Beef Heifer Development and Profitability

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Summary

The determination of the ideal breeding size of beef replacement females is traditionally centered on maximizing pregnancy rate. Relevant physical and economic relationships were combined into a bioeconomic systems model that identified key profit factors. This system-wide approach encapsulated the physical relationships with relevant costs and revenues, including annual and seasonal variations and measures relative to profitability through the application of an incomplete or modified profit function. Optimal outcomes were relative to heifer size and management regime.

Introduction

Researchers at the University of Nebraska–Lincoln have addressed the issue of heifer development cost (Funston and Deutscher, *Journal of Animal Science*, 2004, 82:3094-3099; Martin et al., *Journal of Animal Science,* 2008, 86:451-459). These experiments challenged conventional wisdom that heifers must reach 65% of mature body weight for optimal pregnancy. This work is a continuation of that work and provides an economic focus.

Procedure

This work was undertaken to provide economic interpretation of the biological results by: 1) building mathematical constructs that were representative of the biological system; 2) identifying the pertinent cost and revenues; 3) combining costs, revenues, and biology into a systems model; and 4) using the model to evaluate the economic outcomes of heifer development strategies.

Data from the above cited experiments were combined and reanalyzed using economic methodologies. This work translated the biological information from the scientific investigations into a series of mathematical equations integrated into an economic model The overall frame work of the system was designed to measure relative profitability through the application of a Modified Profit Function (MPF). The MPF captured only those dollar values which related to heifer maturity differences.

Individual animal profitability was mathematically simulated from the interrelationships derived from the many biological performance and economically relevant variables identified using Ordinary Least Squares (OLS) and Profit regression techniques with a loss function criteria.

Only relationships whose coefficients were statistically significant at the 95% confidence level and identified as most efficient by the Akaike Loss Criteria (AIC) were included in the analysis.

Price information was obtained from publications from the United States Department of Agriculture, Livestock Marketing Information Center, and Cattle-Fax.

Profitability was measured via a Modified Profit Function (MPF). The MPF used five revenue and three cost sources that captured profitability differences among heifers at varying maturity levels. A Maturity Index (MI) was developed that used information collected before first breeding, described in the *2009 Nebraska Beef Cattle Report,* p. 15.

The MI score was a prediction of an individual animal's pre-breeding weight as a percentage of her actual mature body weight. The MI was made up of nine coefficient estimates that represented six factors. These six included: heifer's age in days, her pre-breeding weight in pounds at the start of the breeding period, her birth weight in pounds, her dam's age, and the level of development nutrition. These six factors were economically relevant and key contributors to the physical performance of the heifers up through and including the weaning of their first calves. The six factors, nine coefficient estimates, and their relationships to the MI are enumerated in equation 1.

Equation 1

$$MI = \underset{(<0.01)}{43.351} + \underset{(<0.01)}{0.03109Wt_{Pb}} - \underset{(<0.01)}{0.1419Wt_{Birth}} + \underset{(<0.01)}{0.000089Age^2_{Heifer}} - \underset{(<0.01)}{0.01272Wt_{Dam}}$$

$$+ \underset{(<0.03)}{1.756Age_{Dam}} - \underset{(<0.03)}{0.1448Age^2_{Dam}} + \underset{(<0.01)}{4.888T1} + \underset{(<0.01)}{2.645T2} + \underset{(<0.01)}{2.588T3}$$

Where: MI – Maturity index
Wt_{Pb} – Pre breeding weight
Wt_{Birth} – Birth weight
Age^2_{Heifer} – Pre breeding Age, (in days)
Wt_{Dam} – Mature weight of the heifer's Dam
Age_{Dam} – Dam's age in years when the heifer was born
Age^2_{Dam} – Dam's age in years squared when the heifer was born
T1 – Dummy/Indicator variable for the feed treatment group resulting in a traditional group average pre-breeding weight of 58% of herd average
T2 – Dummy/Indicator variable for the feed treatment group resulting in a traditional group average pre-breeding weight of 53% of herd average
T3 - Dummy/Indicator variable for the feed treatment group resulting in a traditional group average pre-breeding weight of 56% of herd average

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To facilitate the estimation of the regression equation, it was necessary to omit the fourth feed treatment. This omission resulted in this treatment being the basis from which all other treatments were measured, reflected in their coefficient estimates and statistical significance. This omitted group had the lowest nutritional rate and resulted in a traditional group average pre-breeding weight of 51% of herd average. The four feed treatments were utilized to produce different pre-breeding weights. The full description of the methodology can be found in the original papers.

