TECHNICAL BULLETIN
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GMX GENEMAX Advantage™

GENEMAX ADVANTAGE REFRESH & EXPANSION

For commercial Angus replacement females

KEY POINTS

- GeneMax® Advantage™ is a genomic test for prospective commercial Angus replacement females that are high-percentage Angus breed composition. GeneMax Advantage provides commercial users of Angus genetics with the most advanced genetic information available for making whole-herd selection, breeding and marketing decisions.
- GeneMax Advantage predictions are based on marker effects derived from the single-step Angus National Cattle Evaluation (NCE), by Angus Genetics Inc. (AGI®), enabled by up to 1.8 million seedstock animals tested by Angus breeders that were available as of Summer 2025.
- GeneMax Advantage delivers genomic predictions for 22 individual traits, including the newly added Functional Longevity (FL), Teat Size (Teat), and Udder Suspension (UDDR) trait scores. It also includes three economic index scores (Cow, Feeder and Total Advantage) and five Angus dollar value indexes (Maternal Weaned Calf Value ($M), Beef Value ($B), Feedlot Value ($F), Grid Value ($G) and Combined Value ($C)).
- The $Values are directly comparable to those for registered Angus sires, and all the genomic predictions provided with GeneMax Advantage are benchmarked with percent ranks against nearly 130,000 tested commercial Angus replacement heifer candidates. This gives customers a clear view of how their animals compare to the historic population of GeneMax tested females.
- GeneMax Advantage allows direct access to a customer's registered Angus bulls' genomic profile for parentage determination, with no additional retesting.
- This latest version of GeneMax Advantage generally explains larger proportions of genetic variation across maternal, feedlot, management and carcass traits, and correlations between index values and component traits indicate favorable predicted correlated response.
- Simulated return-on-investment (ROI) in testing and selection based on $Combined ($C) or Total Advantage index scores as compared to traditional selection, indicated projected average ROI over 10 years of $3.40: $1 or $3.23: $1 respectively, assuming selected females produce an average of six calves.

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INTRODUCTION

The availability of genetic predictions for beef seedstock versus commercial cow-calf producers is a "Tale of Two Worlds". Historically, seedstock producers have had an abundance of genetic information at their fingertips, while most commercial cow-calf producers only have sparse access to similar information about their cow herds and calf crops. Thanks to genomics, that began to change in the spring of 2014 with the introduction of GeneMax Advantage, designed jointly by Angus Genetics Inc. (AGI®), the American Angus Association® and Zoetis, and offered exclusively through AGI.

GeneMax Advantage is for commercial females that are high-percentage Angus breed composition, and its features are designed to better inform replacement heifer selection and breeding decisions. The traits, economic index scores, as well as Angus sire parentage components of GeneMax Advantage were specifically developed to complement Angus bull-buying based on genomically-enhanced expected progeny differences (GE-EPDs) powered by HD50K™ and Angus GS℠. The 2024 addition of $Values to the GeneMax Advantage portfolio – and updates in Summer 2025 - enables commercial cattlemen to confidently compare their commercial females to the seedstock Angus bulls they are targeting to use in their herds.

Replacement heifer selection and breeding decisions are challenging and economically impactful for commercial cow-calf producers. Replacement costs for heifers and bulls often rival annual feed costs as the two highest-ranking sources of expense. Yet typically, commercial producers select replacement heifers based on visual appearance and age (earliest born), which only provide limited insights regarding differences in genetic merit for economically important traits. With visual appraisal, there is also the tendency to select the biggest, highest growth heifers, which often translates into larger mature cow sizes, higher feed requirements and other related costs, as well as cows that may not be as effectively adapted to ranch resources.

Since retained replacements comprise one-half of the genetic merit of future calf crops — and given heifer development and cow costs — it is economically beneficial to select heifers with genetic potential for sensible lifetime costs relative to their lifespan and the value of calves produced. Beyond selection, GeneMax Advantage predictions complement other sources of information for breeding decisions. These include GE-EPDs for selection of A.I. service sires and bull batteries that complement strengths and correct weaknesses as documented by GeneMax Advantage. With $Values available for tested commercial Angus females that are directly comparable to those for registered Angus bulls, commercial cow-calf producers can make more synergized and informed replacement heifer selection and bull buying decisions for added productivity.

