	0.75[d]	1.15[d]	0.77[e]	1.15[e]

[a]Determined in vitro; [b]Unit Fourragere Lait/Unit Fourragere Viande; [c]Values for Ireland; [d]UFL values; [e]UFV values.

Statistical analysis
Data were analysed using the mixed model methodology in PROC MIXED of the Statistical Analysis Systems Institute. Sire of the animal was included as a random effect in all analyses and genetic group was always included in the model. For the analysis of feed intake, body measurements and live animal scores, age, centred within measurement time, was included as a covariate. Feed level and intake run were included in the model as fixed effects for the analysis of feed intake for the 1st winter period with slaughter group included as a fixed effect for the feed intake analysis in the finishing period. For the body measurements and live animal scores taken at slaughter, slaughter group was also included in the model. Measurement time was included as a repeated effect with a compound symmetry structure assumed between successive records within animal. The choice of residual covariance structure was based on the Akaike Information criterion.

In the analysis of live weight, week of age was included as a covariate in the model along with genetic group. In the analysis of live weight gain, week of birth was included where significant ($P \leq 0.05$) as a covariate with genetic group. When the dependent variables were slaughter related traits then genetic group, slaughter group, and age nested within slaughter group, were included as fixed effects in the model. In all analyses contrast statements were used to partition the variance into orthogonal components, namely, H v L, AA v BB, interaction between H/L and beef breed, FR v HO, beef breeds v dairy strains, and relevant interactions (e.g. slaughter group, measurement time).

Live weights and live weight gains
BB were significantly heavier than AA at all times and H animals were significantly heavier than L animals from the end of the 1st grazing season to slaughter (Table 11). However, a genetic merit × beef breed interaction ($P \leq 0.05$) was evident for live weight at slaughter. This manifested itself as a significant difference between the H and L genetic merit groups in AA but not in BB. Live weights of the two dairy strains differed at the end of the 1st grazing season ($P \leq 0.001$) and end of the 1st winter ($P \leq 0.05$), when FR were heavier than HO. However, the 14 kg difference at slaughter in favour of FR was not significant (P=0.23). Dairy animals were heavier ($P \leq 0.05$) than beef animals at all times from the end of the 1st grazing season up to slaughter when the difference was close to significance (P=0.07). The weight difference at slaughter between the Light and Heavy slaughter groups was 58 kg ($P \leq 0.001$). Live weight gains during the 1st grazing season were significantly greater for H than L, for FR than HO, and for the dairy strains than the beef breeds. There were no differences among the six genetic groups in live weight gain during the 1st winter, during the 2nd grazing period or during the finishing period. Taking animals to the Heavy slaughter weight reduced ($P \leq 0.05$) 2nd winter and finishing period live weight gains.

Feed intake
Intakes for the period of individual feeding in the 1st winter are shown in Table 12. Absolute silage and total DMI did not differ between genetic merit groups or beef breeds. However, as there were differences in mean live weight between the genetic merit groups, and between the beef breeds, DMI per kg live weight differed significantly for both, being higher for L and AA than for H and BB, respectively. There were genetic merit × beef breed interactions ($P \leq 0.05$) for both measures of DMI, as the difference between H and L occurred to a greater extent in AA than in BB. NE intake paralleled total DMI and efficiency of NE utilisation for live weight gain was not significantly affected by either genetic merit or beef breed, and there was no significant interaction between these. Other than total DMI per kg live weight, which was greater ($P \leq 0.05$) for HO, there were no differences between FR and HO for the various measures of intake and efficiency of energy utilisation. The dairy strains had significantly higher values for all measures

of feed and energy intake than the beef breeds accompanied by lower ($P \leq 0.05$) efficiency of energy utilisation.

Compared with silage only, offering a concentrate supplement of 3 kg/day (2.41 kg DM) reduced silage DMI by 0.61 kg/day and increased total DMI by 1.81 kg/day. The corresponding increase in total NE intake was 2.34 UFL/day. All intake differences between the two feed levels were highly significant ($P \leq 0.001$). Efficiency of NE utilisation was not estimated for the feeding levels because the intake measurement period (seven weeks) was considered too short to obtain reliable estimates of live weight gain. (Over a short measurement period, differential changes in gastrointestinal contents due to different feeding levels, can result in inaccurate measurement of body weight changes).

DM and NE intakes during the finishing period are shown in Table 13. Genetic merit had no significant effect on any of the intake measurements or on efficiency of NE utilisation, and there was no genetic merit × beef breed interaction. Absolute feed and NE intake did not differ between the beef breeds and neither did efficiency of NE utilisation for live weight gain. However, total DMI per kg live weight was lower ($P \leq 0.01$) for BB than AA. There was no significant difference between the dairy strains for any of the intake measurements or for efficiency of NE utilisation. Compared with the beef breeds, the dairy strains had higher ($P \leq 0.001$) DM and NE intakes, but when DMI was scaled for live weight, the difference was not significant. Efficiency of NE conversion to live weight was poorer ($P \leq 0.01$) for the dairy strains. Total DM and NE intake was not significantly affected by slaughter weight, but when scaled for live weight, DMI was lower ($P \leq 0.001$) for the Heavy slaughter weight group. Efficiency of conversion of NE to live weight was also poorer ($P \leq 0.001$) for the Heavy slaughter weight group.

