

## Fundamentals of bull selection

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### Abstract

Bull selection is a critically important decision, as bulls contribute to genetics of the farm well beyond their lifetime. Irrespective of the method of breeding (natural service or artificial insemination), a sire will produce more calves in his lifetime compared to a cow. In addition, the genetic make-up of each calf is 50% from the calf's sire, and of the 50% from the dam, half of that is from her sire and one quarter from her grandsire, etc. Thus, a calf's genetics is derived from several generations of bulls. This paper discusses important criteria and provides guidelines for successful bull selection.

**Keywords:** Bull selection, genetic improvement, estimated progeny differences, breeding management

### Introduction

Genetic make-up of all bulls is not equal – the range is very wide! To achieve economic success, it is important to select bulls with genetics that sire offspring with desirable traits.<sup>1</sup> For breeding purposes, bulls are grouped into three major categories: 1) maternal bulls used for breeding heifers (to produce calves with low birthweight, but good weaning weight and perhaps future cows); 2) maternal bulls used for breeding cows (to produce future cows); and 3) terminal bulls used for breeding cows (to produce market cattle). One, two, or all three categories can be useful in a breeding program, depending on the farm's goals and resources (e.g. nutrition and environment). In that regard, veterinarians should assist producers in selecting appropriate bulls. There are several factors and steps involved in the selection process.

### Farm goals

Farm goals are the basis for bull selection; they should guide selection of bulls with traits of economic importance.<sup>2,3</sup> In addition, it is essential that the farm environment and the producer's production and marketing strategies are also considered. Key questions include:

- How will this sire be used in the overall breeding program?
- Will the bull be used to breed heifers, mature cows, or both?
- Will replacement females be retained?
- How will the calf crop be marketed?
- What are the nutritional resources?
- What are the labor and management resources?
- What are the environmental conditions?

### Farm strengths and weaknesses

Good records are essential to recognize overall strengths and weaknesses of a cattle operation. Knowing basic production and reproduction parameters (e.g. length of breeding and calving seasons, calving and weaning percentage, weaning weights, average daily gain, carcass data, etc.), is necessary to assess overall performance of the farm, areas of strength and those needing improvement; this will indicate what trait(s) should be given highest priority during bull selection.<sup>2</sup>

### Selection priorities

Emphasize factors expected to have the largest impact on profitability that can be impacted by bull selection. Income is derived from weaning percentage, weight at sale, value per pound, carcass merit, etc. Although costs are related to a combination of several production and reproduction traits, bull selection should focus on a few priority traits (weighted for economic importance) rather than attempting

to change many traits simultaneously. Because performance is a function of both genetics and environment/management, the potential economic advantage of superior genetics can be annulled by poor management. Therefore, veterinarians should assist producers in evaluating the impact of management (nutrition and animal health), as well as the impact of genetics, based on the priorities of that farm.<sup>3</sup>

### **Utilization of selection tools**

Once selection priorities have been established (through close examination of farm goals and current status), there are several useful tools to assist in making genetic improvement. For a commercial cattle operation, there are two basic ways to provide genetic improvement: crossbreeding and selection of parent animals. Genetic improvement using these pathways can relate to farm goals. For example, if the emphasis is to improve reproductive parameter (fertility) and longevity, crossbreeding should be emphasized and selection of parent animals given a lower priority. In contrast, if the focus is to improve carcass traits (increased marbling or decreased back-fat) selection of parent animals should be a much higher priority than crossbreeding.

