End of Project Report

A Comparison of the Productivity of Suckler Cows of Different Breed Composition

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Summary

The findings obtained in a comparison of 5 suckler dam breed types {Limousin x Friesian (LF), Limousin x (Limousin x Friesian) (LLF), Limousin (L), Charolais (C) and Simmental x (Limousin x Friesian) (SLF)} and their progeny through to slaughter were as follows:

Cow serum and colostrum immunoglobulin (IgG_1) concentration of cows and subsequent immune status of their calves

- The decrease in serum IgG_1 in cows between 90 days pre-partum and parturition was greater for LF cows than all other breed types, except SLF. There was no difference between LLF, L, C and SLF cows.
- There was no cow breed type effect on colostrum IgG_1 concentration.
- Calf serum IgG_1 concentration and ZST units were higher for the progeny of LF cows than all others except SLF. There was no difference between LLF, L, C and SLF cows progeny.
- Differences in calf immunoglobulin status were presumably due to differences in colostrum volumes produced and therefore immunoglobulin mass consumed by the calf.

Cow and Calf Performance

- There were no cow breed type effects for grass dry matter (DM) intake but when expressed relative to liveweight the LF & SLF with higher milk yields had greater intakes than L & C with LLF intermediate.
- Silage DM intake (measured during pregnancy) was greater for C and SLF dams than L and LLF, while LF were intermediate. There were no cow breed type differences in silage intake when expressed as a proportion of liveweight.
- Breed effects for silage DM intake showed that the heavier C cows and the cows of greater milk yield (LF and SLF) had the greatest intakes.
- Liveweight was greater for C cows than all other breed types. Liveweight of L cows was greater than that of LF and LLF cows. The liveweight of L and SLF cows was similar, as were LF, LLF and SLF.
- The decrease in liveweight over the winter period (indoors) was greater for L and C dams than for LLF and SLF, while LF were intermediate.

- The increase in liveweight during the grazing season was greater for C dams than for all except L, which were intermediate.
- Dam breed type did not affect annual liveweight change.
- Body condition score was lower for LF cows than LLF, L and SLF cows, with C cows intermediate.
- Dam breed type did not effect body condition score changes for any of the periods examined.
- There was no consistent relationship between body condition score and liveweight.
- There was no effect of cow breed type on gestation length.
- Calving difficulty score was greater for C dams than LLF, L and SLF, while LF were intermediate.
- Birth weight of calves from C dams was greater than all except L. Calves from LLF dams had lower birth weights than all except SLF, while calves from LF, L and SLF dams were similar.
- Birth weight was positively correlated with calving difficulty score.
- Milk yield was greater for LF and SLF dams than for the 3 other breed types, which did not differ.
- Pre-weaning growth rates were greater for progeny of LF and SLF than L and C with LLF intermediate.
- Progeny growth rates reflected milk yield but the response to milk yield was lower at higher levels of milk production.

Growth and carcass traits of progeny

- Post-weaning gain was not affected by dam breed type.
- Slaughter weight was greater for progeny of LF and SLF dams than for progeny of L and LLF dams, while C were intermediate.
- Daily gain from birth to slaughter was higher for progeny of LF and SLF cows than for L and LLF. The progeny of C dams had intermediate gains and differed only from LF progeny.
- Cold carcass weight and carcass gain per day of age were greater for the progeny of LF & SLF cows than LLF and L progeny with C progeny intermediate.

- Killing-out rate was greater for the progeny of L cows than all other breed types except LLF, which was similar to the three remaining breed types.
- Carcass conformation score was higher for the progeny of L and C dams than for LF and LLF, while SLF was intermediate.
- Carcass fat score was lower for the progeny of C and L dams than LF and SLF. The progeny of LLF dams had similar fat scores to all breed types except C.
- Body condition score pre- slaughter was higher for progeny of LF cows than L, LLF and C progeny with SLF intermediate.
- Perinephric and retroperitoneal fat weight was higher for progeny of LF and SLF dams than L and C progeny with LLF intermediate.
- The proportion of meat in the carcass hindquarter was greater for L cows progeny than all other breed types except C. There was no differences between the remaining four groups.
- Fat proportion in the hindquarter was lower for progeny of L and C dams than LLF, SLF, and LF which were similar.
- Bone proportion in the hindquarter was lower for the L progeny than all others except LLF progeny. C progeny had a higher proportion of bone than all except LF progeny.
- Meat to bone ratio was greater for the progeny of L than LF, C and SLF with LLF intermediate.
- There were small dam breed type effects for muscle distribution expressed relative to weight of carcass and hindquarter and weight of meat in the carcass and hindquarter.
- Dam breed type did not effect net energy intake expressed relative to liveweight or feed conversion ratio of the progeny.

Ultrasonically scanned muscle and fat measurements, visual muscular scores and measurements of cows and their progeny and progeny carcass measurements

- The ultrasound *M. longissimus dorsi* muscle measurements at the 3rd lumbar (and at the12/13th rib) expressed as a proportion of liveweight were generally greater for L cows than all other groups except LLF which were intermediate.
- Ultrasound fat measurements of cows were low and inconsistent.

- Chest width and circumference at birth was greater for calves from C cows than LLF and SLF while head width was greater for C calves than all except LF calves.
- There was no dam breed type effect for progeny longissimus dorsi muscle measurements at the 3rd lumbar at weaning or slaughter. However, when expressed relative to liveweight muscle measurements were generally greater for progeny of L cows than LF and SLF cows while progeny of LLF and C were intermediate.
- There were no dam breed type effects for progeny ultrasound fat measurements.
- Signet muscular score of cows post-housing was greater for C and L than LLF and SLF which were in turn greater than LF.
- At birth progeny of L and C cows had higher muscular scores than LF and LLF progeny with SLF intermediate.
- There was no dam breed type effect on muscular scores of their progeny at weaning.
- The Signet and Irish Cattle Breeding Federation (ICBF) musuclar score at slaughter was similar for progeny of C and L cows. The Signet score was greater for the progeny of these 2 breeds than for progeny of LF and LLF cows, which were also similar, while progeny of SLF cows were intermediate. The ICBF score was greater for the progeny of C cows than LF, LLF and SLF with L intermediate.
- Carcass fat depth was greater for progeny of LF dams than all except SLF, the remaining 4 breed types not differing.
- There were few and inconsistent breed effects for live animal body measurements.

Introduction

Growth rate and carcass value are important determinants of profitability, with carcasses of good conformation (muscularity) commanding the highest prices on the premium export markets (mainland EU). Therefore, the objective in suckling is that the progeny are of high growth potential and produce carcasses of good conformation. Breed is the major factor influencing conformation, with the late-maturing continental breeds superior to the early-maturing British breeds (Hereford and Aberdeen Angus) and vastly superior to the Friesian/Holstein. The continental breeds also have greater growth potential than the other breeds. The type of carcasses required are similar to those produced from the suckler herd in France where over 80% of cows are purebred Charolais, Limousin or Blonde d'Aquitaine. However, experimental data have shown that the heterosis (hybrid vigour) resulting from use of a crossbred as opposed to purebred cows increases the weight of calf weaned per cow bred by 14%, with a further 8% arising from using a third breed of sire on a crossbred cow. Because of the emphasis on conformation, producers are retaining replacements from within the herds with a tendency towards purebreds rather than crossbreds. It is thus important to examine the relative productivity of various crossbred and purebred cows to provide clear guidelines on the most desirable breeding programme for the suckler herd. The project involved 5 cow breed types (0.5, 0.75 and 1.0 Limousin genes, Simmental x (Limousin x Friesian) and purebred Charolais) with a common sire used on all cows. Progeny were taken to slaughter. The usefulness of ultrasonic scanning and visual muscular scoring in predicting carcass conformation, fat and composition was also examined.

Materials and Methods

<u>Herd management</u>

The Grange spring-calving suckler herd was used in a cow breed comparison over 4 consecutive years (2001 to 2004). The five cow breed types examined were Limousin × Friesian (LF), Limousin × (Limousin × Friesian) (LLF), Limousin (L), Charolais (C) and Simmental × (Limousin × Friesian) (SLF). In Year 1 the herd comprised of first parity cows, while first and second parity animals were present in year 2, with first parity animals present for all cow breed types except C. This herd was retained in years 3 and 4 and first parity cows were introduced for the crossbred breed types only. An easy-calving Limousin sire was used on all 1st parity animals and they were bred by artificial insemination (A.I.) to calve at two years of age. Two Charolais sires (A.I.) of similar growth, one of excellent and one of average conformation, were used each year on the mature cows. Mature cows were offered silage only during the indoor winter period while first parity animals received an additional 1.5kg of concentrates from parturition until turnout to grass. The progeny had a mean birth date of April 4th and a mean turnout to grass date of April 24th. They remained at pasture with their dams until weaning. The calves were weaned on the 16th November, 24th October, 11th November and 19th October in years 1, 2, 3 and 4, respectively and were subsequently housed in a slatted floor shed.

