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Effects of finishing strategy on performance of Belgian Blue × Friesian and Limousin × Friesian steers

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Belgian Blue and Limousin bulls are used for cross-breeding with Holstein Friesian dairy cows in Ireland. In beef winter-finishing enterprises, a preliminary feeding period sometimes precedes the finishing period. The optimum feeding level for this period has not been established. The objective of this study was to compare lifetime performance of Belgian Blue × Holstein Friesian (BB) and Limousin × Holstein Friesian (LM) steers and to determine the effects of three finishing strategies on performance and carcass traits. Forty-eight spring-born male calves (24 BB and 24 LM), the progeny of Limousin and Belgian Blue bulls out of Holstein Friesian cows, were reared together to slaughter. At about 19 months of age they were assigned to one of three finishing strategies involving grass silage *ad libitum* plus 0, 3 or 6 kg concentrates per head daily for 112 days (preliminary period) followed by concentrates *ad libitum* to slaughter at 610 kg live weight. Slaughter weight and carcass weight did not differ between the breed types but BB had a higher kill-out proportion, better carcass conformation and lower carcass fatness. Live-weight gains during the preliminary period were 431, 914 and 1134 g/day (s.e. 31.8; $P < 0.001$) for the 0, 3 and 6 kg/day concentrate levels, respectively. Overall gains for the combined preliminary and finishing periods for the treatments in the same order were 945, 1101 and 1081 g/day (s.e. 36.1; $P < 0.01$). There were few differences between the finishing treatments in slaughter weight, carcass weight or carcass traits. It is concluded that general productivity is similar for BB and LM but BB have superior carcass traits. Where a preliminary feeding period precedes a finishing period on *ad libitum* concentrates, animals fed a low level of supplementary concentrates require less feed energy to reach a fixed slaughter weight than those fed none or a higher level of supplementary concentrates.

Keywords: beef × dairy breeds; beef production; concentrates; finishing strategy

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Introduction

About half of Irish Holstein Friesian dairy cows are crossed with beef breed bulls of which late maturing breeds comprise approximately 0.4 (AIM Bovine Statistics Report, 2008). The most commonly used late-maturing beef breeds are Limousin and Belgian Blue (CMMS Statistics Report, 2007; AIM Bovine Statistics Report, 2008). Apart from the reports of Steen (1995) and Steen and Kilpatrick (1995), who used autumn-born calves finished in their second winter, there is no published information on comparisons of spring-born calves of these breed types in standard Irish beef production systems. High concentrate finishing diets for beef cattle are now widely used but they are expensive and profitability depends on high animal performance and efficient feed utilisation (Keane 1995, 2001). Profitability of winter finishing systems can be enhanced by retaining the animals until late spring or early summer when prices are higher. This results in a longer finishing period with a risk of over-fat carcasses if the animals are full-fed throughout. To minimise the likelihood of this, a preliminary period of variable feeding may precede the finishing period. The optimum feeding level for such a preliminary period has not been established.

Where different feeding levels have been evaluated for finishing cattle, it has usually been for a fixed period of time resulting in different slaughter weights and carcass traits (Steen and McIlmoyle, 1982; Drennan and Keane, 1987a,b; Caplis *et al.*, 2005). As growth rate and feed efficiency decline with increasing weight and fatness (Keane, Drennan and Moloney, 2006), and as specific markets require carcasses within defined weight and fatness ranges, it is desirable that comparisons of feeding levels be to a fixed slaughter weight or carcass weight. The objectives of this experiment were: (i) to compare the life time growth rate of Belgian Blue × Holstein Friesian (BB) and Limousin × Holstein Friesian (LM) steers, (ii) to determine the effects of different feeding levels in a preliminary period before finishing, and (iii) to characterise any interactions between breed type and finishing strategy.