Body measurements
Body measurements at three time points (end of 1st grazing season, end of 1st winter and end of 2nd grazing season) for the six genetic groups expressed relative to live weight are shown in Table 14. The body measurements at slaughter are shown in Table 15. An interaction between breeds and measurement time existed across all traits, with the differences in measurements between genetic groups decreasing with time.

Across the four measurement times, L tended to have greater body measurements per kg live weight than H, but they also tended to be lighter, and measurements (relative to live weight) were greater at lighter weights. Chest girth was consistently greater for L than H animals, and the other traits, while less consistent, followed a similar trend. Differences between the beef breeds were consistent across measurement times with AA generally taller and longer per kg live weight than BB. AA animals also had greater chest girth and depth and were lighter at each measurement time than BB animals. There were significant genetic merit × beef breed interactions for withers height at the end of the 1st grazing season and at slaughter, for chest girth at the end of the 1st and 2nd grazing seasons, for back length at the end of the 1st grazing season and for chest depth at the end of the 2nd grazing season and at slaughter. For all these variables, the effect was evident for AA animals only and not for BB. Dairy strain differences, while not as consistent as those for the beef breeds, also followed a consistent pattern. HO animals were significantly taller per kg live weight than FR animals at all times, and overall tended to have greater body measurements. There were no differences between beef and dairy animals in body measurements until time of slaughter (Table 15) when dairy animals where significantly taller per kg live weight but the beef animals had significantly greater chest girth and pelvic width. All measurements at slaughter were significantly affected by slaughter weight, with lower values in animals slaughtered at the Heavy weight.

Skeletal and muscular scores and ultrasound measurements
Skeletal and muscular scores at nine months of age and at slaughter are summarised in Tables 16 and 17, respectively. At nine months of age (Table 16), H had a greater length of back and a higher average skeletal score than L. BB had greater width at hips and higher average skeletal score than AA. There was no genetic merit × beef breed interaction for skeletal scores. The dairy strains differed only for width at hips (FR had greater value), and they had greater height at withers than the beef breeds. Muscular scores were not affected by genetic merit and there were no genetic merit × beef breed interactions. All muscular scores were higher for BB than AA, and were higher for FR than HO. Compared with the beef breeds, the dairy strains had lower values for width behind withers, development of hindquarter and average muscular score. Scanned *m. longissimus* depth was greater for H than L, for BB than AA, for FR than HO and for beef breeds than dairy strains. There was a significant genetic merit × beef breed interaction because the difference in scanned *m. longissimus* depth existed for AA only and not for BB. There was no genetic merit × beef breed interaction or effect of genetic merit on scanned fat depth. Otherwise, scanned fat depth was greater for AA than BB, for FR than HO, and for dairy strains than for beef breeds.

At slaughter (Table 17), height at withers and average skeletal score were greater for H than L. Height at withers was greater for BB than AA but width at hips was greater for AA than BB. HO had greater values than FR for height at withers, length of back and average skeletal score, and all skeletal score values were greater for dairy strains than beef breeds. All skeletal score values increased with increasing slaughter weight. Genetic merit had no effect on muscular scores but all muscular scores were higher for BB than AA. There was a genetic merit × beef breed interaction for thigh/hindquarter width in that it was greater for H than L in AA but lower in BB. All muscular scores were higher for FR than HO and for beef breeds than dairy strains. With the exception of width behind withers which was not affected, all muscular scores increased with increasing slaughter weight. Genetic merit did not affect scanned *m. longissimus* or fat depths. There was a genetic merit × beef breed interaction for scanned *m. longissimus* depth due to the value for H being greater than L in AA but not in BB. Scanned *m. longissimus* depth was greater for FR than HO, for beef breeds than dairy strains and for the Heavy than Light slaughter weight. Beef breed × time of measurement (nine months of age or at slaughter) interactions for skeletal scores were due to differences being smaller or absent at slaughter. The corresponding interaction for scanned fat depth was due to differences being greater at the Heavy than at the Light slaughter weight.

Slaughter and carcass traits
The effect of genetic merit and slaughter weight on carcass traits is summarised in Table 18. H and BB animals had heavier ($P \leq 0.001$) carcasses than L and AA animals, respectively, but because of a genetic merit × beef breed interaction, the difference between H and L was significant ($P \leq 0.01$) for AA animals only with no difference for BB. No difference in carcass weight existed between FR and HO. Slaughter weight per day of age was significantly greater for H and BB than for L and AA, respectively, but again there was a genetic merit × beef breed interaction ($P \leq 0.05$) resulting in the genetic merit effect being present for AA only and not for BB. Carcass weight per day of age followed a similar trend. BB, FR and beef breeds had greater kill-out proportions than AA, HO and dairy strains, respectively, but there was no difference in kill out proportion between H and L animals although H tended to have greater values ($P=0.06$). BB, FR and beef breeds had better ($P \leq 0.001$) carcass conformation than AA, HO and dairy strains, respectively. There was no effect of genetic merit on carcass fat class but BB and HO had significantly lower carcass fat class values than AA and FR, respectively.

