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Milk yield and estrous behavior during eight consecutive estruses in Holstein cows fed standardized or high energy diets and grouped according to live weight changes in early lactation

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ABSTRACT

Cows managed for extended lactation go through several estruses before rebreeding. The aims of this study were (1) to quantify the effect of the first 8 estruses after calving on milk yield, milking frequency, and estrous behavioral activity, and (2) to determine the effects of early lactation live weight gain (LWG) as an indication of energy balance on milk yield, plasma insulin-like growth factor 1 (IGF-1) concentration, estrous behavioral activity, interval from calving to first estrus, between-estrus intervals, and pregnancy risk. Milk yield, live weight, and estrous behavioral activity were measured daily in 62 Holstein cows, 17 primiparous and 45 multiparous, managed for an 18-mo calving interval. Blood plasma obtained at wk 3, 5, 12, and 24 after calving was analyzed for IGF-1. Estrus was detected by use of milk progesterone profiles combined with visual observations (i.e., mounting behavior and other). The cows were divided into 2 groups: the cows having a negative LWG in each of the first 5 wk postpartum and the cows having a positive LWG in at least 1 of the first 5 wk after calving. The results indicate a similar decrease of 0.56 kg of milk per day of estrus during each of the 8 consecutive estruses. The activity level was 17 ± 1 movements per hour higher during the 8 estruses compared with the basic activity level. More cows expressed mounting behavior at estrus 8 than at estrus 2 (63.3 and 45.9%, respectively). The negative LWG cows had lower IGF-1 and higher milk production than the positive LWG cows. Both LWG groups had similar interval from calving to first estrus, on average 55 d. To conclude, the decrease in milk yield during estrus is marginal and similar in consecutive estruses. Moreover, estrous behavior is more highly expressed in the later estruses compared with the earlier estruses. Reproductive parameters (frequency of mounting, pregnancy risk, interval to first estrus, and between-estrus intervals) were not influenced by the live weight change during early lactation.
Key words: extended lactation, estrus, pregnancy risk, energy balance

INTRODUCTION

High-yielding dairy cows have been selected over generations for increased milk yield, but this is associated with a decrease in reproductive performance (Gilmore et al., 2011). This decrease is mainly due to the negative energy balance (**EB**) associated with high yields in early lactation (Walsh et al., 2011) and the relationship between body lipid reserves and the reproductive cycle (Friggens, 2003). With an 18-mo calving interval, as compared with a traditional 12-mo interval, rebreeding is postponed (Sorensen et al., 2008) to take place during a period in which most if not all cows are in a positive EB. Indeed, the EB is negative in early lactation (Lucy, 2001), but it returns to positive starting around 6 wk after calving (Butler et al., 1981; Gilmore et al., 2011); therefore, the first ovulations typically occur while the high-yielding cow is still in negative EB. Postponing rebreeding to later estruses seems to be a good management option in some situations (Sorensen and Knight, 2002); however, it will also result in more consecutive estruses, which might have a negative effect on milk production and will likely increase mounting activity. Increased activity and expression of mounting behavior during estrus might, however, have a positive influence on the ease of estrus detection (Nielsen et al., 2010). Nevertheless, increased activity could also negatively affect short-term milk production (Steensels et al., 2012). It has been shown that the milk production decreases, on average, 2.25 kg during the day of estrus with a traditional 12-mo calving interval (Schofield et al., 1991). A cow is in estrus when it is sexually receptive; usually this occurs every 21 d (range = 18–24 d) and the estrus lasts for some hours (14.1 ± 4.5 h in Kerbrat and Disenhaus, 2004). This

