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Development of a Lifetime Merit-based selection index for US dairy grazing systems

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ABSTRACT

Pasture-based dairy producers in the United States face costs, revenue streams, and management challenges that may differ from those associated with confinement dairy production systems. Three Grazing Merit indices (GM$1, GM$2, and GM$3), parallel to the US Lifetime Net Merit (NM$) index, were constructed using economic values appropriate for grazing production in the United States. Milk prices based on averages from the previous 5 yr were used for GM$1, whereas GM$2 and GM$3 used milk prices found in NM$. Cull prices and interest rates from NM$ were used in GM$3 but were updated for GM$1 and GM$2. All other inputs remained constant among GM$1, GM$2, and GM$3. Economic costs and revenues were obtained from surveys, recent literature, and farm financial record summaries. Derived weights for GM$ were then multiplied by the predicted transmitting abilities of 584 active artificial insemination Holstein bulls to compare with NM$. Spearman rank correlations for NM$ were 0.93 with GM$1, 0.98 with GM$2, and 0.98 with GM$3. Traits (and their percentages of weight) comprising GM$1, GM$2, and GM$3, respectively, included milk volume (24, 0, 0%), Fat yield (16, 21, 21%), protein yield (4, 17, 17%), productive life (7, 8, 7%), somatic cell count (−8, −9, −9%), feet and legs composite (4, 4, 4%), body size composite (−3, −4, −4%), udder composite (7, 8, 8%), daughter pregnancy rate (18, 20, 20%), calving ability (3, 3, 3%), and dairy form (6, 6, 6%). These weights compared with NM$ weights of 0, 19, 16, 22, 10, 4, 6, 7, 11, 5, and 0% for the same traits, respectively. Dairy form was added to GM$ to offset the decrease in strength associated with selection to reduce stature through selection against body size. Emphasis on productive life decreased in GM$ because grazing cattle are estimated to remain in the herd considerably longer, diminishing the marginal value of productive life. Although NM$ provides guidance for grazing dairy producers, a GM$ index based upon appropriate costs and revenues allows for selection of cows and bulls for more optimal genetic progress.

Key words: economic value, genetic, grazing, selection index

INTRODUCTION

The increased focus on pasture-based dairy production has prompted several studies in the United States and other countries to determine the effect of genotype by environment interaction (**G×E**) for grazing production compared with confinement dairy production. These studies have involved several economically important traits such as milk production, SCC, conception rate, and milk component percentages. A G×E effect occurs when the environment affects the way genes are expressed, resulting in a change in the phenotype of the animal in one environment versus another (Bourdon, 2000).

Recent studies have pointed out that a modest G×E primarily because of scaling does exist; however, the effect is not sufficient to create an economically feasible impetus for separate progeny tests for confinement and pasture-based production systems (Weigel et al., 1999; Boettcher et al., 2003; Kearney et al., 2004; Coleman et al., 2009). Although G×E is minimal for individual traits, the aggregate value of the animal in each distinct environment may be different. Many grazing dairy producers are convinced that current US genetics do not and cannot meet their needs because the current US indices are based largely on DHIA test data. Many grazing producers do not participate in DHIA tests, for various reasons but commonly to avoid the associated costs. Therefore, grazing data are under-represented in US genetic evaluations of AI bulls and selection indices.

Traditionally, the theory of index selection utilizes phenotypic correlations, heritabilities, and the genetic relationships among desired traits to enhance accuracy and generate a single PTA per animal that represents the aggregate breeding value. However, many produc-

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ers may benefit from the availability of individual trait PTA to achieve selection for their specific breeding goals. Because a single whole-animal PTA is not generated, multiple PTA are calculated that account for heritabilities and correlations. In the selection index approach typically used for US selection indices, only economic weights need be considered, because the supplied PTA include the genetic parameters in their calculation (VanRaden, 2004).

Historically, the US economic indices used only production traits to estimate the economic value of an animal. However, in 1994, the idea of the US Net Merit$ (**NM$**) index was expanded to include fitness traits. This new index added the concepts of economic value of productive life and SCS, as well as the traditional production traits (VanRaden, 2004).