Slaughter weight had a significant effect on all slaughter and carcass traits except slaughter weight per day of age. Increasing slaughter weight increased carcass weight per day of age, kill-out proportion, carcass conformation class and carcass fat class.

It is concluded that progeny of sires of high genetic merit for growth rate grew faster and produced heavier carcasses. The extra carcass weight was attributable mainly to their higher growth rate and slaughter weight rather than to an increased kill-out proportion. High merit progeny exhibited greater muscle depth and were more compact as indicated by their lower body measurements per kg live weight. There were interactions between genetic merit and beef breed for growth and carcass weight traits, implying that the expression of genetic merit differed between the breeds; it was clearly evident in AA but not at all in BB. Differences between the beef breeds were as expected and in line with their known patterns of maturity. The results confirm the advantages of the late maturing beef breeds for beef production traits; BB were more compact and had superior carcass traits to AA. There were no important interactions between genetic group and slaughter weight for the growth or carcass traits recorded. In summary, use of sires of high genetic merit for growth rate improves beef performance through increased live weight gain and greater carcass weight, but these effects were not consistent across breed types. The expression of genetic merit was not dependent feeding level or slaughter weight.

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Table 11: Mean live weights (kg) and live weight gains (g/day) from arrival to slaughter for the six genetic groups, at Light and Heavy slaughter weights, together with orthogonal contrasts

	AA		BB		Dairy		Slaughter weight (S)		SE[a]	Probability/Significance of contrasts[b]					
	H	L	H	L	FR	HO	Light	Heavy		G	B	G x B	D	A	S
Live weight at															
8 weeks of age	69	64	76	78	79	66			2.2	0.63	***	0.10	0.23	0.80	
End of 1st grazing season	187	167	199	194	210	183			5.7	*	**	0.20	***	*	
End of 1st winter	294	264	305	301	317	295			7.9	*	**	0.13	*	*	
End of 2nd grazing season	447	407	464	452	466	452			7.6	**	***	0.07	0.17	*	
Slaughter	596	547	605	605	612	597	565	623	10.0	**	***	*	0.23	0.07	***
Live weight gain for															
1st grazing season	653	559	657	635	786	662			27.9	*	0.17	0.21	**	***	
1st winter	547	500	556	554	550	537			30.9	0.44	0.31	0.47	0.76	0.87	
2nd grazing season	854	819	875	843	852	893			44.4	0.47	0.63	0.97	0.49	0.52	
2nd winter[c]	989	904	913	968	848	913	953	890	54.0	0.79	0.92	0.22	0.35	0.18	*
Finishing period	1066	1004	1061	1130	896	1033	1073	991	62.6	0.95	0.36	0.32	0.10	0.07	*

[a]Pooled standard error for genetic group, multiply by $\sqrt{\frac{28}{84}}$ for Slaughter weight SE; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy, S = Light v Heavy. Where *P*>0.05 the *P* value is shown, otherwise * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$ in this and subsequent tables; [c]From housing to slaughter.

Table 12: Silage and total dry matter intake (DMI), net energy (NE) intake and efficiency of NE utilisation for the six genetic groups offered two feeding levels in the 1st winter, together with orthogonal contrasts

	AA		BB		Dairy		Feed level[a] (F)		SE[b]	Probability/Significance of contrasts[c]					
	H	L	H	L	FR	HO	-	+		G	B	G×B	D	A	F
DMI (kg/day)															
Silage	3.47	3.24	3.37	3.53	4.05	3.90	3.90	3.29	0.10	0.72	0.33	*	0.27	***	***
Total	4.68	4.45	4.58	4.74	5.26	5.10	3.90	5.71	0.10	0.73	0.33	*	0.27	***	***
DMI per kg live weight (g/day)															
Silage	15.7	16.5	15.3	15.7	16.8	17.5	18.3	14.2	0.30	*	*	0.42	0.10	***	***
Total	21.1	23.1	20.6	20.9	21.7	22.7	18.4	25.0	0.34	***	***	*	*	**	***
NE intake (UFL/day)															
Silage NE	2.60	2.43	2.52	2.64	3.03	2.92	2.91	2.47	0.07	0.73	0.34	*	0.27	***	***
Total NE	3.99	3.82	3.91	4.03	4.42	4.31	2.91	5.25	0.07	0.74	0.34	*	0.27	***	***
Efficiency of NE for live weight gain[d] (g/UFL)	145	142	145	141	124	134	[e]	[e]	7.5	0.62	0.93	0.97	0.39	*	***

[a]Feed level: (-) = grass silage only, (+) = grass silage plus 3 kg concentrates/day; [b]Pooled standard error for genetic group, multiply by $\sqrt{\frac{11}{68}}$ for Feed level SE; [c]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy, F = - v +; [d]During 1st winter period; [e]Intake period too short for reliable measurement of live weight gain; UFL = Unit Fourragere Lait). There were no genetic group × F interactions.

