VALUE OF DNA MARKER INFORMATION FOR BEEF BULL SELECTION[1]

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INTRODUCTION

There is clear value associated with using DNA information to identify animals that are carriers of recessive alleles. Tests are now available for specific genetic defects, color, and horned/polled status. Prior to the advent of DNA tests, the only way to test if a bull was a carrier of a genetic defect was to do progeny testing. Even then, definitive conclusions could only be drawn if he sired an afflicted calf. DNA-marker technology can also be used to verify or assign parentage, and this has value in terms of pedigree integrity or assigning paternity to calves conceived in multi-sire breeding pastures. Recently, a range of genetic tests have been developed to test for production traits ranging from fertility and longevity to growth and carcass merit. A question that often arises in conversations with producers is “What is the value of these tests?”

The answer to that question depends on what the tests are being used for. Some breeders are testing animals and listing the results as an additional source of information in sale catalogs. If this adds value, increasing the animal’s sale price beyond the cost of the test, then this makes economic sense. Other people are using tests to make culling or selection decisions on traits that are not currently in breed EPDs (e.g. feed efficiency or tenderness). Working out whether this pays is a little more complicated. While these traits have obvious value, without more information, it is not possible to decide how much emphasis should be placed on these traits versus other important traits. For example, should you eliminate animals from your herd based solely on a poor feed efficiency DNA test result? That depends on how accurate the test is at predicting superior versus inferior animals. The more accurate a test is, the more opportunity there is to accelerate genetic improvement. It also depends on the importance of feed efficiency versus all the other traits contributing to your overall profitability. One way to make this decision is to develop a “selection index” that weights all traits on their relative economic importance. Indexes consider the "input" or expense side of selection decisions and enable cattle producers to make balanced selection decisions, taking into account the economically-relevant growth, carcass and fertility attributes of each animal to identify which animals are the most profitable for their particular commercial enterprise.

From the perspective of a seedstock breeder, the response to selection and therefore the value associated with the use of a DNA test is dependent upon how much the DNA information improves the accuracy of genetic evaluations at the time of selection, and the value of a unit of

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genetic improvement. To determine the value of DNA testing I recently did a simulation study with a hypothetical multi-trait DNA test and asked "**What is the value of DNA tests to increase the accuracy of beef bull selection in the seedstock sector?**"

Structure of the seedstock herd. A simple two-tier industry example was modeled where the seedstock breeder was incurring the costs of DNA testing to improve the accuracy of bull selection. In this example the seedstock tier consisted of a closed nucleus of 600 breeding females (Table 1). It was assumed that in the absence of DNA test information, breeding value estimates on young, untested bulls were informed by their own performance records on selection criteria (Table 2) along with those of their sire, dam and 20 paternal-half sibs. Each year the top 8 bulls were selected to be stud sires, and 125 (remaining bulls from the top half of the calf crop) were made available for sale to commercial producers. Commercial sires were then used to sire four calf crops at a mating ratio of 25 females: 1 male (i.e. they were exposed to a total of 100 cows if they were in the herd for 4 breeding seasons).

Parameters	**Value**
Number of live stud calves available for sale/selection per exposure	0.89
Stud cow:bull ratio	30
Number of stud cows	600
Number of bulls calves available for sale/selection	267
Number of stud bulls selected each year	8 (~3%; i = 2.27)
Number of bulls sold for breeding (annual)	125 (~50%; i = 0.8)
Cull for age threshold of cow	10
Age structure of breeding cow herd (2-10 yr)	0.2, 0.18, 0.17,0.15, 0.12, 0.09, 0.05, 0.03, 0.01
Bull survival (annual)	0.8
Age structure of bulls in stud herd (2-4 yr)	0.41, 0.33, 0.26
Age structure of bulls in commercial herd (2-5 yr)	0.34, 0.27, 0.22, 0.17
Planning horizon	20 years
Discount rate for returns	7%
Maximum age of commercial sire	5 (4 breeding seasons)
Commercial cow:bull ratio	25
Number of commercial females	9225

Table 1. Attributes of the modeled seedstock and commercial herd structure.

Breeding objectives and index accuracy.

Breeding objectives were developed for both maternal (self-replacing) and terminal herds targeting either the domestic Australian market where steers are finished on pasture (GRASS), or a high value market where steers are finished on concentrate rations in feedlots and marbling has a high value (FEEDLOT). The proportion of trait genetic variation explained by the DNA test (r^2) was set to the h^2 of ALL selection criteria (Table 2). Selection index theory was used to predict index accuracy. Discounted gene flow methodology was used to calculate the value derived from the use of superior bulls. These values were then compared to selection based on performance recording alone as a baseline. It was assumed that all of the bulls in the annual cohort were DNA tested to enable selection of the best 3% as stud sires, and 50% as sale bulls. The extra cost of using DNA testing was assumed to be only the cost of the test, and resulting benefits were expressed on a per DNA test basis.

Selection Criteria	Heritability
Birth weight	0.39
200 d Weight	0.18
400 d Weight	0.25
600 d Weight	0.31
P8 fat	0.41
RIB fat	0.34
Eye Muscle Area	0.26
Intramuscular Fat	0.25
Scrotal Size	0.39
Days to Calving	0.07
Mature Cow Weight	0.41

Table 2. Selection criteria available from performance recording, and heritabilities (h^2).

Results and discussion.