### **Crossbreeding**

Crossbreeding, namely mating sires and dams of different breeds, usually results in calves with beneficial characteristics from both breeds. Crossbreeding is an important production practice, as it offers advantages from both heterosis and complementarity.<sup>4</sup> Utilization of different breeds in a complementary fashion through a structured crossbreeding strategy provides opportunities for improvement in multiple traits.<sup>5</sup> Cattle producers can gain hybrid vigor and complementarity simply by crossing appropriate breeds. However, sustaining acceptable levels of hybrid vigor and breed complementarity over the long term requires a well-planned crossbreeding system. Useful criteria for designing crossbreeding systems<sup>6,7</sup> include:

- advantages of component breeds – the breed included in a crossbreeding system must be well chosen and must bring favorable characteristics to the offspring
- hybrid vigor – in crossbreeding, the offspring are often bred to have better vigor than either parent, along with a specific number of desired traits. Most crossbreeding systems do not achieve maximal hybrid vigor; backcrossing should be limited to maintain acceptable levels of hybrid vigor.
- breed complementarity – refers to production of a more desirable offspring by crossing breeds that are genetically different from each other, but have complementary attributes. A good example would be mating a Charolais bull (growth and retail yield) to a Gelbvieh-Angus cross cow. The result – the cow has good milk production and fertility, and the calf has more growth/retail yield. The characteristics gained from this mating complement each other.
- strength of performance – an ideal crossbreeding system should produce a consistent product. It is much easier to market a uniform group of animals than a varied one. From the management aspect, it is also much easier to manage a female population that is essentially one type, rather than one made up of many types, each with its own requirements. Design a crossbreeding system with less variation to offer increased consistency.
- replacement consideration – in terms of hybrid vigor, the eventual female is an F1. Although many commercial producers would like to have entire herds of F1 females, it is difficult to produce a continuous supply of F1s without a compromise. This can be addressed by either maintaining purebred parent populations to cross to produce F1s or purchasing all the replacements needed. In practice, neither of these methods is optimal for most producers. A number of crossbreeding systems manage to overcome the replacement female quandary by allowing breeders to produce replacement heifers from their own hybrid populations. However, this expediency results in loss of hybrid vigor, breed complementarity and simplicity.

- ease of application – the breeding program should be relatively simple. Expensive and/or complex systems requiring high levels of management are not ideal, as complex breeding systems often conflict with vital management practices unrelated to breeding. Therefore, crossbreeding systems should fit with other aspects of cattle production.
- precision of genetic prediction – the higher the accuracy of genetic prediction, the more predictable the offspring and lower selection risk. Because relatively little performance information on commercial animals is recorded and even less is analyzed and reported, the accuracy of prediction in a commercial operation is limited to the accuracy of prediction for seed stock inputs to the crossbreeding system – typically sires. In many cases, accurate estimated progeny differences (EPDs; for at least some traits) are available for purebred sires, and crossbreeding systems using purebred sires benefit as a result.

Although the effect of breed difference is powerful (Table 1), the choice of individuals from within a breed is also very important. Poor choices of breeds and animals from within a breed will have a lasting impact on the success of any crossbreeding program.

Crossbreeding systems are in two general categories: 1) production of replacement females as well as market cattle (rotational and composite systems); and 2) production of market cattle (terminal cross).<sup>9</sup> In rotational (or composite) systems, bulls must be selected with maternal traits in mind as well as growth and carcass traits, since replacement heifers are retained from within the herd. Terminal systems allow for greater emphasis on selection for growth and carcass traits in bulls, since female replacements are supplied from outside the herd. The genetic merit of a terminal bull for maternal traits is of no consequence, since his female progeny will not be bred. Calving ease must be considered (particularly for heifer dams), regardless of the type of crossing system. Briefly, different traits respond to heterosis to varying extents (reproduction and longevity are strongly influenced, growth is moderately influenced, carcass traits are minimally influenced, etc.).

### Parent animals

In any breeding program, there are four basic pathways of genetic improvement, corresponding to the total of four sources of parental genes of male and female progeny.<sup>10,11</sup> These four pathways are:

- male parents of male progeny (sires of males, *sm*)
- female parents of male progeny (dams of males, *dm*)
- male parents of female progeny (sires of females, *sf*)
- female parents of female progeny (dams of females, *df*)

### Sires of males

Since typically only limited numbers of young bulls are subjected to performance and progeny testing, and every sire can produce tens of thousands of doses of semen, we need only a few sires to produce these young bulls each generation. Thus we need to select only the top one or two percent of tested bulls as sires of sons. These sires have high accuracy of genetic evaluation, since progeny tests generally give high accuracy. The generation interval will, however, be at least six years, due to the interval from birth of the young bull, through the birth of his first crop of test daughters, through their first calving.