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period was previously detected by observing specific mounting behavior (the cow stands still while mounted by another cow), but these days fewer cows are expressing mounting behavior (Kerbrat and Disenhaus, 2004). Measurements of milk progesterone can be used (Kerbrat and Disenhaus, 2004), associated with visual observations (i.e., chin resting, color and consistency of the mucus in the vulva; Esslemont et al., 1980; Foote, 1975), and measurements of activity (i.e., pedometers, collars; Hurnik et al., 1975) to precisely detect the day of estrus (Kerbrat and Disenhaus, 2004). The type of housing affects the number of cows expressing estrus. Indeed, more cows housed in stanchion barns expressed mounting than the cows housed in freestalls or pasture when driven twice daily to an observation area for 30 min (De Silva et al. 1981), and more mountings were observed on dirt than on concrete floors (Britt et al. 1986). A decline in estrous behavior expression is often associated with a decrease in reproductive performance and an increase in milk production (Spalding et al., 1975). Spicer et al. (1990) showed that cows expressing estrous behavior during the first and second estrous cycle, as detected by blood progesterone levels, had less negative EB than cows that did not express estrous behavior. Finally, IGF-1 has been identified as a mediator of EB-related effects on luteal function as it stimulates progesterone production (McArdle and Holtore, 1989).

We intended to quantify the decrease in milk production due to estrus and the mounting behavior over several consecutive estruses in cows managed for extended lactation (18-mo calving interval) in a loose housing system with milking robots. Thus, the objectives of the present study were to determine (1) the effect of consecutive estruses on milk yield, milking frequency, and estrus-related activity in dairy cows during extended lactation, and (2) the effect of live weight changes in early lactation on estrous behavioral activity, return to estrus, pregnancy risk, and plasma IGF-1 of cows in extended lactation.

MATERIALS AND METHODS

Animals, Housing, and Feeding Strategies

The experiment was carried out at the Danish Cattle Research Centre at Aarhus University, Foulum. It involved 62 Holstein cows, 17 primiparous and 45 multiparous, managed for an 18-mo calving interval. The number of cows was optimized for the measurement of production parameters of this feeding trial. All the cows were housed in one group pen on slatted floor with freestalls equipped with mattresses and sawdust bedding. The cows had access to water and an automatic milking system (**AMS**; DeLaval AB, Tumba, Sweden) and were voluntarily milked (mean ± SD) 2.77 ± 0.18 times per day during the period studied.

The cows were fed according to 1 of 2 strategies using 2 partially mixed rations, one with a high energy density (**HD**; 7.81 MJ of NE_L/kg of DM) and 50:50 forage-to-concentrate ratio; and one with a lower standardized energy density (**LD**; control diet, 7.49 MJ of NE_L/kg of DM) and 60:40 forage-to-concentrate ratio, but still sufficient to meet the daily energy demands of a high-yielding lactating cow. Half of the cows were fed ad libitum the LD diet during the entire lactation (control strategy **LD-LD**, with 9 primiparous and 22 multiparous cows). The other half of the cows was fed the HD diet until they reached at least 42 DIM and a live weight gain (**LWG**) $\geq$0 kg/d based on a 5-d live weight (**LW**) average, and were then shifted to the LD diet (strategy **HD-LD**, with 8 primiparous and 23 multiparous cows). Insemination was initiated at first estrus after 220 DIM (e.g., at estrus 7.8 ± 1.4 d postpartum). The herd-average milk production for a 305-d lactation period was around 11,000 kg in 2014.

Measurements and Calculations

Estrus Detection, Behavior, and Determination of the Day of Estrus. Estruses were detected and recorded for each cow until estrus number 8. The day of estrus was defined based on milk progesterone profiles in combination with the visual observations. Progesterone (ng/mL) was automatically measured in individual cow milk, based on an immunoassay in the Herd Navigator (Lattec I/S, Hillerød, Denmark) system connected to the AMS. Visual observations [mounting or being mounted (i.e., estrous behavior), vulva swollen red, mucus discharge (i.e., viscous, clear elastic strands of mucus hanging from the vulva), presence of blood in the genital area] were recorded by the farm personnel (2 experienced persons) daily for the cows at 21 ± 3 d after the latest estrus and for those having high activity. The activity of the cows was recorded by a collar activity meter system (DelPro, DeLaval, Tumba, Sweden) mounted around the neck of each cow. The collar recorded the activity of each animal continuously and it was then expressed as number of movements per hour. The activity at the day of estrus was compared with the activity at d 5 relative to the day of estrus. To determine the day of estrus, the following procedure was followed. First, the period in which an estrus could occur was defined by a low level of progesterone (<3 ng/mL; Lamming and Bulman, 1976). Within this period, the day of estrus was defined based on the visual observations in the following anticipated order of importance: (1) the day where the cow is mounting another cow or being mounted itself. If these observa-