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# Development of Terminal and Maternal Economic Selection Indices in Beefmaster Cattle

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# Development of Terminal and Maternal Economic Selection Indices in Beefmaster Cattle

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### Summary with Implications

*Two economic selection indices were developed for Beefmaster cattle, one for a terminal objective and one for a maternal objective. The terminal index was developed assuming bulls would be mated to mature cows with all resulting progeny harvested. The maternal index was developed assuming bulls would be mated to a combination of heifers and mature cows, with resulting progeny retained as replacements or sold at weaning. Relative economic values for the terminal objective traits hot carcass weight, marbling score, ribeye area, 12th-rib fat and feed intake were 91.29, 17.01, 8.38,-7.07 and-29.66, respectively. Relative economic values for the maternal objective traits calving difficultly direct, calving difficulty maternal, weaning weight direct, weaning weight maternal, mature weight and heifer pregnancy were-2.11,-1.53, 18.49, 11.28,-33.46 and 1.19, respectively. The application of economic selection indices facilitates genetic improvement of beef cattle by aiding producers with their sire selection decisions.*

### Introduction

Economic selection indices are used to maximize genetic improvement in a specific objective. Most currently available selection indices are designed to be used by multiple breeders for specific marketing endpoints. Selection emphasis may differ between production systems and goals set forth for a particular operation. Before using economic indices to make selection decisions, it is important to define the operation goals and choose an index that closely aligns with those goals.



While EPD are the traditional genetic tools used to select seedstock, they represent genetic merit in only one trait while in reality multiple traits influence an animal's economic value as a parent. Selection indices simplify comparisons of animals by accounting for multiple traits simultaneously and by considering both biological production levels and economics. Currently, Beefmasters Breeders United (BBU) reports ten EPD, but provides no tool for multitrait selection. Therefore, economic selection indices are needed by Beefmaster producers to aid them in selecting seedstock. The objective of this study was to develop 2 economic selection indices for Beefmaster cattle tailored to terminal and maternal production systems.

### Procedure

#### *Economic Values of Objective Traits*

Traits chosen for the breeding objective of each index should be those that affect the income and expense of the production system. Five objective traits were considered for the terminal index including hot carcass weight (HCW), marbling score (MS), ribeye area (REA), 12th-rib fat (FAT) and feed intake (FI). Six objective traits were considered for the maternal index including calving difficultly direct (CDd), calving difficulty maternal (CDm), 205-day weaning weight direct (WWd), 205-day weaning weight maternal (WWm), mature weight (MW) and heifer pregnancy (HP). Economic values for each trait in the breeding objective ensure selection emphasis is proportional to the economic importance of each trait. Derivation of economic values requires identifying sources of income and expense for each production system in order to develop a profit equation.

In the production system assumed for the terminal index, all calves were born from mature cows, retained through the feedlot phase, and sold on a grid based system. Phenotypes for the objective traits were simulated from a random normal distribution with the means and SD for each respective trait obtained from literature. Income was derived from marketing animals based on carcass weight, quality grade and yield grade. The 5-year (2010-2014) average price for steers and heifers at slaughter was obtained from the Livestock Marketing Information Center (LMIC) and used as the base price for all slaughter animals. Premium and discount values based on yield grade, quality grade and carcass weight were obtained from United States Department of Agriculture-Agricultural Marketing Service (USDA-AMS). Costs of the system included feed, veterinary, medicine, bedding, marketing, custom operations, fuel, repairs, processing and yardage. Five-year averages of prices for feedstuffs used in the production system were calculated using information obtained from the USDA—National Agricultural Statistics Service (USDA-NASS).

In the production system assumed for the maternal index, calves were born from a combination of heifers and mature cows, with resulting progeny retained as replacements or sold at weaning. Phenotypes for the maternal objective traits were simulated from a random normal distribution with the means and SD for each respective trait obtained from literature. Income was derived from marketing calves at weaning and non-pregnant females based on their weight and the market price of that weight category. Average prices of weaned calves ranging in weight from 350 to 700 lbs were calculated from 5 years of filtered data from the USDA-AMS. Data was filtered to include only states in the region where Beefmaster cattle are the most prevalent. States included were Alabama, Arkansas, Georgia, North Carolina, South Carolina, Florida, Mississippi and Texas. Average prices of cull females were estimated as a 5-year average obtained from the LMIC. Costs of the system were feed and expenses associated with calving difficultly. A 5-year average of prices for feedstuffs used in the production system was calculated using information obtained from the USDA-NASS.