The grassland area was divided into four equal areas. Each area was randomly assigned to one of two production systems (Semi-intensive and Extensive) to give two replicates per treatment similar to those described by Drennan, Fallon and Davis (2004). The cows and their progeny therefore grazed in four groups. Cows from each of the five breed types were randomly allocated (within breed) across the four grazing groups as they calved. The herds rotationally grazed a predominately perennial ryegrass *(Lolium perenne)* sward. The cows were vaccinated 1 to 3 months pre-calving against *E-coli* and Rotavirus and post-calving for *Leptospirosis* and Bovine Viral Diarrhoea. The calves were treated for lung and gastrointestinal worms during the pre-weaning grazing season and at housing.

<u>Cow serum, colostrum immunoglobulin concentration and subsequent immune status of their calves.</u>

This study was conducted over the second and third year of the experiment. The cows were blood sampled by jugular venipuncture commencing with the earliest calvers in mid-December. Samples were subsequently taken at monthly intervals from the whole herd and each cow was sampled at parturition. A further sample was taken at approximately 30 (15+) days post-partum. In order to present cow serum immunoglobulin concentration at three time-points pre-partum, the samples taken from each cow were allocated to the following categories according to the number of days pre-partum; 90 ($\geq$75), 60 (74 to 45) or 30 (44 to 15) days pre-partum. Immediately post-partum and prior to suckling a 20 ml sample of colostrum was obtained from the right front quarter of the udder, which has been shown to adequately reflect a representative sample from all four quarters (McGee, 1997). If no colostrum was available from the right front quarter, colostrum was taken from the right hindquarter.

Immediately post-partum tincture of iodine was applied to the umbilical cord of the calf. Colostrum was fed to a small minority of calves, usually following a difficult birth, using a stomach tube. A blood sample was obtained from all calves at 48 (40 to

56) h post-partum. The concentration of IgG_1 Y in serum and colostrum were measured quantitatively by single radial immunodiffusion procedures. Additionally, the zinc sulphate turbidity (ZST) test was performed on calf serum samples at 20°C, with the turbidity measured at 520 nm using a spectrophotometer.

Feed intake of cows

In year 2 individual *ad libitum* cow intakes of zero-grazed grass was recorded over 4 consecutive days (following 3 days acclimatisation) between July 19^{th} and August 30^{th}. Intake was recorded on cows from each of the four grazing groups separately using a minimum of 15 animals (at least 3 animals from each of the 5 breed types). The animals were removed from pasture and individually tied at random in a slatted floor shed. The calves were located in an adjoining pen and were restricted to twice a day suckling with grass offered *ad-libitum*. Fresh grass was mowed each morning (0800 hours) and baled using a round baler to facilitate easy transport to the sheds. Grass was offered with the objective of providing at least 0.1 in excess of the previous days' intake. The grass offered and refused was weighed and recorded daily. The refusals were discarded daily.

Individual *ad libitum* silage intakes of cows were measured over a 3-week period both in year 3 (4 days per week (14^{th} Feb - 7^{th} Mar)) and in year 4 (7 days per week (24^{th} Nov - 15^{th} Dec and 9^{th} - 30^{th} Jan)). In year 3 all the cows were tied at random in a slatted floor shed while in year 4 the cows were either individually tied or accommodated in individual loose pens bedded with wood chip. Fresh silage was offered daily to at least 0.1 in excess of intake. Refusals were weighed and discarded daily and twice weekly in years 3 and 4, respectively.

Samples of grass and silage were taken daily for dry matter (DM) determination. Grass DM was determined by drying at 98^{o}C for 15 hours and silage DM by drying at 40^{o} C for 48 hours. The grass and silage samples retained for chemical analysis were stored at $-25\,^{o}$C and subsequently thawed and composited to give 2 samples per 4 – 7 days recording. The silage juice extracts were stored at $-25\,^{o}$C.

Liveweights and body condition scoring

Cow liveweight was recorded at regular intervals over the entire year and additionally post-calving, turnout to pasture, weaning and housing. Liveweight of the progeny was recorded at birth, turnout to pasture, at regular intervals during the grazing season and at weaning. Body condition score of the cows was assessed at the time of weighing using the Scottish scoring method (Lowman, Scott and Somerville, 1976). The same operator carried out the assessments over the 4 years.

Milk yield

In years 2, 3 and 4, milk yield was estimated using the weigh-suckle-weigh technique at on average day 135 (67-199) of lactation. Two to three estimates per cow were obtained on consecutive days. During the recording period in year 2 the cows were individually tied in a slatted floor shed and offered fresh grass to appetite. In years 3 and 4 the cows remained at pasture. In order to facilitate measurements the calves were housed in a slatted floor shed in all three years. On the morning before the milk yield estimation commenced the calves were separated from their dams and were allowed access to them that evening to ensure that the dams were thoroughly suckled out prior to recording the following morning. They were subsequently allowed access to the cows in the morning and evening and were weighed to the nearest 0.1 kg before and after suckling. The separation period was 16.5 hours between evening and morning suckling and 7.5 hours between morning and evening suckling. Both differences were combined to give a 24-hour milk yield estimate.

Male progeny management

The male progeny were left intact in all years and information on performance to slaughter and carcass data is presented for the first three years. They were housed post-weaning (at 238, 210 and 212 days of age in years 1, 2 and 3, respectively) in a slatted floor shed for the duration of the finishing period (217, 254, 239 days in years 1, 2 and 3, respectively). The concentrate offered was barley-based and average intakes during the finishing period were 4.0, 4.5 and 5.5 kg/hd/day in years 1, 2 and 3, respectively. In years 1 and 2 the silage and concentrates were fed separately. In year 3 the silage and concentrates were fed separately for the first 61 days and subsequently as a total mixed ration (2:1 silage to concentrate ratio). In Years 1 and 3 the male progeny were penned by dam breed in groups. In Year 2 the bulls were tied-up at random during the final 105 days prior to slaughter in order to obtain individual intakes.

Female progeny management

The female progeny in years 1, 2 and 3 were housed post-weaning as per males. They were fed moderate quality (67 % DMD or more) grass silage plus 1 kg/head/day of a barley based concentrate until turnout to pasture (15th April 2002, 4th April 2003, and 1st April 2004 in years 1, 2 and 3, respectively). They remained at pasture for 192, 214 and 205 days in years 1, 2 and 3, respectively following which they were accommodated on wood chip out-wintering pads in years 1 (for 36 days) and 2 (for 27 days) and in a slatted floor shed in year 3 (for 47 days). During this final finishing period they were offered grass silage and a barley-based concentrate, which was initially fed at pasture. The average daily intake of concentrate during the finishing period was 3.3 (84 days), 3.5 (111 days) and 4.0 (96 days) kg/head/day in years 1, 2 and 3, respectively.

Liveweights and carcass assessment

Liveweights of progeny were recorded pre-slaughter and at regular intervals throughout their lifetime. Following slaughter at a commercial abattoir, perinephric plus retroperitoneal fat was weighed. Hot carcass weight was recorded from which cold carcass weight was calculated (hot carcass weight × 0.98). The carcasses were scored using the EU carcass classification system (Commission of the European Community, 1982) for conformation (E, U, R, O, P (worst)) and fat (1 to 5 (fattest)). The five scores for both conformation and fat were subdivided into 3 categories, giving a 15 point scale for each.

Carcass dissection

In year 1 each carcass was dissected into meat, fat and bone. The carcass was cut between the 12th/13th rib and 10th/11th rib for the male and female progeny, respectively. The weight of each meat cut (from which bone and dissectable fat had been removed) was recorded individually. The weight of fat and bone from each meat cut was combined across hind and fore quarter cuts separately, to give the total weight for both hind- and fore-quarter. The weight of meat was equal to the sum of meat cuts and lean trim weights. In year 1 there were seven retail cuts in the hindquarter (silverside, topside, striploin, rump, knuckle, fillet and flank steak) and six in the forequarter (chuck, cube roll, brisket, clod, shoulder blade and flat rib). In years 2 and 3 an eight rib Italian pistola (no flank) from the right side of each carcass was dissected for both male and female progeny. The pistola was dissected into eleven meat only retail cuts (topside, silverside, knuckle, rump, cube roll, striploin, fillet, heel, shin, cap of rib and tail of rump) and the procedure adopted was as outlined for year 1.

Feed intake and efficiency of bulls

In years 2 and 3 silage offered was weighed 3 or 4 days (Monday/Tuesday – Thursday) per week (54 and 42 days in years 2 and 3, respectively). Refusals were weighed daily but only discarded on Friday in year 2. In year 3 refusals were weighed and discarded on Friday from week 1 to 6. In weeks 7 to 10 refusals were weighed and discarded on Wednesday and Friday. Silage was offered to at least 0.1 in excess of intake. Net energy intake was calculated by reference to O'Mara (1996).

In year 1 silage samples (6) taken from the pit were used for dry matter determination and chemical analysis while 1 sample per month was taken of the concentrates being fed. Daily samples of silage and concentrates were taken for dry matter determination and chemical analysis in year 2 and samples (including feed) were taken twice weekly in year 3. The silage, concentrate and feed samples retained for chemical analysis in year 2 were composited to give 2 samples per week. Sample storage, dry matter determination and chemical analyses were carried out using methods described by McGee (1997).
Analyses for all feeds are shown in Appendix table1.