To help ensure effectiveness over time, GeneMax Advantage predictions are periodically refreshed to reflect the most accurate aggregate marker effects, evolving economic assumptions, and an expanded reference population of tested commercial females. In summary, the latest enhancements incorporate new marker effects, importantly continue to include five Angus $Value Indexes that are congruent with those available for Angus seedstock, and report scores for three additional traits - Functional Longevity (FL), Teat Size (Teat), and Udder Suspension (UDDR).

PRODUCT DEVELOPMENT, DESCRIPTION & OVERVIEW

GeneMax Advantage trait predictions are based on marker effects derived from AGI's single-step Angus NCE, implemented July, 2025.[1] Generally, "Single Step" refers to streamlined methods for integrating genomic information into the NCE through use of truer genomic-informed pedigree relationships between animals across the evaluated population. While the

Table 1. Traits, acronyms, and definitions for scores included in GeneMax Advantage.

TRAIT	ACRONYM	DEFINITIONS FOR GENEMAX ADVANTAGE SCORES
Birth Weight	BW	Higher BW Score = Genetics for Lighter BW
Calving Ease Maternal	CEM	Higher CEM Score = Genetics for Higher CEM (easier calving)
Weaning Weight	WW	Higher WW Score = Genetics for Heavier WW
Heifer Pregnancy	HP	Higher HP Score = Genetics for Higher HP (more fertile)
Milk	Milk	Higher Milk Score = Genetics for More Milk
Teat Size[1]	Teat	Higher Teat Score = Genetics for Smaller Teat Size
Udder Suspension[1]	UDDR	Higher UDDR Score = Genetics for Stronger Udder Attachment
Functional Longevity[1]	FL	Higher FL Score = Genetics for Greater Cow Longevity
Yearling Height	YH	Higher YH Score = Genetics for Taller YH
Mature Weight	MW	Higher MW Score = Genetics for Heavier MW (cows)
Cow Cost	CC	Higher Cow Cost Scores = Lower Cow Cost (from cow size & milk)
Docility	DOC	Higher DOC Scores = Genetics for Calmer Temperament
Claw & Angle Composite	CAC	Higher CAC Scores = More Desirable CAC Soundness
Gain	Gain	Higher Gain Scores = Genetics for Higher Gains
Feed to Gain	F:G	Higher F:G Score = Genetics for Lower F:G (more desirable)
Carcass Weight	CW	Higher CW Scores = Genetics for Heavier CW
Marbling Score	MARB	Higher Marb Scores = Genetics for More Marb
Ribeye Area	RE	Higher RE Scores = Genetics for Larger Carcass RE
Fat Thickness	Fat	Higher Fat Scores = Genetics for Less Carcass Fat
Tenderness	TND	Higher TND Score = Genetics for Lower Shear Force (more tender)
Hair Shed	HS	Higher HS Score = Genetics for More Heat Tolerance
Pulmonary Arterial Pressure	PAP	Higher PAP Score = Genetics for Lower Risk of High-Altitude Disease

[1]New traits

previous single-step evaluation and derived set of marker effects for GeneMax Advantage included over one million seedstock Angus animals with high-density genotypes, the latest set of marker effects were derived from up to 1.8 million genotyped seedstock animals.

Genetic predictions, in the underlying form of Genomic Progeny Differences (GPD), for 22 individual traits are included in the latest version of the product (Table 1). For ease of interpretation, underlying GPDs are reported as normally distributed, transformed scores ranging from 1 to 100, where higher scores generally indicate more favorable genetic merit. Scores of 50 represent average genetic merit for each trait as benchmarked against the reference population of tested commercial Angus females.

As a result, underlying trait GPDs drive Angus $Values and Cow, Feeder and Total Advantage indexes, ranking animals for combined genetic merit. Percentile rankings associated with $Values and the 1 to 100 Advantage score benchmarks are provided in Table 2. Percent ranks for Advantage indexes' scores are directionally like ranks associated with individual traits scores, so the latter are not included in Table 2.

Table 2. Minimum GeneMax Advantage index values, scores associated with top percentile rankings.

