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Genetic analysis of efficiency traits in Austrian dairy cattle and their relationships with body condition score and lameness

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ABSTRACT

This study is part of a larger project whose overall objective was to evaluate the possibilities for genetic improvement of efficiency in Austrian dairy cattle. In 2014, a 1-yr data collection was carried out. Data from 6,519 cows kept on 161 farms were recorded. In addition to routinely recorded data (e.g., milk yield, fertility, disease data), data of novel traits [e.g., body weight (BW), body condition score (BCS), lameness score, body measurements] and individual feeding information and feed quality were recorded on each test-day. The specific objective of this study was to estimate genetic parameters for efficiency (related) traits and to investigate their relationships with BCS and lameness in Austrian Fleckvieh, Brown Swiss, and Holstein cows. The following efficiency (related) traits were considered: energy-corrected milk (ECM), BW, dry matter intake (DMI), energy intake (INEL), ratio of milk output to metabolic BW ($ECM/BW^{0.75}$), ratio of milk output to DMI (ECM/DMI), and ratio of milk energy output to total energy intake (LE/INEL, LE = energy in milk). For Fleckvieh, the heritability estimates of the efficiency (related) traits ranged from 0.11 for LE/INEL to 0.44 for BW. Heritabilities for BCS and lameness were 0.19 and 0.07, respectively. Repeatabilities were high and ranged from 0.30 for LE/INEL to 0.83 for BW. Heritability estimates were generally lower for Brown Swiss and Holstein, but repeatabilities were in the same range as for Fleckvieh. In all 3 breeds, more-efficient cows were found to have a higher milk yield, lower BW, slightly higher DMI, and lower BCS. Higher efficiency was associated with slightly fewer lameness problems, most likely due to the lower BW (especially in Fleckvieh) and higher DMI of the more-efficient cows. Body weight and BCS were positively correlated. Therefore, when selecting for a lower BW, BCS is required as additional information because, otherwise, no distinction between large animals with low BCS and smaller animals with normal BCS would be possible.
Key words: efficiency, body condition score, lameness, genetic parameter

INTRODUCTION

The dairy industry is under constant pressure to further improve production efficiency and a greater emphasis is being placed on reducing the negative effects of dairy production on the environment. Emissions of greenhouse gas and nutrient losses to the environment should be reduced (Connor, 2015). Improving feed efficiency provides a way to tackle both challenges. The focus is on how much milk is produced from a feed unit and not the performance per animal (VandeHaar, 2014).

Feed efficiency is a complex trait, with many definitions in lactating dairy cows. Efficiency can be expressed as ratio-based traits (e.g., ratio of milk output to feed input) or residual-based traits (e.g., residual feed intake; Berry and Crowley, 2013). However, the difficulty of recording feed intake hinders direct selection for feed efficiency. As an alternative, the use of moderately to highly correlated indicator traits (e.g., milk yield, BW) has been suggested (Berry and Crowley, 2013).

The Federation of Austrian Cattle Breeders initiated the project "Efficient Cow" at the end of 2012 with a 1-yr data collection in 2014. In addition to routinely recorded data (e.g., milk yield, fertility, disease data), data of novel traits (e.g., BW, BCS, lameness score, body measurements) and individual feeding information and feed quality were recorded at each test-day. Data were recorded in the Austrian central cattle database following extensive plausibility checks. The overall goal of this project was to develop and evaluate efficiency traits in dairy cattle breeding considering Austrian circumstances. Farms were selected to cover diverse production environments in Austria, ranging from mountainous regions to intensive farms in climatically favorable regions. Despite this, the average herd

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size (32.6 cows) was approximately twice as high as the Austrian average (Steininger et al., 2015).

Detailed phenotypic analysis results of the "Efficient Cow" data are given by Gruber and Ledinek (2017) and Ledinek et al. (2017). The objectives of this study were to estimate genetic parameters for ECM, BW, DMI, energy intake, and efficiency traits, and to investigate their relationships with BCS and lameness based on data from the "Efficient Cow" project.