### Sires of females

Since there are many more cows than bulls used, many more bulls are required to produce the necessary amount of semen each generation. In an efficient scheme, the top 10-15% of young bulls can be selected, giving lower selection intensity than for sires of sons. Accuracy of selection is the same as for sires of sons, because they are chosen on the basis of the same information. The generation interval is, however, approximately one year longer, since it takes time to breed a large population of cows and better bulls will be retained and used longer than those of lesser merit.

### Dams of males

Since there are numerous cows, but only limited numbers of sons tested, dams of sons can be selected very intensely; perhaps only the best 0.1 to 0.5% are needed. However, evaluation is based on the dam's performance, which has lower accuracy than a progeny test. These cows could be bred in their second lactation (based on their first lactation performance and part of their second lactation performance), so that they would be approximately 4.5 to five years old at the birth of their sons.

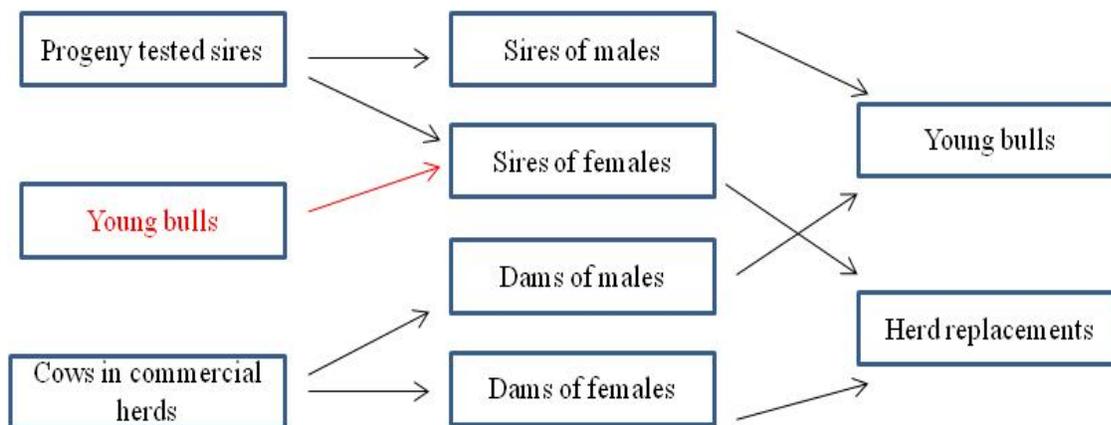
### Dams of females

Dairy cows have a very low reproductive rate, producing less than one live calf per year (based on average calving intervals and mortality of fetuses and calves). Allowing for disease and other losses of growing heifers and that only half the calves are females, only approximately one in three calvings result in a potential replacement heifer for the dairy herd. Since average life in the herd in many western countries is often not much over three lactations, the average cow barely has sufficient time to produce a replacement before she leaves the herd. Consequently, there is limited opportunity for selection of dams of cows, with perhaps 90% of all cows required for breeding. Accuracy of selection would be very similar to that for dams of sires. However, generation interval is generally increased by one to two years since the average cow requires close to three calvings to produce a replacement.

### Accounting for young bulls

In the sire to female path, only the use of progeny-tested sires, to breed cows to produce herd replacements is taken into account. However, young bulls also contribute to the next generation of females.<sup>12</sup> Semen from young bulls can represent as much as 20% of all inseminations in a practical breeding program and should be considered (Figure). In that regard, genetic superiority and generation interval for sires of females must be computed as a weighted average.

Figure. Pathway following incorporation of young bulls in a breeding program.