Live animal measurements

Ultrasonic muscle and fat

Ultrasound scanning equipment was used to obtain *in vivo* measurements of the depth and area of *M. longissimus dorsi* muscle and the depth of back fat. The cows were scanned in February (pre-calving) of years 3 and 4. The progeny were scanned at weaning (~250 days) and at slaughter (bulls ~450 days, heifers ~600 days) in years 2 and 3. The animals were scanned between the 12th and 13th rib and at the 3rd lumbar. An Aloka 500v ultrasound unit (Animal Ultrasound Services Inc., Ithaca, New York, USA) was used to scan the cows in year 3 and the progeny in both years while in year 4 the cows were scanned using a Dynamic Imaging Concept MLV unit (Dynamic Imaging Ltd., Livingston, Scotland). The same person operated the Aloka unit at all times while a second person also operated the Dynamic unit. The hair was clipped from the area to be scanned in order to improve the quality of the ultrasound images and to reduce the time taken to acquire a good image. Corn oil was applied to the animals hide in order to promote acoustical contact between the animal and the transducer. Using the Aloka 500v unit the *M. longissimus dorsi* muscle area and maximum muscle depth was measured at the 12/13th rib and the 3rd lumbar. Muscle depths at approximately 0.25, 0.50 and 0.75 across the width of the muscle were measured at the 12/13th rib only to give an average muscle depth. Fat depths at both locations were also measured. When using the Dynamic Imaging system to scan the cows in year 4 the only muscle measurement recorded was maximum depth at the 3rd lumbar. Fat depths were again recorded both at the 3rd lumbar and at the 12/13th rib.

Visual muscular scores

The cows were assessed post-housing using the Signet live animal visual muscular scoring system in years 1, 2, 3 and 4. The Signet muscular score is based on a scale of 1 to 15, where 1 represents poor conformation and 15 represents excellent conformation. The animals are assessed at 3 locations; development of round, rump width and loin/shoulder width and depth. The progeny were also scored using this system at birth, weaning (250 days) and at slaughter in years 1, 2 and 3. The same two persons scored the cows and their progeny at all times. The progeny were also visually muscular scored at weaning and slaughter using the Irish Cattle Breeding Federation (ICBF) scoring system. This system is also based on a scale of 1 to 15 but the animals were assessed at up to 9 locations (width at withers, width behind withers, loin width, rump width, thigh width, thigh depth, development of inner thigh, development of hind quarter and thickness of loin (x2)).

Skeletal and muscular measurements

Four live animal skeletal measurements were taken on the progeny at birth in years 1, 2, 3 and 4; chest circumference, chest width, pelvic width and head width. Skeletal measurements of the cows were carried out post-housing in years 1 and 3. They were measured at 11 locations; height at withers, height at pelvis, chest circumference, chest depth, chest width, pelvic length, pelvic width, hip width, hind quarter length, back length 1 and back length 2 (Doorley, 2001). The progeny were also measured at these locations pre-slaughter in years 1 and 2. Muscular measurements (Doorley, 2001) of the progeny were also carried pre-slaughter in years 1 and 2. They were measured at six locations; width behind withers, width between withers, loin thickness, hind quarter width (cows also), hind quarter development and length between patellae. The skeletal and muscular measurements were obtained using a measuring pole (180cm), two callipers (91cm and 30cm) and a measuring tape. The animals were held in a head gate in a crush, while standing on a level floor. Measurements were taken while the animal stood in a normal position.

Carcass measurements

Carcass measurements on the progeny were carried out in years 1 and 3 (de Boer *et al.* 1974). Six carcass measurements were taken; carcass length, carcass depth, leg length, round width, round circumference and leg width. The carcass was cut between the 12^{th} and 13^{th} rib for all progeny in year 2 and for the bull progeny in year 3 but between the 10^{th} and 11^{th} rib for the heifer progeny in year 3. The eye muscle area was measured by tracing the outline onto semi-transparent paper. This area was then traced onto paper of a known weight per unit area, which was cut out and weighed on an electronic scales to the nearest 0.0001g. This weight was then used to calculate the eye muscle area. The eye muscle depth was measured directly from the tracing paper using a ruler. The thickness of the fat cover over the eye muscle was measured with a battery-powered callipers. Three fat depths were measured at points 0.25, 0.50 and 0.75 across the width of the muscle to give an average depth.

Results

Cow and calf serum and colostrum immunoglobulin

The decrease in cow serum immunoglobulins (IgG_1) in late pregnancy was greater in LF cows than all other breed types except SLF (Table 1). The decrease in serum IgG_1 for LLF, L, C and SLF were similar. There was no effect of cow breed type on colostrum IgG_1 concentration. The progeny of LF cows had higher serum Ig concentration and ZST units than all of the other breed types except SLF. These two measurements were similar for the progeny of SLF, LLF, L and C cows.

Feed intake of cows

There was no effect of cow breed type on grass intake but when expressed relative to liveweight, intake was greater for LF and SLF than for L and C cows, while LLF were intermediate (Table 2). Silage DM intake was greater for C and SLF than L and LLF cows, while LF were intermediate. However, when expressed relative to liveweight there was no difference in silage intake between the cow breed types.

Liveweights, body condition scores and changes

Liveweight of C cows was greater than all other breed types while L were also heavier than LF and LLF (Table 3). Liveweights of L and SLF were similar as were LF, LLF and SLF. The decrease in LW over the winter period (indoors) was greater for L and C cows than LLF and SLF while LF were intermediate. The increase in LW during the grazing season was greater for C cows than for all other breeds types except L while the remaining 4 groups were similar. Annual LW changes were not affected by dam breed type. The correlation between pasture weight change and indoor change for years 1, 2, 3 and 4 was -0.40, -0.40, -0.73 and -0.54, respectively.

Body condition score was lower for LF cows than LLF, L and SLF with C cows intermediate. There was no affect of cow breed type on body condition score changes for any of the periods examined throughout the year.

There was no effect of cow breed type on gestation length (Table 3). Calving difficulty score was greater for C cows than LLF, L and SLF, while LF were intermediate.

Milk yield of LF and SLF cows was similar and greater than that of LLF, LF and C which did not differ (Table 4). Birth weight of calves from C cows was greater than all other breed types except L and lower for calves from LLF cows than all other breed types except SLF. Birth weight of calves from LF, L and SLF were similar. Daily gain from birth to weaning was greater for the progeny of LF cows than all other breed types except SLF who in turn were greater than progeny of L and C cows but similar to LLF cows progeny. The regression of progeny daily gain from birth to weaning on milk yield was significant for all breeds combined and separately. A 1 kg increase in milk yield for LF, LLF, L, C and SLF cows was associated with an increase of 37, 62, 59, 63 and 51 g, respectively in daily gain from birth to weaning of their progeny. The regression relationship was linear for all breed types but also quadratic for the LF.

<u>Post-weaning performance and carcass data</u>

The combined results for years 1, 2 and 3 for male and female progeny are given in Table 5 while results for males and females are presented separately in Appendix, Table 2. There was no effect of cow breed type on daily gain of the progeny from weaning to slaughter (Table 5). Daily gain from birth to slaughter was however, higher for progeny of LF and SLF cows than for L and LLF. The progeny of C dams had intermediate gains and differed only from LF progeny.

Slaughter weight was greater for progeny of LF and SLF cows than for progeny of L and LLF dams, while C were intermediate. Killing-out rate was greater for the progeny of L dams than all other breed types except LLF. There were no other differences in killing-out rate. Carcass produced per day of age was greater for the progeny of LF and SLF than LLF and L progeny while those from C were intermediate.

Carcass conformation score was higher for the progeny of L and C dams than for LF and LLF progeny while SLF was intermediate. Carcass fat score was lower for the progeny of L and C cows than LF and SLF progeny. The progeny of LLF dams had similar fat scores to all other breed types except C. Body conditions score was higher for progeny of LF cows than LLF, L and C progeny with SLF intermediate. Perinephric and retroperitoneal fat weight was higher for progeny of LF and SLF dams than L and C progeny with LLF intermediate.

The proportion of meat in the hindquarter was higher for the progeny of L cows than LF, LLF and SLF progeny with C intermediate. Progeny of L and C cows had similar proportions of fat in the hindquarter which were lower than that of the other three breed types between which there were no differences. Bone proportion in the hindquarter was higher for C cows progeny than all other breed types except LF. The L cows progeny had lower bone proportions than all breed types except LLF. There was no differences between the progeny of LF, LLF and SLF dams for this trait. The meat to bone ratio was higher for progeny of L cows than LF, C and SLF which were similar with LLF intermediate.

In years 2 & 3 combined the hindquarter formed a greater proportion of carcass weight for the progeny of L and C cows than LF and SLF while LLF was intermediate (Appendix Table 4). However, these differences did not occur in year 1 (Appendix Table 3). Although there were significant differences between the progeny of the different breed types in the proportion of each meat cut in the carcass these were generally small and not of practical importance. However, in year 1 the combined higher value cuts (striploin, cube roll and fillet) expressed as a proportion of carcass weight was greater for the progeny of L dams than all other breed type except C, the remaining breed types being similar. No such difference was evident in the combined results for years 2 & 3. When meat in each cut was expressed as a proportion of total meat the difference between the various animal types were minimal.