Materials and Methods

Animals

Forty-eight male calves (24 BB and 24 LM), the progeny by artificial insemination (AI) of 5 Belgian Blue and 7 Limousin bulls, representative of those available through AI, were purchased on dairy farms. They were managed together from calf arrival to about 18 months of age. Calf rearing indoors was as described by Fallon and Harte (1987). At about 2 months of age the calves were turned out to pasture for the first grazing season. At 3, 8 and 13 weeks after turn-out they were treated with ivermectin (Ivomec, MSD Agvet) by injection for the control of internal parasites. From calf turn-out to about 18 months of age the animals were managed in an extensive production system designed to support moderate growth rate. The calves were castrated on 26 September, and on 20 November they were housed in a slatted-floor shed for the first winter, where they were offered grass silage *ad libitum* plus 1 kg supplementary concentrates (875 g/kg rolled barley, 65 g/kg soya bean meal, 45 g/kg molasses, 15 g/kg mineral/vitamin premix) per head daily until 25 March. They were then turned out to pasture for a second grazing season of 218 days duration after which three finishing strategies were imposed.

Treatments

On 29 October, the animals were ranked on weight within breed type to 8 blocks of

3 animals each and assigned from within blocks to a 2 (breed type) × 3 (finishing strategy) factorial experiment. The three finishing strategies were: (i) silage only *ad libitum* for 112 days followed by concentrates *ad libitum* to a target slaughter weight of 610 kg (S0), (ii) silage *ad libitum* + 3 kg concentrates per head daily for 112 days followed by concentrates *ad libitum* to a target slaughter weight of 610 kg (S3), and (iii) silage *ad libitum* + 6 kg concentrates per head daily for 112 days followed by concentrates *ad libitum* to a target slaughter weight of 610 kg (S6). The concentrate mix was as described above. Animals were adapted to *ad libitum* concentrate intake over periods of 18, 24 and 27 days for S6, S3 and S0, respectively. While providing *ad libitum* access to silage, the concentrate allowance was increased from 0 to 3 kg/day by 1 kg/day, from 3 to 6 kg/day by 0.5 kg/day, and from 6 kg/day to *ad libitum* intake by 0.3 kg/day. When *ad libitum* concentrate intake was reached, silage was reduced to a fixed allowance of 1.15 kg DM per head daily to ensure normal rumen function. Accommodation was in 8 pens in a slatted-floor shed fitted with Calan doors for individual feeding. Each pen (4.6 m × 4.1 m) was designed to accommodate 7 animals but had only 6, giving a floor space per animal of 3.1 m^2. No veterinary treatments were given, and none was indicated, during the finishing period. The animals were weighed every 2 weeks and all animals in a treatment group were slaughtered on the same day when the group mean weight approximated to the target slaughter weight. Animals were slaughtered in a commercial abattoir and, after slaughter, cold carcass weight (0.98 × hot weight), carcass classes for conformation and fatness (Commission of the European Communities, 1982), the weight of perirenal plus retroperitoneal fat and the number of permanent teeth were recorded.

Feeds

Silage was sampled once weekly at feeding and the samples were frozen. Samples were composited for periods of 4 weeks using a bowl chopper. Representative subsamples were dried at 40 °C and analysed for dry matter (DM) crude protein, ash, *in vitro* dry matter digestibility (DMD) and neutral detergent fibre (NDF). An aqueous extract from the fresh silage was used for the measurement of pH and ammonia nitrogen (NH_3-N). Concentrates were also sampled weekly, stored frozen and composited monthly. Representative sub-samples were dried at 98 °C for 16 h for DM determination and at 40 °C for 48 h for measurement of DMD, crude protein, NDF and ash. All feed analyses were carried out according to the methods described by Cummins *et al*. (2007). The chemical composition of the silage and concentrate mix is shown in Table 1.

Statistical analyses

The general linear model procedure of the Statistical Analysis Institute (SAS, 2002–2003) was used to analyse the data. Up to the start of the finishing treatments the data were analysed for breed effects only. The finishing data were analysed as a 2 × 3 factorial with terms for block, breed type, finishing strategy and the breed type × finishing strategy interaction. The data are presented as main effect means with subclass means included as footnotes where there were significant interactions.

