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
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 peri-
ods 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 col-
clected 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 vari-
ous 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 vol-
untary access to the AMS. Feed intake data from this
study were used previously by Li et al. (2016).

Commercial Herds. Commercial herd data were ob-
tained from registrations for Holstein cows housed in
freestall barns and milked in an AMS (Lely, Maassluis,
the Netherlands). Cows were fed partially mixed ra-
tions 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) al-
lowing 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 milk-
ing 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 re-
corded 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 identi-
fied 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 re-
placed 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
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