%RANK	$M	$F	$G	$B	$C	COW ADVANTAGE	FEEDER ADVANTAGE	TOTAL ADVANTAGE
1%	86	124	86	193	308	90	91	91
2%	81	119	80	184	295	88	89	89
3%	78	116	76	178	287	86	87	87
4%	76	113	73	174	281	84	85	85
5%	74	111	71	171	276	83	84	84
10%	68	104	64	160	259	77	78	78
15%	63	99	60	152	247	73	74	74
20%	60	96	56	146	239	69	69	70
25%	57	92	53	142	232	66	66	66
30%	54	90	51	137	225	62	63	63
35%	51	87	48	133	219	59	59	59
40%	49	85	46	129	214	56	56	56
45%	47	82	44	126	208	53	53	53
50%	44	80	42	122	203	50	50	50
55%	42	78	40	119	198	47	47	47
60%	40	75	38	115	192	44	44	44
65%	37	73	36	112	187	41	41	41
70%	35	70	34	108	181	38	38	38
75%	32	68	31	104	175	35	35	35
80%	29	64	29	100	169	32	31	31
85%	25	61	26	95	161	28	28	28
90%	20	56	23	89	151	23	23	23
95%	14	50	18	80	138	18	18	18

GENEMAX ADVANTAGE MULTI-TRAIT INDEXES

GeneMax Advantage includes three economic index scores and five $Value indexes, that rank females for combined genetic merit across different phases of production. These index scores were derived using classic selection index methodology. Economic assumptions (i.e., input costs, output prices/value) were aligned with those used by AGI for $Value indexes for Angus seedstock and generally represent the most recent seven-year averages.[2-8] The weights applied to trait predictions also considered genetic variances and correlations. Importantly, indexes are intended to properly simplify multiple traits selection for net economic return.

Table 3. Definitions and interpretation of Advantage Index scores.

TRAIT	ACRONYM	DEFINITIONS FOR GENEMAX ADVANTAGE INDEXES
Cow Advantage Index	Cow	Higher Cow Advantage Scores = Genetics for Higher Net Returns – cow-calf segment
Feeder Advantage Index	Feeder	Feeder Advantage Scores = Genetics for Higher Net Returns – feeder and carcass segments
Total Advantage Index	Total	Higher Total Advantage Score = Genetics for Higher Net Returns – maternal, feeding and carcass

ADVANTAGE INDEX SCORES

Like individual trait scores, underlying GeneMax Advantage Indexes' values were transformed to the normally distributed 1 to 100 scale for easy ranking, interpretation and use in selection (Table 3).

Higher scores equate to a more desirable net return, with scores of 50 representing an average combined genetic merit as benchmarked against the reference population of nearly 130,000 tested commercial Angus females. The three Advantage indexes are:

- **Cow Advantage** - Index scores rank candidate replacements for differences in net return from combined genetic merit for greater cow functional longevity, heifer pregnancy, maternal and direct calving ease (includes birth weight), direct and maternal weaning weight (milk), docility, foot soundness, teat and udder soundness, earlier hair shedding, as well as associated costs of production due to differences in mature cow size and milk production, while also accounting for variation in cull cow value.
- **Feeder Advantage** - Index scores rank candidate replacements for net returns from combined genetic merit transmitted to progeny for post-weaning gain, carcass weight and grade (USDA Quality and Yield Grades as predicted by component traits), and costs of gain due to genetic differences in dry matter intake and associated feed-to-gain.
- **Total Advantage** - Index scores rank candidate replacements for net returns from combined genetic merit across economically relevant traits captured in the Cow and Feeder Advantage indexes. As such, Total Advantage is the one most simple and comprehensive prediction of system-wide production efficiency upon which to primarily base selection and breeding decisions.

GENEMAX $VALUE INDEXES

This latest version of GeneMax Advantage includes the same $Values used for the registered Angus seedstock population. The economic assumptions and weights used for the $Values are essentially the same, with identical interpretation of values. This was possible by transforming the genetic merit of tested commercial animals estimated through the marker effects.

The results aim to capture the differences between animals in the seedstock population, while respecting the observed genetic difference between commercial and seedstock animals.