When measured for bulls in years 2 and 3, there was no significant effect of dam breed type on net energy intake expressed relative to liveweight or in feed conversion ratio.

Live Animal Measurements

Ultrasound muscle and fat measurements of cows

When measured in year 3, the LF cows had smaller muscle area measurements at the 3rd lumbar than all other breed types except SLF. L had greater muscle areas than all other groups, while LLF, C and SLF were similar (Table 6). Using the combined data for years 3 and 4, maximum muscle depth at the 3rd lumbar was significantly smaller for the LF cows than all other breed types between which there was no differences. When ultrasound measurements were expressed relative to liveweight the L cows had higher values for both muscle area (year 3) and depth (years 3 and 4) measurements at the 3rd lumbar than all breed types except LLF cows. The values for the remaining four breed types were similar. Results of measurements taken at the 12th/13th rib follow a similar trend to that outlined for the third lumbar values. Although there were significant dam breed type effects for ultrasound fat depth measurements in both years, these were generally small and inconsistent.

Progeny visual muscular scores and body measurements at birth

Using the Signet scoring procedure, progeny of L and C cows had greater muscle scores at birth than progeny of LF and LLL cows with SLF intermediate (Table 7). Some differences between progeny of the different cow breed types were evident in chest measurements and head width at birth with values for C generally exceeding LLF and SLF progeny. The correlations between calving difficulty score with progeny visual muscular scores and body measurements at birth were positive on all but one occasion but while occasionally significant explained only a small proportion of total variation (Table 8).

Ultrasound muscle and fat measurements of progeny

There were no dam breed type effects for progeny *longissimus dorsi* muscle measurements at the 3rd lumbar or fat depths over the muscle at weaning or slaughter (Table 9). However, when expressed relative to liveweight muscle measurements were generally greater for progeny of L cows than LF or SLF cows while progeny of LLF and C cows were intermediate. Progeny muscle measurements per 100 kg liveweight increased with increasing proportions of L genes in the dam. Muscle measurements taken at the 12th /13th rib followed a similar trend to that outlined for the 3rd lumbar.

Visual Muscular Scores

When measured post-housing, C and L cows had greater muscular scores than SLF and LLF cows who in turn had greater scores than LF cows (Table 10). There was no dam breed type effect on visual muscular scores of their progeny at weaning. The Signet muscular score at slaughter was greater for the progeny of C and L cows than progeny of LF and LLL cows while SLF progeny were intermediate. The progeny of C cows had greater ICBF scores at slaughter than progeny of LF, LLF and SLF cows with L intermediate.

Live animal skeletal and muscular body measurements of the cows and their progeny

There was no dam breed type effect for the majority of live animal body measurements of the cows post-housing or their progeny pre-slaughter (Appendix Table 5).

Carcass dimensions and carcass muscle and fat measurements of progeny

When measured in years 1 and 3 the progeny of LF dams had greater carcass length than all except SLF, greater carcass depth than all except L and greater leg length than all except C there being no differences between the remaining 4 breed types for these traits (Table 11). Maximum leg width was greater for the progeny of L dams than all other breed types, which were similar. There was no dam breed type effect for carcass muscle measurements of the progeny. Average carcass fat depth was greater for the progeny of LF dams than progeny of LLF, L and C cows with SLF progeny intermediate.

Discussion

The higher level of serum IgG_1 in the progeny of LF cows than all other breed types except SLF is a reflection of the greater transfer of IgG_1 from the cows blood to the mammary gland and a probable higher intake of colostrum (due to higher yield in LF as indicated by milk yield estimates) as the IgG_1 concentration in colostrum was the same for all breed types. As calves are born without immunoglobulins they are completely dependent on receiving them from colostrum to provide immunity against disease. IgG_1 is the immunoglobulin found in highest concentration in blood and colostrum and plays an important role in the calf's defence mechanism.

The greater grass DM intakes when expressed relative to liveweight of LF and SLF over L and C cows was at least partially due to the greater nutrient requirements due to higher milk yields of the former. Silage intakes were obtained during pregnancy and the greater values for SLF over L and LLF probably reflects the greater intake capacity of the Simmental over the Limousin breed. The greater intake of C over L and LLF would mainly be a reflection of the greater size of the C.

Cow liveweights were as expected with C heavier than all other breed types followed by L and with LF lightest. The greater weight gains of C compared the other breed types except L during lactation at pasture probably reflects their lower milk production and greater growth potential. However, annual LW changes were the same for all breed types. There was clear evidence of compensatory growth with those having the lowest gain in winter gaining most at pasture. The lower body condition scores of the LF cows compared to the other 4 breed types is not unexpected as these were artificially reared with fifty percent dairy breeding while the others were suckled with more beef breeding and they also had greater nutritional demands due to greater milk production. The absence of any differences in body condition score changes at any period of the year for the different breed types would indicate that subjective BCS is less effective in monitoring changes than liveweights.

Breed differences in calving difficulty score, which was greatest for C dams than all others except LF, were not due to differences in gestation length as it was similar for all dam breed types. It is apparent from the study that birth weight did influence the incidence of calving problems. However, the overall correlation co-efficient between calving difficulty score and birth weight although significant was low.

The higher milk yield of cows with dairy breeding and Simmental genes (i.e. LF and SLF) compared with purebred L and C is as expected. Likewise, the positive effect of milk production on calf pre-weaning performance is clearly shown from this study a fact that is widely documented in similar studies at Grange and elsewhere (Wright *et al.* 1994; McGee, 1997). Thus, the lower pre-weaning gains of the progeny of L & C compared to LF & SLF progeny is largely a reflection of the milk yield of their dams. The response in calf daily gain to milk yield was linear for all breed types and curvilinear for LF the highest yielding breed type. The greater growth response in the progeny to increased milk with the lower yielding breed types (LLF, L and C) evident in the present study has been shown in other studies (Drennan and Bath 1976b; Le Neindre *et al*. 1976; Russel *et al*. 1979)

The greater birth weights of calves from C dams than all the other breed types except L in the present study follows are as expected although McGee (1997) reported no difference in birth weight of calves from upgraded C and beef x Friesian cows. Fredeen *et al.* (1982b) concluded that progeny of both C dams and sires had greater birth weights than Simmental which in turn were greater than L. The absence of any difference in post-weaning gain from the progeny of the different breed types agrees with previous work at Grange (Drennan and Fallon, 1998) for the progeny of upgraded C cross and Hereford x Friesian cows. However, Rahnefeld *et al.* (1988) reported that progeny of C cross dams had greater daily gains during the feedlot period than those of Si crosses who in turn were greater than L crosses. The higher carcass weight for age of LF and SLF progeny than those from LLF and L dams again indicates that the extra pre-weaning gain was still evident at slaughter. This occurred despite the higher killing-out rate of L progeny than all others except the progeny of LLF dams. The superiority of the L breed in killing-out rate compared to the other breed types in the present study has been previously reported (Kempster, Cook and Southgate, 1982).

The better carcass conformation scores of the progeny of L and C cows than LF and LLF progeny in the present study is in agreement with previous reports showing the higher the proportion of late-maturing breed types the better the conformation score (Drennan 1999a, Kirkland et al 2002)

In agreement with results of the present study a number of other studies have shown that L progeny have a greater proportions of lean and a lower proportion of bone than C or S progeny (Kempster,Cook and Southgate, 1982; Rahnefeld *et al.* 1983). The lack of a significant difference in meat content between the progeny of all breeds except L in the present study is probably due to the fact that all progeny were at least 75% late-maturing breed types.

In general, the various indicators of fat (carcass fat score, perinephric and retroperitoneal fat weight and hindquarter fat content) showed that the progeny of the purebred L and C cows had the lowest fat content.

In a previous study Drennan and Fallon (1998) reported that pistola weight expressed relative to carcass weight was greater for progeny of upgraded C cows than for Hereford x Friesian cows. The present results also show a higher proportion of carcass in the pistola (higher value cuts) for the progeny of the purebred L and C cows but overall the differences between the progeny of the various breed types in meat distribution were relatively small.

The greater ultrasound muscle measurements of L cows and to a lesser extent their progeny compared to all other breed types agrees with previous results (Kempster, Cook and Southgate, 1982). There were no difference in the progeny of the different cow breed types in ultrasound muscle measurements at either weaning or at slaughter.

However, when expressed relative to liveweight muscle measurements were greater for the L progeny than LF and SLF with C and LLF intermediate.