### Utilizing genomic selection

The advent of DNA sequencing and high-throughput genomic technologies has elucidated numerous single nucleotide polymorphisms (SNP) in cattle. Genomic selection refers to selection preferences based on genomic estimated breeding values (GEBV).<sup>12-14</sup> These GEBV are calculated by estimating SNP effects from prediction equations, which are derived from a reference population (a subset of animals) that have SNP genotypes and phenotypes for traits of interest. The correctness of GEBV depends on the heritability of the trait, and the degree of associations between selection candidates and the reference population, and the size of the reference population used to obtain prediction equations.

The advantage of genomic selection is it allows breeders to identify genetically superior animals at an earlier age, even before they reach sexual maturity. Genomic selection involves identifying which SNPs are linked to important functional traits and selecting bulls with DNA patterns to produce superior priority traits.<sup>15,16</sup> Recent advances in DNA/genomic technology and decision support tools will enhance selection accuracy.<sup>17</sup> These approaches not only provide information for selection of bulls with the genetic make up for superior priority traits, but concurrently provide information to eliminate bulls with undesirable genetic traits.<sup>18</sup> However, there are still improvements to be made, as some bulls with a very promising genomic assessment have poor actual performance or progeny. Using only genomic selection this approach is short-sighted; the use of all available tools, including phenotype, genetic information, information from close relatives and individual performance, is strongly recommended.

Ongoing assessment of daughter phenotypes is essential because prediction equations for calculating GEBV should be restructured periodically to increase the size of the reference population, account for changes over time in herd management practices or the genetic background of mates, and maintain high levels of linkage disequilibrium (the non-random association of alleles at two or more loci) between the reference population and the selection candidates.

This genomic information has many advantages, including:

- potential to speed genetic improvement
- enables bull selection from a much wider genetic pool
- provides earlier information regarding genetic differences between siblings
- predicts genetic merit of young animals with more accuracy
- improves the reliability of current progeny testing for low-heritability traits

This technology provides artificial insemination (AI) companies with the ability to carry out accurate selection of bulls at a young age. Hence this technology allows AI companies to purchase fewer bulls, knowing that only males with the highest genetic merit will be marketable. This could reduce sire expansion costs by up to 92%, due to the substantial costs associated with housing and feeding<sup>19</sup>

### Genomic testing

Many progressive breeders are using genomic testing for the majority of their cows and heifers to identify females that received the most favorable combination of genes from their parents. The use of young genomic bulls by breeders as sires of replacement females (sire female (SF) pathway) continues to increase in popularity. Among dairy producers, there has been a major shift toward the use of genomic bulls in the SF pathway. The total number of units of semen sold from young dairy sires increased by 13%, between 2006 and 2010,<sup>20</sup> and the increased acceptance of genomics among dairy cattle producers has allowed extensive marketing of genomic bulls.

At present, a low-density (LD) chip with 6,909 SNP<sup>21</sup> and a medium-density (50K) chip with 54,609 SNP<sup>22</sup> are the products used by breeders, and GEBV for production, health, and conformation traits can be computed using genotypes from either chip. Recently, the LD chip replaced the 3K chip with 2,900 SNP<sup>23</sup> because of greater gains in reliability and improved readability among SNP genotypes. Genomic testing services are currently offered by breed associations, AI stud services, and some private companies. The LD chip costs \$43 to \$55 per animal and reliabilities of the resulting GEBV for production traits in Holsteins are approximately 60 to 65%. The 50K chip is more costly (\$125 to \$135 per animal), but reliabilities for production traits in Holsteins are roughly 70%, whereas they are up to 95% for Angus. The tests that are currently being included in the US Beef Industry are comprised of either 384 SNP or 50K SNP, although the research community is commonly using 50K or 770K genomic tests for discovery of new traits (e.g. feed efficiency and disease susceptibility).

Cost undoubtedly hinders use of this technology; however, recent advances show promise in dramatically decreasing the cost of genotyping.<sup>24</sup> Within-breed genomic predictions based on medium density (i.e. 50K) genotypes add accuracy, particularly to young animals, for several traits (Table 2).