The $Values now available for animals tested with GeneMax Advantage include indexes focused on carcass: Beef Value ($B), Grid Value ($G); feedlot

performance: Feedlot Value ($F); maternal traits: Maternal Weaned Calf Value ($M); and overall profitability: Combined Value ($C). The traits and indexes included in the $Values are the same as those used for seedstock:

- **Beef Value ($B)**: A terminal index, expressed in dollars per carcass, to predict profitability differences in progeny due to genetics for postweaning and carcass traits. This terminal index assumes commercial producers wean all male and female progeny, retain ownership through the feedlot phase and market animals on a carcass grid.
- **Grid Value ($G)**: Expressed in dollars per carcass, to predict profitability differences in progeny due to genetics for carcass grid merit compared to progeny of other parents. The underlying objective assumes producers will market cattle on an above-industry-average carcass grid.
- **Feedlot Value ($F)**: Expressed in dollars per carcass, to predict profitability differences in progeny due to genetics for postweaning feedlot merit compared to the progeny of other parents. The underlying objective assumes producers will retain ownership through the feedlot phase and sell fed cattle on a carcass weight basis, but with no consideration of premiums or discounts for quality and yield grade.
- **Maternal Weaned Calf Value ($M)**: Expressed in dollars per head, predicts profitability differences from conception to weaning, with the underlying breeding objective of producers retaining their own replacement females, selling cull females and all male progeny as feeder calves. The model assumes commercial producers replace 20% of their breeding females in each generation.
- **Combined Value ($C)**: Expressed in dollars per head and includes all traits that make up both Maternal Weaned Calf Value ($M) and Beef Value ($B), with the assumption that commercial producers replace 20% of their breeding females per year with replacement heifers retained within their own herds. The remaining cull heifer and steer progeny are assumed to be sent to the feedlot, with retained ownership and marketing of fed cattle an on a quality-based carcass merit grid.

The $Values can be used to compare tested animals and Angus seedstock in a standardized way, considering economic drivers in the industry for profitability. The $Values have the same interpretation as in the seedstock population, as measured as dollars per head or dollars per carcass (Table 4). As a result, this standardization more readily enables complementary A.I. sire or natural service breeding to females of similarly evaluated genetic merit.

The traits and relative contributions to $Value and Advantage indexes are provided in Table 5 and Figures 1, 2 and 3.

This information helps users of GeneMax Advantage understand the differences between $Values and Advantage indexes that encompass similar sets of traits – namely $M and Cow Advantage, $B and Feeder Advantage, $C and Total Advantage.

For historic GeneMax customers, this information helps evaluate tradeoffs between continuity of selection via continued use of primarily Advantage indexes, versus added congruency of selection using indexes that are aligned across registered Angus bulls and tested commercial females.

Table 4. Definitions and interpretation of Advantage Index scores.

$VALUE	ACRONYM	DEFINITIONS FOR GENEMAX ADVANTAGE $VALUES
Maternal Weaned Calf Value	$M	Higher $M = More profitable females
Feedlot Value	$F	Higher $F = More profitable postweaning feedlot performance
Grid Value	$G	Higher $G = More profitable carcass grid merit
Beef Value	$B	Higher $B = More profitable postweaning and carcass traits
Combined Value	$C	Higher $C = More profitable commercial herd

Table 5. Traits in $Value and Advantage indexes.

TRAIT INCLUDED	$VALUE					ADVANTAGE INDEX		
TRAIT	$M	$F	$G	$B	$C	COW	FEEDER	TOTAL
CED	X				X	X		X
WW	X				X	X		X
Gain		X		X	X		X	X
CEM	X				X	X		X
MILK	X				X	X		X
TEAT	X				X	X		X
UDDR	X				X	X		X
FL	X				X	X		X
HS						X		X
MW	X				X	X		X
MH						X		
YH								X
DOC	X				X	X		X
HP	X				X	X		X
Claw & Angle Composite	X				X	X		X
DMI		X		X	X		X	X
CW		X	X	X	X		X	X
RE			X	X	X		X	X
MARB			X	X	X		X	X
FAT			X	X	X		X	X

Figure 1. Relative contributions of trait groupings to Maternal Weaned Calf Value ($M) and Cow Advantage index scores.

