J. Dairy Sci. 97:1128–1138
http://dx.doi.org/10.3168/jds.2013-7185

Effect of genetic merit for energy balance on luteal activity and subsequent reproductive performance in primiparous Holstein-Friesian cows

R. von Leesen,* J. Tetens,* E. Stamer,† W. Junge,* G. Thaller,* and N. Krattenmacher*[1]
*Institute of Animal Breeding and Husbandry, Christian-Albrechts-University, D-24118 Kiel, Germany
†TiDaTier und Daten GmbH, D-24259 Westensee/Brux, Germany

ABSTRACT

Postpartum energy status is critically important to fertility. However, studies dealing with the relationship between both traits are rare and most refer only to the phenotypic level. In this study, random regression models were used to generate cow-specific lactation curves for daily breeding values (BV) of energy balance (EB) to assess the effect of genetic merit for energy status on different traits derived from progesterone profiles and on subsequent reproductive performance of high-producing dairy cows. Individual feed intake, milk yield, and live weight were recorded for lactation d 11 to 180, and EB was estimated on a daily basis. The results provided the basis for the estimation of BV for 824 primiparous Holstein-Friesian cows. For a subset of these cows (n = 334), progesterone profiles for the resumption of ovarian activity were available. Four different traits describing the genetic merit for EB were defined to evaluate their relationship with fertility. Two EB traits referred to the period in which the average daily EB across all cows was negative (d 11 to 55 postpartum), and 2 parameters were designed considering only daily BV for d 11 to 180 in lactation that were negative. We found that cows with a high genetic merit for EB had a significantly earlier resumption of ovarian activity postpartum. Thus, an EB (indicator) trait should be included in future breeding programs to reduce the currently prolonged anovulatory intervals after parturition.
Key words: dairy cow, energy balance, luteal activity, reproductive performance

INTRODUCTION

Milk production per cow has been considerably improved over the last decades (Lucy, 2001), but the success in breeding for milk yield has been accompanied by negative side-effects, especially in terms of an aggravated negative energy balance (**EB**) in early lactation. Cows require sufficient energy intake to support all physiological functions; that is, to produce milk and grow while maintaining fitness and reproducing (Banos et al., 2006). However, DMI is insufficient to cover the demand in early lactation and, according to Collard et al. (2000), selection for milk traits has resulted in a partial shift of available energy toward milk production at the cost of other biological pathways. Additional energy for milk production is made available by mobilization of body fat and skeletal muscle (Butler and Smith, 1989; Bell, 1995). Bauman and Currie (1980) demonstrated that the average EB of high-yielding dairy cows was negative during the first 100 DIM. Beever et al. (1998), studying cows fed a high-quality diet at an intake level >28 kg of DM/d, reported that the period of negative EB can even persist for 20 wk after parturition. During this critical period (~80 d after calving), the majority of farmers aim to get their cows pregnant again to achieve a calving interval of approximately 1 yr. This situation has given cause for concern but studies dealing with EB and fertility traits are rare, mainly because recording of individual feed intake is costly and difficult to apply in practice (Hüttmann et al., 2009). Available data sets are generally small. Nevertheless, several studies have reported negative effects of an energy deficit or losses of body energy on the reproductive performance of dairy cows. Reist et al. (2003) found that cows exhibiting a severe or prolonged negative EB remained open for longer. This was in line with the results of Patton et al. (2007), who stated that cows not experiencing a pronounced energy deficit have an increased likelihood of conception at first service. A few studies also investigated the genetic association of directly measured body energy and reproductive performance: Veerkamp et al. (2000) reported negative genetic correlations between measures of EB and the interval from calving to first luteal activity (commencement of luteal activity; **CLA**). This is in line with Banos and Coffey (2010), who reported negative genetic correlations between the interval from calving to the first observed estrus and daily EB, energy content, cumulative effective energy, and BCS. For EB, this was true only for the first 105

Received June 26, 2013.
Accepted November 5, 2013.
[1]Corresponding author: nkrattennmacher@tierzucht.uni-kiel.de

DIM, whereas for the other traits, all daily estimates (DIM 4 to 311) were significant. Significant correlations with CLA were found only for the first 107 d of energy content and the first 222 d of BCS. These results substantiate the need to accomplish further investigations on the genetic association between traits for body energy and reproductive performance.