The test also includes the following:

- arthrogryposis multiplex

- coat color
- multi-sire parentage
- horned/polled
- BVD-PI diagnostic test

Methodology related to the use of this technology in crossbred or composite animals is critically needed to fully benefit the commercial livestock sector. The importance of adoption will be getting commercial producers to realize the value of, and thus pay for, increased GEBV accuracy. There is still a need to collect and routinely record phenotypic information by seed-stock producers and commercial producers need to realize that GEBV, and economic index values, are critically important for optimizing selection. In that regard, although genomic technology makes these tools stronger, it does not replace them.

### **Establishing benchmarks**

Estimated progeny difference values for sires can be utilized to establish benchmarks.<sup>18</sup> Estimated progeny differences are a useful selection tool for many of the traits (Table 3).

It is noteworthy that EPDs predict the expected performance of calves sired by a bull, compared to the expected performance of calves sired by another bull. They are based on:

- performance records of an individual, records of relatives and progeny
- adjustments for differences in the genetic merit of mates
- genetic correlations (genetic relationship between traits) to improve estimates
- accounting for genetic changes over time and genetic relationships among individuals
- increased validity of some estimates, due to associations
- total herd reporting, so records are provided on more individuals
- adjustments for differences among contemporary groups in environment and management (e.g. climate and nutrition)
- current EPDs are directly comparable within a breed for all individuals (males and females) in all locations and management systems across all years.

Many breed associations have EPDs on individual animals that can be obtained from published sire summaries and searchable internet databases. Breed associations also publish EPD data to indicate where individual animals rank within the breed for specific traits.

Selection for improved efficiency should account for production, reproduction, longevity, and feed costs.<sup>26</sup> The use of EPDs is a tool to aid purebred and commercial producers in selecting potential breeding stock. Cattlemen must clearly define their breeding objectives and determine what sort of bull is needed to meet these goals and then carefully consider the EPDs of the bull (as well as his relatives), if possible. The basic steps to choosing a herd sire are:

### **Retaining ownership**

Birth weight and carcass traits (weight, yield grade, quality grade) are of primary importance. Maternal traits and mature weight must be considered if daughters are being retained for breeding.

### **Selling calves as yearlings**

Birth weight and yearling weight are of primary importance. Maternal traits, such as milk, stayability and mature size are important if replacement heifers are retained. Stayability is the probability of daughters remaining in the herd for at least six years and have the opportunity to become part of the breeding herd.

## Cow/calf operation

If calves are sold at weaning, birth weight and weaning weight are the primary considerations. Maternal traits (milk, stayability) and mature size must also be considered if replacement heifers are being selected.

Bull selection becomes more complex as the number of breeding objectives increases. For example, rapid growth and superior maternal traits are *not* usually found in the same genetic package. Producers selecting their own replacements heifers while retaining ownership beyond weaning must make a decision. They can either find a sire that does all jobs acceptably well (a balance of maternal and growth traits), or split the cow herd, breeding some cows to a sire with strong maternal traits (calving ease, milk, stayability) to produce replacement heifers, and breeding the rest to a terminal sire (growth, carcass traits) to produce feeder or slaughter cattle. The table below provides some general guidelines for using EPDs in commercial scenarios (Table 4).

Expected progeny differences are easily interpreted. They are expressed in various units, depending on the specific trait. To demonstrate how EPDs work, consider the following examples.

### *Example A*

Bull	Milk EPD
1	+20
2	+5
Difference	10 lb

Interpretation: Due to high milking ability, daughters of Bull 1 wean calves 15 pounds heavier than daughters of Bull 2.

### *Example B*

Bull	Calving ease EPD
1	+ 7
2	+ 3
Difference	4%

Interpretation: 4% fewer calves sired by Bull 1 need assistance at delivery compared to calves sired by Bull 2.

## Preparation for selection

There are many sources of bulls that warrant consideration, including production sales, test stations and private sales. Of critical importance is that the bull be from a trustworthy source which will provide assurance of satisfaction and good service. It may be necessary to consider several sources in order to find an appropriate bull.

