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Effects of long-term, near-term, and real-time energy balance, and blood progesterone concentrations, on the pregnancy rate of contemporary dairy cows

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ABSTRACT

This study aimed to contribute to understanding the interface between reproductive and nutritional energetic physiology in contemporary dairy cattle. Multiparous Holstein cows (n = 32) between 70 and 180 days in milk were used in a study starting 10 d prior to the artificial insemination (AI) date and were estrous synchronized using a hormonal regimen. Fourteen cows were determined pregnant on day 39 post-AI. Coccygeal blood samples of all cows were collected on d −10 and −3 prior to AI to determine estrous cyclicity, as well as at AI and at 6, 13 and 20 d post-AI. Milk progesterone was measured 20 d post-AI, and body condition was scored (BCS; 1–5 scale) on days −10, 0, 13 and 27 relative to AI. Blood non-esterified fatty acid concentrations, measured on the same days as BCS, and changes of BCS from d −10 to AI were not predictive of pregnancy outcome. The BCS of cows on the day of AI was greater (P = 0.02) for pregnant cows with an approximate minimum BCS for a high probability of conception being 2.50. Serum progesterone concentrations of pregnant cows were greater (P < 0.05) on days 6, 13 and 20 post-AI, as was milk progesterone at day 20 post-AI (P < 0.01). Pregnant cows had greater (P = 0.02) net energy output (NE_L), which is inconsistent with a common belief that low pregnancy rates in contemporary dairy cows are due to excessive milk production, but is consistent with published studies in this study area. The present research indicates that current low pregnancy rates in commercial high-producing multiparous dairy cattle may be partly due to breeding cows that have insufficient BCS to support pregnancy.

1. Introduction

Milk production and overall energetic efficiency of commercial lactating dairy cows have increased in the past few decades, and there has been a concomitant substantive decrease in reproductive performance (Beam and Butler, 1999; Lucy, 2001). While contemporary herds of multiparous dairy cows with a first service conception rate of only ~30%–35% are common, reasons for such poor fertility remain unclear.

A factor influencing fertility of cows is their energetic state (Leroy et al., 2008a,b) wherein over- and under-conditioned cows have lesser conception rates and are less likely to maintain a pregnancy. The influence of the body condition score (BCS) of cows on

Abbreviations: AI, artificial insemination; BCS, body condition score; BW, body weight; DIM, days in milk; DM, dry matter; NEBAL, negative energy balance; NEFA, non-esterified fatty acid; NE_L, net energy for lactation; OVSYNC, ovulation synchronization; TMR, total mixed ration

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their reproductive performance can be affected by the metabolic status during the transitional lactation period, generally defined as the 6 wk period from 3 wks before parturition to 3 wks postpartum (Grummer, 1995; Drackley, 1999). A key event during this period is mobilization of body fat to meet energetic demands because of the onset of lactation (Bauman and Currie, 1980). Although metabolized lipid from fat deposits provides energy to compensate for the generally lesser intakes of dry matter (DM), and thus lesser intake of net energy for lactation (NE_L), compared to that needed to support milk energy output, this source of energy is rarely enough to maintain an energetic balance. During early lactation, commercial dairy cattle nutritionists often attempt to address these problems by increasing diet NE_L density. This seldom, however, provides contemporary high-producing dairy cows with sufficient NE_L and nutrients required to reach even a neutral energy balance. As a result, the energetic balance of contemporary lactating dairy cows generally remains negative for several months past the onset of lactation and, as a result, their body weight (BW) and BCS decreases.

A common way to assess the gross metabolic state of a cow is to assign a BCS, as it provides a rapid measure of a cow's body energy reserves while providing an assessment of the long-term body energetic status prior to the scoring (Edmonson et al., 1989). The BCS is positively related to the potential for conception and maintenance of pregnancy in cattle (Domecq et al., 1997; Santos et al., 2009). For example, Santos et al. (2009) evaluated BCS as an indicator of pregnancy 58 d after AI in primiparous and multiparous lactating dairy cows. In that study, Holstein cows from four dairy farms were body condition scored following calving, at AI, and at 69–82 days in milk (DIM) postpartum, and allocated to groups with BCS values: ≤2.75, 3.00–3.50 and ≥3.75. Of the 6114 cows, 2025 were pregnant on day 58 after AI, of which 63% had a BCS ≥ 3.00. Using BCS as an index of long-term energy balance can, therefore, assist with breeding decisions of individual cows by providing information on their potential to conceive. Santos et al. (2009) also reported the implications of changes in BCS on reproductive performance wherein cows losing BCS from calving to AI were less likely to be pregnant. This demonstrates the potential that medium-term changes in BCS affect fertility. In contrast, there have been few studies assessing BCS change immediately before and after AI (i.e., near term energy balance). Use of this technique could be combined with quantification of non-esterified fatty acid (NEFA) concentrations on the day of AI (i.e., an index of real-time energy balance) to determine real-time energy metabolism as a predictor of pregnancy in dairy cows.

Another theory addressing the decrease in reproductive performance of contemporary lactating dairy cattle emphasizes the importance of concentrations of progesterone in systemic circulation for maintenance of pregnancy. Because progesterone contributes to priming the reproductive tract and enhancing the uterine environment (Spencer and Bazer, 2002; Bazer et al., 2008), low concentrations are considered detrimental to pregnancy maintenance (Starbuck et al., 2004; Lonergan, 2011). Low concentrations of circulating progesterone, therefore, may result from greater liver blood flow, causing increased steroid metabolism (Parr et al., 1993; Sangsritavong et al., 2002), and has been suggested to be involved in the decrease in the reproductive performance of dairy cattle (Lucy, 2001; Wiltbank et al., 2014).

The goals of the study were to determine effects of long-term, near-term, and real-time energy balance, and blood progesterone concentrations, on the pregnancy rate of contemporary dairy cows.

2. Materials and methods

2.1. Animals and management

This study was conducted on a dairy farm near Hanford (California, USA) from October to December (2015) when low and high ambient temperatures averaged 4.3 and 29.1 °C with an overall relative humidity of 74.6%. The farm maintained ~5000 milking cows milked 3× daily at 8 h intervals commencing at 04:00 h. All early lactation multi-parity cows were housed in five (i.e., pens 1–5) pens of ~320 cows/pen, each with 300 head gates and free stalls bedded with dry manure solids as well as an adjacent manure-pack exercise lot. Cows were assigned to these five pens weekly, in approximately equal numbers, from a common fresh pen. Cows in Pens 1–5 were milked in the same parlor in the sequence one to five in each milking shift day at approximate 45-min intervals. Cows in all pens were fed the same total mixed ration (TMR; Table 1), with a nutrient profile appropriate for high-producing lactating cows (NRC, 2001; Table 2), twice daily before they returned from their 04:00 h milking and prior to leaving for their 12:00 h milking.

Table 1
Average feed ingredient composition of diet dry matter (g/kg).

Alfalfa, hay	125.6
Almond, hulls	133.6
Oat, hay	20.4
Corn, steam flaked	206.5
Cottonseed, Pima (cracked)	20.7
Canola, meal (solvent)	130.9
Distillers Grains, corn (dried)	66.7
Corn, silage	44.3
Wheat, silage	171.2
Pomegranate, pomace (wet)	22.6
Corn, gluten feed	16.0
Molasses, liquid	11.7
Mineral, premix[a]	29.8

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