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Association of calf growth traits with production characteristics in dairy cattle

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ABSTRACT

The objective of this study was to understand the associations of calf growth traits with subsequent milk yield and body weight (BW). Data were collected for 281 Holstein heifer calves from 6 different calf trials of varying lengths (4 to 8 wk) conducted at Pennsylvania State University between 2003 and 2010. Calves were classified as high, medium, or low for hip height, starter feed intake, BW, and growth rate. Milk yield and cow BW were recorded during subsequent lactations. In total, there were 169,734 daily milk records and 136,153 cow BW records available. Data were evaluated using mixed model equations. Separate models were used for each calf growth trait initially, followed by models that considered multiple growth measures. Each model included age at calving, treatment within trial, parity, days in milk, lactation, and one of the calf growth traits as well as the interaction between lactation and days in milk as fixed effects. Cow and calendar week by year were fitted as random effects. Heifers from the low hip height classification as calves produced less milk across lactations after accounting for BW differences. Cows from the medium BW classification as calves produced more milk in early lactation than cows from the high BW classification as calves after accounting for differences in height. Calves that grew more quickly, ate more, and weighed more were heavier as first-lactation heifers and as mature cows. Our results suggest that the type of preweaning growth is an important consideration for future milk yield. Calves that were the shortest had the lowest milk production potential and were the least likely to remain in the herd until first lactation.

Key words: calf growth, mature body weight, milk yield, stayability

INTRODUCTION

Strategic selection of replacement heifers could reduce herd input costs as production of replacement heifers accounts for approximately 20% of the total expenses on dairy farms (Heinrichs, 1993). Moreover, investment in rearing is not fully recovered on a sizeable proportion of replacement animals, as one-third of first-lactation cows do not calve a second time (Wathes et al., 2008). Therefore, it would be helpful to identify indicators early in life that could aid in selecting heifers that are more likely to remain in the herd longer and produce optimal milk yields. Previous studies have suggested that calf measurements could be used to predict productivity later in life, but information in the scientific literature is limited. Swali and Wathes (2006) reported that lighter heifer calves at birth continued to have lesser BW during their first lactation. Lesser birth weights did not affect growth rate, subsequent milk production, or fertility. In contrast, Ghoraishy and Rokouei (2013) reported that low birth weight calves produced less milk later in life. Those authors reported that heifers with high birth weight were younger at first calving but had greater calving to first service, first service to conception and calving intervals, and an increase occurrence of dystocia. Grain intake at weaning, growth rate, and wither height have also been reported to have positive relationships with first-lactation milk yield (Shamay et al., 2005; Moallem et al., 2010; Heinrichs and Heinrichs, 2011; Soberon et al., 2012).

Moderate to strong relationships exist among body and growth measures. Heinrichs et al. (1992) developed quadratic equations to predict BW in Holstein heifers based heart girth, wither height, hip width, and body length. For all the equations, the coefficient of determination was $\geq$0.96. London et al. (2012) reported a rank correlation of 0.26 between hip height and BW in 8-mo-old calves at dairy cattle shows in Georgia, whereas Heinrichs and Hargrove (1987) reported a correlation of 0.40 between wither height and BW for 24-mo-old heifers. Positive relationships between height measurements and ADG, which is a function of feed

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intake, have also been reported (Bar-Peled et al., 1997; Hoffman, 1997; Macdonald et al., 2005; Shamay et al., 2005). Nonetheless, relationships among calf measurements within a population can be difficult to define, as they may vary from calf-to-calf depending upon genetic background (Heinrichs and Hargrove, 1987; Heinrichs et al., 1992).

Understanding the relationships between calf growth characteristics and future productivity would facilitate the development of management strategies to optimize calf growth and enable the selection of replacement heifers based on early-life measurements that are relatively easy to record (Wathes et al., 2008). The objective of our study was to evaluate associations of calf hip height, BW, growth rate, and starter feed intake with subsequent milk yield and BW.