Results

Performance to start of finishing

Recorded mean birth and arrival dates were 6 April and 7 May for BB, and 31 March and 5 May, for LM, respectively (Table 2). There was no difference between the breed types in calf arrival or turn-out weights. At the time of first housing, LM were 11 kg heavier ($P < 0.05$) than BB. This

Table 1. Mean (s.d.) values for pH and for the chemical composition of the silages and concentrate mix used

Variable	Silage		Concentrate mix
	1st Winter	Finishing	
pH	3.9 (0.13)	3.9 (0.11)	–
Dry matter (DM) (g/kg)	194 (11.6)	208 (12.9)	853 (5.8)
Crude protein (g/kg DM)	144 (9.5)	146 (9.8)	129 (5.2)
Neutral detergent fibre (g/kg DM)	533 (20.2)	529 (22.4)	–
DM digestibility *in vitro* (g/kg)	713 (19.5)	701 (23.1)	848 (8.9)
Ash (g/kg DM)	72 (8.4)	83 (9.5)	50 (5.6)
NH_3-N (g/kg total N)	64 (7.9)	72 (7.5)	–

Table 2. Live weights and live-weight gains for Belgian Blue × Holstein Friesian (BB) and Limousin × Holstein Friesian (LM) steers from calf arrival to start of finishing

Growth trait	Breed type		s.e.	Significance
	BB	LM		
Live weight (kg) at:				
Arrival†	61	60	1.9	
Calf turn-out (6 June)	78	78	1.8	
First housing (20 Nov.)	157	168	3.3	*
Yearling turn-out (25 Mar.)	230	244	4.6	*
Second housing‡ (29 Oct.)	368	391	1.63	***
Live-weight gain (g/day) from:				
Arrival to calf turn-out (30/32)§	598	753	99.5	
Calf turn-out to first housing (167)	476	538	17.2	*
First housing to yearling turn-out (125)	586	616	44.2	
Yearling turn-out to second housing (218)	634	695	25.7	
First housing to second housing (343)	616	666	15.1	*
Calf turn-out to second housing (510)	570	624	8.6	***

† At Grange Beef Research Centre at about 1 month of age.
‡ Start of finishing treatments.
§ Number of days (in the case of arrival to calf turn-out the interval was 30 and 32 days for BB and LM, respectively).

had increased to 14 kg (P < 0.05) at yearling turn-out and to 23 kg (P < 0.001) when the finishing treatments commenced. These differences in live weight reflected corresponding differences in growth rate. During the first grazing season LM gained 62 g/day more (P < 0.05) than BB. During the first winter and second grazing season differences of 30 and 61 g/day, respectively, in favour of LM were not statistically significant. For the total period from calf turn-out to the start of the finishing treatments, there was a mean difference in live-weight gain of 54 g/day (P < 0.001) in favour of LM.

Feed intake

During finishing there was no significant difference between the breed types in absolute intake or in intake scaled for mean live weight (Table 3). There was also no difference in total net energy intake (expressed as Unite Fourragere Viande (UFV); Jarrige, 1989) or in the efficiency of utilization of UFV for live-weight gain (106 and 100 (s.e. 3.7) grams live-weight gain per unit UVF for BB and LM, respectively). During the preliminary period, feeding 3 kg (2.57 kg DM) concentrates per head daily reduced silage DM

Table 3. Effects of breed type and finishing strategy on silage and concentrate dry matter (DM) intake during the finishing period

Variable	Feed component	Breed type (B)		Finishing strategy (F)			s.e.†	Significance‡
		BB	LM	S0	S3	S6		F
Daily intake (kg DM) for:								
Day 0–112	Silage	5.78	5.84	6.87^{a}	5.94^{b}	4.63^{a}	0.137	***
	Concentrates	2.57	2.57	–	2.57	5.13	–	
Day 112–147	Silage	2.26	2.39	2.75^{a}	2.23^{ab}	2.00^{b}	0.135	*
	Concentrates	7.33	7.33	5.62^{a}	7.43^{b}	8.95^{c}	0.085	***
Day 147–214	Silage	1.15	1.15	1.15	1.15	1.15	–	
	Concentrates	11.92	11.92	11.73^{a}	11.89^{ab}	12.15^{b}	0.125	*
Day 214–249	Silage	1.15	1.15	1.15	–	–	–	
	Concentrates	10.83	11.27	11.05	–	–	0.069	***
Total intake (kg DM)	Silage	820	830	985^{a}	822^{b}	668^{c}	16.6	***
	Concentrates	1469	1476	1369^{a}	1345^{a}	1702^{b}	8.98	***
Total net energy intake (UFV§)	All	2267	2282	2276^{a}	2128^{b}	2418^{c}	21.8	***
Mean daily intake (kg DM)	Silage	3.64	3.68	3.96^{a}	3.84^{a}	3.13^{b}	0.069	***
	Concentrates	6.51	6.54	5.50^{a}	6.29^{b}	7.96^{c}	0.041	***
	All	10.15	10.22	9.46^{a}	10.13^{b}	11.09^{c}	0.087	***
Mean daily DM intake per unit live weight (g/kg)	Silage	7.46	7.29	7.95^{a}	7.74^{b}	6.32^{c}	0.139	***
	Concentrates	13.34	12.96	11.06^{a}	12.67^{b}	16.07^{c}	0.242	***
	All	20.79	20.25	19.02^{a}	20.40^{b}	22.39^{c}	0.241	***