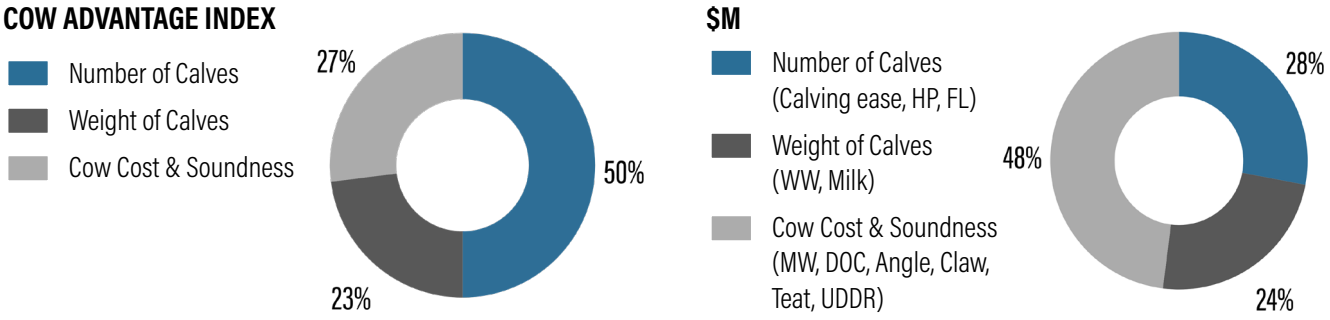


Figure 2. Relative contributions of trait groupings to Beef Value ($B) and Feeder Advantage index scores.

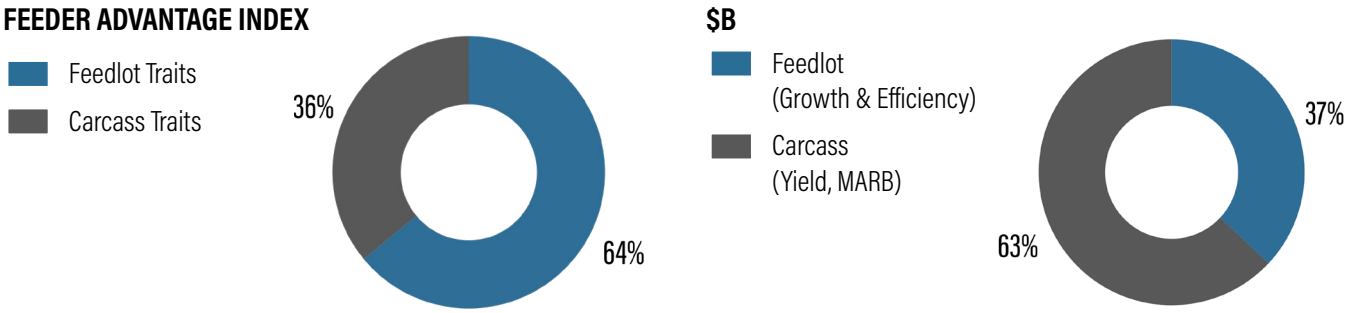
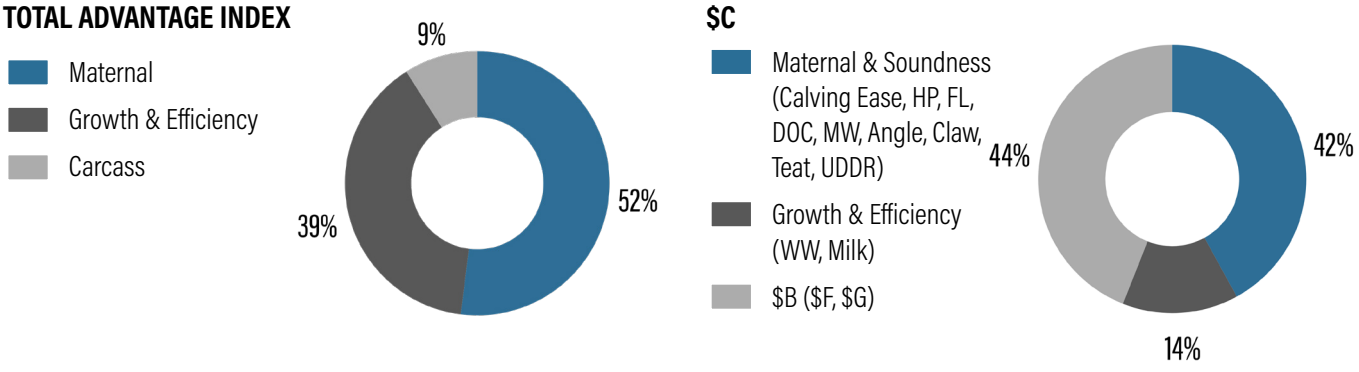


Figure 3. Relative contributions of trait groupings to Combined Value ($C) and Total Advantage index scores.