The greater muscular scores at birth of the progeny of L and C cows than LF and LLF progeny with SCF progeny intermediate precisely mirrowed the findings for similar scores pre-slaughter and for carcass conformation scores. However, there was no dam breed type effect or visual muscular scores of the progeny when recorded at weaning. This clearly indicates that while live animal visual muscular scores are excellent indicators of muscularity/conformation this can only be shown if animals are provided with a high plane of nutrition. The absence of an effect at weaning is most likely due to the progeny of purebred L and C animals which were shown to have high muscularity/conformation on other occasions having lower pre-weaning gains (as a result of low milk intakes) than the LF and SLF progeny. This finding would suggest that scoring at weaning is less than an ideal time for monitoring muscularity unless progeny are provided with adequate creep feed to offset the effect of different milk intakes. Muscular scores taken on the cows largely reflected those obtained on the progeny with L and C having greater values than SLF and LLF who in turn had greater scores than the LF cows.

Difference in the various body measurements taken on the calves at birth largely reflect difference in mature size with C progeny tending to have higher values. Although such body measurements were positively correlated with the incidence of calving difficulty they explained only a small proportion of total variation.

Live animal skeletal and muscular body measurements generally did not show any difference between the breed types and were not considered very useful in describing the cows or their progeny.

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Table 1: Weekly change in IgG_1 cow serum pre-calving, colostrum IgG_1 concentration, and calf serum IgG_1 concentration and ZST units at 48 h post-partum

Variable	Cow breed [1]					s.e.[2]	F - test[2]
	LF	LLF	L	C	SLF		
Weekly change in IgG_1 concentration in cow serum (mg ml^{-1} $week^{-1}$)	-0.54[b]	-0.40[a]	-0.35[a]	-0.28[a]	-0.45[ab]	0.064	**
IgG_1 in colostrum (mg/ml)	79.7	76.4	75.7	95.5	89.3	7.87	
Immunoglobulins in calf serum at 48 h post partum							
IgG_1 (mg/ml)	27.1[b]	21.6[a]	20.6[a]	18.1[a]	24.2[ab]	2.15	**
ZST (units)	17.9[b]	14.0[a]	14.6[a]	12.6[a]	14.7[ab]	1.08	**

[1]LF = Limousin x Friesian, LLF = Limousin x (Limousin x Friesian). L = Limousin, C = Charolais. SLF = Simmental x (Limousin x Friesian).
[2]Maximum standard error.
[abc]Within rows, means with a different superscript differ significantly.

Table 2: Mean values for DM intake and intake expressed relative to liveweight of five beef cow genotypes

Variable	Dam breed					s.e.	F-test[3]
	LF	LLF	L	C	SLF		Breed
DM intake (kg) (No. of animals)							
Grass (Year 2)	11.0 (11)	10.4 (12)	9.9 (12)	12.5 (12)	11.6 (12)	0.88	
Silage (Years 3 & 4)	8.3 [ab] (26)	7.8 [a] (22)	7.0 [a] (24)	8.7 [b] (24)	9.2 [b] (28)	1.04	**
DM intake (g/ kg liveweight)							
Grass (Year 2)	22.5 [b]	19.4 [ab]	17.5 [a]	18.3 [a]	21.2 [b]	1.27	**
Silage (Years 3 & 4)	14.6	13.2	11.0	11.3	15.6	1.90	

[1] Year 2 parities 1 & 2; Year 3 parities 2 & 3; Year 4 parities 1,2 & 3

Table 3: Mean values for liveweight, body condition score, and changes, gestation length and calving score of five beef cow genotypes for years 1, 2, 3 and 4 combined

Variable	Dam breed					s.e.	F-test		
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)	B*P
No. of cows	31	36	21	15	28				
No. of records	81	76	62	53	83				
Liveweight (kg)									
Housing	552 [a]	574 [a]	616 [b]	702 [c]	582 [ab]	10.3	***	***	
Liveweight change (kg)									
Winter (Indoor)	-43 [ab]	-26 [a]	-52 [b]	-52 [b]	-32 [a]	6.01	**	**	
Grazing season	79 [a]	74 [a]	84 [ab]	101 [b]	69 [a]	6.4	**		
Annual	35	48	33	48	41	5.5			*[5]
[1]*Body condition score (units)*									
Housing	2.26 [a]	2.73 [b]	2.71 [b]	2.46 [ab]	2.66 [b]	0.118	**		
Body condition score change (units)									
Winter (Indoor)	-0.152	-0.251	-0.369	-0.039	-0.226	0.116			
Grazing season	-0.031	0.119	0.256	0.131	0.206	0.117			
Annual	-0.212	-0.114	-0.107	0.093	-0.039	0.107			
Gestation length (days)	291	288	290	290	290	1.45			
[2]Calving difficulty score (Scale 1-5)	1.89 [ab]	1.39 [a]	1.64 [a]	2.23 [b]	1.61 [a]	0.212	**		

[1] scale used was 0 to 5 (0 emaciated and 5 obese) [2]1 = unassisted and 5 = caesarean

Table 4: Mean values for milk yield (Years 2, 3 & 4 combined) and progeny birth weights and pre-weaning liveweight gains (Years 1, 2, 3 & 4 combined) of five beef cow genotypes

Variable	Dam breed					s.e.	F-test [2]	
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)
No. of cows	21	22	20	21	25	-		
No. of records	41	43	40	33	46	-		
Milk yield (kg/day)	9.7 ^{b}	7.0 ^{a}	5.5 ^{a}	6.9 ^{a}	8.7 ^{b}	0.47	***	
Calf performance								
Birth weight	47.9 ^{b}	43.4 ^{a}	48.7 ^{bc}	50.5 ^{c}	46.2 ^{ab}	1.34	***	
Daily gain birth to weaning (g/day)	1123 ^{c}	997 ^{ab}	918 ^{a}	982 ^{a}	1067 ^{bc}	30.6	***	*

Table 5: Mean values for liveweight, carcass weight, killing–out rate, weight gains and carcass traits for the bull and heifer progeny of five beef cow breed types for years 1, 2 and 3 combined

Variable	Dam breed					s.e.	F-test		
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)	B*P
Weaning weight (kg)	290.8 ^{c}	255.6 ^{a}	247.9 ^{a}	265.8 ^{ab}	278.6 ^{bc}	5.76	***	***	
Slaughter weight (kg)	573.1 ^{b}	536.2 ^{a}	532 ^{a}	553.1 ^{ab}	567.6 ^{b}	7.81	***	***	* [5]
Killing–out (g/kg)	554 ^{a}	562 ^{ab}	571 ^{b}	559 ^{a}	558 ^{a}	3.30	***	***	* [6]
Cold carcass (kg)	318 ^{b}	301.7 ^{a}	303.7 ^{a}	309.7 ^{ab}	317.3 ^{b}	4.78	**	***	* [7]
[1]Carcass conformation score	3.23 ^{a}	3.23 ^{a}	3.55 ^{b}	3.54 ^{b}	3.36 ^{ab}	0.093	**	**	
[2]Carcass fat score	2.88 ^{c}	2.81 ^{bc}	2.52 ^{ab}	2.46 ^{a}	2.83 ^{c}	0.100	***		
Body condition score	2.63 ^{b}	2.46 ^{a}	2.20 ^{a}	2.19 ^{a}	2.55 ^{ab}	0.126	**	**	*[8]
Perinephric & retroperitoneal fat (kg)	7.5 ^{b}	6.4 ^{ab}	5.3 ^{a}	5.4 ^{a}	7.0 ^{b}	0.369	***	**	
Daily gain (g / d)									
Weaning to slaughter	960	953	961	985	982	21.2		***	
Birth to slaughter	1014 ^{c}	950 ^{a}	931 ^{a}	969 ^{ab}	1004 ^{bc}	14.9	***	***	* [9]
Carcass	614 ^{b}	583 ^{a}	585 ^{a}	596 ^{ab}	613 ^{b}	9.5	**	***	
Hind quarter composition									
Meat (g/kg)	746 ^{a}	748 ^{a}	767 ^{b}	756 ^{ab}	748 ^{a}	4.7	***	***	
Fat (g/kg)	79 ^{b}	82 ^{b}	66 ^{a}	64 ^{a}	79 ^{b}	4.0	***	***	* [10]
Bone (g/kg)	175 ^{bc}	171 ^{ab}	166 ^{a}	181 ^{c}	173 ^{b}	2.3	***	***	
Meat to bone ratio	4.31 ^{a}	4.42 ^{ab}	4.68 ^{b}	4.25 ^{a}	4.37 ^{a}	0.079	***	***	

[1] Scale 1 to 5 (best conformation); [2]Scale 1 to 5 (fattest)

Values for breed by parity interaction where significant; Parity **(P)** = 1, 2 & 3; Breed (B) = LF, LLF, L, C, SLF

[5]Slaughter weight (kg) **P1** 514.7 ^{b} 491.0 ^{ab} 474.7 ^{a} 520.1 ^{b} 517.8 ^{b}; **P2** 598.5 ^{b} 562.2 ^{a} 564.3 ^{a} 551.9 ^{a} 575.3 ^{ab}; **P3** 606.3 555.4 557.1 587.4 609.8

[6]Killing–out rate (g/kg) **P1** 563 ^{a} 570 ^{a} 593 ^{b} 572 ^{a} 570 ^{a}; **P2** 544 ^{a} 552 ^{a} 561 ^{a} 548 ^{a} 549 ^{a}; **P3** 555 ^{a} 564 ^{a} 558 ^{a} 558 ^{a} 556 ^{a}

