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Sustainable breeding objectives and possible selection response: Finding the balance between economics and breeders' preferences

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ABSTRACT

To optimize breeding objectives of Fleckvieh and Brown Swiss cattle, economic values were re-estimated using updated prices, costs, and population parameters. Subsequently, the expected selection responses for the total merit index (TMI) were calculated using previous and newly derived economic values. The responses were compared for alternative scenarios that consider breeders' preferences. A dairy herd with milk production, bull fattening, and rearing of replacement stock was modeled. The economic value of a trait was derived by calculating the difference in herd profit before and after genetic improvement. Economic values for each trait were derived while keeping all other traits constant. The traits considered were dairy, beef, and fitness traits, the latter including direct health traits. The calculation of the TMI and the expected selection responses was done using selection index methodology with estimated breeding values instead of phenotypic deviations. For the scenario representing the situation up to 2016, all traits included in the TMI were considered with their respective economic values before the update. Selection response was also calculated for newly derived economic values and some alternative scenarios, including the new trait vitality index (subindex comprising stillbirth and rearing losses). For Fleckvieh, the relative economic value for the trait groups milk, beef, and fitness were 38, 16, and 46%, respectively, up to 2016, and 39, 13, and 48%, respectively, for the newly derived economic values. Approximately the same selection response may be expected for the milk trait group, whereas the new weightings resulted in a substantially decreased response in beef traits. Within the fitness block, all traits, with the exception of fertility, showed a positive selection response. For Brown Swiss, the relative economic values for the main trait groups milk, beef, and fitness were 48, 5, and 47% before 2016, respectively, whereas for the newly derived scenario they were 40, 14, and 39%. For both Brown Swiss and Fleckvieh, the fertility complex was expected to further deteriorate, whereas all other expected selection responses for fitness traits were positive. Several additional and alternative scenarios were calculated as a basis for discussion with breeders. A decision was made to implement TMI with relative economic values for milk, beef, and fitness with 38, 18, and 44% for Fleckvieh and 50, 5, and 45% for Brown Swiss, respectively. In both breeds, no positive expected selection response was predicted for fertility, although this trait complex received a markedly higher weight than that derived economically. An even higher weight for fertility could not be agreed on due to the effect on selection response of other traits. Hence, breeders decided to direct more attention toward the preselection of bulls with regard to fertility.
Key words: breeding objective, economic value, selection response, total merit index

INTRODUCTION

In animal breeding, the genetic merit of future generations needs to be improved to ensure adequately efficient production under future economic, natural, and social circumstances (Groen et al., 1997). According to Fewson (1993), all economically important traits should be considered in the breeding objective; thus, production and functional traits, the latter increasing profit by reducing costs, need to be taken into consideration. Realizing the economic and socioeconomic benefits, more and more countries have started to include functional traits in their cattle breeds' breeding objectives (e.g., Miglior et al., 2005). In Holsteins, Reents and Rensing (2009) observed a noticeable increase of functional traits in various countries' breeding objectives between the years 2000 to 2009. However, the inclusion of health traits is primarily reliant on indirect health

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traits (correlated traits) due to a lack of recording and genetic evaluation of direct health traits (disease diagnoses, direct observations of impaired health).

According to selection index theory (Hazel and Lush, 1942), which is the basis for the optimal weighting when selecting for more than one trait, the total merit index (**TMI**) represents the mathematical definition of the breeding objective. When all traits are estimated multivariately, the TMI may be calculated as

$$TMI = b_1X_1 + b_2X_2 + \ldots + b_nX_n,$$

where n is the number of traits, b the index weights, and X the breeding values. If results of different genetic evaluations are combined, individual breeding values and their reliabilities as well as economic values and genetic correlations between all traits considered need to be known. Economic values, as defined by Hazel (1943), represent the value of one unit superiority of a trait when all other traits in the aggregate genotype remain constant. If relative levels of economic values are correct, optimum levels of genetic improvement are possible (Groen et al., 1997).

To optimize the long-term genetic gain of Austrian cattle breeds, the project OptiGene started in 2011. Among the aims of this project was the optimization of breeding objectives and breeding programs as well as the improvement of the TMI calculation (Egger-Danner et al., 2015). As such, economic values needed to be re-estimated for the breeds Fleckvieh and Brown Swiss based on updated prices, costs, and population parameters. A working group (breeding goals) within the joint genetic evaluation team Austria/Baden-Württemberg/Bavaria (Germany) was established to provide support. Working group members and experts in related fields from Austria, Germany, and the Czech Republic met regularly between 2013 and 2015.

In Austria, the first TMI in cattle was introduced in 1998 (Fürst et al., 2016). Economic values in the TMI were based on the results described by Miesenberger (1997). In 2002, economic values in the TMI were adapted without prior derivation when establishing the joint genetic evaluation Austria/Baden-Württemberg/Bavaria. A re-estimation (Lind, 2007) following the approach of Miesenberger (1997) provided the basis for the TMI of both breeds up to the year 2016. As health data were not available before 2006 (Egger-Danner et al., 2012a), Lind (2007) did not consider health traits other than the SCC including costs for mastitis. Since 2010 (Fleckvieh, dual-purpose Simmental; Fuerst et al., 2011) and 2013 (Brown Swiss; Fuerst and Egger-Danner, 2014), breeding values for mastitis, early reproductive disorders (retained placenta, puerperal diseases, and metritis), ovarian cysts, and milk fever have been published in the context of the joint Austrian-German genetic evaluation. Along with the introduction of the genetic evaluation for health traits in Brown Swiss, all health traits, with the exception of milk fever, were also included in the TMI. Preceding model calculations revealed a slight negative trend for udder health and fertility when direct health traits were not considered (Egger-Danner et al., 2012b). Economic values for early reproductive disorders, ovarian cysts, and milk fever were already derived by Fuerst-Waltl et al. (2010) by adapting the computer program originally used by Lind (2007). Following earlier studies in Fleckvieh and Brown Swiss (Fuerst-Waltl and Fuerst, 2010, 2012), a new routine genetic evaluation for the trait rearing losses has recently been developed; however, so far, no economic values have been derived for this trait.

The aims of the current study were therefore to derive economic values for dairy, beef, and functional traits and the breeds Fleckvieh and Brown Swiss. Based on the computer program described by Fuerst-Waltl et al. (2010), mastitis and SCC should be split into 2 separate traits and economic values for ketosis and rearing losses should also be calculated. Another aim of our study was to compare the expected selection response for the TMI with previous and newly derived economic values, but also for alternative scenarios considering the needs of breeders. These were previously collated by means of a questionnaire (Steininger et al., 2012; Egger-Danner et al., 2015) and were discussed further in the working group and in regional meetings of farmers in 2015. The challenge for the definition of a new TMI was to find the balance between economics and breeders' preferences.

MATERIALS AND METHODS

Model for Deriving Economic Values

A computer program originally designed to optimize management-related decisions on cattle farms (Amer et al., 1996) and modified for the estimation of economic values in cattle by Miesenberger (1997), Lind (2007), and Fuerst-Waltl et al. (2010) was used. A dairy herd with milk production, bull fattening, and rearing of replacement stock was modeled over an infinite planning term. All relevant revenues and costs were calculated per day. Daily results were weighted by the proportion of the respective cow classes and were summarized over the calving interval or until culling. Cow classes arose from the percentage of culls for infertility, involuntary, and voluntary reasons in each lactation (Table 1). According to Smith et al. (1986), changes that correct