a,b,c Values without a common superscript within finishing strategy differ significantly in this and subsequent tables.
† For Breed type (n = 24), multiply by √1.5 for finishing strategy in this and subsequent tables.
‡ There was no significant effect of B and no significant B × F interaction.
§ UFV = Unite Fourragere Viande calculated using the values in O'Mara (1996).

intake by 0.93 kg/day (substitution rate of 0.36 kg silage DM per 1 kg concentrate DM). The second 3 kg/day concentrate increment reduced silage DM intake by a further 1.31 kg/day (substitution rate of 0.51 kg silage DM per 1 kg concentrate DM).

For the first 35 days (Days 112–147) following the end of the preliminary period, animals on S6 had a significantly higher concentrate intake than those on S3, which in turn had a significantly higher concentrate intake than animals on S0. There were differences in the opposite direction in silage intake. These differences were due mainly to the differences between the finishing strategies in the interval required to adapt to *ad libitum* concentrate intake. From 147 to 214 days, when all groups were fully adapted to *ad libitum* concentrates, animals on S6 had a significantly higher concentrate intake than those on S0, with animals on S3 intermediate and not significantly different from the other two. However, animals on S6 also had a higher mean live weight than those on S0 as a consequence of the higher feeding level and higher daily gain earlier. Thus, when concentrate intake was expressed per kilogram mean live weight there was no significant difference between the groups. During the period 214 (day of slaughter for animals on S3 and S6) to 249 days, the concentrate intake for animals on S0 (the only group remaining) was somewhat lower than earlier.

For the entire duration of finishing, total silage intake differed significantly amongst the strategies. It was highest for animals on S0 and lowest for those on S6. Total concentrate intake did not differ significantly between animals on S0 and S3 but was significantly higher for those on S6. Compared with animals on S0, animals on S3 consumed 163 kg less silage DM and 24 kg less concentrate DM, while those on S6 consumed 317 kg less silage DM and 333 kg more concentrate DM. Total net energy intake was significantly higher for animals on S0 than those on S3, and for animals on S6 than those on S0. Mean daily silage intake did not differ between S0 and S3 but was lower for animals on S6, while mean daily concentrate intake was higher for animals on S3 than those on S0, and for animals on S6 than those on S3. Mean daily total DM intake followed a similar pattern to concentrate intake. Silage, concentrate and total DM intakes per kilogram mean live weight differed significantly amongst the finishing strategies. Silage intake was highest, and concentrate and total DM intake were lowest for animals on S0. Silage intake was lowest, and concentrate and total DM intake were highest for animals on S6. The values for animals on S3 were intermediate between those for S0 and S6. Total UFV intake from the start to slaughter differed significantly among the three finishing strategies. As there was no difference between animals on S3 and those on S6 for live-weight gain, the efficiency of utilization of UFV was significantly better for animals on S3 than S6, with S0 not significantly different from these (103, 110 and 96 (s.e. 4.5) grams live-weight gain per unit UFV for S0, S3 and S6, respectively).

Live weight and live-weight gain

LM were 23 kg heavier ($P < 0.001$) than BB at the start, 18 kg heavier ($P < 0.001$) at the end of the preliminary period, and 9 kg heavier (not significant) at slaughter (Table 4). There was no significant difference between the breed types in live-weight gain from the start of the feeding treatments to slaughter but, overall, BB gained 67 g/day more in this period.

