

CROSSBREEDING STRATEGIES FOR PHENOTYPIC UNIFORMITY OF PRODUCTION AND CARCASS CHARACTERISTICS

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Summary

A crossbreeding strategy with an objective of phenotypic uniformity was designed to address problems associated with traditional crossbreeding strategies. A distinct component of this strategy was the use of composite bulls, which are increasingly available. The crossbreeding strategies, compared by use of simulation, were a 3-breed rotational and a new "uniformity" strategy. Overall, the uniformity strategy significantly improved phenotypic uniformity at desirable levels of production and carcass characteristics. Composite bulls were shown to be effective in contributing to both heterosis and uniformity at a desirable level of production.

Introduction

The main components of a feasible crossbreeding strategy include maximizing heterosis both in cows and calves and complementarity of phenotypes. Complementarity can be described as matching breeds or animal types in such a way that the calves produced from the mating of a bull and a cow are superior phenotypically compared to either parent. However, traditional crossbreeding strategies, such as a 3-breed rotation can produce problems, some of which include heifer replacement, phenotypic uniformity of both production and product, and achieving a desirable level of production. The objective of this research was to compare a 3-breed rotational crossbreeding strategy to a new phenotypic uniformity-based crossbreeding strategy. The uniformity crossbreeding strategy was devised to achieve high levels of heterosis, utilize complementarity, and incorporate solutions for the problems previously mentioned for other crossbreeding strategies. A distinct component of the uniformity strategy was the use of composite bulls and does not require using only purebred sires, as with most other crossbreeding strategies.

Methods

A simulation was constructed utilizing across breed genetic, phenotypic, residual and fixed effect parameters that were obtained from Beef Improvement Ontario (BIO) and the U.S. Meat Animal Research Center (MARC). Heterosis estimates were multiplicative such that as phenotypic performance changed so did the amount of heterosis. A total of 16 traits were simulated and included: birth weight direct and maternal, weaning weight direct and maternal, post weaning gain, yearling height, slaughter weight, carcass weight, marbling score, rib-eye area, back-fat, mature cow weight, mature cow height, mature cow condition, gestation length, and age at puberty.

Potential herd bulls were simulated as yearling test bulls with a random genetic merit. Bull breeds were assigned randomly, producing 750 purebred and 750 composite bulls per yearly crop of test bulls. Ten breeds were used in the simulation such that the percentage of purebred bulls were 10% Hereford, 15% Black Angus, 15% Red Angus, 15% Charolais, 20% Simmental, 10% Limousin, 5% Gelbvieh, 5% Blonde D'Aquitaine, 2.5% South Devon and 2.5% Shorthorn. Composite bulls were simulated such that all breeds in the purebreds were present in the composite population and that F1 (2 breed) bulls were 84% of the composites, F2 (4 breed) were 12%, and F3 (8 breed) were 4%. A new crop of test bulls was simulated for each of the 10 production years.

Cows were initially simulated as purebred Hereford with average genetic merit and age. Cows were randomly assigned to herds such that each herd had 100 cows. In total 100 herds were simulated, and so there were 10000 cows in the starting year. Each herd was assigned a random phenotypic mean in the starting year of the simulation. The herds were randomly assigned to either the 3-breed rotational strategy or the uniformity crossbreeding strategy, resulting in 50 herds per strategy.

The rotational strategy herds selected only purebred bulls in a specific rotation. The general form of the

rotation was Hereford X Exotic Maternal X Exotic Terminal. Rotational strategy herds had a fixed replacement rate of 20%. The breeding objective for the rotational herds was maximization of total maternal weaning gain. Bulls from the test bull crop were selected for natural service and used 1 year and then culled. A 20:1 female to bull ratio was maintained because all bulls were yearlings.