[7]Cold carcass (kg) **P1** 290.5 280.3 282.0 297.1 295.1; **P2** 326.2 311.3 317.2 303.3 316.9; **P3** 337.4 313.6 311.9 328.5 340.0

[8]Body condition score2 **P1** 2.02 2.01 1.65 2.17 2.20; **P2** 2.61 ^{ab} 2.40 ^{a} 2.30 ^{a} 1.92 ^{a} 2.63 ^{b}; **P3** 3.26 2.96 2.66 2.48 2.81

[9]Daily gain birth to slaughter (g) **P1** 905 ^{b} 871 ^{ab} 822 ^{a} 909 ^{b} 914 ^{b}; **P2** 1054 ^{b} 1000 ^{a} 986 ^{a} 966 ^{a} 1015 ^{ab}; **P3** 1083 980 986 1032 1084

[10]Hind quarter fat (g/kg) **P1** 58 ^{ab} 62 ^{b} 40 ^{a} 55 ^{a} 70 ^{b}; **P2** 82 84 78 65 77; **P3** 95 99 81 72 90

Table 6: Mean values for pre-calving ultrasonically scanned muscle and fat measurements of five beef cow breed types for years 3 and 4

	Year[1]	Dam breed					s.e. [1]	F-test[3]	
		LF	LLF	L	C	SLF		Breed (B)	Parity (P)
No. of cows	3	20	20	17	18	21			
	4	17	19	13	11	19			
3rd lumbar muscle									
Area (cm^2)	3	50.9 [a]	61.2 [b]	71.1 [c]	62.3 [b]	55.7 [ab]	2.56	***	
Max. depth (cm)	3 and 4	5.49 [a]	6.44 [b]	7.06 [b]	6.79 [b]	6.10 [b]	0.259	***	
3rd lumbar fat									
Avg. depth (mm)	3	3.2 [b]	3.3 [b]	2.5 [a]	1.7 [a]	3.0 [ab]	0.48	*	
Avg. depth (mm)	4	3.2	3.2	3.8	3.8	3.7	0.23	*	
Per 100 kg liveweight									
3rd lumbar muscle									
Area (cm^2)	3	9.1 [a]	10.2 [ab]	11.4 [b]	9.0 [a]	9.4 [a]	0.40	***	
Max. depth (cm)	3 and 4	1.02 [a]	1.09 [ab]	1.15 [b]	0.99 [a]	1.06 [a]	0.04	*	***

[1] Year 3 = Aloka 500v scanner, Year 4 = Dynamic Imaging scanner

[3] Breed*Parity P > 0.05 for all traits

Table 7: Mean values for visual muscular score and body measurements at birth for progeny of five beef cow breed types for years 1, 2, 3 and 4

Variable	Dam breed					s.e.	F-test[1]
	LF	LLF	L	C	SLF		Breed
No. of calves	79	77	61	45	75		
[2]Signet muscle score at birth	5.2 [a]	4.8 [a]	5.4 [b]	5.4 [b]	5.2 [ab]	0.26	**
Calf body measurements at birth (cm)							
Chest circumference	81.5 [b]	78.2 [a]	81.0 [ab]	81.7 [b]	80.1 [a]	1.06	*
Chest width	17.1 [ab]	16.5 [a]	17.5 [b]	17.5 [b]	16.6 [a]	0.34	***
Pelvic width	21.8	21.5	21.7	22.4	22.3	1.00	
Head width	12.6 [ab]	12.3 [a]	12.5 [a]	13.0 [b]	12.5 [a]	0.19	**

[1]Parity and Breed*Parity P > 0.05 for all traits; [2]Scale 1 to 15

Table 8: Correlation between calving score with visual muscular score and calf measurements at birth for bull and heifer progeny in years 1, 2, 3 and 4

		Calf measurements at birth				
Year	Sex	Signet muscle score	Chest girth	Pelvic width	Head width	Chest width
1	Bulls	0.49***	0.57**	0.04	0.30*	0.30*
	Heifers	0.03	0.24	0.25	0.16	0.24
2	Bulls	0.51***	0.51***	0.50**	0.28*	0.32*
	Heifers	0.30	0.32*	0.28	0.41***	0.28
3	Bulls	0.24	0.19	0.17	0.12	0.13
	Heifers	0.30	0.14	0.23	0.13	0.17
4	Bulls	0.45**	0.34*	0.17	0.17	0.45**
	Heifers	0.09	0.13	0.16	-0.08	0.13
1,2,3 & 4	Bulls	0.07	0.28***	0.06	0.28***	0.16*
	Heifers	0.10	0.21*	0.21**	0.10	0.20*

Table 9: Mean values for ultrasonically scanned muscle and fat measurements for the progeny of five beef cow breed types for years 2 and 3 combined

Variable	Dam breed					s.e.	F-test[1]		
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)	B*P
No. of progeny	36	35	27	26	38				
3rd lumbar muscle									
Weaning									
Area (cm^2)	42.9	41.2	39.6	41.1	41.3	2.27			
Max. depth (cm)	5.54	5.62	5.44	5.54	5.43	0.194			
Slaughter									
Area (cm^2)	70.9	69.6	69.6	72.9	70.2	2.92			
Max. depth (cm)	7.29	7.38	7.41	7.48	7.23	0.222			
Fat depth (mm)									
Weaning									
3rd lumbar	1.3	1.1	1.0	1.0	1.2	0.17			
Slaughter									
3rd lumbar	3.1	2.7	2.2	2.2	2.9	0.39	*		
Per 100 kg liveweight									
3rd lumbar muscle									
Weaning									
Area (cm^2)	15.4 ^{a}	16.9 ^{ab}	17.5 ^{b}	15.7 ^{a}	15.9 ^{a}	0.82	*	**	
Max. depth (cm)	2.01 ^{a}	2.32 ^{b}	2.40 ^{b}	2.14 ^{ab}	2.10 ^{a}	0.097	***	*	
Slaughter									
Area (cm^2)	12.5	13.1	13.4	13.0	12.4	0.51			
Max. depth (cm)	1.30 ^{a}	1.39 ^{b}	1.43 ^{b}	1.34 ^{ab}	1.29 ^{a}	0.045	***	*	

[1]Values for breed by parity interaction where significant; Parity **(P)** = 1, 2 & 3; Breed (B) = LF, LLF, L, C, SLF

[2] Weaning muscle area /100 kg lwt **P1** 22.3^{a} 29.2^{b} 32.4^{b} 23.3^{a} 26.6^{ab} **P2** 22.7^{a} 25.0^{a} 31.2^{b} 24.2^{a} 24.7^{a} **P3** 20.9 20.1 17.4 22.5 18.8

[3] Weaning avg. muscle depth /100 kg lwt **P1** 2.01^{a} 2.67^{b} 2.97^{b} 2.18^{a} 2.42^{ab} **P2** 1.82^{a} 2.16^{a} 2.68^{b} 2.18^{ab} 2.06^{a} **P3** 1.71 1.58 1.49 1.93 1.61

[4] Weaning max. muscle depth /100 kg lwt **P1** 2.68^{a} 3.52^{b} 4.12^{b} 2.84^{a} 3.25^{ab} **P2** 2.48^{a} 2.94^{b} 3.61^{c} 2.79^{ab} 2.78^{a} **P3** 2.31 2.28 2.02 2.56 2.14

Table 10: Mean values for visual muscular scores of five beef cow breed types and their progeny

Variable	Dam breed					s.e.	F-test[3]	
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)
No. of records for cows	88	82	69	61	86			
No. of cows	35	39	28	23	30			
Signet visual muscular scoring[1]								
Cows post-housing	5.5 ^{a}	6.8 ^{b}	8.0 ^{c}	7.8 ^{c}	6.2 ^{b}	0.20	***	**
Progeny								
Weaning	6.8	6.4	7.1	6.8	6.8	0.30		
Slaughter	7.4 ^{a}	7.5 ^{a}	8.5 ^{b}	8.3 ^{b}	7.7 ^{ab}	0.37	**	
ICBF visual muscular scoring[2]								
Progeny								
Weaning	7.8	7.8	7.9	8.1	8.1	0.34		
Slaughter	9.1 ^{a}	9.1 ^{a}	9.7 ^{ab}	9.9 ^{b}	9.5 ^{a}	0.29	**	

[1]Signet scorers over 4 years for cows & 3 years for progeny
[2] Irish Cattle Breeding Federation scorer over 3 years scoring at 3 locations at weaning and 5 locations at slaughter
[3]Breed*Parity P > 0.05 for all traits

Table 11: Mean values for carcass measurements of progeny of five beef cow breed types