Table 13: Total dry matter intake (DMI), net energy (NE) intake and efficiency of NE utilisation in the finishing winter for the six genetic groups at Light and Heavy slaughter weights, together with orthogonal contrasts

	AA		BB		Dairy		Slaughter weight (S)		SE[a]	Probability/Significance of contrasts[b]					
	H	L	H	L	FR	HO	Light	Heavy		G	B	G x B	D	A	S
DMI[c] (kg/day)	11.2	10.6	11.1	11.2	11.6	11.6	11.2	11.2	0.19	0.13	0.19	0.11	0.96	***	0.79
DMI per kg live weight (g/day)	20.6	21.3	20.1	20.2	20.5	21.1	21.5	19.8	0.25	0.13	**	0.28	0.11	0.23	***
NE intake (UFV/day)	11.6	11.0	11.5	11.5	12.0	12.0	11.6	11.6	0.19	0.13	0.19	0.11	0.96	***	0.80
Efficiency of NE for live weight gain[d] (g/UFV)	93	92	93	98	78	87	95	85	4.9	0.72	0.54	0.51	0.17	**	***

[a]Pooled standard error for genetic group, multiply by $\sqrt{\frac{28}{84}}$ for Slaughter weight SE; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy, S = Light v Heavy; [c]Of 30:70 silage:concentrate ratio diet; [d]During the finishing period; UFV = Unit Fourragere Viande. There were no genetic group × S interactions.

Table 14: Mean body measurements relative to live weight (mm/kg) at end of 1st grazing season, end of 1st winter and end of 2nd grazing season for the six genetic groups, together with orthogonal contrasts

	AA		BB		Dairy		SE[a]	Probability/Significance of contrasts[b]				
	H	L	H	L	FR	HO		G	B	G×B	D	A
End of 1st grazing season												
Withers height	5.5	6.1	5.2	5.2	5.3	5.8	0.11	**	***	*	***	0.72
Chest girth	7.3	8.0	7.0	7.1	7.0	7.5	0.12	**	***	**	**	0.37
Back length	4.8	5.3	4.5	4.6	4.5	4.9	0.12	**	***	*	**	0.22
Chest depth	2.7	2.9	2.5	2.5	2.5	2.8	0.06	*	***	0.07	***	0.59
Pelvic width	1.8	2.0	1.8	1.8	1.8	1.8	0.04	*	**	0.16	0.92	0.42
End of 1st winter												
Withers height	4.1	4.4	4.0	4.0	4.0	4.3	0.10	0.06	**	0.18	**	0.96
Chest girth	5.7	6.1	5.5	5.6	5.4	5.7	0.11	*	**	0.11	0.06	0.07
Back length	3.6	4.0	3.5	3.5	3.4	3.6	0.08	*	***	0.09	0.06	0.11
Chest depth	2.1	2.3	2.0	2.1	2.0	2.2	0.05	0.07	**	0.26	*	0.71
Pelvic width	1.5	1.6	1.5	1.5	1.4	1.5	0.03	0.15	0.09	0.25	0.59	0.16
End of 2nd grazing season												
Withers height	2.8	3.0	2.6	2.8	2.8	3.0	0.06	**	***	0.63	*	0.14
Chest girth	4.0	4.3	3.9	4.0	3.9	4.1	0.05	**	***	*	*	0.10
Back length	2.5	2.7	2.4	2.5	2.4	2.5	0.04	**	***	0.14	0.08	0.16
Chest depth	1.5	1.6	1.4	1.5	1.5	1.6	0.02	***	***	**	**	0.67
Pelvic width	1.0	1.1	1.0	1.1	1.0	1.0	0.01	*	0.06	0.32	0.74	**

[a]Pooled standard error for genetic group; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy.
All B × T (measurement time, including at slaughter) interactions were significant ($P \leq 0.05$) and all D × T interactions except for Pelvic width were also significant ($P \leq 0.05$). There were no G × T interactions. For live weight at time of measurement see Table 11.

Table 15: Mean body measurements relative to live weight (mm/kg) at slaughter for the six genetic groups at Light and Heavy slaughter weights, together with orthogonal contrasts

	AA		BB		Dairy		Slaughter weight (S)		SE[a]	Probability/Significance of contrasts[b]					
	H	L	H	L	F	O	Light	Heavy		G	B	G×B	D	A	S
Withers height	2.19	2.30	2.20	2.17	2.22	2.34	2.32	2.15	0.03	0.21	0.08	*	**	*	**
Chest girth	3.48	3.65	3.40	3.44	3.40	3.42	3.55	3.39	0.05	*	**	0.16	0.65	*	***
Back length	2.01	2.10	1.89	1.96	1.92	2.00	2.06	1.90	0.04	0.06	**	0.82	0.16	0.48	***
Chest depth	1.25	1.33	1.22	1.22	1.25	1.30	1.30	1.22	0.02	*	***	*	*	0.19	***
Pelvic width	0.91	0.95	0.91	0.95	0.89	0.87	0.94	0.89	0.01	**	0.82	0.96	0.18	***	***

[a]Pooled standard error for genetic group, multiply by $\sqrt{\frac{28}{84}}$ for Slaughter weight SE; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy, S = Light v Heavy. There was a B × S interaction ($P \leq 0.05$) for Pelvic width. There were no other interactions involving S. For live weight at slaughter see Table 11.