Other than at the start and at slaughter, live weights differed significantly for the three finishing strategies. At the end of the preliminary period animals on S3 were

Table 4. Effects of breed type and finishing strategy on live weights and live-weight gains of steers

Variable	Breed type (B)		Finishing strategy (F)			s.e.	Significance		
	BB	LM	S0	S3	S6		B	F	B × F
Live weight (kg) at:									
Start	368	391	380	379	380	1.6	***	–	
112 days	463	481	428[a]	481[b]	507[c]	3.5	***	***	
159 days	540	551	518[a]	555[b]	562[b]	5.1		***	**‡
209 days†	595	608	580[a]	614[b]	611[b]	6.3		**	
Slaughter	609	618	615	614	611	6.7			
Days to slaughter	225.7	225.7	249	214	214	–		***	
Live-weight gain (g/day) from:									
Start to 112 days	848	805	431[a]	914[b]	1134[c]	26.0		***	*§
112 to 159 days	1638	1477	1921[a]	1570[b]	1181[c]	66.7		***	
159 to 209 days†	1108	1152	1226[a]	1190[a]	974[b]	64.3		***	
209 days to slaughter	1038	728	883	–	–	40.2			
112 to 209 days†	1365	1310	1563[a]	1374[b]	1074[c]	57.3		***	
Start to slaughter	1076	1009	945[a]	1101[b]	1081[b]	29.5		**	

† Last common weight before slaughter of any animals.
‡ Values for S0, S3 and S6 were 500, 547 and 572 kg, respectively, for BB, and 501, 537 and 536 kg, respectively, for LM.
§ Values for S0, S3 and S6 were 401, 901 and 1234 g/day, respectively, for BB, and 453, 927 and 1035 g/day, respectively, for LM.

53 kg heavier ($P < 0.05$) than those on S0, and animals on S6 were 26 kg heavier ($P < 0.05$) than those on S3. These represented the live-weight responses to the 3 and 6 kg/day concentrate inputs during the preliminary period. By Day 159 (47 days after introduction to *ad libitum* concentrates), these differences had declined to 37 kg ($P < 0.001$) and 7 kg, respectively. There was a breed-type × finishing-strategy interaction for live weight on Day 159 due to a difference between animals on S3 and S6 for BB but not for LM. By day 209, animals on S3 had overtaken those on S6 in live weight and the difference between animals on S0 and S3 had declined to proportionately 0.64 of its initial (Day 112) value. Both S3 and S6 reached the target slaughter weight at the same time and were slaughtered together, while animals on S0 required a further 35 days to reach the target slaughter weight.

During the preliminary period, the response to the first 3 kg/day concentrate increment was 483 g/day and the response to the second 3 kg/day increment was 220 g/day. There was a breed type × finishing strategy interaction for live-weight gain in the preliminary period due to a higher value for BB than LM on S6 but not on S0 or S3. During the first 47 days after introduction to *ad libitum* concentrates, there was significant compensatory growth by S0 and S3 relative to those on S6, and by S0 relative to S3. The growth rate for S3 was 389 g/day higher ($P < 0.05$) than for those on S6, while that for S0 was 351 g/day higher ($P < 0.05$) than for S3. Thereafter, the animals on both S0 and S3 continued to gain significantly faster than those on S6, and the animals on S0 continued to gain faster than those on S3 but the difference was not statistically significant. For the 97 day period on *ad libitum* concentrates up to the date of final common weighing (Day 209), mean daily gains were 189 g higher ($P < 0.05$) for animals on S0 than those on S3, and 300 g higher ($P < 0.05$)

for animals on S3 than those on S6. After 209 days, the daily gain for S0 (the only group remaining) declined compared with earlier. For the entire period from start to slaughter, mean daily gain was similar for S3 and S6 but was significantly lower for those on S0. Thus, the higher daily gain for animals on S0 compared with those on S3 and S6 during the finishing period was not sufficient to fully offset the lower daily gain achieved during the preliminary period.