Variable	Dam breed					s.e.	F-test[3]		
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)	B*P
[1]Carcass measurements (cm)									
No. of progeny	31	29	33	26	34				
Carcass length	132.9 ^{b}	127.5 ^{a}	126.5 ^{a}	129.7 ^{a}	129.9 ^{ab}	1.43	***		
Carcass depth	48.0 ^{b}	44.2 ^{a}	45.0 ^{ab}	44.6 ^{a}	43.7 ^{a}	0.94	***	*	***[4]
Leg length	72.2 ^{b}	69.9 ^{a}	69.9 ^{a}	70.9 ^{ab}	70.2 ^{a}	0.89	*	*	
Round width	42.6	42.5	40.6	43.9	42.7	1.39			
Round circum.	120.4	118.8	117.1	120.5	121.1	1.61			
Leg width (max.)	28.3 ^{a}	27.7 ^{a}	31.6 ^{b}	28.4 ^{a}	28.5 ^{a}	0.79	**	*	**[5]
[2]Muscle and fat									
No. of progeny	36	35	27	26	38				
Muscle area (cm^2)	110.7	107.4	117.9	110.0	108.9	4.17			
Muscle depth (cm)	8.45	8.43	8.54	8.61	8.48	0.525			
Fat depth (mm)	5.20 ^{b}	4.46 ^{a}	3.44 ^{a}	4.14 ^{a}	4.78 ^{ab}	0.66	*		*[6]

[1] Years 1 & 3 combined
[2] Years 2 & 3 combined and measured at the 12/13th rib for all progeny except for the heifers in year 3 which were measured at the 10/11th rib
[3]Values for breed by parity interaction where significant; Parity **(P)** = 1, 2 & 3; Breed (B) = LF, LLF, L, C, SLF
[4] Carcass depth **P1** 43.5 44.3 43.3 44.6 44.0 **P2** 55.1 ^{b} 43.6 ^{a} 46.8 ^{ab} 44.8 ^{a} 43.2 ^{a} **P3** 45.2 44.8 45.0 44.3 43.9
[5] Carcass leg width (max.) **P1** 28.0 27.0 27.3 27.9 27.2 **P2** 28.7 ^{a} 28.0 ^{a} 38.8 ^{b} 29.0 ^{a} 28.5 ^{a} **P3** 28.3 28.1 28.7 28.3 29.8
[6] Carcass fat depth **P1** 3.64 2.67 1.56 3.56 3.73 **P2** 6.05 5.35 4.30 3.90 3.96 **P3** 5.90 5.35 4.46 4.95 6.65

Appendix Table 1 Chemical composition of grass, silage and concentrates offered to cows and progeny

Year	Feed	Animals	Dry matter[1]	pH	NH_3N[2]	Crude protein[3]	Ash[3]	*In vitro* DMD[1,4]	Net energy[5]
2	Grass	Cows	173	-	-	158	96	772	-
3	Silage	Cows	167	3.9	57	146	89	658	-
4	Silage	Cows	218	3.8	64	139	90	667	-
1	Silage	Bulls	197	3.7	-	144	83	774	0.84
1	Silage	Heifers	163	3.8	-	155	92	713	0.76
2	Silage	Bulls	169	4.0	63	143	87	680	0.71
2	Silage	Heifers	159	3.8	-	142	82	743	0.80
3	Silage	Bulls	194	3.8	61	135	92	667	0.70
3	Silage	Heifers	158	3.9	-	-	89	697	0.74
3	Mixed Diet	Bulls	371	-	-	132	86	703	0.74
1	[1]Concentrate	Bulls & heifers	842	-	-	127	38	879	1.13
2	Concentrate	Bulls & heifers	855	-	-	128	39	882	1.13
3	Concentrate	Bulls & heifers	861	-	-	121	39	863	1.13

[1]Composition (g/kg): barley 865, soyabean meal 70, molasses 50 and minerals/vitamins 15

Appendix Table 2 Mean values for liveweight, carcass weight, killing–out rate, weight gains and carcass traits for the bull and heifer progeny of five beef cow breed types for years 1, 2 and 3 combined

Variable	Sex	Dam breed					s.e.[1]	F – test[2]	
		LF	LLF	L	C	SLF		Breed (B)	Sex (S)
Birth weight (kg)	M	46.6^{a}	43.0^{a}	48.0^{ab}	50.6^{b}	47.6^{a}	1.74	**	
	F	43.9	40.3	42.6	44.4	41.3	1.43		
Weaning weight (kg)	M	308.0^{c}	267.5^{a}	259.8^{a}	272.2^{ab}	291.1^{bc}	8.11	***	**
	F	273.3^{b}	243.5^{a}	236.9^{a}	255.8^{ab}	266.8^{b}	6.73		
Slaughter weight (kg)	M	596.2^{b}	561.7^{a}	547.5^{a}	561.5^{a}	588.4^{b}	11.45	***	***
	F	549.8^{b}	511.4^{a}	518.9^{a}	537.7^{a}	546.5^{ab}	9.20		
Killing–out rate (g/kg)	M	572^{a}	581^{ab}	588^{b}	572^{a}	578^{a}	4.8	***	***
	F	536^{a}	543^{a}	553^{b}	543^{ab}	537^{a}	3.9		
Cold carcass (kg)	M	341.0	325.9	321.6	321.0	339.8	6.99	**	***
	F	294.9	278.1	287.4	292.6	293.8	5.62		
Carcass conformation score[1]	M	3.32^{a}	3.42^{a}	3.72^{b}	3.56^{a}	3.62^{ab}	0.135	**	**
	F	3.13	3.05	3.38	3.43	3.02	0.109		
Carcass fat score[3]	M	2.59^{b}	2.39^{a}	2.09^{a}	2.20^{a}	2.41^{a}	0.144	***	*
	F	3.18^{a}	3.23^{ab}	2.98^{a}	2.81^{a}	3.30^{b}	0.118		
Body condition score[4]	M	2.45	2.16	2.03	2.17	2.28	0.184	**	*
	F	2.81	2.74	2.37	2.33	2.85	0.149		
Kidney + channel fat (kg)	M	7.7^{b}	6.2^{a}	5.0^{a}	5.4^{a}	6.3^{a}	0.53	***	
	F	7.3^{ab}	6.7^{a}	5.6^{a}	5.6^{a}	7.9^{b}	0.43		
Daily gain (g/ d)									
Birth to weaning	M	1189^{b}	1015^{a}	959^{a}	1003^{a}	1107^{ab}	35.6	***	**
	F	1038^{b}	927^{a}	870^{a}	952^{a}	1018^{b}	29.6		
Weaning to slaughter	M	1200	1228	1203	1231	1243	31.6		***
	F	718	681	724	732	714	25.1		
Birth to slaughter (g)	M	1196^{b}	1125^{ab}	1086^{a}	1113^{a}	1176^{b}	21.7	***	***
	F	833	775	785	811	832	17.4		
Carcass	M	742	708	700	699	740	13.8	**	***
	F	486	458	473	482	484	11.1		
Hind quarter composition									
Meat (g/kg)	M	748^{a}	756^{a}	772^{b}	755^{a}	757^{a}	6.8	***	*
	F	745^{a}	739^{a}	764^{b}	752^{ab}	736^{a}	5.9		
Fat (g/kg)	M	75	75	61	60	70	5.8	***	
	F	82^{ab}	88^{b}	70^{a}	69^{a}	89^{b}	5.0		
Bone (g/kg)	M	177^{bc}	168^{a}	167^{a}	185^{c}	172^{ab}	3.4	***	
	F	173^{a}	173^{a}	166^{a}	179^{b}	175^{ab}	2.9		
Meat to bone ratio	M	4.28^{a}	4.54^{ab}	4.71^{b}	4.18^{a}	4.47^{a}	0.114	***	*
	F	4.34^{ab}	4.31^{a}	4.65^{b}	4.24^{a}	4.22^{a}	0.098		

[1] Maximum standard error; [2] Breed*Sex P > 0.05 for all traits; [3] Scale 1 to 5 (best conformation); [4] Scale 1 to 5 (fattest)

Appendix Table 3: Mean values for the hind and fore quarter commercial meat only cuts and lean trim expressed relative to the cold carcass weight and the weight of meat in the carcass for the bull and heifers progeny of five beef cow breed types in year 1