Table 16: Mean skeletal and muscular scores, and ultrasound measurements at nine months of age for the six genetic groups, together with orthogonal contrasts

	AA		BB		Dairy		SE[a]	Probability/Significance of contrasts[b]				
	H	L	H	L	FR	HO		G	B	G×B	D	A
Skeletal scores[c]												
Height of withers	4.9	4.4	5.1	4.9	5.3	5.1	0.20	0.17	0.09	0.40	0.39	*
Length of back	5.4	4.4	5.4	5.0	5.3	5.2	0.20	***	0.14	0.19	0.66	0.25
Width at hips	4.3	3.7	5.0	4.8	5.1	4.3	0.22	0.08	***	0.35	**	0.22
Average skeletal score	4.9	4.2	5.1	4.9	5.2	4.8	0.18	*	*	0.26	0.11	0.08
Muscular scores[d]												
Width behind withers	3.9	3.6	4.6	4.4	4.1	3.2	0.23	0.32	***	0.83	**	*
Loin development	3.7	3.3	4.7	4.5	4.4	2.9	0.26	0.22	***	0.67	***	0.11
Development of hindquarter	3.4	2.8	4.3	4.4	3.4	2.7	0.21	0.28	***	0.10	*	**
Thigh/hindquarter width	4.5	4.0	5.1	5.0	5.1	3.7	0.27	0.26	**	0.51	***	0.35
Average muscular score	3.9	3.4	4.7	4.6	4.2	3.1	0.21	0.18	***	0.42	***	*
Ultrasound measurements (mm)												
Scanned *m. longissimus* depth	35.1	30.6	38.6	39.5	35.2	30.6	0.74	*	***	***	***	***
Scanned fat depth	1.1	1.0	0.8	0.8	1.2	0.9	0.06	0.65	***	0.14	***	*

[a]Pooled standard error for genetic group; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy; [c]Scale 1 (short/narrow) to 10 (long/wide); [d]Scale 1 (hollow, poorly muscled) to 15 (wide, thick muscled).

Significant ($P \leq 0.05$) B × T (time of measurement, nine months of age (Table 16) or slaughter (Table 17)) interactions for Width at hips, Average skeletal score and Scanned fat depth. Significant ($P \leq 0.05$) D × T interactions for all variables except Thigh/hindquarter width and Scanned *m. longissimus* depth. There were no G × T interactions.

Table 17: Mean skeletal and muscular scores, and ultrasound measurements at slaughter for the six genetic groups at Light and Heavy slaughter weights, together with orthogonal contrasts

	AA		BB		Dairy		Slaughter weight (S)		SE[a]	Probability/Significance of contrasts[b]					
	H	L	H	L	FR	HO	Light	Heavy		G	B	G×B	D	A	S
Skeletal scores[c]															
Height of withers	7.5	6.7	7.7	7.5	8.3	9.3	7.6	8.1	0.19	*	*	0.12	***	***	***
Length of back	7.4	7.0	7.5	7.5	7.6	8.2	7.1	8.0	0.20	0.39	0.18	0.27	*	**	***
Width at hips	7.3	7.1	6.7	6.6	8.2	7.9	6.9	7.7	0.17	0.32	**	0.55	0.25	***	***
Average skeletal score	7.4	6.9	7.3	7.2	7.9	8.4	7.2	7.9	0.16	*	0.47	0.18	*	***	***
Muscular scores[d]															
Width behind withers	5.9	5.7	6.3	7.0	4.7	1.9	5.2	5.3	0.40	0.58	*	0.24	***	***	0.66
Loin development	7.0	6.6	7.7	7.9	6.2	3.4	6.2	6.8	0.33	0.76	**	0.39	***	***	**
Development of hindquarter	6.0	5.7	8.2	8.3	4.9	3.3	5.6	6.6	0.27	0.75	***	0.48	***	***	***
Thigh/hindquarter width	7.4	6.8	8.3	8.8	7.4	5.4	7.2	7.6	0.21	0.83	***	*	***	***	*
Average muscular score	6.5	6.3	7.6	8.0	5.5	3.3	6.0	6.4	0.26	0.89	***	0.25	***	***	*
Ultrasound measurements (mm)															
Scanned *m. longissimus* depth	65.7	62.4	70.0	70.9	65.2	60.0	63.5	67.9	0.96	0.23	***	*	***	***	***
Scanned fat depth	4.7	4.6	2.0	2.2	3.9	2.9	2.9	3.8	0.25	0.89	***	0.50	**	0.70	***

[a]Pooled standard error for genetic group, multiply by $\sqrt{\frac{28}{84}}$ for Slaughter weight SE; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy, S = Light v Heavy; [c]Scale 1 (short/narrow) to 10 (long/wide); [d]Scale 1 (hollow, poorly muscled) to 15 (wide, thick muscled).
There were G × S and B × S interactions ($P \leq 0.05$) for Width at hips, and D × S interactions ($P \leq 0.01$) for Loin development and Average muscular score. There were no other interactions involving S.