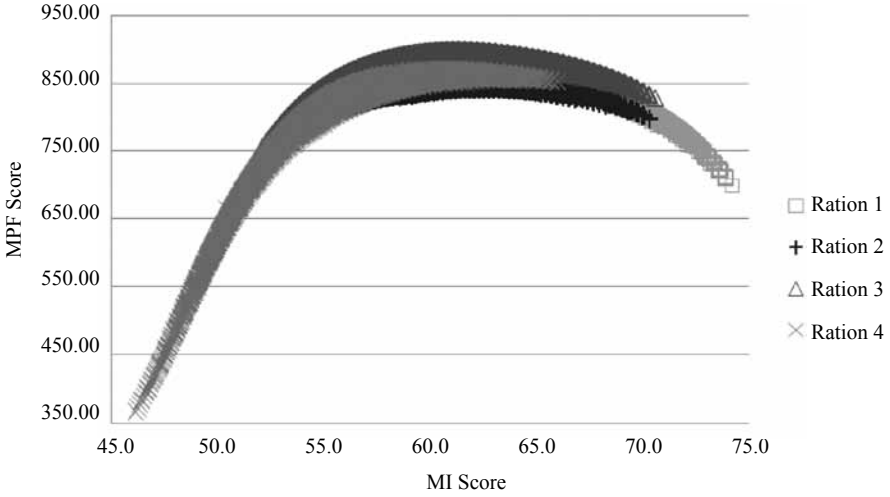

Figure 1. The 2003 Modified Profit Function (MPF) scores for all feasible Maturity Index (MI) scores for all feed treatment levels.

Results

The economically optimal MI score was 61.3, representing a prediction that the optimal heifer was of 61.3% (714 lb) of her mature weight and 456 days of age. This heifer was developed on the feed regime that produced an average heifer weight of 53% of the herd's average mature weight, was born to a 5-year-old dam with a mature weight of 1,420 lb. Given the amount of variation within a herd of cattle, accumulating a group of heifers with these exact characteristics would be unrealistic, making the application of this one statistic of little or no value.

A total of 39,168 different MI combinations were considered. This number of combinations represented the set of feasible outcomes for cows in the University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory cow herd. A full description of this set of variables is available on request from the authors. Figure 1 illustrates the modified profits from all 39,168 combinations of heifer type. Results are graphed by ration which is representative of feed treatment. The first ration, ration 1, is the highest level of nutrition; ration 3 was the second highest; ration 2 the third highest; and ration 4 the least nutritious. The level of nutrition corresponds exactly with each treatment group's average percent mature body weight. The highest level of nutrition resulted in heifers having the highest average mature weight. The different shades on the graph illustrate the range and effects that nutrition has on MI and MPF scores. The wide range in results demonstrates how the different physical characteristics of heifers with varying nutrition regimes altered MI and profitability. Most strikingly is the fact that MIs with like values don't necessarily result in like profitability. The same MI can be achieved using different combinations of the six factors.

Conclusions

Individuals in a population have a significant impact on determining a system's economic optimum. The original work this analysis is based on demonstrated that differences in pregnancy rates of randomized groups were difficult to identify with small changes in nutrition. However, differences among individuals within groups were found to be statistically significant.

From the feed treatment effects on animals of various characteristics, some powerful conclusions can be drawn. Heifers from larger dams developed with the lowest level of nutrition, which are younger at pre-breeding, were restricted in profitability. Conversely, higher levels of nutrition negatively impacted profitability of older heifers from smaller dams.

The MI was valuable in predicting physical factors of production performance but was an unsatisfactory predictor of profitability. This was true because MI scores relied on six factors that had differing costs and influence on productivity and profitability.

Important points to consider are: 1) specific combinations of heifer age and potential size change the nutritional regimes needed to optimize their profitability; 2) the more homogeneous the group of heifers with respect to the critical variables identified here, the higher the profitability potential from appropriate management regimes; 3) potential loss is greater for large heifers fed lower rates of nutrition than for small heifers fed higher rates of nutrition; 4) large heifers require more days of age and higher levels of nutrition to optimize profitability; 5) when managed correctly, heifers from larger dams are more profitable than those from smaller dams, given historical information used and the range of the study.

Wide variations in animal characteristics in a homogenously managed group can cause large disparity in individual animal profitability. When managing in groups, decision makers should either select like animals that match the management regime, or the management regimes should be adjusted to match the animals selected.

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