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Bio-economic Model Predicts Economic Values for Beef Production

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Introduction

Defining the breeding objective or goal is the most important step in a breeding program. The objective is a combination of economically important traits in a production system. The economic importance of biological traits to be included in a breeding goal are evaluated by their economic value, or the expected increase in profit resulting from a unit increase in a trait due to selection. Modeling is the main tool for derivation of economic values for important production traits through the application of profit equations or through bio-economic models. According to Roughsedge et al. (2003), bio-economic models integrate complex models of animal biology with principles of farm management and prices of farm inputs and outputs. The objective of this study was to estimate economic values for production traits in a full life cycle system using a bio-economic model with Angus purebred and a terminal crossbreeding system with Nelore sires mated to Angus dams.

Experimental Procedures

Phenotypic data were collected from the Bifequali crossbreeding scheme from the Embrapa Pecuária Sul Research Center of the Brazilian Agricultural Research Corporation (Embrapa), located in the city of Bagé, Rio Grande do Sul State, Brazil. The data consisted of progeny performance and carcass trait phenotype (Table 1) of Angus purebred and Nelore sires mated to Angus dams raised in a pasture-based production system from birth to slaughter.

The economic characterization (Table 2) of the system was based on fixed costs (taxes, depreciation, land opportunity, and opportunity costs of invested capital) and variable costs (sanitation, handling, reproduction, labor, etc.). Since the system was pasture-based, measures of forage consumption was not possible. Instead, the costs of feed were estimated through energy requirements for different animal categories (growing animals, heifers in reproduction, and dams in reproduction) according NRC equations and Buskirk et al. (1992) equations.

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The bio-economic model was developed in 'R' programming language using phenotypic performance data and associated production costs. Fertility and survival rates were used to develop a Leslie matrix model that considers the age at first calving of heifers (in this case three years old), pregnancy rates for each age class of dams, and the survival of each animal category. In the Leslie matrix, the herd started with 500 females distributed in categories from 0- to 15-years-old and after a cycle of 500 years the herd stabilized at an inventory of 642 females.

In the crossbred scheme, all of the offspring are marketed, so replacement heifers need to be purchased or produced in a separate breeding unit. In the current simulation, purchased replacements were modeled. A replacement rate of 28.5% was modeled using the stayability rate or the probability of a female staying in production to at least six years of age.

In Brazil, slaughter companies have a premium system based on age as measured by dentition and carcass weight (Table 3). These premiums are paid according to the base market price and pricing schedule. Mean carcass weight and its standard deviation determine which category each animal would fit into for this model. Revenues came from the sale of finished steers, cull heifers, and cows.

To estimate the resulting economic values, the bio-economic model was initially parameterized and a base profit calculated. The breeding goal was selected considering a full life cycle production system which defined the traits that have economic importance. Each trait in the breeding objective was sequentially increased one unit without changing the other traits. The difference in profit observed between simulations and profit from the baseline simulation divided by the number of dams generated the relative economic value of respective characteristics. The traits in the breeding objective are mature cow weight, birth rate, yearling weight, live weight at slaughter, carcass weight, dressing percentage, and fat thickness.

Results and Discussion

The profitability of an activity tells us if such activity will be able to continue in the long term. If the profit is positive, the revenue can cover direct expenses, depreciation and also the opportunity costs of land and invested capital. In this study, both systems were profitable; however, the crossbreeding system generated more profit per herd (Angus herd = $16,316.23, Nelore × Angus herd = $30,881.28).

Economic values (Table 4) vary across the two systems due to the difference in the importance of each trait as a return and a cost. Mature cow weight had a positive but smaller economic value because increasing cow weight affects the revenue of cull cows increasing directly, but selection for high mature weight can increase the energetic costs associated with maintenance.

Birth rate is known to affect all sources of revenue and costs. In this case, when the birth rate was changed in the crossbreeding scenario, the costs were higher because of the energetic cost to produce one calf is higher due the weight of the cow and the weight of the calf. Additionally, the marginal value of increasing birth rate through selection is diminished due to the expected higher reproductive rate of the crossbred cows due to heterotic effects.

Dressing percentage had the largest numeric economic value. This occurred because when dressing percentage is increased, the carcass weight is increased and the associate revenue from carcass weight increases. The Nelore × Angus cows had a larger economic weight than Angus cows. Traditionally, crossbreed Zebu animals have higher dressing percentages than British animals. Additionally, Nelore × Angus cows have lower relative weight for the legs, head, hide, and digestive tract.

Implications

The use of crossbred animals is a good tool to improve economically important traits and profitability in a full cycle beef production system in Brazil.

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Table 1. Phenotypic means for two alternative breeding groups

Traits	Angus	Nelore × Angus
Cow weight, lb	956.14	1007.73
Weaning rate, %	72.25	72.25
Weaning weight, lb	370.38	381.24
Initial weight, lb[1]	677.39	799.17
Slaughter weight, lb	1045.63	1119.28
Carcass weight, lb	530.96	593.66
Dressing percentage	50.78	52.93
Fat thickness, in	0.143	0.171

[1]Initial weight at fattening phase.

Table 2. Costs per year and returns per year[1] estimated by the bio-economic model

Items	Angus	Nelore × Angus
Costs[2]		
Cows	105.56	105.56
Bulls	110.95	110.95
Calves	44.54	44.54
Heifers 1-2 years old	84.92	198.50[3]
Heifers 2-3 years old	102.64	102.64
Steers 1-2 years old	70.70	70.70
Total energetic cost[4]	85,966.30	91,473.00
Returns		
Steers carcass price/lb	1.32	1.32
Heifers carcass price/lb	1.22	1.22
Cull cows carcass price/lb	1.22	1.22

[1]Amount in U.S. dollars per head per year.
[2]Fixed + variables.
[3]Acquisition of heifers for replacement.
[4]There were 642 cow/calf pairs in herd.

Table 3. Premium payment system according to cow maturity (determined by dentition) and carcass weight (lb)

	Maturity by dentition		
Premium	Milk tooth	Two teeth	Four teeth
3%	363-441	363-441	363-520
7%	441-485	441-520	520-573
8%	485-520	520-573	573-617
10%	520-573	>573	>617

Table 4. Estimated economic weightings[1] per unit change for Angus and Nelore × Angus crosses

	Genetic group	
Economic value	Angus	Nelore × Angus
Cow mature weight, lb	0.11	0.12
Birth rate, %	2.57	0.83
Initial weight, lb	0.49	0.53
Final weight, lb	0.49	0.99
Carcass weight, lb	1.88	2.10
Dressing percentage	8.70	9.86
Fat thickness, in	-0.015	-0.032

[1]Amount in U.S. dollars.