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New breeding objectives and selection indices for the Australian dairy industry

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ABSTRACT

This study comprises an update of the economic values for dairy traits for the Australian industry and the formulation of updated selection indices. An economic model, which calculates partial economic values for each trait individually, was developed to determine the economic implications of selective dairy breeding, based on the effect of trait changes on the profit of commercial dairy farms in Australia. Selection indices were developed from economic values, which were transformed into base economic weights by including the discounted genetic expressions coefficients. Economic weights (in Australian dollars) were 1.79, 6.92, −0.10, −5.44, 8.84, 7.68, 1.07, 4.86, 1.91, 3.51, 4.90, 0.31, 2.03, 2.00, and 0.59, for milk fat (kg), milk protein (kg), milk volume (liters), body weight (kg), survival (%), residual survival (%), somatic cell count (cells/mL), fertility (%), mammary system [Australian Breeding Value (ABV) unit], temperament (ABV unit), milking speed (ABV unit), udder depth (%), overall type (%), fore udder attachment (%), and pin set (%), respectively. The updated economic weights presented in this study constituted the basis of the definition for 3 new indices. These indices were developed from combination of bioeconomic principles, patterns of farmer preferences for trait improvements, and desired gains approaches. The 3 indices, Balanced Performance Index, Health Weighted Index, and Type Weighted Index, have been released to the industry.
Key words: economic value, selection index, dairy cattle, farmer preferences

INTRODUCTION

Economically efficient multiple-trait selection is usually achieved through the definition of breeding objectives and the development of appropriate selection indices for specific production systems (James, 1980). The total genetic merit of an animal is frequently expressed in the form of an economic selection index, which uses the available information from the combination of an individuals' genetic merit and the breeding objective (James, 1980). Selection indices enable both breeders and commercial farmers to direct breeding emphasis toward specific market outcomes or address key production aspects of their particular farming system (Byrne et al., 2010).

In nations with well-structured dairy industries, an across-industry common breeding objective is often controlled at the national level (e.g., Veerkamp et al., 2002; Harris et al., 2007). The Australian Dairy Herd Improvement Scheme (**ADHIS**) is the institution in charge of the National Breeding Objective (**NBO**) implementation and monitoring. The aim of the NBO is to increase net farm profit; therefore, it must evolve over time in response to new knowledge and the demands of dairy businesses. Consequently, the NBO is reviewed on a regular basis to ensure that it remains relevant to the industry, and is supported by scientific and economic principles, as well as farmer's preferences. The first multitrait selection index released by ADHIS was in 1987 and included fat and protein yields. This was replaced by the Australian Selection Index in 1997 and Australian Profit Ranking (**APR**) index in 2001, which evolved to include 9 traits: milk volume, fat, and protein as well as survival, BW, SCC, fertility, milking speed, and temperament. In 2009, the assumptions and economic values of the APR were updated through the release of a new index, which deviated from strict economic values to include weights that had a component of desired gains (Pryce et al., 2009).

In the latest NBO review, which this study is part of, ADHIS put greater focus on obtaining direct input from farmers to support the scientific review of economic inputs and genetic parameters to be used in the construction and update of the breeding objective and selection index. The Australian Dairy Herd Improve-

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ment Scheme conducted a large-scale on-line survey of farmers' trait preferences, which revealed a desire to improve how traits were weighted and to review the range of traits to include in the updated NBO (Martin-Collado et al., 2015).

The current study is the second stage of the NBO review, which comprises an update of the economic values (**EV**) for dairy traits for the Australian industry and the formulation of updated selection indices. This includes the reassessment of the economic parameters and calculation procedures, giving particular attention to farming system variation, and to the definition of additional selection indices based on results of the economic analysis, the outcomes of the farmer survey (Martin-Collado et al., 2015), and direct input by farmer consultation. Farmer consultation was conducted via a NBO review task force group, consisting of a selected group of farmers and industry representatives charged with delivering the best outcome for the Australian dairy industry.

MATERIALS AND METHODS

An economic model, which calculates partial economic values for each trait individually, was developed to determine the economic implications of selective dairy breeding, based on the effect of trait changes on the profit of commercial dairy farms in Australia. The formulation of the new NBO included 8 of the 9 traits considered in the previous NBO (as previously mentioned) plus 3 additional traits (mammary system, overall type, and feed saved). Feed saved has partially replaced BW, as it is a combination of residual feed intake and feed required for maintenance predicted from BW (Pryce et al., 2015). This additional set of traits was included in response to an industry consultation process carried out as the first stage of the ADHIS NBO review (Martin-Collado et al., 2015). The bioeconomic model computed industry-average production performance, taking into account farming system variation, to determine the EV of profit traits used to establish selection indices. The model can be divided into the following 3 stages.

(1) Calculation of economic values: Input cost variables and revenue streams were computed to determine the EV of each dairy trait. The EV of a trait is the marginal value of 1 unit change in the respective trait.
(2) Derivation of economic weights: Selection indices were developed from EV, which were transformed into base economic weights (**EW**) by including the discounted genetic expression (**DGE**) coefficients. Discounted genetic expression coefficients account for the different rates and timing of expression of the genetic superiority for the trait over a planning horizon in the progeny of the selection candidates (Hill, 1974; Amer, 1999). In some cases, base EW were in turn multiplied by genetic regressions, which account for the effect of specific trait changes on other trait changes, and conversion factors used to standardize differences in units of trait expressions, to get the final EW of each trait.
(3) Development of selection indices: Once the final EW of traits were calculated, different selection indices were developed. For several of the selection indices, a desired gains approach was used to align trait economic weightings to patterns of farmer preference revealed in the farmer survey and in consultation with the NBO review task force.

The specific calculations described in the following 3 sections correspond to each of the stages above. The results of each stage, which are presented at the end of each section, inform the calculation of the subsequent stage.

Calculation of EV

This section presents the calculations of EV for all dairy traits included in the Australian NBO review. All the equations used to calculate EV are described in detail in each specific trait subsection. Equations are presented with 2 kinds of parameters: (a) input parameters (always in lowercase), and (b) intermediate parameters derived from calculations in intermediate equations (always in capital letters). Some trait EV (e.g., the economic values for BW and fertility) consist of different components. These components were calculated discretely because for BW, for example, some are expressed by cows (cow maintenance weight) and some by replacements (replacement heifer costs); this requires an account of differences in timing and frequency of expressions of each component in the herd when the EW is expressed per cow per lactation. Then, components were aggregated, with inclusion of the respective DGE coefficients, together to comprise the overall trait EW. For clarity, input parameters and assumptions are presented either in the trait EV description or in the Appendix.

EV of Milk Production Traits. Three milk production traits were included in the breeding objective: protein yield (kg), fat yield (kg), and milk volume (L), which were calculated under a milk solids payment scenario and under a volume of milk payment scenario.