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Genetic parameters of rumination time and feed efficiency traits in primiparous Holstein cows under research and commercial conditions

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ABSTRACT

Feed efficiency has the potential to be improved both through feeding, management, and breeding. Including feed efficiency in a selection index is limited by the fact that dry matter intake (DMI) recording is only feasible under research facilities, resulting in small data sets and, consequently, uncertain genetic parameter estimates. As a result, the need to record DMI indicator traits on a larger scale exists. Rumination time (RT), which is already recorded in commercial dairy herds by a sensor-based system, has been suggested as a potential DMI indicator. However, RT can only be a DMI indicator if it is heritable, correlates with DMI, and if the genetic parameters of RT in commercial herd settings are similar to those in research facilities. Therefore, the objective of our study was to estimate genetic parameters for RT and the related traits of DMI in primiparous Holstein cows, and to compare genetic parameters of rumination data between a research herd and 72 commercial herds. The estimated heritability values were all moderate for DMI (0.32–0.49), residual feed intake (0.23–0.36), energy-corrected milk (ECM) yield (0.49–0.70), and RT (0.14–0.44) found in the research herd. The estimated heritability values for ECM were lower for the commercial herds (0.08–0.35) than that for the research herd. The estimated heritability values for RT were similar for the 2 herd types (0.28–0.32). For the research herd, we found negative individual level correlations between RT and DMI (−0.24 to −0.09) and between RT and RFI (−0.34 to −0.03), and we found both positive and negative correlations between RT and ECM (−0.08 to 0.09). For the commercial herds, genetic correlations between RT and ECM were both positive and negative (−0.27 to 0.10). In conclusion, RT was not found to be a suitable indicator trait for feed intake and only a weak indicator of feed efficiency.

Key words: genetics, rumination time, feed efficiency

INTRODUCTION

Feed costs comprise over half of the operating costs of European dairy herds (European commission 2015). Thus, achieving high feed efficiency of dairy cows is essential to increasing the profitability of milk production (VandeHaar 1998; Veerkamp, 1998). Feed efficiency can be improved through optimization of feeding and management (Kristensen et al., 2015). Additionally, feed efficiency has been shown to vary with respect to genetic background, which implies that genetic selection may be a used to improve feed efficiency (Williams et al., 2011; Tempelman et al., 2015).

Feed efficiency is increasingly expressed as residual feed intake (**RFI**), defined as observed DMI minus predicted DMI based on milk production, BW, and BW change. Thereby, feed efficiency is expressed as metabolic efficiency, independent of production level and size (Connor et al., 2013). Thus, to include RFI in a breeding selection index, phenotypic information on individual DMI is required. However, as individual DMI recording is only performed in research facilities, including DMI in the selection index is challenged by the shortage of phenotypic data (Berry, et al., 2014; Manzanilla Pech et al., 2014; Tetens et al., 2014). Alternatively, traits that are already being recorded in large-scale commercial dairy herds might serve as correlated indicator traits for DMI. Rumination time (**RT**) may be such a trait. On-farm automatic recording of RT is enabled by sensor-based systems that record rumination activity sounds produced by jaw or by ear movements (Schirmann et al., 2009; Braun et al., 2013; Bikker et al., 2014). The observation that rumination activity is stimulated by fiber intake (Mertens, 1997; Nørgaard et al., 2010) suggests that RT might constitute a DMI indicator if DMI and RT have a robust genetic correlation.

To enable DMI to be predicted based on RT in commercial herds, data quality and genetic parameters found under practical conditions must resemble the data quality and genetic parameters found in research facilities. Neither the genetic parameters of RT nor

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the potential of using RT as an indicator trait of DMI have been compared between research facilities and commercial herds. The objectives of our study were 2-fold. First, we sought to identify genetic parameters for RT and the related traits of DMI, RFI, and milk production at early, peak, mid, and late lactation periods in primiparous Holstein cows. Second, we examined whether genetic parameters of rumination are similar between commercial herds and research facilities.

