SENSITIVITY OF RANKINGS OF BEEF SIRES FOR NON-LINEAR MULTIPLE TRAIT BREEDING OBJECTIVES

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INTRODUCTION

Selection of beef sires to improve a population of animals (either purebred or composite) and choice of sires to use in commercial production programs involving crossbreeding are two distinctly different aspects of beef cattle breeding. Selection based on the use of a linear additive breeding objective, even for non-linear economic functions, has been justified by Goddard (1983), using current genetic levels and optimal management. An example of the development of a linear additive breeding objective has been given by Wilton and Goddard (1996). The economic values were based on the classical approach of using the partial derivatives of the economic function with respect to changes in each genetic variable independently, evaluated at the current population means. Procedures for choosing sires for use in commercial production have, on the other hand, been based on absolute progeny performance for a variety of traits, as evaluated through a bio-economic model of production (e.g. Barwick *et al.,* 1994 ; Wilton *et al.,* 1998). Customization of evaluations is possible through these bio-economic models for variables such as price grids and population means as influenced by choices of breeds and crossbreeding programmes. The importance of customization in terms of considering price grids in evaluating sires has been shown by Wade *et al.* (2001).

The objective of this paper is to compare the rankings of sires as evaluated using a linear additive breeding objective and as evaluated through a bio-economic modeling approach with varying levels of population means of traits. This comparison is based on a population of Charolais bulls evaluated for growth, feed intake, scrotal circumference, backfat, longissimus muscle area and marbling in central evaluation centers as the population of sires to be ranked.

MATERIAL AND METHODS

Data were available on 62 Charolais sires evaluated in central evaluation centers in Ontario, Canada in 2001 as part of the Beef Improvement Ontario (BIO) bull evaluation program. Sires were evaluated for total gain on test over 112 days, feed intake over 112 days, and backfat, longissimus muscle area, scrotal circumference and marbling at end of test.

Sires were evaluated for a linear breeding objective ($T = v'\hat{g}$), using the genetic evaluations for the traits listed above (the vector $\hat{g}$ containing across breed genetic evaluations) and economic values (the vector v being estimated from the impact of a unit change in genetic value of each trait holding other traits constant in a bio-economic model). The bio-economic model used was described by Wilton *et al.* (1998). This bio-economic model represented an integrated beef production program. Revenues were based on market animals (males and surplus replacement females) and cull cows. Prices included consideration of non-linear price grids relative to market weight, yield and marbling. Costs included feed, labour, housing, and other variable costs for both the feedlot and cow-calf sectors of the program. Economic values were calculated for two situations. One set of values was generated for progeny performance levels for Charolais-Angus crossbred progeny with the Charolais used as the terminal sire breed, and another set for progeny levels of purebred Charolais.

Sires were also evaluated for net economic value as calculated from absolute predicted progeny performance for market weight, marbling grade, retail yield and feed intake. Absolute progeny performance levels included consideration of the population means of the Charolais (sire line) and Angus (dam line) breeds used in a simple terminal sire by dam line cross. Performance levels for carcass weight, retail yield, feed intake, and marbling were based on the genetic evaluations for gain on test, feed intake on test, and backfat, longissimus muscle area and marbling at end of test. Population means of the Angus were studied over a range of –2 to +2 genetic standard deviations for gain on test and backfat.

The price grid structure was one in which there was an optimum market weight with discounts for over- and under-weight carcasses and in which there were varying non-linear prices for differing categories of marbling. Proportions of progeny in each grid category were calculated based on the predictions of performance described above.

Rank correlations were calculated among the evaluations of sires for each possible cow population as well as with the evaluations based on the linear breeding objectives.

RESULTS AND DISCUSSION

Rankings of Charolais bulls in this study were very sensitive to the average levels of both growth potential (measured by post-weaning growth) and finishing ability (measured by backfat at end of test) of the cow populations to which they were assumed to be mated (table 1). For example, the rank correlation of bulls was only 0.33 if they were evaluated for use in a population of somewhat lower finishing Angus cows (1 genetic standard deviation lower on average than the base population Angus values) than if they were evaluated for use in a population of somewhat higher finishing Angus cows (1 genetic standard deviation higher on average). The impact of changes in the cow populations was not as pronounced for changes in growth potential of these populations, but the rank correlation was still only 0.46 for the parallel change in population averages to those discussed above. Differences in the impacts of different population averages are due to different impacts on the non-linear economic functions involved. In the pricing system in this study there was an optimum market weight with significant discounts for over-weight carcasses. Carcass weight predicted for the progeny population was dependent on both growth potential and finishing ability of the sires and the cow population. Finishing ability was somewhat more important than growth in the predictions of carcass weight.