The uniformity strategy was designed with an overall objective of maximizing heterosis in the calves equally with performance. Either composite or purebred bulls could be selected. The performance criterion was established for each cow each year such that the overall objective of selection was for the herd mean performance to be equal to the performance targets (Table 1) for each trait. A group of cows from each herd was identified that were producing calves the closest to the desired performance targets. This group of cows (called the replacement female nucleus) was then assigned to be bred AI and the resulting heifers considered for replacements. The number of cows in the female replacement nucleus fluctuated over time. Approximately 40 cows per uniformity strategy herd were assigned to the female replacement nucleus to be bred AI, leaving approximately 60 cows to be bred by natural service for terminal calves. Cows assigned to the terminal group were divided into groups of 20 such that the cows were as similar as possible in terms of production. The breeding group's average performance was then used to select a bull from the test bulls that closest matched the group performance needs and maximized heterosis. The female replacement nucleus cows were then individually mated to AI bulls, which were selected from the test bulls, to produce optimum replacement heifers and maximize retained heterosis.

The simulation was carried out for 10 years of production for the 100 herds producing 95000 calves in total.

Results and Discussion

Although many traits were studied, this paper will deal only with the traits slaughter weight, carcass weight, marbling score, back-fat, and rib-eye area.

Uniformity was measured as the amount of phenotypic variation present in the calves produced each year. The unit of measure for variation is the phenotypic

standard deviation. For a group of animal's measured for a trait, we would expect 94% of the measurements to fall within a range of four standard deviations around the average. Therefore as the calculated standard deviation becomes larger so does the range in animal measurements. The comparison of the uniformity herds to the 3-breed rotational herds was used to evaluate the effectiveness of the uniformity strategy in producing improved uniformity or, equivalently, reduced variation.

Slaughter weight uniformity was significantly improved in the uniformity strategy compared to the 3-breed rotation. (Fig. 1) As expected from the slaughter weight results, carcass weight results showed the same overall pattern over time as slaughter weight and showed a significant improvement in uniformity compared to the rotational crosses over all years (Fig. 2).

The traits back-fat and rib-eye produced results that were quite similar to each other as illustrated in Figs. 3 and 4. The overall patterns illustrated an improvement in uniformity in years 2 through to year 9. Statistically back-fat variation was significantly reduced for the uniformity strategy. Rib-eye area variation was not significantly different between the two strategies because additional variation was introduced through replacement heifers from the replacement female nucleus.

Marbling score is a trait that is currently receiving a great deal of attention mainly due to its association with meat quality. Fig. 5 illustrates the results for marbling score variation over time. Overall, a significant reduction in variation in favor of the uniformity strategy occurred. As reported in Table 1, one of the overall targets for the uniformity strategy was for a high level of marbling (equivalent to a high AAA). This study illustrates that uniformity for marbling score could be achieved at a high level of production.

Conclusions

The uniformity crossbreeding strategy produced improved uniformity in both production and carcass characteristics at slaughter compared to the 3-breed rotational crossbreeding strategy. Composite bulls were used in the uniformity strategy and were effective in contributing to improvement in uniformity

of production and product.

Significance to the Industry

Crossbreeding strategies can be developed that improve uniformity of production and product while still achieving genetic improvement in economically important traits and high levels of heterosis. Composite bulls can be used to improve uniformity in a correctly structured crossbreeding strategy, as well

as to genetically improve production and carcass characteristics.

Acknowledgements

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Table 1: Phenotypic Targets for the Uniformity Strategy

Traits	Performance Goal
Slaughter Weight (kg) ^a	550
Carcass Weight (kg) ^a	330
Carcass Back-Fat (mm) ^b	7.0
Rib Eye-Area (cm ²) ^d	87.10
Marbling Score (score) ^c	5.5

^a Slaughter weight and carcass weight in Canadian Quality Audit ideal range.

^b Back-fat level was set as mid A1 level

^c Marbling Score was targeted as mid AAA.

^d Rib-Eye Area estimated to be an ideal portion size for a boneless striploin (8-oz).

Figure 1.

Figure 2.