**Table 1. Relative economic values (REV) and relative emphasis of the objective traits.**

| | REV | Relative emphasis (%) |
|---|---|---|
| Terminal objective | | |
| FI, lbs | -29.66 | 19.3 |
| HCW, lbs | 91.29 | 59.5 |
| REA, sq. in. | 8.38 | 5.5 |
| FAT, in. | -7.07 | 4.6 |
| MS, units[1] | 17.01 | 11.1 |
| Maternal objective | | |
| CDd, % | -2.11 | 3.1 |
| CDm, % | -1.53 | 2.2 |
| WWd, lbs | 18.49 | 27.2 |
| WWm, lbs | 11.28 | 16.6 |
| MW, lbs | -33.46 | 49.2 |
| HP, % | 1.19 | 1.7 |

[1]4.0 = $Sl^0$ and 5.0 = $Sm^0$

Profit of each system (terminal and maternal) was determined by subtracting simulated cost from simulated income for 100,000 animals. Economic values were determined by approximating the partial derivatives of the profit function by perturbing one trait at a time, by one unit, holding the other traits constant at their respective means. The relative economic value of each trait was estimated as a product of the respective economic value and genetic SD. The relative contribution of each objective trait was calculated as a percentage of the sum of the absolute value of the relative economic values for the objective traits.

### *Selection Index Coefficients*

Ideally, selection criteria would include all traits in the breeding objective, but in practice some traits in the objective are not readily observed so selection criteria may include indicator traits. In this study, selection criteria were chosen from EPD currently reported by BBU. Terminal selection criteria were yearling weight (YW), ultrasound ribeye area (UREA), ultrasound 12$^{th}$-rib fat (UFAT) and ultrasound intramuscular fat (UIMF). Maternal selection criteria were birth weight (BWT), WWd, WWm, YW and scrotal circumference (SC). Index coefficients for selection criteria EPD were calculated as the product of an inverted genetic (co)variance matrix among selection criteria, a genetic (co)variance matrix between selection criteria and objective traits, and the vector of economic values for each objective trait. The genetic (co)variances assumed in these calculations were based on estimates reported in literature.

## Results

The relative economic values and the relative emphasis of objective traits for the terminal and maternal selection indices are presented in Table 1. In the terminal objective, decreasing FAT and FI while increasing HCW, REA and MS would increase profitability. Hot carcass weight is the primary contributor to profit, receiving 59.5% of the emphasis. Feed intake receives the next highest emphasis at 19.3%. This implies improving efficiency is crucial to increasing the profitability of an operation with a terminal objective.

In the maternal objective, decreasing CDd, CDm and MW while increasing WWd, WWm and HP would increase profitability of the operation. Mature weight is the primary driver receiving 49.2% of the emphasis, implying that for the assumed parameters decreasing MW will do the most to improve profitability of operations with a maternal objective. Weaning weight direct is the second highest priority objective trait receiving 27.2% of the emphasis. These two traits are antagonistic to each other relative to the breeding objective, but since the assumed correlation between them is not unity progress can be made in both traits simultaneously.

The selection index value for an animal is the weighted sum of its EPD for the selection criteria, with each EPD being weighted according to the index coefficient of that EPD (Table 2). The accuracy of the terminal index lies between 0.338 and 0.503, and the accuracy of the maternal index lies between 0.218 and 0.428. The accuracy of an index reflects the correlation between the index and the aggregate genotype. The lower bound of the accuracy estimate assumes that phenotypic measures are the selection criteria. The upper bound of the accuracy estimate assumes that EPD known without error are the selection criteria. However, EPD would never be known with complete certainty given the heterogeneity of the residual variance. Thus, the upper bound of the index accuracy would be the 'best case scenario,' presuming that the accuracy of each EPD included in the index for each animal was unity. We would expect the true accuracy of the index to lie somewhere between the two accuracies presented herein that were produced by assuming the index was comprised of either phenotypic measures or by EPD that are known without error.

As expected, the accuracy of the maternal index was slightly lower than the terminal index because a greater number of indicator traits were included among the

**Table 2. Index coefficients for EPD of selection criteria.**

| Terminal index | |
|---|---|
| YW | 1.715 |
| UREA | 0.806 |
| UFAT | -36.60 |
| UIMF | 12.375 |
| Maternal index | |
| BWT | -1.371 |
| WWd | 1.426 |
| WWm | 0.945 |
| YW | -0.660 |
| SC | 2.725 |

selection criteria. Some indicator traits (e.g., SC) were used because they were the only traits with a non-zero correlation to important breeding objective traits (e.g., HP). However, SC and HP are lowly correlated, meaning SC is not a strong indicator of HP. The accuracy of selection based on an index including SC as selection criteria could be greatly improved if instead EPD for HP were reported and could be included in the selection criteria. Having EPD available for other economically relevant traits such as stayability (STAY) would also greatly improve the accuracy. However, in this case STAY was not even included among the objective traits because there were no correlated EPD available as selection criteria.

## Conclusion

Adding more EPD for economically relevant traits is an important next step for all beef breed associations to improve the accuracy of selection indices, and thus increase profitability of operations utilizing selection indices as a tool when making breeding decisions. For the available selection criteria, implementation of the selection indices presented herein will increase profitability and facilitate genetic improvement of Beefmaster cattle.

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