

Crossing Angus cattle with Limousin as a method of increasing meat yield

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ABSTRACT

The myostatin mutation in Limousin cattle affects both dressing percent and meat yield, without a negative impact on calving difficulty. A trial was designed to introgress this mutation into Angus cattle, using double-copy Limousin bulls to produce F1 Limousin x Angus. Crossing the F1 individuals would produce F2 individuals with a quarter carrying two copies of the mutation. A pure-bred Angus herd was maintained as a Control, for breed and genotype comparisons. A total of 269 F1, 34 F2 and 129 Angus calves were born in the first four years of this trial, before a lack of funding led to early closure. A total of 112 surplus bulls were slaughtered, and measurements taken over three years, including a "butchers' dissection" into saleable meat, fat and bone of one hind-quarter per animal. Limousin crosses were 9% heavier as yearlings, 7% heavier at slaughter and had 2.3% higher dressing percent (55.3% vs. 53.0%) than Angus. Hindquarters from Limousin crosses were 14% heavier than from Angus, and their meat yields were greater by 1.8% (77.0% vs. 75.2%), due mainly to breed differences in bone weight. Overall, the Limousin-cross advantage was 6.5 kg (17%) of saleable meat per hind-quarter, with most of the extra meat in high-value cuts.

Keywords: cattle; beef; meat yield; myostatin; mutation.

INTRODUCTION

Meat processing companies in New Zealand are moving to the use of yield-based payment systems following the installation of various technologies to estimate yield whilst a carcass is still on the chain. These systems will in time replace the current bonus/penalty system based on a visual three-level conformation score.

The traditional British breeds of Angus and Hereford are still widely used in hill country systems where offspring are mainly sold as weaners. In some cases, these cows are mated to terminal breeds to increase the value of weaners with higher growth rates and increased muscling.

A joint AgResearch-University of Adelaide QTL trial identified a mutation (*m*) in the myostatin gene in Limousin cattle which is responsible for moderate increases in dressing percentage and retail yield of meat (Esmailizadeh *et al.*, 2008). This mutation does not lead to increased calving difficulty, as the muscling effect is much less than that observed in Belgian Blue cattle. The action of the mutation is slightly recessive, meaning that two copies are required in an animal to derive the full benefit, with two copies of the gene having approximately four times the effect of a single copy of the gene. A trial was designed to introgress this mutation into Angus cattle (wild type myostatin, +/+) sourced from the Weight Selection line at Whatawhata (Morris & Cullen, 1995), whilst still preserving the productive assets of the Angus cow under hill-country conditions.

In a large breed comparison at Ruakura in the 1970s, the Limousin and six exotic breeds of cattle from Europe were compared with Angus, Hereford, Friesian, and Jersey bulls when mated to Angus and Hereford cows. Limousin-sired calves had the lowest birth weights, calving assistance and calving difficulty of the seven exotic breeds, and highest calf survival to 48 hours (Baker *et al.*, 1990). They grew more slowly to 13 months than the other exotics, and this continued to pre-slaughter weight and carcass weights when slaughtered at 20 and 31 months of age, with Limousin crosses having the highest dressing percent (Morris *et al.*, 1990). They were ranked low (lean) for fat depth and almost top for eye muscle area. For reproduction, comparisons of Limousin-cross females with Angus and other breeds and crosses were reported (Morris *et al.*, 1993). Overall, Limousins appeared to be very similar to Angus or Hereford in terms of live weight but had increased muscling which led to higher yields of lean meat, offset by much poorer reproductive performance.

The economics of beef cow production systems hinge mainly on the ability of a cow to get in calf repeatedly, produce a live calf which survives to weaning and then produces a marketable carcass. Under hill country conditions, the Limousin-Angus would appear to be at a disadvantage to a pure Angus breed, except for its carcass attributes.

The trial described here was an attempt to increase muscling in the Angus breed by introducing through introgression an alternative copy of a muscling gene from the Limousin breed,

using cross-breeding and subsequent interbreeding. Two copies of the myostatin gene would be introgressed, with as many of the Angus advantages as possible being retained through selection. Every animal would be genotyped for the mutation from the F2 stage until complete fixation in the population, and the changes in carcass traits and productivity from this introgression were to be evaluated. Funding constraints led to termination after four years. The objective of this paper is to present the results up to termination, with full details of live weight and carcass data from the F1 and early data from the F2 generations.