Variable	Unit	Information available	GRASS INDEX		FEEDLOT INDEX	
			Terminal	Maternal	Terminal	Maternal
Selection response improvement resulting from DNA testing	%	Performance records	.	.	.	.
		Records + DNA test	20%	26%	24%	41%
Value of ΔG in commercial sires selected from top half of stud herd	(AU$/ bull)	Performance records	301	318	245	345
		Records + DNA test	363	396	306	480
Value of ΔG in stud sires selected from top 3% of stud herd	(AU$/ bull)	Performance records	17899	15922	14579	16751
		Records + DNA test	21617	19724	18211	23110
Increased value derived from DNA testing commercial sires	(AU$/ DNA test)	Performance records	.	.	.	.
		Records + DNA test	31	39	30	67
Increased value derived from DNA testing stud sires	(AU$/ DNA test)	Performance records	.	.	.	.
		Records + DNA test	111	114	109	191
Total value per DNA test to seedstock operator	(AU$/ DNA test)	Performance records	.	.	.	.
		Records + DNA test	**143**	**153**	**139**	**258**

Table 3. Improvement in selection response (%) resulting from a DNA-test enabled increases in index accuracy as compared to performance recording alone, value of genetic gain (ΔG) in commercial and stud sires, and value derived per DNA test used to increase the accuracy of male selection in a closed seedstock breeding program.

DNA test information was combined with performance records to increase the accuracy of EPDs. This increased selection response 20-41% over that obtained with performance recording alone, depending upon the index (Table 3). Because DNA information is particularly useful to improve genetic predictions for traits that cannot be measured on juvenile individuals, the DNA-enabled selection response was highest for the maternal feedlot index, because the delayed measurement of maternal and carcass traits means that these traits are hard to improve based on phenotypic measurement The value of DNA-tests to enable more accurate selection of genetically-superior commercial bulls ranged from AU$61-135 for commercial bulls, and AU$3,631-6,359 for stud bulls. Assuming that the entire bull calf crop (n = 267) was tested and that the top 3% (n=8) bulls were selected as stud sires, and the remaining top half of the bulls (n=125) were sold as commercial sires, the breakeven value of the genetic gain derived from DNA testing ranged from AU$143-258 per test.

It is important to understand that these values assumed commercial producers were willing to pay a price premium for genetically-superior bulls, and some form of industry vertical integration or profit sharing between sectors such that benefits realized by downstream sectors (e.g. feedlot, processor) of the beef cattle supply chain were efficiently transferred back to the seedstock producer incurring the expense of DNA testing. The value of DNA tests to increase the accuracy of selection criteria to improve traits of direct value to commercial cattle enterprises (e.g. maternal traits like cow weaning rate or mature cow weight) would be less than that calculated for the total industry merit indexes modeled in this study. For example, 69% of the returns from including DNA data in commercial sire selection for the terminal feedlot index were derived from improved dressing %, saleable meat %, and marbling score; traits that generate to the processing sector.

These results were based on using a relatively powerful hypothetical DNA test panel that predicted ***ALL*** of the selection traits with relatively high accuracies[2]. The accuracy of DNA-based predictions of breeding value is dependent on trait heritability and the size of the training set used to develop the test. A DNA test like the one modeled in this simulation study might be expected if it was developed using a relatively large (~2,500 animals) genotyped training population.

The values obtained in this study assumed that the commercial bull:cow ratio was 1:25. A 20% increase in this ratio (i.e. increasing it from 1:25 to 1:30) would increase the values in Table 3 by 20%. A major determinant of seedstock profitability is the proportion of young bulls that can be sold for breeding, and eliminating half of possible sale bulls from contention based on DNA testing may be unrealistic. Some seedstock breeders may only be interested in using DNA information to improve the accuracy of replacement stud sire selection for their own herd, and

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[2] Note that the term accuracy here is referring to the genetic correlation (r) between the test result and the true breeding value, not the "BIF" accuracy.

$$Accuracy(r) = \sqrt{1 - (1 - ACC_{BIF})^2}$$

$$ACC_{BIF} = 1 - \sqrt{1 - r^2}$$

not to additionally select the better half of the commercial bulls for sale as was modelled in this study.

If a breeder instead chose to sell all physically-sound bull calves, the value associated with testing commercial sire candidates would disappear. However, it would increase the value of replacement stud bulls due to the larger number of marketable descendants each stud bull would produce. For example, selling 80% of the bull crop as commercial sires, assuming 20% were culled for non-genetic reasons, would increase the value of a stud bull selected based on performance records for the terminal feedlot market from $14,579 to $24,143. If the DNA information from the hypothetical test modeled in this study was additionally used to select those replacement stud bulls, the value derived from each stud bull selected would also increase ~ 66% to $30,157. The value per DNA test in this case would depend upon what proportion of the bull crop was tested to select replacement stud bulls. If the seedstock operator continued to test 100% of the bull calves, this value would be ~ $180/test.

Until recently, commercialized DNA tests for beef cattle targeted only a handful of traits (e.g. marbling score, tenderness and feed efficiency). As DNA testing becomes more comprehensive and encompasses a larger number of traits, it will become increasingly important to integrate this information into national cattle evaluations. The incorporation of this DNA test information into carcass trait evaluations by the American Angus Association (www.angus.org/AGI/GenomicEnhancedEPDs.pdf) represents an important milestone in the application of DNA testing in beef cattle. It is difficult to make optimal selection decisions or even estimate the value of these multi-trait DNA tests in the absence of information on their accuracy, and the incorporation of DNA test results and target traits into genetic evaluations. However these developments will require the availability of additional genotyped, phenotyped populations to obtain the required genetic parameter estimates. Further, breeds may need to develop their own populations that are distinct from the original discovery populations to develop breed-specific estimates of the genetic parameters that will be required for the inclusion of DNA information into genetic evaluations. Although DNA information clearly has the potential to provide value to seedstock producers, making optimal use of this information will likely require the concurrent development of multi-trait selection indexes for breeding objectives of relevance to U.S. beef production systems.