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Genetic regulation of prepartum dry matter intake in Holstein cows

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ABSTRACT

The objective of this study was to estimate genetic parameters for dry matter intake (DMI) in prepartum nonlactating and in lactating Holstein cows. Measurements were recorded on cows from Iowa State University (ISU) and the University of Florida (UF) dairy herds. Individual feed intake data were recorded daily at ISU from approximately 30 d prepartum through 150 d in milk (DIM). Individual intakes from cows at UF were recorded for approximately 42 d pre- and postpartum. Prepartum DMI traits were defined as DMI on d −15 (multiparous) or d −8 (primiparous) relative to calving date (DRYDMI), DMI on d −1 before parturition (CALVEDMI), and the negative of the slope of a regression line fitted through the last 14 (multiparous) or 7 (primiparous) days before calving (DEC). Lactation DMI traits were defined as DMI at 30 DIM (DMI30) and 100 DIM (DMI100; ISU data only). The final data set included 245 primiparous and 221 multiparous cows from ISU, and 125 multiparous cows from UF. Heritability estimates were 0.43, 0.64, 0.32, and 0.62 for DRYDMI, CALVEDMI, DEC, and DMI30, respectively. The estimate of heritability for DMI100 (ISU only) was 0.52. The genetic correlation between DRYDMI and DMI30 was 0.97. Thus, DMI prepartum is a moderately heritable trait that is highly correlated with intake during early lactation. Genetic correlations between DEC and DMI during lactation were lower and similar to standard error estimates (-0.24 ± 0.22 for DEC and DMI30 for combined data, and -0.13 ± 0.27 for DEC and DMI100 in ISU data). Thus, selection for altered DMI during lactation may not dramatically affect the depression in intake that occurs before parturition.
Key words: heritability, correlation, feed efficiency

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INTRODUCTION

Feed efficiency is a critical factor in the economic and environmental sustainability of the dairy industry because feed costs account for more than half of the total production costs of dairy operations (USDA-ERS, 2014). Genetic selection and improved management methods have significantly increased milk production, resulting in increased feed intake and feed costs, but also improved feed efficiency. When commodity prices are especially high, feed costs cause major concern among producers. One approach to control these costs in an environmentally sustainable way is to select cows for improved feed efficiency.

To improve feed efficiency through selection, a thorough understanding of the genetic regulation of DMI is needed. Genetic parameters for feed intake have been estimated from various individual and pooled populations of lactating Holstein cattle, and the average heritability for DMI was 0.34 (Berry et al., 2014). Thus, the regulation of DMI has a strong genetic component, and selection on this trait will likely be successful. It is also important to consider DMI at different stages of lactation, as the relative effect of genes controlling DMI may vary throughout a lactation cycle. Estimates of genetic correlations between DMI measured at different times during lactation have a wide range, from 0.10 to 0.97 (Veerkamp and Thompson, 1999; Berry et al., 2007; Hüttmann et al., 2009; Buttchereit et al., 2011; Spurlock et al., 2012; Tetens et al., 2014). However, the genetic regulation of DMI during the nonlactating phase has received minimal attention to date, most likely because the dry period accounts for less than 60 d per year per cow. Also, because milk production is not occurring when cows are dry, production efficiency cannot be determined during this time. However, prepartum intake, especially during the final weeks of gestation, plays a crucial role in the upcoming lactation. The prepartum transition period is characterized by a sharp decline in DMI, and the magnitude of this decline may affect health and productivity after parturition (Grummer, 1995). It is therefore important to understand the genetic relationship between intake during nonlactating and lactating periods to fully appreciate potential consequences of selection for altered DMI during lactation, particularly as it relates to improved feed efficiency.

The objectives of the current study were to estimate heritability for prepartum intake traits and to investigate their genetic relationships with DMI during lactation.