Examination and evaluation of the bull's performance record to determine those that meet the EPD and other specifications that have been established. Follow rigorously the selection criteria and qualifications/specifications that have been established. All of these criteria should be set before selection. Select those which meet the specifications and eliminate those that do not meet the specifications. Once selection has been narrowed to only bulls which meet the criteria, further refining of the evaluation and selection may be used. Having a list of suitable bulls prior to arrival at the auction or farm not only saves time, but also assists in ensuring that an appropriate bull is purchased.

Upon narrowing the list of potential bulls, they can be evaluated for suitability of phenotypic traits and the potential candidate list shortened. Not all relevant traits have EPD (e.g., disposition, structural and foot soundness, fleshing ability, etc.) and, therefore, must be evaluated visually (up to 3% of young bulls are eliminated after visual inspection).<sup>10</sup>

### How to use EPD percentile tables

Most of the major breed associations publish EPD percentile tables, which indicate where a bull ranks within a breed for each of the traits of interest. Some breeds even produce multiple tables-current (active) sires, current (active) dams, non-progeny sires, etc. For most producers, a comparison against the active sires would be appropriate. For example, assume we are interested in an Angus bull with a calving ease EPD (CE) of 5.5, weaning weight EPD (WWT) of 38, milk EPD (MLK) of 5, and yearling weight EPD (YWT) of 62. Using the table from the American Angus Association, this bull is in the top X<sub>1</sub>% of the breed for calving ease, the top X<sub>2</sub>% for weaning weight growth, the top X<sub>3</sub>% for milking ability, and the top X<sub>4</sub>% for yearling weight growth. Consequently, we expect this bull will be relatively easy calving, high growth, and produce daughters with about average (for Angus) milking ability.

### Evaluation of bull breeding potential

Before purchase and before each breeding season, bulls should be evaluated to ensure that they meet the Society For Theriogenology breeding soundness evaluation criteria for structural and physical soundness, sperm motility and morphology, and be free of venereal diseases.<sup>27-29</sup> Reasons that bulls are classified as unsatisfactory potential breeders include: 25% due to poor sperm parameters (usually morphology), seven percent due to inadequate scrotal circumference, and three percent have poor structural conformation.<sup>27</sup>

### Test for genetic defects

Genetic defects occur due to random mutations in the genome; they are more common in purebred cattle, although crossbreds that contain a breed from an at-risk population are also at risk. Several genetic defects are autosomal recessive, whereas environmental factors can produce phenotypes similar to genetic defects. There are DNA tests for several genetic defects, which can confirm whether the defect is due to genetic or environmental causes. With advancements in molecular technology, genetic defects can be effectively managed in cattle populations. Instead of abolishing entire lines of cattle, carrier animals can be identified and either culled or used in certain circumstances with confidence. Numerous genetic defects are currently being monitored by US breed associations and others likely will be discovered in the future.

### Managing newly purchased bulls

Purchasing a new bull is a relatively infrequent occurrence. This further emphasizes the importance of selecting an appropriate bull, particularly in single-sire farms. The value of an appropriate bull should not be underestimated. Investments in good genetics will pay dividends, both short- and long-term, through the influence the bull has on each calf crop, as well as his daughters that are retained for breeding.

Care and management of the newly acquired bull is essential. Genetic progress and increased profit can be achieved only if the bull has satisfactory reproductive performance. With most new sires purchased as yearling bulls, management prior to, during and after the first breeding season is particularly important. Plan ahead by acquiring a new yearling bull at least 60 to 90 days prior to the breeding season, so ample time is available to allow for adjustment to a new environment, commingling with other bulls with known temperament and disease status, and getting the bull in proper breeding body condition. Bulls must be properly acclimated to the environment and management conditions present on the farm; lack of adaptation is likely to lead to poor reproductive performance.

It is important to maintain performance record for bulls to monitor their economically important productive and reproductive performance parameter and to determine progress. In multi-sire breeding schemes, some producers may increase the intensity of their management by testing all or a sub-set of calves for parentage to determine the number of calves actually sired by each bull and how each bull's progeny performed. Some herds may elect to determine parentage on only the best performing calves and the poorest performing calves as an aid in bull culling decisions.