Table 18: Slaughter and carcass characteristics for the six genetic groups at Light and Heavy slaughter weights, together with orthogonal contrasts

	AA		BB		Dairy		Slaughter weight (S)		SE[a]	Probability/Significance of contrasts[b]					
	H	L	H	L	FR	HO	Light	Heavy		G	B	G×B	D	A	S
Carcass weight (kg)	314	283	334	333	317	305	294	335	4.7	***	***	**	0.08	0.26	***
Slaughter weight per day of age (g)	782	719	795	793	804	783	779	778	12.9	**	***	*	0.22	0.07	0.98
Carcass weight per day of age (g)	415	372	438	436	413	401	406	419	5.8	***	***	***	0.16	0.10	*
Kill-out (g/kg)	526	518	553	550	519	511	522	537	2.9	0.06	***	0.30	*	***	***
Carcass conformation class[c]	6.2	5.4	8.0	7.9	5.3	3.7	5.7	6.4	0.26	0.11	***	0.27	***	***	***
Carcass fat class[d]	9.8	9.3	7.4	7.2	9.3	8.2	8.0	9.1	0.26	0.19	***	0.47	**	0.14	***

[a]Pooled standard error for genetic group, multiply by $\sqrt{\frac{28}{84}}$ for Slaughter weight SE; [b]G = H v L, B = AA v BB, D = FR v HO, A = Beef v Dairy, S = Light v Heavy; [c]Scale 1 (poorest) to 15 (best); [d]Scale 1 (leanest) to 15 (fattest). There were no genetic group × S interactions.

Grass silage intake, rumen and blood variables, ultrasound and body measurements and behaviour in pregnant beef heifers differing in phenotypic residual feed intake

As the provision of feed is the largest variable production cost, beef breeding strategies need to focus on improving feed efficiency. Traditionally, feed efficiency was expressed as the ratio of weight gain to feed intake but selection for this measure leads to an increase in mature size and thus, in maintenance requirements and costs. An alternative measure of feed efficiency is residual feed intake (RFI). This is defined as the difference between an animal's actual intake and its predicted intake (negative or lower values being desirable), and is independent of growth and body size. The objective in the current study was to characterise productivity related variables in pregnant beef heifers differing in phenotypic RFI.

Data were obtained on a total of 73 pregnant beef heifers, comprising 54 purebred Simmentals and 19 Simmental × Friesian-Holsteins, bred to Simmental sires. They were individually offered grass silage *ad libitum*. Live weight, body condition score (BCS), muscularity score, skeletal measurements, ultrasonically scanned muscle (3^{rd} lumbar vertebra) and fat (mean of 13^{th} rib and 3^{rd} vertebra) depth and blood variables (albumin, β-hydroxy butyrate, creatinine, globulin, glucose, non-esterified fatty acids, total protein, triglycerides, urea, alkaline phosphatase, anti-oxidant status, aspartate-aminotransferase, creatine kinase, fibrinogen, haptoglobin, and total bilirubin) were determined. Samples of rumen fluid were obtained orally (*Elevator* - rumen sampler) to assess rumen fermentation characteristics. Feeding behaviour was recorded for each animal by measuring silage disappearance rate over 24 hours. Time spent lying, standing and active was determined using pedometers (*IceTag 2.004, IceRobotics Ltd*.) on 26 heifers. Expected dry matter intake (DMI) was calculated by regressing average daily DMI on average daily live weight gain (ADG), mean live weight$^{0.75}$ and calving day over an 84-day period, for each heifer breed group (BG) separately. The RFI for each animal was calculated as actual DMI minus the expected DMI predicted from the regression model generated for each BG. Within BG, heifers were ranked by RFI into low (efficient), medium and high (inefficient) RFI groups. Subsequent statistical analysis was carried out using PROC GLM with a model containing fixed effects for RFI group, BG and RFI × BG. Calving day was included as a covariate. Models pertaining to progeny had additional fixed effects for calf gender and sire.

Pregnant heifers with high RFI had 0.14 and 0.21 higher ($P<0.001$) DMI than those with medium and low RFI, respectively (Table 19). Differences in daily DMI pattern between high and low RFI groups reflected differences in DMI. Live weight, ADG, body condition score, ultrasonic muscle and fat depth, skeletal measurements, blood variables (except for bilirubin - higher ($P < 0.01$) for low than other RFI groups), calf birth weight and calving difficulty score did not differ ($P > 0.05$) between RFI groups. Muscularity score was higher ($P < 0.05$) for low than high RFI heifers, with medium RFI animals being intermediate. Mean rumen pH and molar proportion of acetic acid did not differ between RFI groups for purebred heifers, but were higher ($P < 0.05$) in high than medium and low RFI crossbed heifers, which were similar ($P>0.05$) (Table 20). There was no effect ($P>0.05$) of RFI on mean values for other rumen fermentation variables. Proportion of time spent lying, standing and active did not differ ($P > 0.05$) between the RFI groups.

In conclusion, the 0.21 difference in DMI between low and high RFI pregnant beef heifers was not noticeably attributable to differences in live weight, ADG, body or ultrasound measurements, concentration of blood variables, lying and standing time, or calf birth weight.