Rankings for bulls evaluated for use in a Charolais cow population had a correlation of 0.58 with those based on use in the base Angus population. Correlations were considerably higher in those populations of Angus that were higher for post-weaning growth or lower for backfat than the base population since these would be closer to the average levels of traits in the Charolais population.

Rankings of bulls based on linear indexes derived from the bio-economic model followed the same pattern of relationships as population means changed for backfat (table 2) or post-weaning gain (table 3). Rankings of sires evaluated using a linear index in which economic values were obtained from the bio-economic model with cow population means at the average of the Angus breed had a correlation of 0.49 with rankings based on a linear index in which economic values were obtained using the Charolais breed means for the cow population (table 3). This correlation was somewhat lower than the 0.58 value found for the similar situation with bio-economic evaluations. Evaluations of purebred sires based on progeny results in that purebred population would clearly be inappropriate for use in commercial populations or for breed improvement of a population to use in crossbreeding.

Table 1. Spearman rank correlation coefficients between bio-economic evaluations at varying population means for backfat and post-weaning gain (n = 62) [A]

	Angus (-2)	Angus (-1)	Angus (0)	Angus (+1)	Angus (+2)	Charolais (0)
Angus (-2)		0.97	0.76	0.49	0.44	0.94
Angus (-1)	0.99		0.63	0.33	0.28	0.99
Angus (0)	0.91	0.93		0.91	0.89	0.57
Angus (+1)	0.43	0.46	0.71		0.99	0.27
Angus (+2)	0.40	0.42	0.68	0.98		0.22
Charolais (0)	0.27	0.30	0.58	0.97	0.98	

[A] Above diagonal, mean backfat is varied by indicated number of genetic standard deviations. Below diagonal, post-weaning gain is varied by indicated number of genetic standard deviations.

Table 2. Spearman rank correlation coefficients between bio-economic evaluations and linear indexes (n = 62) [A] for differing backfat genetics in the cow population

	Linear index	
Bio-economic evaluation	Angus base	Charolais base
Angus (-2 BF)	0.70	0.94
Angus (-1 BF)	0.56	0.98
Angus (0 BF)	0.98	0.56
Angus (+1 BF)	0.94	0.25
Angus (+2 BF)	0.92	0.25
Charolais (0)	0.51	0.99

[A] Mean backfat (BF) is varied by indicated number of genetic standard deviations.

Table 3. Spearman rank correlation coefficients between bio-economic evaluations and linear indexes (n = 62) [A] for differing post-weaning gain genetics in the cow population

	Linear index	
Bio-economic evaluation	Angus base	Charolais base
Angus (-2 PWG)	0.94	0.25
Angus (-1 PWG)	0.96	0.28
Angus (0 PWG)	0.98	0.56
Angus (+1 PWG)	0.64	0.96
Angus (+2 PWG)	0.62	0.97
Angus base linear index	--	0.49

[A] Mean post-weaning gain (PWG) is varied by indicated number of genetic standard deviations.

Rank correlations were high between the evaluations from linear indexes and those from the bio-economic model (0.98 for sires used on an Angus cow population). These evaluations would be expected to be high because they are based on the same bio-economic model using the same progeny means. The correlations were not unity because the evaluations from the bio-economic model use absolute progeny performance of each sire and the subsequent effect on net revenue rather than the impact of changes in traits at the general progeny population mean. These correlations would not necessarily reflect the possible sensitivities of rankings of sires across breeds because the range in sire effects would be larger and subject to greater differences from optimum levels of traits.

CONCLUSION

Rankings of populations of Charolais sires evaluated for use on a range of populations were found to be very sensitive to the means of those populations, at least for the two traits of backfat and post-weaning growth rate. The progeny performance levels of these traits influenced prediction of carcass weights which were subject to non-linear pricing involving an optimum level. Selection criteria in such cases of non-linearity require careful definition of commercial population means.

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