## Conclusions

Bull selection is one of the most important producer decisions, as it offers an opportunity to enhance the genetic merit and profitability of the farm. To effectively select sires, producers must use selection tools such as EPD indices and understand both within- and between-breed differences of these indices. In addition, producers must also accurately and objectively assess their current genetics, nutritional resources, and management. This will help producers with decision making. The selection and addition of bulls must not only meet revenue-improving priority traits, but also compliment other important production traits. Recent advances in DNA/genomic technology and decision support tools will enhance selection accuracy. Producers who utilize these advances in beef cattle genetics in the selection process should not only increase profit from improved revenue and reduced production costs, but best match genetics to their operation's production demands. Also it is important to use all available tools such as phenotypic, genetic information, information from close relatives, and individual performance.

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Table 1. Units and percentage of heterosis by trait<sup>§</sup>

Trait	Bos taurus crossbred dams		Bos taurus crossbred calves		Bos taurus by Bos indicus crossbred dams		Bos taurus by Bos indicus crossbred calves
	Units	%	Units	%	Units	%	Units
Calving rate	3.5	3.7	3.2	4.4	15.4	-	4.3
Calf survival	0.8	1.5	1.4	1.9	1.6	1.8	-1.4
Birth weight	1.6	1.8	1.7	2.4	1.36	16.2	11.4
Weaning weight	18.0	3.9	16.3	3.9	0.97	17.0	78.5

Table 2. Production and reproduction traits<sup>§</sup> currently tested using genomic techniques.

Angus*	Holstein <sup>25</sup>	Jersey <sup>25</sup>	Brown Swiss <sup>25</sup>
Calving Ease Direct	Milk (kg)	Milk (kg)	Milk (kg)
Birth Weight	Fat (kg)	Fat (kg)	Fat (kg)
Weaning Weight	Protein (kg)	Protein (kg)	Protein (kg)
Yearling Weight	Fat (%)	Fat (%)	Fat (%)
Dry Matter Intake	Protein (%)	Protein (%)	Protein (%)
Yearling Height	Productive Life (mo)	Productive Life (mo)	Productive Life (mo)
Yearling Scrotal (cm)	SCS	SCS	SCS
Docility	Daughter pregnancy rate	Daughter pregnancy rate	Daughter pregnancy rate
Milk	Sire calving ease		
Mature Weight	Daughter calving ease		
Mature Height	Sire stillbirth		
Carcass Marbling	Daughter stillbirth		
Carcass Rib-eye Area			
Carcass Fat			
Carcass Weight			

\*American Angus Association currently utilizes genetic correlations between traits and their genetic indicators offered by Ingenuity (384 SNP) and Pfizer (50K) for the following traits.

<sup>§</sup>It should be noted that the genetic markers available will vary by breed.

Table 3. List of production and reproduction traits with expected progeny differences

Growth trait EPDs	Carcass trait EPDs	Maternal/Paternal trait EPDs
Birth weight	Carcass weight	Milk
Weaning weight	Marbling	Protein
Yearling weight	Rib-eye area	Fat
Mature weight	Fat thickness	Daughter pregnancy rate
Mature height	Tenderness	Docility
Average daily gain	Quality grade (percent choice)	Calving ease (maternal and direct)
Feed efficiency		Stayability (longevity)
Feed intake (dry matter and residual)		Scrotal circumference
		Heifer pregnancy rate

Table 4. Recommendations for EPDs for various commercial scenarios

Use of individual	Breed	Birth weight	Weaning weight	Yearling weight	Milk
Terminal sire on mature cows	Large carcass	Not excessive	High	High	Not relevant
Bull to use with heifers	Small to medium size	Low	Moderate	Moderate	Consider if keeping heifers
Sire replacement heifers	Medium size maternal	Low to moderate	Moderate to high	Moderate to high	Varies