MATERIALS AND METHODS

Ethics

This work was carried out with the approval of the AgResearch Ruakura Animal Ethics Committee.

Trial design

Limousin bulls available from “artificial insemination” companies and two Limousin breeding herds were screened to ensure they were carrying two copies of the myostatin mutation (m/m). In 2003 and 2004, synchronised artificial insemination (AI) using four bulls over Angus cows (three-year-old and older at mating) was followed by tail-up matings using six m/m Limousin bulls. In 2005 and 2006, four m/m Limousin bulls were used across Angus cows to produce further F1 progeny, and six F1 $m/+$ bulls were mated to F1 $m/+$ heifers to produce the first F2 progeny. Mendelian sampling meant that, from the F2, we should expect that a quarter would carry two copies (m/m) of the myostatin mutation. Two-year-old Angus cows were not inseminated with Limousin semen, to avoid any potential calving problems due to calf size. All F2 bulls were genotyped and only m/m individuals retained as potential sires to subsequently be used across all crossbreds to increase the proportion of double-copy animals in the herd. A pure-bred Angus herd was maintained as a Control, with seven bulls used in this four-year period, to provide a breed comparison as well as to test differences between breeds and the generated genotypes of Angus ($+/+$), Limousin x Angus F2 ($+/+$, $m/+$ and m/m).

Calves were tagged and weighed at birth and identified to their dams. A total of 432 calves being 303 Limousin x Angus (269 F1 and 34 F2) and 129 Angus, were recorded in the first four years of this trial (Table 1). Calves were then weighed at approximately two months of age when their dams were drafted for the next mating and again at weaning at approximately 5 months of age. All live calves were retained. Calves were routinely weighed until the bulls were slaughtered or the heifers joined the breeding herd. Adult cows were weighed three times a year; at the start of mating, at weaning and

TABLE 1: Numbers of calves born by breed and year of birth.

Year	Breed		
	Limousin x Angus		Angus
	F1	F2	
2004	70	-	47
2005	80	-	26
2006	85	5	12
2007	34	29	44
Total	269	34	129

prior to calving. Bull calves born in the first year were transferred to the AgResearch Tokanui farm where they grazed until slaughter at 20 months of age. Subsequent crops of bull calves and all heifers were grazed on AgResearch Whatawhata. Yearling bulls were chosen at 13 months for use as service sires in the appropriate herd; selection was based on liveweight gain, scrotal circumference and the requirement to sample as many of the founder Limousin bulls as possible.

All heifers were mated over an 8 to 9 week period from 14 to 16 months of age; generally for two cycles of single-sire mating followed by one cycle where all cows and heifers were mated to a group of bulls of the required breed-type. This was to avoid sub-fertile bulls affecting pregnancy rates.

Reproductive traits

Cows were pregnancy tested by manual palpation *per rectum*, with ultrasound scanning as a confirmation in difficult cases. Empty cows were culled. A total of 199 mating records were taken over three years, with ages of females ranging from 15 months to 3-year-old. Calvings in only two seasons were recorded (72 records), as in the third year cows were culled after pregnancy testing due to termination of the trial.

Carcass traits

Bulls, apart from those retained as future sires, were slaughtered through the Ruakura Abattoir in May/June at around 20 months of age. This applied to all surplus bulls born in 2004 and 2005, and to about half of the 2007 calf crop. The severe drought in late summer 2008 meant that the 2006-born bulls had to be sold prematurely, without carcass details recorded. In total, 112 bulls had carcass data recorded (76 Limousin x Angus (69 F1 and 7 F2) and 36 Angus). Weights of individual organs and internal fats were recorded at slaughter and hot carcass weight (HCW) and a conformation score were obtained from abattoir records. The following morning after being held in a chiller for approximately 22 hours, one hind-quarter from each animal was boned out into individual joints using a

“butchers” dissection procedure, and the weight of saleable meat, fat and bone for each hind-quarter recorded. Total weights and proportions of each were then calculated. Complete dissection data were obtained on 107 of the 112 bulls processed. The exception was five animals from the 2005 calf crop.

The small number of F2 progeny produced and evaluated meant we were not able to evaluate the effect of two copies of the myostatin mutation and are only able to report the differences between Limousin x Angus and purebred Angus. This also means that we cannot separate the effect of the myostatin mutation from the Limousin breed effect as a whole.