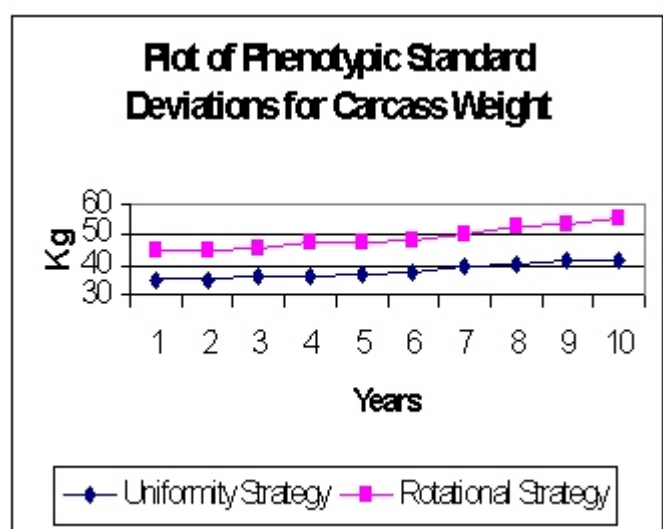
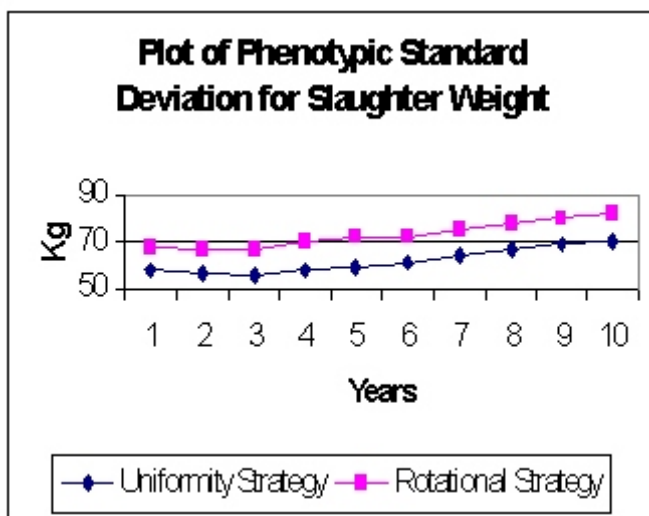


Figure 3.

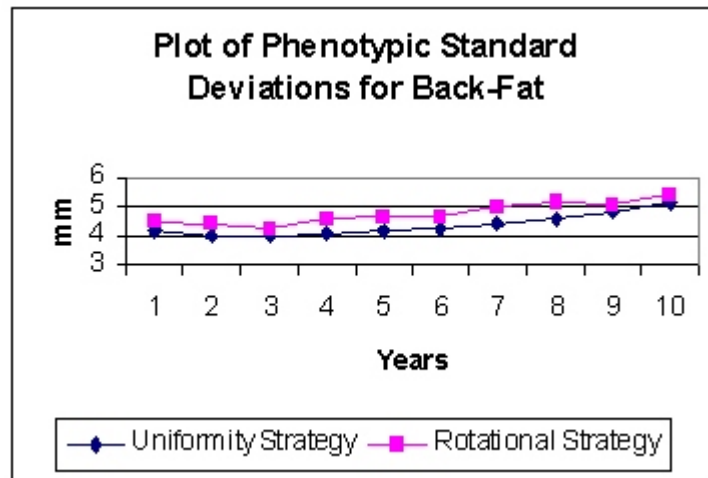


Figure 4.

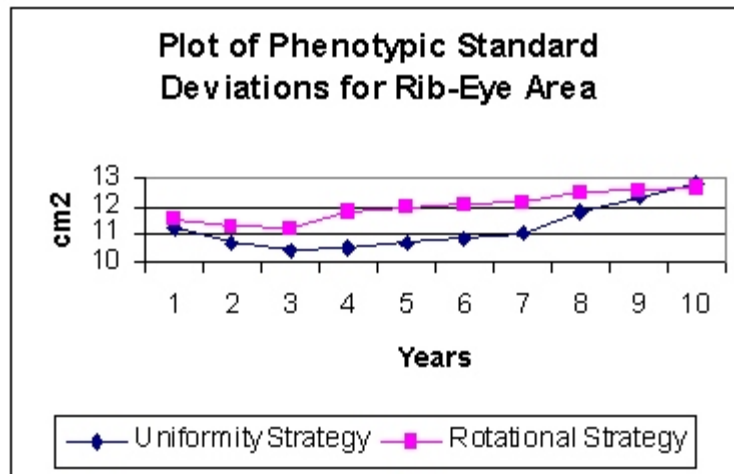


Figure 5.