Slaughter traits

Carcass weight was similar for the two breed types despite the numerically higher slaughter weight of LM (Table 5). This was because BB had a higher (23 g/kg; $P < 0.001$) kill-out proportion. BB also had better ($P < 0.01$) carcass conformation, a lower ($P < 0.001$) carcass fat score and a lower weight ($P < 0.01$) and proportion ($P < 0.05$) of perirenal plus retroperitoneal fat. Although birth date differed by only one week, BB tended to have a lower number of permanent teeth.

Finishing strategy had no significant effect on slaughter or carcass traits other than carcass fat score, which was significantly higher for animals on S0. There was an interaction between breed type and finishing strategy for carcass fat score reflecting the fact that the difference between the feeding strategies applied to LM only.

Discussion

Breed type

The similar slaughter and carcass weights of BB and LM is in agreement with the findings of Steen (1995) for a direct comparison of Limousin × Friesian and Belgian Blue × Friesian cattle. However, other data indirectly suggest higher values for BB. For example, Southgate, Cook and Kempster (1988), Keane (2002) and Wheeler *et al*. (2005) rank Limousin progeny inferior to Charolais progeny for daily gain and weight for age, while Hardy and Fisher (1996) and Keane (2006) found no differences between Charolais and Belgian Blue progeny for these traits. Thus, taken together, the results of these studies indicate that Limousin progeny have inferior growth rate to both Belgian Blue and Charolais progeny.

There are also inconsistencies in the literature on kill-out proportion. In a direct

Table 5. Effects of breed type and finishing strategy on slaughter and carcass traits of steers

Variable	Breed type (B)		Finishing strategy (F)			s.e.	Significance		
	BB	LM	S0	S3	S6		B	F	B × F
Carcass weight (kg)	338	329	333	334	334	4.0			
Kill-out value (g/kg)[†]	556	533	542	545	547	2.8	***		
Conformation score[‡]	3.13	2.88	2.94	3.00	3.06	0.066	**		
Fat score[§]	3.09	3.79	3.58[a]	3.35[b]	3.39[b]	0.045	***	*	***§
Weight of perirenal + retroperitoneal fat (kg)	9.5	10.8	10.4	9.9	10.0	0.34	**		
Weight of perirenal + retroperitoneal fat (g/kg)[¶]	28.3	32.7	31.5	30.0	30.1	1.18	*		
Permanent teeth (no.)	1.46	1.79	1.88	1.38	1.63	0.137			

[†] Of slaughter weight.

[‡] EU Beef Carcass Classification Scheme with conformation 1 = P (poorest) to 5 = E (best) and fat 1 = (leanest) to 5 (fattest).

[§] Values for S0, S3 and S6 were 3.00, 3.00 and 3.26, respectively, for BB, and 4.15, 3.70 and 3.55, respectively, for (LM).

[¶] Relative to carcass weight.

comparison of Limousin × Friesian and Belgian Blue × Friesian, Steen (1995) found no difference between these breed types in kill-out proportion, and others reported no difference between Limousin and Charolais progeny in kill-out proportion (Keane, 2002; Wheeler *et al*., 2005). However, Hardy and Fisher (1996) found that Belgian Blue progeny had a higher kill-out proportion than Charolais progeny. Steen and Kilpatrick (1995) found no difference in carcass conformation between Limousin × Friesian and Belgian Blue × Friesian. Other evidence indicates similar carcass conformation for Belgian Blue and Charolais progeny (Hardy and Fisher, 1996; Keane, 2006), and there are results showing that carcass conformation, or indicators of conformation, are similar for Charolais and Limousin progeny (Keane, 2002; Wheeler *et al*., 2005). Thus, based on the evidence in the literature, the conformation advantage to BB in the present study was not expected but is in line with a relatively small advantage for Belgian Blue sires in breeding value for conformation. The lower carcass fat score, together with the weight and proportion of perirenal plus retroperitoneal fat, are in agreement with published results (Steen, 1995; Hardy and Fisher, 1996; Keane, 2002).