Data analysis

Data were analysed using JMP (SAS, 1995). Models were fitted with the following fixed effects: breed of calf, year of birth, age of dam, with age of calf at the measurement date of each trait as a covariate. All two-way interactions were fitted and those that were significant (P <0.05) were retained in the final model.

RESULTS

The results for F1 and F2 animals have been combined because of the small numbers of F2 individuals produced before the trial’s termination. The DNA sample taken from the seven F2 animals was not of sufficient quality to ascertain the myostatin-copy status. However, we would expect F2 individuals on average to have means similar to

F1 individuals but possibly reduced due to the reduction in any heterosis. Also the variability of measures on F2 individuals would also be increased due to the random assortment of genes inherited from the purebred grandparents.

Limousin crosses were heavier than Angus at all ages (Table 2) but the difference reduced as animals aged, being 15 to 17% heavier at birth and at two months of age, 9% heavier as yearlings and 7% at slaughter.

Carcass traits

The Limousin-cross bull carcasses were heavier by 10% (Table 3), reflecting the higher dressing percentage of 55.3%, compared to Angus at 53.0%. Their hindquarter was 14% heavier than that of Angus and the yield of saleable meat from the hindquarters of Limousin crosses was 77.0% compared to 75.2% for Angus. This was due mainly to differences in bone weight between the two breeds, with a much smaller difference in trimmed fat since the slaughtered animals were bulls. In total, there was an increase of 6.5 kg (17%) of saleable meat from one hind-quarter or 13 kg of hind-quarter meat from a whole carcass. A high proportion of this extra meat came from high-value cuts.

There were no significant breed x location interactions for any of the carcass traits recorded, in spite of a 65 kg (16%) difference in pre-slaughter weight between bulls at Tokanui (2004) vs. Whatawhata (2005, 2007), and a 5.3 percentage-point difference in dressing percentage.

TABLE 2: Count and least square mean of live weight (kg) by breed for all animals from birth to 13 months of age, and for all experimental bulls prior to slaughter.

Trait	Breed				SED	Difference (%)	Significance
	Limousin x Angus		Angus				
	Number	Mean	Number	Mean			
Birth weight	301	28.6	126	24.8	0.5	15.4	**
In weight (~2 mo.)	275	84.9	106	72.6	1.4	16.9	**
Weaning weight (~5 mo.)	275	170.7	104	151.6	2.6	12.6	**
Yearling weight (~13 mo.)	235	299.9	81	274.0	5.3	9.5	**
Pre-slaughter weight (~20 mo.)	76	444.2	36	415.7	8.5	6.9	**

TABLE 3: Counts and least square means of carcass traits by breed, for bulls slaughtered at 20 months of age.

Trait	Breed				SED	Difference (%)	Significance
	Limousin x Angus		Angus				
	Number	Mean	Number	Mean			
Hot carcass weight (kg)	76	246.1	36	224.4	5.6	9.7	**
Dressing percentage (%)	76	55.3	36	53.0	0.4	4.3	**
Hind-quarter weight (kg)	76	57.9	36	50.7	1.2	14.2	**
Hind-quarter meat weight (kg)	71	44.6	36	38.1	1.0	17.2	**
Hind-quarter meat percentage (%)	71	77.0	36	75.2	0.2	2.3	**

TABLE 4: Overall means for pregnancy and calving data by breed. All differences between breeds were non-significant ($P > 0.05$). Pregnancy rate calculated from three mating years with the remainder of the traits calculated from first two years only, as all animals were culled after pregnancy testing in the third year.

Trait	Number of records	Breed				
		Limousin x Angus		Angus		
		Number	Mean	Number	Mean	
Pregnancy rate (%)	Heifers	127	98	69	29	69
	Two-year-old	70	43	81	27	70
Calving percentage (% of cows pregnant)	72	43	77	29	83	
Weaning percentage (% of calves born)	57	33	82	24	83	
Calves weaned/cow joined (%)	108	70	39	38	53	

Reproductive traits

Over all ages, the pregnancy rates for the two breeds were very similar at 73% for Limousin-crosses and 70% for Angus (Table 4). However, in 2005, the first year of mating Limousin-cross heifers, we achieved only a 39% pregnancy rate in the F1 heifers compared to 68% for the Angus. The subsequent heifer matings achieved pregnancy results of 81% and 70% for Limousin crosses and Angus respectively, although only small numbers of Angus heifers were involved.