Table 19: Productivity traits in pregnant beef heifers differing in phenotypic residual feed intake (RFI)

Variable	RFI group			SEM	Sig.
	Low	Medium	High		
Expected feed intake (kg DM/day)	7.8	8.1	7.8	0.12	NS
Feed intake (kg DM/day)	7.1	8.1	8.6	0.15	***
Live weight (kg)	559	575	565	10.0	NS
Daily live weight gain (kg)	0.46	0.53	0.46	0.038	NS
Body condition score (0-5)	2.9	2.8	2.8	0.03	NS
Ultrasonic fat depth (mm)	3.1	3.3	3.0	0.20	NS
Ultrasonic muscle depth (mm)	59.9	58.8	57.0	0.92	NS
Muscularity score (1-15)	5.8[a]	5.6[ab]	5.2[b]	0.18	*
Withers height (mm)	1221	1264	1254	23.4	NS
Chest depth (mm)	709	721	713	9.8	NS
Back length (mm)	1161	1177	1133	19.2	NS
Pelvis width (mm)	516	526	522	5.2	NS
Chest circumference (mm)	1967	1958	1953	20.7	NS
Calf birth weight (kg)	43.8	46.6	44.7	1.33	NS
Calving difficulty (scale 1-5)	2.7	3.0	2.6	0.36	NS

Table 20: Mean rumen fermentation characteristics in pregnant beef heifers differing in phenotypic residual feed intake (RFI) and offered grass silage

Variable	RFI group			SEM	Sig.
	Low	Medium	High		
pH[a]	6.80[a]	6.79[a]	6.89[b]	0.299	*
Lactic acid (mg/l)	25.5	24.5	19.7	2.06	NS
Ammonia (mg/l)	90.2	92.4	86.2	9.91	NS
Total VFA (mmol/l)	81	80	85	2.8	NS
Molar proportions (mmol/mol)					
Acetic acid [b]	667	667	689	5.3	**
Propionic acid	201	198	189	4.5	NS
Butyric acid	105	109	99	3.9	NS
Valeric acid	27	26	23	1.9	NS

[a]RFI × Breed group interaction, 6.81, 6.79, 6.81, 6.76, 6.82 and 6.97 for purebred and crossbred, Low, Medium and High RFI groups, respectively.
[b]RFI × Breed group interaction, 674, 661, 679, 654, 683 and 695 for purebred and crossbred, Low, Medium and High RFI groups, respectively.

RMIS No. 5522

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Organic beef production – sire breed comparison for years 1 and 2

The aim of the current experiment, location at Johnstown Castle Environmental Research Centre, is to determine the effects of sire breed type (Charolais and Aberdeen Angus) on production and meat quality in organic beef production. A 44-cow continental-cross spring-calving herd has been established to produce cross-bred calves. This herd is principally made up of Limousin x and Simmental x cows. This herd is maintained by bringing in mature cow replacements of the same breed type. Using a representative group of sires from each breed 50% of the cows were each bred to Aberdeen Angus or Charolais sires. AI was used to the greatest extent possible with two natural service bulls being used to cover repeat matings.

The overall plan is to slaughter the progeny of the herd on three dates. In year 1, on the first date half the Charolais and Aberdeen Angus heifers were each slaughtered. At the middle date the remaining heifers were slaughtered as well as half the steers from each breed group and at the final date the remainder of the steers were slaughtered.

The cow-calf herd followed a rotational grazing system in a designated area of the 60 ha farm. The yearling heifers and steers also had a rotational grazing programme on a different land area of the same land unit.

During the winter months animals were accommodated on straw bedded sheds according to Organic Standards.

Calf birth and weaning weights

In years 1, 2 and 3 the Charolais calves were approximately 10 kg heavier at birth than the Aberdeen Angus calves (Table 21). Performance from birth to weaning was consistent over the three years. In each year the performance from birth to weaning, of the progeny was satisfactory, averaging 1.20, 1.00 and 1.05 in years 1, 2 and 3, respectively (Table 21). The growth advantage of the steers over the heifers and that of Charolais over Aberdeen Angus was comparable to that achieved in conventional production systems.

Table 21: Effect of sire breed on calf performance to weaning (kg)

	AA		CH	
	Male	Female	Male	Female
Year 1 (2006)				
Birth wt. (kg)	49	43	54	50
Weaning wt. (kg)	292	275	326	298
Liveweight gain (kg/d)	1.17	1.17	1.31	1.12
Year 2 (2007)				
Birth wt. (kg)	44	39	52	49
Weaning wt. (kg)	264	226	269	264
Liveweight gain (kg/d)	1.02	0.91	1.06	1.04
Year 3 (2008)				
Birth wt. (kg)	46	41	51	49
Weaning wt. (kg)	269	242	289	280
Liveweight gain (kg/d)	1.04	0.94	1.14	1.12

The liveweights of the Aberdeen Angus and Charolais steers and heifers was 535, 534, 512 and 543 kg respectively at the end of the grazing season (October 2007). The corresponding values for 2008 were 514, 519, 453 and 513 kg (Table 22).