Additional changes were made to the US NM$ in 2000, when the development of a lifetime profit function made inclusion of type traits (conformation composites) possible. Scientists in the USDA regional research project S-284, "Genetic Enhancement of Health and Survival for Dairy Cattle," constructed the function that included traits milk volume (**MY**), fat yield (**FY**), protein yield (**PY**), udder composite (**UC**), SCS, feet and legs composite (**FLC**), body size (**BS**), and productive life (**PL**).

Over time, additional changes have been made to the US NM$, essentially broadening the focus of the index. These updates have moved the index from being purely production oriented to a balanced index with concurrent emphasis on both production and functional traits. In 2003, 2006, and 2010, financial weights were re-evaluated, revised, and updated to maintain relevance in a changing dairy industry. Additional traits were added to the index as evaluations became more readily available. In 2003, NM$ was changed to include daughter pregnancy rate (**DPR**) and service sire (**SCE**) and daughter (**DCE**) calving ease. In 2006, SCE and DCE were combined with service sire stillbirth and daughter stillbirth to create calving ability dollars (**CA$**).

Today, the economic values used in NM$ are the result of several major studies and data from the DHIA. These sources allow NM$ to include accurate estimates of the values to be placed on traits; however, the data are based on records primarily from confinement dairies, due to the low participation rates of grazing dairies in DHI testing and conformation scoring through breed associations. Existing genetic evaluation data may fairly represent breeding objectives for grazing farmers; however, the actual degree to which they are represented has yet to be determined.

The objective of this study was to evaluate the suitability of NM$ for grazing production and determine the suitability of separate grazing merit indices developed by replacing the input values found in the net merit equations with values more relevant to grazing production systems.

MATERIALS AND METHODS

Input Equations

Grazing Merit 1 (**GM$1**), Grazing Merit 2 (**GM$2**), and Grazing Merit 3 (**GM$3**) were derived using a similar approach to that used for the NM$ equations obtained from Animal Improvement Programs Laboratory of the USDA (Cole et al., 2010). Adjustments to appropriate input values were made to more accurately reflect values found in grazing dairy production systems. Basic input values for all indices are in Table 1.

The current NM$ consists of 4 additive parts: Yield $, Udder $, Other $, and CA$, each of which are described below (Cole et al., 2010). In the components of Yield $ are the contributions of MY, PY, and FY, whereas Udder $ includes UC and SCS. The contributions of PL, BS, FLC, and DPR are included in Other $. The CA$ portion of the index is a composite calving ability that includes sire and daughter dystocia and still birth. The original NM$ equations can be found in the Appendix.

Yield $

The equations for MY, FY, and PY are as follows:

$$\text{MY} = (\textit{milkval} - \textit{milkfeed} - \textit{milkhealth}) \times \textit{lactns},$$

$$\text{FY} = (\textit{fatval} - \textit{fatfeed} - \textit{fathealth}) \times \textit{lactns}, \text{ and}$$

$$\text{PY} = (\textit{protval} - \textit{protfeed} - \textit{prothealth}) \times \textit{lactns};$$

where *milkval*, *fatval*, and *protval* are the income values of milk volume and fat and protein yields, respectively; *milkfeed*, *fatfeed*, and *protfeed* are the added feed costs for milk, fat, and protein, respectively; *milkhealth*, *fathealth*, and *prothealth* are the added health costs for milk, fat, and protein, respectively, for cows producing the additional milk; and *lactns* is the average number of lactations of a cow.

Input values for MY, FY, and PY under GM$1 were derived using average prices of the National Agriculture Statistics Services (NASS) milk, Cheddar cheese barrel, and butter prices from 2006 to 2011. The values of butterfat (*fatval*) and protein (*protval*) were derived from Cheddar cheese barrel and butter prices using USDA equations. Milk volume price is the residual value after accounting for the value of butterfat and protein. Feed values (*milkfeed*, *fatfeed*, *protfeed*) were determined to be 41% of added income from the NASS milk price/cwt.