MATERIALS AND METHODS

Animals and Facilities

Research Herd. Research facility data were collected from Danish Holstein cows housed in a freestall barn with cubicles and slatted floor and milked in an automatic milking system (**AMS**; DeLaval, Tumba, Sweden) allowing free cow traffic at the Danish Cattle Research Centre (Foulum, Denmark). The cows had ad libitum access to TMR varying in nutritional content in accordance with the particular trial in which the cows were involved. Data were collected during various trial periods and cows were not nested within trial. The nutritional value of the TMR were all within the recommended requirements, formulated to support the milk yield level of the herd, and allocated in amounts allowing approximately 10% orts to ensure ad libitum intake. In addition, cows were supplemented with a maximum of 3 kg of daily concentrate to ensure voluntary access to the AMS. Feed intake data from this study were used previously by Li et al. (2016).

Commercial Herds. Commercial herd data were obtained from registrations for Holstein cows housed in freestall barns and milked in an AMS (Lely, Maassluis, the Netherlands). Cows were fed partially mixed rations and supplemented with concentrates in the AMS during milking.

Data Recording

Research Herd. Individual feed intake was recorded by feed bins (Insentec, Marknesse, the Netherlands) allowing access via feed gates controlled by neck collars. The feed bins registered the amount of feed leaving the feed bin during the time between each cow's bin entry and exit. Feed intake per visit values were summed into daily feed intake values, from which daily DMI values were calculated with the DM content of the feed offered to each individual cow. Dry matter content of each TMR and concentrate was analyzed within each trial. Milk yield per visit in the AMS was recorded at each milking and condensed into daily milk yield with a moving average approach. Milk composition was assayed for at least two 24-h periods per week and used for estimation of ECM yield. Daily DMI, milk production, and BW data were recorded from January 2003 to April 2015. Rumination time was recorded from May 2013 to May 2016 by a microphone-based rumination monitoring sensor (RuminAct by SCR Engineers Ltd., Netanya, Israel) placed on the left side of each cow's neck. The sensor identifies RT by the sound of regurgitation of feed boluses and by the specific, regular sound pattern related to rumination behavior. Rumination time was recorded in 2-h intervals and daily RT was estimated by accumulation of the 12 2-h intervals within each day. The recordings on DMI, RT, and milk yield were summarized as weekly averages for each individual cow before being subjected to further analysis.

Commercial Herds. Feed intake was not recorded in the commercial dairy herds. However, RT was recorded by the same type of rumination sensor (sold as Qwes HR by Lely) used in the research herd. Cows in the commercial herds were milked in AMS (Lely), and daily milk yields were calculated by the procedure used for the research herd. Milk samples were drawn routinely once every month and analyzed for content of fat and protein. Lactose content was not determined in milk samples from commercial herds.

Data Editing

Research Herd. Outliers of feed intake were identified as being outside the range of 4 times the residual standard deviation of the regression between intake per visit and visit duration. Outlier detection was performed as 2 runs of this procedure, wherein outliers identified in the first run were omitted for the second run and replaced by predicted values from the regression between intake per visit and visit duration. A DMI data range of 5 to 42 kg/d was used. Weekly averages of DMI allowed a maximum of 2 missing records per weekly average. Weekly milk yield averages were required to have at least 2 valid ECM records. Outliers on RT were detected by a filter that sorted out unrealistic RT due to sensor errors or disturbed rumination behavior due to heat. Furthermore, data with missing RT records within 24 h were eliminated. Data on weekly averages of RT were allowed to have missing daily records due to the limited number of records available. Ultimately, 22,901 DMI and ECM records from 650 cows and 4,045 RT records from 159 cows were obtained, all 1 to 44 wk after calving.

Commercial Herds. Milk yield data outside 3 times the standard deviation were considered outliers. Rumination time and ECM outliers were determined by the same procedure as in the research herd. Ultimately, 695,516 RT records from 10,475 cows and 28,516 ECM