Variable	Dam breed					s.e.[1]	F -test
	LF	LLF	L	C	SLF		Breed
Hind quarter							
Proportion of carcass weight (g/kg)							
Hind quarter	493	496	498	494	488	2.9	
Silverside	61^{a}	61^{a}	68^{b}	62^{a}	61^{a}	1.1	***
Topside	57^{a}	57^{a}	61^{b}	57^{a}	56^{a}	1.2	*
Striploin (S)	34	34	35	35	34	0.7	
Rump	34	33	33	33	33	0.6	
Knuckle	27^{ab}	27^{a}	29^{b}	27^{a}	26^{a}	0.6	**
Fillet (F)	16	16	16	16	16	0.3	
Flank steak	5	6	6	6	6	0.2	
Hind quarter lean trim	139^{ab}	138^{a}	144^{b}	139^{a}	134^{a}	2.1	**
S + CR + F	85^{a}	82^{a}	87^{b}	85^{ab}	84^{a}	1.1	**
Proportion of weight of meat in the carcass (g/kg)							
Silverside	85^{a}	86^{a}	90^{b}	85^{a}	85^{a}	1.1	**
Topside	78	80	80	78	79	1.3	
Striploin (S)	47	48	46	49	48	1.0	
Rump	46	46	44	45	46	0.7	*
Knuckle	37	37	38	37	36	0.7	
Fillet (F)	22	22	22	22	22	0.4	
Flank steak	8	8	7	8	8	0.2	
Hind quarter lean trim	192	194	189	191	187	2.1	
S + CR + F	117	115	114	118	118	1.2	
Fore quarter							
Proportion of carcass weight (g/kg)							
Fore quarter	506	502	502	506	512	3.1	
Chuck	45^{ab}	41^{a}	48^{b}	46^{b}	46^{b}	1.0	***
Cube roll (CR)	34^{ab}	32^{a}	35^{b}	34^{a}	34^{a}	0.7	*
Brisket	31^{a}	29^{a}	34^{b}	31^{a}	31^{a}	0.6	***
Clod	22^{a}	21^{a}	23^{b}	22^{ab}	21^{a}	0.5	**
Shoulder blade	20	20	21	20	20	0.4	
Flat rib	17^{a}	17^{a}	18^{b}	16^{a}	18^{ab}	0.5	*
Fore quarter lean trim	182^{a}	179^{a}	188^{b}	183^{ab}	180^{a}	2.1	**
Proportion of weight of meat in the carcass (g/kg)							
Chuck	62^{a}	58^{a}	63^{a}	63^{ab}	65^{b}	1.4	*
Cube roll (CR)	48	45	46	47	48	0.8	
Brisket	42^{a}	41^{a}	45^{b}	42^{a}	43^{ab}	0.7	**
Clod	30	30	31	30	30	0.5	
Shoulder blade	28	28	27	28	28	0.4	
Flat rib	23	24	24	23	25	0.7	
Fore quarter lean trim	252	253	248	252	252	2.4	

[1] Maximum standard error

Appendix Table 4: Mean values for the hind quarter commercial meat only cuts and lean trim expressed relative to the cold carcass weight and weight of meat in the hind quarter for the bull and heifers progeny of five beef cow breed types for years 2 and 3 combined

Variable	Dam breed [1]					s.e. [2]	F-test		
							Breed	Parity	B*P
	LF	LLF	L	C	SLF		(B)	(P)	
Proportion hind quarter and of each cut relative to cold carcass weight (g/kg)									
Hind quarter	487 ^{a}	494 ^{ab}	500 ^{b}	504 ^{b}	488 ^{a}	5.2	***	*	
Silverside	57 ^{a}	59 ^{ab}	61 ^{b}	58 ^{a}	58 ^{a}	1.4	*	*	
Topside	64 ^{a}	68 ^{b}	68 ^{b}	67 ^{ab}	65 ^{a}	1.5	**		
Striploin (S)	30	31	32	31	30	1.2			
Rump	40 ^{a}	41 ^{a}	42 ^{ab}	45 ^{b}	41 ^{a}	1.6	*		
Knuckle	40 ^{ab}	40 ^{b}	41 ^{b}	39 ^{a}	39 ^{a}	0.9	***	**	***[3]
Fillet (F)	19	19	19	20	19	0.6			
Cube roll (CR)	27	27	27	26	27	0.8			
Heel	16 ^{a}	17 ^{ab}	17 ^{b}	18 ^{b}	16 ^{a}	0.5	***		
Shin	14 ^{a}	14 ^{ab}	15 ^{b}	16 ^{b}	14 ^{a}	0.4	***		
Cap of rib	13	14	14	14	14	0.8			
Tail of rump	9	9	9	9	8	0.3			
Hind quarter lean trim	40	41	42	42	40	2.3			
S + CR + F	76	77	79	77	76	1.6			
Proportion of each cut relative to hind quarter meat (g/kg)									
Silverside	155.5	155.7	155.6	151.4	155.5	3.37			
Topside	173.0	176.5	175.0	173.8	174.9	3.22			
Striploin (S)	81.6	81.8	84.5	82.6	83.2	3.09			
Rump	107.2	107.8	108.7	117.6	110.0	3.45			
Knuckle	108.4 ^{b}	107.4 ^{ab}	106.9 ^{a}	101.2 ^{a}	104.5 ^{a}	2.43	*		*[4]
Fillet (F)	53.0	51.5	50.2	52.1	50.4	1.58			
Cube roll (CR)	73.5	70.5	70.2	67.0	72.1	2.38			
Heel	43.8	44.7	44.9	46.7	43.9	1.35			
Shin	38.9	38.3	38.5	40.6	37.6	1.12			
Cap of rib	35.7	36.4	35.2	36.2	37.4	2.24			
Tail of rump	23.5	23.4	22.1	22.5	22.8	0.88			
Hind quarter lean trim	119.3	108.8	111.1	109.6	110.0	6.57			
S + CR + F	207.2	203.1	203.5	201.4	205.1	3.66			

[1] Parities 1, 2 and 3 combined; [2]Maximum standard error

Values for breed by parity interaction where significant; Parity **(P)** = 1, 2 & 3; Breed (B) = LF, LLF, L, C, SLF;

[3]Knuckle relative to cold carcass weight (g/kg) **P1** 21.2^{bc} 22.0^{c} 22.1^{c} 17.0^{a} 19.4^{ab}; **P2** 19.7^{a} 20.5^{ab} 20.3^{a} 21.2^{b} 20.1^{a}; **P3** 18.5 18.3 19.3 19.8 18.4

[4]Knuckle relative to hind quarter meat (g/kg) **P1** 110.6 ^{b} 108.4 ^{ab} 110.6 ^{b} 86.7 ^{a} 102.1 ^{a}; **P2** 108.2 107.3 108.7 110.2 107.5;**P3** 106.4 104.9 102.9 106.7 103.9

Appendix Table 5: Mean values for body measurements of five beef cow breed types (years 1and 3) and their progeny (years 1 and 2)

Variable	Dam breed					s.e.	F-test[1]	
	LF	LLF	L	C	SLF		Breed (B)	Parity (P)
Skeletal measurements								
Cows post housing (cm) [2]								
Height at withers	129.2	129.8	130.4	132.6	131.0	0.99		
Height at pelvis	134.8	134.3	138.1	138.5	134.5	0.99		
Chest circum.	202.4^{a}	197.0^{a}	206.7^{ab}	216.3^{b}	193.9^{a}	4.72	*	*
Chest depth	74.4	74.3	75.4	75.9	75.6	1.03		
Chest width	46.5	48.6	49.9	51.4	48.4	0.88		
Pelvic length	52.5	52.2	52.9	55.9	52.3	0.78		
Pelvic width	49.3	49.5	50.3	54.0	49.4	0.83		*
Hip width	49.7	50.1	50.4	53.7	56.1	4.29		
HQ length	59.4	59.9	60.7	61.0	60.9	1.18	*	
HQ width	52.0	53.9	55.8	61.2	53.4	1.00		*
Back length 1	138.2	137.0	140.8	148.3	139.3	1.76		
Back length 2	90.5	88.8	91.8	96.0	90.8	1.41		
Progeny pre- slaughter (cm) [3]								
Height at withers	133.9	132.0	132.5	131.6	132.9	1.17		
Height at pelvis	143.9	141.4	141.8	141.6	141.7	1.29		
Chest circum.	190.3	186.1	186.5	186.2	189.2	1.89	*	
Chest depth	73.8^{b}	72.7^{a}	70.5^{a}	72.7^{ab}	74.1^{b}	1.06	**	
Chest width[4]	47.2	46.5	46.5	44.3	46.8	1.59		
Pelvic length	48.0	47.2	47.0	47.4	47.3	0.98		
Hip width	47.3	45.6	46.3	46.1	45.6	1.01		
HQ length	64.1	63.6	62.8	61.3	63.4	1.20		*
Back length 1	137.0	136.5	136.8	138.4	139.5	2.22		
Back length 2	87.6	87.6	88.2	89.6	90.7	2.03		
Ratios								
Weight/ ht. at withers	4.13^{b}	3.96^{a}	3.93^{a}	4.08^{a}	4.09^{ab}	0.084	*	
Weight/ ht. at pelvis	3.84^{b}	3.70^{a}	3.67^{a}	3.79^{ab}	3.84^{b}	0.076	*	
Progeny pre-slaughter muscular measurements[3]								
Width between withers	21.1	21.0	21.1	22.1	22.2	0.96		
Width behind withers	26.0	26.6	26.1	24.9	26.4	1.00		
Loin thickness	15.5	15.8	15.9	16.0	16.2	0.33		
HQ width	51.6	50.9	51.7	51.9	52.0	1.21		
HQ develop.	61.5	64.9	65.3	63.8	65.9	2.45		
Length between patellea	127.2	125.2	127.6	125.9	127.1	1.85		
Ratios								
HQ width/ ht at withers	0.38	0.39	0.39	0.39	0.39	0.009		
HQ width/ ht at pelvis	0.36	0.36	0.37	0.37	0.37	0.009		

[1] Breed*Parity P > 0.05 for all traits; [2,3]No. of (cows, progeny) = LF (43,36) LLF(38,37) L(37,32) C(33,24) & SLF(40,38); [4] Width of chest year 2 only