Table 22: Effect of sire breed on calf performance to yearling (kg)

	AA		CH	
	Male	Female	Male	Female
Year 1 (2006)				
Birth wt. (kg)	46	43	58	50
Mid-April 2007 wt. (kg)	348	314	353	359
23rd October 2007	535	512	534	543
Year 2 (2007)				
Birth wt. (kg)	44	39	57	49
Mid-April 2008 wt. (kg)	357	314	362	345
23rd October 2008	514	453	519	513

Performance of the progeny to the end of the 2nd grazing season was consistent over both years where the liveweights of the steers were in excess of 500 kg for both Aberdeen Angus and Charolais sired animals. The key production values achieved for animals born in year 1 are presented in Table 23 and the corresponding values for animals born in year 2 are presented in Table 24.

Table 23: Effect of sire breed and gender on performance of calves born in spring 2006

	AA		CH	
	Male	Female	Male	Female
No. of animals	13	9	12	10
Birth wt.	50	43	58	46
06 June 06	152	124	155	157
21 Nov. 06	338	305	342	344
19 April 07	348	314	353	359
24 Aug 07	492	461	477	496
23 Oct 07	535	512	534	543

Table 24: Effect of sire breed and gender on performance of calves born in spring 2007

	AA		CH	
	Male	Female	Male	Female
No. of animals	11	8	12	13
Birth wt.				
18 June 07	159	130	151	159
08 Nov. 07	282	240	290	271
19 April 08	357	314	362	345
14 Aug 08	470	410	475	454
23 Oct 08	513	453	519	502

The slaughter data generated from year 1 and year 2 of the study (Table 25) shows a 42 kg increase in carcass weight between the early and late slaughter dates for the heifers. The corresponding value for the steers was 35 kg. The difference between Aberdeen Angus and Charolais heifer carcasses was 24 kg in favour of the Charolais sires (Table 26). The corresponding differences for the steers was 11 kg.

Table 25: Effect of different slaughter dates on the performance (kg) of male and female calves born in spring 2006 and spring 2007

	Heifers		Steers		
	Early	Late	Early	Late	sed
Birth wt	44.7	46.1	48.6	50.9	1.35
Final wt	508.4	560.1	606.8	673.5	10.81
Carcass (kg)	268.8	311.4	336.8	371.9	6.48
Carcass gain from birth (g)	0.42	0.43	0.47	0.48	0.009
KO%	52.9	55.4	55.5	58.0	0.475
Conformation	3.02	3.15	2.96	2.84	0.095
Fat Score	3.15	3.21	2.92	3.27	0.125

Table 26: Effect of sire breed and sex on carcass characteristics of calves born in spring 2006 and spring 2007

	AA		CH		
	Female	Male	Female	Male	sed
Birth wt	40.6	44.9	50.2	54.6	1.35
Final	523.3	639.9	545.3	640.5	10.84
Carcass (kg)	278.2	348.8	301.7	359.7	6.51
Carcass gain from birth (g)	0.41	0.47	0.44	0.48	0.009
KO%	53.2	56.1	55.2	57.4	0.48
Conformation	2.99	2.75	3.18	3.05	0.095
Fat Score	3.50	3.56	2.86	2.63	0.128

The results to date, from this contrasting sire breed comparison study, indicates that is possible to achieve animal performance comparable with well managed conventional suckler calf to beef systems.

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Organic beef and lamb production
The current lamb and beef production system operating at the Livestock Production Research Centre, Athenry is operating a grazing management system where there is a complementary role for cattle and sheep in the same organic system.

The organic farm (Eagles) consists 28 ha, 14 ha which is suitable for silage conservation and sheep and cattle grazing. The remaining 14 ha has rock outcrops, a shallow soil cover and is used for grazing by the cows and calves and for grazing by the yearling animals. A further 10 ha, adjacent to the winter accommodation (at Athenry Research Centre) is used for early and late season grazing, mid-season this land area is also used for silage. Farm yard manure and slurry from the winter accommodation is used to ensure soil fertility and in particular protect the area used for silage conservation from nutrient depletion.

Two thirds of the pasture have been reseeded with a grass-clover mixture with minimum cultivation. A rotational grazing programme is practiced to ensure that the clean worm free pasture is provided for ewe and lambs each year with a 2 year break where only cattle graze.

Grange Beef Research Centre

Suckler cows
The aim of the current study is to establish a 30 spring calving suckler cows herd with a low incidence of calving difficulties and the potential to finish progeny at a young age; heifers off grass at 18 to 21 months of age and finishing steers indoors at 21 to 24 months of age.

The ewe flock consists of 30 Texel-Belclare cross and 45 Belclare ewes lambing in spring-time mated to Texel and Belclare rams. The aim of the ewe flock is to finish all lambs off grass during their first season.

The performance of the calves born to the original 20 cow herd (Sim x Fr and Lim x Fr) for 2008 are presented in Table 27 for both the female and male calves from birth to weaning.

Table 27: Effect of cow breed type on performance of calves from birth to weaning in 2008

	Sim X		Lim X	
	Male	Female	Male	Female
Number of calves	5	4	9	6
Birth wt (kg)	48	43	47	42
Weaning wt (kg)	281	261	249	228
On Daily LWG (kg)	1.10	1.00	0.93	0.89

The performance of the lambs born to the Belclare ewes in spring 2008 are presented in Table 28.

Table 28: Organic lamb performance in 2008

	Actual	Target
Birth Wt	4.3	4.5
Weaning Wt	32.0	34.0
Days to weaning	115	100

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