In the context of the similar overall growth rate of the two breed types, the fact that LM had a higher value than BB up to the start of finishing, whereas the opposite was so during finishing, is of particular interest, and suggests that the relative lifetime performance of the two breed types may depend on the relative lengths of the growing and finishing periods. It is difficult to establish if this phenomenon was observed in the other breed comparison studies as the intermediate weights and gains are often not reported. In the study of Southgate *et al*. (1988), the differences between breed types seemed to be consistent across the various production phases, whereas More O'Farrell and Keane (1990) observed that Charolais × Friesian steers had significantly higher daily gain than Hereford × Friesian steers for all periods up to the start of finishing but that Hereford × Friesian steers had significantly higher gain during finishing.

There is no obvious explanation for why the relative growth rates of BB and LM should differ between the growing and finishing phases. There is a perception amongst Irish beef producers that Limousin-cross calves are more robust than calves by Belgian Blue sires, which, if true, could explain their better early-life performance. The production systems of the purebred Limousin and Belgian Blue breeds in their regions of origin (France and Belgium, respectively) would suggest that Limousin, are more robust. In the case of the Limousin, herd size is relatively large, cows generally calve unattended and calves remain with their dams at pasture until weaning at 6 to 9 months of age (Kempf, Rouquette and Chotteau, 1995). In contrast, the Belgian Blue is typically associated with a rather small herd size, cows receive assistance (regularly caesarean section) at calving, and the calves are often weaned early and reared indoors on a high concentrate diet (Fiems and Boucque, 1995). As a consequence of these different backgrounds, it may be that the Limousin breed has been selected to be more suited to extensive pastoral conditions (as obtained up to the start of finishing in the present study), whereas the Belgian Blue breed has been selected to be more suited to feed-lot type conditions (as in the finishing period of the present study). Some support for this hypothesis is provided by the significant interaction for daily gain in the preliminary period when BB had a higher daily gain than LM on the highest feeding level but not on the lower feeding levels (S6:1234 v. 1035; S3:901 v. 927; S0:401 v. 453, g/day). The difference in relative live-weight gain between the growing and finishing periods may also be associated with differences in maturity. The carcass fatness indicators show that LM were more mature at slaughter, and live-weight gain declines with advancing maturity (Keane *et al*., 2006). Thus, if both breed types had been slaughtered at the same stage of maturity (fatness), the daily gain difference during finishing may have been less.

Finishing strategy

Silage intake for animals on S0 during the preliminary period was 6.9 kg/day, or 17.0 g/kg mean live weight per day, which was towards the upper end of the expected range. Drennan and Keane (1987a), Caplis *et al*. (2005) and Keane *et al*. (2006) all reported daily intakes of unsupplemented silage in the range 13.6–17.4 g/kg live weight. The reduction in silage intake and increase in total DM intake with increasing supplementary concentrate level are in good agreement with published results (Drennan and Keane, 1987a; Caplis *et al*., 2005; Keane *et al*., 2006).

After the preliminary period, intake during the adaptation period to *ad libitum* concentrates inevitably differed between the treatments as two groups (S3 and S6) were already partially adapted to concentrates, whereas S0 was not. After all groups reached *ad libitum* concentrate intake, the significantly higher daily concentrate intake for animals on S6 paralleled the higher mean live weight for this group, consequent on the higher feeding level and higher growth rate earlier. As animals on S0 required 5 weeks longer than those on S3 (and S6) to reach slaughter weight, during which time they consumed as much concentrates as those on S3 did in the preliminary period, the total concentrate intake of these two groups was similar. However, because of higher silage intake during the preliminary period, total silage intake for animals on S0 was higher. Likewise, although animals on S3 and S6 reached slaughter weight at the same time, animals on S3 had consumed more silage DM (because of their higher silage intake in the preliminary period) but had consumed less concentrate DM (because of their lower daily allowance during the preliminary period). Overall daily DM intakes (19.0–22.4 g/kg live weight) across the finishing strategies were similar to those reported by Drennan and Keane (1987a) and Keane *et al*. (2006) for diets of similar silage to concentrate ratios.

The live weight response to the first concentrate increment (3 kg/day) in the preliminary period was 188 g/kg concentrate DM. This is in close agreement with the values of 173 and 182 g/kg concentrate DM reported by Caplis *et al*. (2005) and Keane *et al*. (2006), respectively. In agreement with many other studies, the response to the second concentrate increment was less than that to the first with values of 86, 54 and 45 g/kg concentrate DM for the present study, Caplis *et al*. (2005) and Keane *et al*. (2006), respectively.