INDEX USE

Producers often ask, "What index should I use?" The intention of economic indexes is to simplify proper multiple trait selection and breeding decisions to optimize tradeoffs between traits that impact costs versus those that generate revenues from different phases of production.

The increased number of indexes is not intended to add complexity, but rather is designed to enhance alignment between indexes used to select registered Angus bulls and indexes available to select commercial Angus replacement heifers.

Given the diversity of commercial cow-calf operations, it's not a matter of "one size (index) fits all." Rather, there's financial beneficials to using the index option(s) that best fit individual producers' breeding objectives.

As genetic information becomes more available for commercial cattle, and bridges across industry segments, a strong case can be made for commercial cow-calf producers to primarily use broadly inclusive indexes, namely $C or Total Advantage.

Focusing first on $Value indexes, $C can be used to simplify selection of females and sires that provide overall economic returns from combined maternal, production and carcass trait genetic merit (Table 7).

On some occasions, $Values tailored for specific segments of the supply chain can be targeted for selection in tandem with $C, across females and bulls. For example, if cow-calf operations wish to enhance their pools of maternally strong replacement females and profitability up to weaning (maternal traits), while not overly compromising feeding and carcass traits, bulls and heifers with higher combinations of $M and $C are advised for selection.

Table 6. Pearson correlation between Cow, Feeder and Total Advantage economic Index.

	FEEDER ADVANTAGE	TOTAL ADVANTAGE
COW ADVANTAGE	0.16	0.87
FEEDER ADVANTAGE		0.54

Table 7. Pearson correlation between Maternal Weaned Calf ($M), Feedlot ($F), Grid ($G) and Beef ($B) economic indexes.

	$F	$G	$B	$C
$M	-0.05	0.20	0.08	0.52
$F		0.25	0.82	0.68
$G				0.74
$B				0.90

Table 8. Pearson correlation between $Values (Maternal Weaned Calf - $M, Feedlot - $F, Grid - $G, Beef - $B and Combined - $C) and Advantage Scores indexes (Cow, Feeder and Total Advantage).

	COW ADVANTAGE	FEEDER ADVANTAGE	TOTAL ADVANTAGE
$M	0.74	-0.04	0.69
$F	0.17	0.73	0.42
$G	0.23	0.47	0.45
$B	0.25	0.76	0.55
$C	0.55	0.64	0.78

Correlations between $Value and Advantage indexes are provided in table 8. While $C and Total Advantage are substantially correlated (.78), and both are positively related to maternal, feeding and carcass merit, the components are not equally weighted. Total Advantage index scores are more highly correlated to Cow Advantage (.87 with maternal set of traits) as compared to Feeder Advantage (.54 with feeding and carcass set of traits) – table 6. Conversely, as indicated in table 7, $C is more highly correlated with $B (.90) as compared to $M (.52). Relative to the maternal set of traits included in Cow Advantage and $M, neither of these indexes are strongly correlated respectively, with feedlot and/or carcass indexes.

It follows that for GeneMax Advantage customers, it's handy to have two all-inclusive index options, one that's more influenced by maternal traits (Total Advantage – although not aligned with what's available for bulls) and another that's more driven by feedlot and carcass performance ($C – aligned with bulls), while both are anticipated to yield across-the-board improvements in genetic merit for net returns.

USE OF GENEMAX ADVANTAGE IN BREEDING DECISIONS

GeneMax Advantage provides flexibility in replacement heifer selection and a wealth of information for mating and marketing decisions. While $C or Total Advantage provides a simple and comprehensive assessment of an individual heifer's future contribution to supply chain profitability, there are instances where other indexes and individual trait predictions may be more applicable and used to inform selection and bull buying.

For example, in instances where environmental constraints put a premium on cow adaptability, use of $M or Cow Advantage Scores, coupled with culling undesirably outliers based on Hair Shed and/or Pulmonary Arterial Pressure Scores, help match genetic potentials to specific environments.

Alternatively, most all producers can benefit from feedlot and carcass performance or from special feeder cattle marketing programs such as AngusLink℠, through appropriately balanced emphasis on $B or Feeder Advantage for enhanced post-weaning and carcass performance.