MATERIALS AND METHODS

Animals and Data Collection

All animal experiments conducted at Iowa State University (**ISU**) were approved by the ISU Institutional Animal Care and Use Committee (Ames). Feed intake data were collected from a single lactation for 466 cows at the ISU Dairy Farm from March 2008 through November 2010. Cows ranged from parity 1 to parity 7. Feed intake data collection began approximately 30 d prepartum and continued through approximately 150 DIM. Cows on the study descend from 103 sires and 362 dams.

Cows were housed in group pens equipped with a Calan Broadbent Feeding system, and each cow was assigned a bin and trained to gain access only to that bin. A TMR was fed ad libitum once (during the dry period) or twice (during lactation) daily. The TMR was formulated to meet or exceed nutritional requirements as determined by the NRC (2001). Once a day, the refusals from each bin were removed. Both the quantity of feed dispensed and the feed reclaimed were recorded electronically to obtain daily intake. Samples of the TMR were taken 4 times per week and pooled to a weekly sample that was analyzed for DM content (Dairyland Laboratories Inc., Arcadia, WI). Daily DMI records were discarded if a cow consumed all feed provided on a particular day because it was not a fair representation of the feed consumed had the cow been fed ad libitum. This represented a small percentage (<3%) of the data. Data were also unavailable if a cow was removed from the pen for medical treatments. Cows were weighed and scored weekly for body condition (Elanco Animal Health, 1996) by a single trained evaluator.

Feed intake data were recorded for a total of 128 multiparous cows primarily during the summer months from August 2007 through October 2011 at the University of Florida (**UF**) Dairy Unit, as described by do Amaral et al. (2009, 2011), Tao et al. (2011, 2012), and Thompson et al. (2014). After editing, a total of 125 cows were included in analyses. Briefly, similar to ISU, cows were fed at UF using a Calan gate system, and feed amounts offered and refused were recorded daily during the dry period and lactation. Approximately half of the cows at UF were housed in a barn with no methods to alleviate heat stress, whereas the other half were housed in a barn with cooling methods. All experimental procedures in the aforementioned studies were approved by the Animal Research Committee or the Institutional Animal Care and Use Committee of the University of Florida.

Definition of Dry Matter Intake Traits

To predict missing values and minimize day to day variation, smoothing splines were applied to the daily intake data using the PROC TRANSREG procedure and a smoothing parameter of 70 (SAS Institute, 1999). All analyses were done using data predicted from this procedure. Cows were excluded if they did not have 2 or more feed intake records 1 wk (primiparous) or 2 wk (multiparous) before parturition. Some cows did not have both pre- and postpartum data because intake was not recorded if a cow was undergoing treatment for a medical condition, and some cows did not continue on the study after parturition. The final ISU data set included 432 cows with prepartum and 400 cows with postpartum data, whereas the final UF data set included 125 cows with prepartum and 103 with postpartum data.

Multiple traits were defined to characterize DMI at different stages before and after parturition. Intake during the dry period was represented by DRYDMI, defined as DMI on the day before initiation of the rapid decline in feed intake that precedes parturition. For primiparous cows, DRYDMI was represented by d −8 relative to parturition (d 0); for multiparous animals, DRYDMI was represented by d −15. Intake immediately before calving (**CALVEDMI**) was DMI on d −1 for all cows. The decrease in intake before parturition (**DEC**) was calculated as the slope of the regression line fit through the daily DMI before parturition. The negative of this slope was used in calculations so that greater values corresponded to larger declines in intake. The regression for primiparous cows was fitted for d −7 through −1 while the regression was fitted through d −14 through −1 for multiparous cows. Similarly, **INC** represented the rate of increase in DMI after parturition and was calculated as the slope of the regression line fitted through d 1 to 21 postpartum. The INC data were omitted from individuals who lacked data during the first 21 DIM due to illness or other reasons. The DMI at 30 DIM (DMI30) was chosen to represent a point in early lactation, but after the transition period, DMI at 100 DIM (DMI100) was selected as a time when lactating cows had returned to positive energy balance, on average (Spurlock et al., 2012). Dry matter intake at 100 DIM could only be calculated for the ISU cows because intake records for cows at UF ended at approximately 42 d after calving.