MATERIALS AND METHODS

Data

Data of routinely recorded milk yield, as well as data of novel traits (BW, BCS, and lameness) and individual feeding information and feed quality recorded by trained staff from the milk recording organizations on each test-day (approximately every 5 wk), was available from the "Efficient Cow" project from January 2014 to December 2014. Further information about recording diet information, handling of forage analyses, nutrient content of concentrate, and calculation of energy content of forage is given in Ledinek et al. (2016, 2017). In total 45,944 records from 6,519 cows from 161 herds were available.

Traits

ECM. Milk yield was standardized to ECM at each test-day according to the recommendations of GfE (2001) as follows:

$$\text{ECM} = (0.38 \times \text{fat percentage} + 0.21 \times \text{protein percentage} + 0.95)/3.2 \times \text{milk yield}.$$

BW. In Austria, standard housing systems for dairy cows lack equipment for routine weighing. During the observation period of the project, all cows were weighed on each test-day. If no scale was available on-farm, a mobile device was used.

DMI. As individual feed intake was impossible to measure on-farm, DMI at each test-day had to be estimated. For this purpose, the prediction model no. 1 of Gruber et al. (2004) was used:

$$\text{DMI} = 3.878 + \text{Country} \times \text{Breed} + \text{Parity} + \text{DIM} + \text{bBW} \times \text{BW} + \text{bMilk yield} \times \text{Milk yield} + \text{bConcentrate amount} \times \text{Concentrate amount} + 0.858 \times \text{NE}_{\text{L}}\ \text{Forage}.$$

The model considers the fixed effects of country and breed, parity, DIM, and the regression coefficient for the energy content of forage (NE_L Forage). Depending on the DIM, the regression coefficients (b) for BW, milk yield, and amount of concentrate have to be calculated. Feeding information was recorded for each cow on each test-day. Dairy cow rations and forage analyses were recorded and included in the prediction as well. A more detailed description of the model and calculation is given by Ledinek et al. (2016). Jensen et al. (2015) evaluated the up-to-date feed intake models of NRC (2001), Volden et al. (2011), TDMI-Index (Huhtanen et al., 2011), Wageningen-DCM (Zom et al., 2012a,b), and Gruber model no. 5 (Gruber et al., 2004) and found the Gruber model to be the most accurate. In this study, Gruber model no. 1 was chosen to take advantage of the high coefficient of determination (R^2 = 86.7%) and the low residual standard deviation (RSD = 1.32 kg of DM) compared with prediction model no. 5 (R^2 = 83.5%, RSD = 1.46 kg of DM; Gruber et al., 2004).

Energy Intake. For each cow and test-day, energy intake (**INEL**) was calculated as follows, whereas DMI was estimated according to the model of Gruber et al. (2004):

$$\text{INEL} = \text{DMI} \times \text{energy concentration}\ (\text{MJ of NE}_{\text{L}}/\text{kg of DM}).$$

Efficiency Traits. Calculation of efficiency parameters was based on the description of Berry and Pryce (2014). As feed intake had to be estimated, residual feed intake could not be considered; therefore, only ratio-based efficiency traits were investigated. Efficiency at each test-day was defined as ratio of milk output to metabolic BW ($ECM/BW^{0.75}$, BW efficiency), ratio of milk output to DMI (ECM/DMI, feed efficiency), and ratio of milk energy output to total energy intake (**LE/INEL**, where LE = energy in milk; energy efficiency).

BCS. Body condition score was recorded at each test-day on a scale from 1 (severe underconditioning) to 5 (severe overconditioning) in increments of 0.25 (Edmonson et al., 1989).

Lameness. Lameness was recorded at each test-day using the scoring system by Sprecher et al. (1997), where 1 = normal, 2 = mildly lame, 3 = moderately lame, 4 = lame, and 5 = severely lame.

Data Edits

Analyses were carried out for Fleckvieh, Brown Swiss, and Holstein cows with a maximum foreign gene proportion of 25% from all parities; only data from 5 to 365 DIM were considered. Dry cows were excluded