SIMULATED VALUE RETURN FROM INVESTMENT IN GENEMAX ADVANTAGE

Value-return from selection of replacement heifers based on $C and Total Advantage index scores were simulated over a 10-year period[9]. The simulation included the following assumptions: 500 head cow herd; 92% weaned calf crop; an initial replacement rate of 20% and the testing of two heifers for every one selected (200 tested, 100 retained); testing cost per selected heifer of $56 ($28 per head); 25% annual replacement rate and continuous index ($C)

advancement for purchased bulls. The simulation evaluated use of $C and Total Advantage versus traditional selection of replacement heifers and associated impacts on the cow herd and calf-crops over time. Traditional replacement heifer selection and genetic gain was defined as equivalent to parent-average $C index values for simulated calf crops.

Depending upon the time horizon and assuming the average number of calves produced from selected replacement heifers was six, projected returns on investment (ROI) from selection based on $C as compared to traditional selection ranged from a high of $4.07 in year-10 to a low of $2.57 in year-1, per $1 invested in testing. Similarly, selection based on Total Advantage as compared to traditional selection yielded projected ROI that ranged from a high of $3.89: $1 in year-10 to a low of $2.46: $1 in year-1.

As $C and Total Advantage indexes were used year-over-year, the pool of heifers for selection improved more rapidly than traditional selection, resulting in increased ROI over time. This doesn't include unquantified benefits related to lower replacement rate from greater cow functional longevity, smarter Angus bull buying and mating decisions that more effectively accentuate genetic strengths and correct weaknesses of the cow herd, better identified through use of GeneMax Advantage. As well, avoidance of inbreeding and labor savings due to anticipated reduction in problems related to traits such as calving ease, docility, foot and claw soundness, teat and udder soundness, and brisket disease in high altitude environments are at least somewhat unaccounted for in this simulation.

Overall, simulated use of GeneMax Advantage and selection based on $C or Total Advantage indicated a $32 or $30 per calf advantage, respectively, as compared to traditional selection. The strategy of testing two heifers for every one selected – ideally the earliest born and visually acceptable – means that most all viable candidates are evaluated and competitively considered, but costs are saved from not testing the entire heifer crop.

Based on customer experiences, this strategy also sometimes enables identification of excess heifers that possess documented genetic merit for value-added marketing as either open or bred replacements – rather than as feeder cattle. It follows that this testing strategy also provides insights about feedlot and carcass performance of steer mates, as benchmarked by the average $F, $G, $B and Feeder Advantage indexes. These insights may be used to inform retained ownership decisions or help with feeder cattle price discovery through programs such as AngusLink℠.

SIRE MATCH ENABLED WITH HD50K & ANGUS GS

GeneMax Advantage matches potential Angus sires to tested heifer progeny (with no re-testing of bulls). This feature requires Angus bulls to be registered with the Association and transferred at the time of sale to the GeneMax Advantage customer's AGI account. This feature enables producers with HD50K and Angus GS-tested bulls to document sires and proactively manage inbreeding, the avoidance of closely related common ancestors among sires of tested heifers and service sires.

Hence, Sire Match enables known parentage with the flexibility of multi-sire breeding systems. Inbreeding has generally been documented to adversely affect reproductive, survival and fitness traits.

Ideally, customers are advised to designate candidate sires with their AAA registration numbers at the time of order submission. This is especially important if tested females were potentially out of A.I. sires. In cases where candidate sires have not yet been genomic tested, or if ownership has not yet been transferred at the time heifers are tested, Sire Match may be requested following the initial delivery of GeneMax Advantage results.

LIMITATIONS TO USE OF GENEMAX ADVANTAGE

GeneMax Advantage is a collaborative effort between AGI and Zoetis, designed for use in high-percentage Angus commercial replacement females. This primarily includes progeny of genomic tested, registered Angus bulls mated to half-blood or greater Angus cows. It is not intended for use in registered Angus females or bulls. Regarding the latter, genomic determination of female sex is required for reporting – genomic males do not receive results. The predictions obtained with GeneMax Advantage are not incorporated into the AGI's NCE and do not influence the GE-EPDs of registered Angus animals.

Thanks go out to the team that worked to execute this set of refreshments and additions, including Dr. Rafael Medeiros, AGI Geneticist; Dr Larissa Novo, AGI Genetic Research Analyst; Kelli Retallick, President of AGI; and former colleague Dr. Steve Miller; Dr. Tom Short of Zoetis Outcomes Research; and Dr. Kent Andersen, Zoetis Beef Genetics Global Technical Service.

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