The objectives of this study were (1) to define adequate parameters characterizing cow-specific lactation curves for daily breeding values (**BV**) of EB, and (2) to estimate the effect of these parameters on the resumption of first luteal activity postpartum as well as on subsequent reproductive performance. To the best of our knowledge, no comparable research has been done on this issue to date.

MATERIALS AND METHODS

Energy Balance Raw Data and Estimation of Daily Breeding Values

Data were collected from primiparous Holstein-Friesian cows. Data recording was done between March 2006 and December 2012 on the dairy research farm Karkendamm (Bimöhlen, Germany). This farm runs a bull dam performance test, and all Karkendamm bull dam candidates had to complete a test period under commercial conditions in a freestall barn until DIM 180. Nonqualified primiparous cows left the herd afterward. Therefore, only records between 11 (start of feed intake recording) and 180 DIM were used in the present investigation. Animals were milked twice a day and milk yield was recorded at every milking. Milk composition was analyzed weekly based on samples collected from 2 consecutive milkings. Milk was corrected for energy following the formula of Kirchgeßner (1997):

$$\text{ECM (kg)} = (0.39 \times \text{fat \%} + 0.24 \times \text{protein \%} + 0.17 \times \text{lactose \%}) \times \text{milk yield (kg)}/3.17.$$

For this purpose, milk composition per day was obtained by weighting the respective or previous analysis values per day with the respective milk yield. Cows were weighed after every milking and the daily value was derived by averaging morning and evening BW. Animals were fed a TMR ad libitum, and daily intake was recorded for each animal via single feeding troughs. As cows were generally housed separately during the first 10 DIM, no feed intake data were available for this period. The average NE_L of the TMR was 7.1 MJ/kg of DM. Fixed amounts of concentrates were dispensed via concentrate feeders. Energy balance was calculated as described by Buttchereit et al. (2010). Animals were discarded from the analyses if the number of EB estimates per cow across the entire period was fewer than 4. This resulted in 824 primiparous cows and an average of 83 EB estimates per cow.

A pedigree file was created by tracing the pedigree of cows with data 3 generations back. The resulting file consisted of 5,683 animals. Energy balance BV (**EBBV**) were estimated via ASReml 3.0 (Gilmour et al., 2009) using a random regression animal model. Test-day, age at first calving, and stage of lactation were considered as fixed effects. Age at first calving was divided into 5 classes (21 to 25, 26, 27, 28, and 29 to 38 mo). The general lactation curve was modeled by the function according to Ali and Schaeffer (1987), and random regression coefficients for permanent and additive genetic effects were modeled applying Legendre polynomials of 2 degrees:

$$y_{ijklm} = TD_i + AFC_j + \sum_{n=1}^{4} b_n x_{ijklmn}(d) + \sum_{n=0}^{2} p_{kn} x_{ijklmn}(d) + \sum_{n=0}^{2} a_{ln} x_{ijklmn}(d) + e_{ijklm},$$

where y_{ijklm} is the mth observation of EB, TD_i represents the fixed effect of the test-day i ($i = 1$ to 1,714), and AFC_j is the fixed effect of age at first calving ($j =$

Table 1. Descriptive statistics for ECM, fat content, protein content, lactose content, energy balance (EB), DMI, BCS, and BW (n = 824 primiparous dairy cows, DIM 11 to 180)

Trait	No. of observations	Mean	SD	Minimum	Maximum
Age at first calving (mo)	824	27.36	2.33	21.00	38.00
ECM (kg/d)	165,805	32.72	4.69	2.50	53.64
Fat (%)	24,138	3.64	0.59	1.22	8.68
Protein (%)	24,138	3.24	0.24	1.96	6.01
Lactose (%)	24,237	4.88	0.15	3.17	5.38
EB (MJ of NE_L/d)	68,436	5.16	35.86	−141.80	185.59
DMI (kg/d)	93,797	20.17	4.83	1.99	45.45
BCS	5,662	2.95	0.33	1.50	3.90
BW (kg)	130,452	600.03	54.48	404.00	847.00