The percentage of cows calving from those that were retained in-calf was 77% and 83% for Limousin crosses and Angus, again with the first heifer mating showing very poor maintenance of pregnancy. Only 45% and 62% of those Limousin-cross and Angus heifers diagnosed as pregnant subsequently produced a calf. Later matings had much better embryo survival ranging from 88% to 100%, for Limousin-crosses and Angus respectively. Calf survival from birth to weaning, although slightly poorer in the first year, averaged 82% and 83% for the two breeds. The percentage of calves weaned per cow joined overall for the two years where the cycle was completed, were 39% and 53% respectively; a very poor result because of the poor performance in the first year of mating heifers.

DISCUSSION

With the early termination of this trial before large numbers of F2 individuals were born, it was not possible to test the benefits of double-copy carriers of the Limousin mutation (m/m) on carcass composition. However, the 13 kg (17%) of extra saleable meat in the hind-quarters of the F1 individuals, and the expectation that m/m animals would have more than that because of the partially recessive nature of the gene, shows the potential of this intercross for beef production. The 5.3 extra percentage points of dressing percentage at Tokanui from bulls heavier by 65 kg at slaughter might indicate that either, animals should be grown to

heavier weights to exploit the genetic potential, or else sold and/or moved after weaning to better producing pastures than are available under typical North Island hill country conditions.

With the limited reproductive records, we confirmed the issue identified in the large breed comparison at Ruakura in the 1970s; namely poor pregnancy results in the F1 individuals. Limousin-crosses in the Ruakura trial had an average age of puberty of 423 days or approximately 14 months. This is almost the age at which yearling heifers are mated, leading to poor pregnancy results. The fact that the Angus heifers also had lower pregnancy rates than usual, point to some systemic difference. This could be due to mineral deficiencies, or to the fact that the 2004-born heifers were almost 20 kg lighter at the start of mating than they were at the more successful mating in the succeeding year.

Limousin cattle have had a reputation of poor temperament. Some examples were evident in this trial. However, the Breed Society has made rapid progress with the issue of temperament through recording and selection, and removing sires with poor Breeding Values for Docility from their list of recommended bulls. With this example, we believe that this issue could be resolved very quickly with selection in F2 individuals.

Angus cattle have a large advantage in being naturally polled. Limousins are a horned breed, although the polled gene, along with a black coat, have been introgressed by breeders over the past 30 to 40 years. One of the Limousin bulls used by artificial insemination was a Polled Black. This is another trait which would easily be handled by selection, especially now that gene tests are available for identifying homozygous polled animals. The absence of horns means that scurs are possible. There was a large increase of scurs appearing in the Limousin crosses, from the near zero incidence occurring in the Angus cattle.

Heterosis has been reported as being of the order of 2% to 6% for live weight in the large

Ruakura trial. Estimates were much higher for reproductive traits from the same trial, ranging from 12 to 21%. The levels of heterosis would be expected to be the same in this trial but would reduce with continued intercrossing; although gains from selection could counteract this.

Our objective of breeding a cow with the productive assets of the Angus breed under hill country conditions but with the ability to produce a more muscled animal was not completed, through the early termination of this work. However, we were able to show the benefits of a single copy *m/+* in animals produced in the intermediate stage. Only further work over several generations would be able to test whether a cow with a *m/m* genotype for myostatin and the productive genes of an Angus would be more productive in these conditions. Productive longevity, the ability of a cow to repeatedly get in calf and produce a live calf will remain the critical economic traits for beef cows on hill country. The ability to produce a more valuable carcass should also lead to increases in profitability.

ACKNOWLEDGEMENTS

We wish to acknowledge the AgResearch staff who were involved with this work; from the artificial insemination team in the beginning, farm staff at both Whatawhata and Tokanui for the management and recording of these animals, Marty Berg who performed the pregnancy testing, and the Ruakura Abattoir staff who assisted in the collection of data at slaughter. This experiment was conceived by Allan Crawford of Invermay and we are grateful to AgResearch Farms for their support over the six years of this trial. Most of the funds for this study were provided by AgResearch Ltd.

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