MATERIALS AND METHODS

Data Set

Calf Measurements. Data were collected from 281 Holstein heifer calves from 6 different calf trials of varying lengths conducted at Pennsylvania State University from 2003 to 2010. Details on treatment length, time, and calf nutrition were previously described by Heinrichs et al. (2003, 2009), Lesmeister and Heinrichs (2004, 2005), Lesmeister et al. (2004), Kehoe et al. (2007, 2008), and Quezada-Mendoza et al. (2011). Hip height, starter feed intake, growth rate, and BW were measured on each calf for a period ranging from 4 to 8 wk. Two trials had measurements for 6 wk and 4 trials had measurements for 8 wk. Data were truncated at 4 wk for 2 of the trials that lasted 8 wk due to incomplete feed intake records. Heifer calf data were ranked into 3 classifications (high, medium, low) of an equal number of calves for hip height, starter feed intake, growth rate, and BW. Our goal was to identify high, medium, and low groups that were due to differences in calf effects and not due to treatment or trial effects. Therefore, hip height, starter feed intake, and BW were evaluated with mixed models that included week of treatment within trial as a fixed effect and calf as a random effect. Calves were then assigned to groups based on the random calf effect. We also wished to evaluate growth rate independent of BW. To do this, we included a random regression of BW on age nested within calf, with the regression coefficient used to determine high, medium, or low growth rate. This effect was not significant for hip height or starter feed intake, so it was not considered for those traits. Means, standard deviations, and ADG for the high, medium, and low groups for each trait are reported in Table 1.

Milk Yield and Cow BW Measurements. A total of 169,734 daily milk yield records from 226 heifers from the calf trials were collected following twice-daily milkings at the Pennsylvania State University dairy barn. Cow BW was recorded after each milking using an AfiWeigh scale (Afimilk Ltd., Kibbutz Afikim, Israel). In total, 136,153 BW records from 225 cows were included in the data set used for analysis. Heifers without more than 1 milk record were excluded from the milk yield and BW data set. Lactation groups were classified as 1, 2, and $\geq$3. Days in milk were classified in biweekly groups. Milk yield records greater than 400 DIM were deleted. Total milk yields for 305-d lactations were generated as the sum of daily milk yield from 5 to 305 DIM. For cows with lactation lengths $\geq$100 d but $<$305 d, lactation total milk yield was extrapolated to 305-d totals. Age at calving was classified on a monthly basis.

Statistical Analysis

Each individual cow was considered the experimental unit. Separate models were used to analyze data from the first lactation and data from all lactations. Furthermore, separate models were used to analyze milk yield from all lactations for wk 1 to 10, 11 to 20, 21 to 30, and 31 to 40 of lactation and 305-d lactation total yield for each growth trait. Statistical differences were reported when model source of variation was $P \leq 0.05$. When a main effect was a significant source of variation, levels from each main effect were separated using the PDIFF option and a Tukey-Kramer adjustment (SAS ver. 9.3 PROC MIXED, SAS Institute Inc., Cary, NC) was used to account for multiple comparisons between levels. Results for fixed effects are reported as least squares means $\pm$ standard errors. Results for continuous variables are reported as the regression coefficient $\pm$ standard errors.

Milk Yield. The effect of calf growth trait group on milk yield was evaluated using mixed model equations (SAS ver. 9.3 PROC MIXED; SAS Institute Inc., Cary, NC). Models for milk yield for the first lactation included biweekly DIM, one of the calf growth traits, age at calving, and treatment within trial as fixed effects. Cow and calendar week by year were included as random effects. Models for 305-d first lactation total milk yield included age at calving, one of the calf growth traits, and treatment within trial as fixed effects with a random effect of year. The models for milk yield for all lactations included lactation (1, 2, $\geq$3), biweekly DIM, lactation $\times$ biweekly DIM, one of the calf growth traits, age at calving, and treatment within trial as fixed effects. Cow, cow $\times$ lactation, and calendar week by year were included as random effects. Models for