The expression of compensatory growth during the finishing period by the animals on the lower feeding levels in the preliminary period was such that animals on S3 reached the target slaughter weight at the same time as those on S6, but while animals on S0 also showed compensatory growth relative to those on S3, they were still significantly lighter when the latter reached the target slaughter weight. The phenomenon of compensatory growth has been widely recognised (Wilson and Osborne, 1960; O'Donovan, 1984; Ryan, 1990; Keane and Drennan, 1994) and its exploitation in beef production systems has generally involved differential feeding levels in winter followed by re-alimentation at pasture (Drennan, 1979; Wright, Russel and Hunter, 1986; Baker, Young and Laws, 1992; Keane and Drennan, 1994). Animals exhibiting compensatory growth have similar absolute intake to their non-compensating counterparts but because they are lighter, as a consequence of the earlier feed restriction, intake per kilogram live weight is higher (Wright *et al*., 1986; Baker *et al*., 1992). The present results are not directly comparable with those in the literature because the animals were re-alimented to a fixed slaughter weight indoors rather than for a fixed time period at pasture. Nevertheless, in the period when all animals were offered concentrates *ad libitum*, absolute intakes were similar even though there were differences in live weight.

There is some equivocation in the literature as to whether complete live weight recovery can be achieved following a period of under nutrition. Drennan (1979), Keane and Drennan (1994) and Steen (1986) all reported recovery indices <0.5, while Wright *et al*. (1986) recorded a recovery index of 0.71. The latter calculated that complete recovery was possible if the differential feeding period did not exceed 135 days and the recovery period was at least 230 days. In the present study, there was complete recovery by animals on S3 relative to those on S6 by Day 209 but not by those on S0 relative to animals on S3. This agrees with previous results for similar levels of feeding (Keane and Drennan, 1994). Even if the comparison had continued beyond Day 209, it is unclear if animals on S0 would have reached the same live weight as those on S3 (or S6). Initially, after both groups reached *ad libitum* concentrate intake daily live-weight gain was significantly higher for animals on S0. However, the rate of gain declined with time, and while it was still higher for animals on S0, the difference was not significant over the 50-day period before slaughter of animals on S3. Considering that the rate of gain of animals on S0 continued to decline with time, it seems that even if the comparisons had continued, complete recovery would either not have been achieved or would have been long delayed.

As all treatment groups were slaughtered at the same live weight and from the same diet few differences in carcass traits would be expected. The significantly higher carcass fat score for animals on S0 compared with the other two groups was probably due to chance and was not accompanied by a similar difference in perirenal plus retroperitoneal fat weight or proportion. It applied only to LM and not to BB (significant breed type × finishing strategy interaction). With just 8 animals per breed type and feeding strategy, the fat score difference observed could have occurred if the classification of just 3 carcasses had been inadvertently inflated by one class (this study predated the introduction of mechanical grading). If however it is assumed that the higher fat score for animals on S0 was real, it could indicate a higher proportion of carcass fat associated with their higher live-weight gain in the finishing period (Robelin and Daenicke, 1980), or it could be a carry-over effect of higher fat deposition on the unsupplemented silage diet in the preliminary period (Baker *et al*., 1992). Since all groups were slaughtered at similar live weights and had similar carcass weights, feed intake is a direct reflection of feed efficiency. Animals on S0 and S3 had similar concentrate intakes but as animals on S0 consumed more silage DM they had inferior feed efficiency. Similarly, animals on S3 had superior feed efficiency to those on S6 because their greater silage consumption was more than offset by reduced concentrate consumption.

Conclusions

There were few differences between BB and LM in feed intake or lifetime live-weight gain, but breed effects on live-weight gain varied with production phase and/or nutritional environment, being higher for LM in the growing phase but higher for BB in the finishing phase. The optimum level of concentrate supplementation in the preliminary period was 3 kg/day. This resulted in lower silage intake and a similar concentrate intake to offering silage only in the preliminary period. Both these strategies led to a lower concentrate intake than offering 6 kg/day concentrates in the preliminary period, and while they led to a higher silage intake, the difference was less than the difference in concentrate intake.

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