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## Consistent magnitude of postpartum body weight loss within cows across lactations and the relation to reproductive performance

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### ABSTRACT

Great variation exists among cows in the magnitude of tissue mobilization during early lactation; however, it is not known whether this is an intrinsic trait. Our aims were (1) to test whether the degree of body weight (BW) loss is consistent within cows across lactations by examining daily BW records of 4 to 5 consecutive lactations and their relation to milk yield, health disorders, and reproductive performance; and (2) to examine, in an intensive study, the possible underlying physiological mechanism. Data from 416 first to fifth consecutive lactations obtained from 92 Israeli high-yielding Holstein dairy cows were analyzed. Cows were divided according to percentage of BW loss from wk 1 to 5 postpartum in their last lactation, into groups of (1) low weight loss (LWL; -3 to 6%;  $n = 37$ ) and (2) high weight loss (HWL; 7 to 17%;  $n = 55$ ). The average percentage of BW loss was 7.6% in the HWL group and 5.3% in the LWL group, and the pattern was consistent between groups across lactations. Milk and 4% fat-corrected milk yields during the first 30 d in milk across lactations were higher in HWL than in LWL groups, but 305-d yields were similar. The number of open days and the interval between lactations were consistent across lactations, 17 and 20 d longer, respectively, in HWL versus LWL cows. Across lactations, the conception rates from first, second, and third artificial inseminations were 9.6% higher in LWL than in HWL cows. No differences in the incidence of health disorders were observed between groups. The intensive study was conducted with 12 randomly selected peripartum cows divided into c-HWL and c-LWL groups according to the same criteria. Similar dry matter intake and efficiency calculations were observed between groups postpartum, implying that the differences may not be related to these factors. In response to a glucose-tolerance test, c-HWL cows had higher insulin secretion

pre- and postpartum than c-LWL cows, suggesting the former had lower sensitivity to insulin. This is the first study demonstrating that the magnitude of BW loss postpartum within cows is consistent across lactations, and this trait is associated with reproductive performance. The degree of BW loss postpartum, regardless of genetic merit for milk production, seems to be an intrinsic trait that represents the variation in trade-off toward tissue mobilization between cows.

**Key words:** body weight, consistent pattern, reproduction, dairy cow, insulin sensitivity

### INTRODUCTION

The transition from late gestation to lactation involves a great metabolic challenge: shifting from a nonlactating lipogenic period to a state of tremendous energy demand for milk production. That energy demand results in mobilization of adipose and muscle tissues, as the cow is not able to consume sufficient nutrients to meet the energy requirements of the mammary gland (Bell and Bauman, 1997), and also appears to have a genetic basis (Friggens et al., 2007). The transition period is also characterized by immune dysfunction (Mallard et al., 1998), negative energy balance (Goff and Horst, 1997; Drackley, 1999), and increased incidence of health and metabolic disorders (Goff and Horst, 1997; Mallard et al., 1998). In addition, the negative energy balance in early lactation has adverse effects on cow fertility (Butler and Smith, 1989).

Great variation exists among cows in tissue mobilization during early lactation, and dairy cows in the same herd and consuming the same diet show great variation in feed intake, milk yield, BW gain, and energy balance (McNamara, 2012). The variation in metabolic pathways in adipose tissue, muscle, and liver is striking; within a herd of similar cows on the same diet, use of energy for metabolic functions can vary by 100% among animals (Onken et al., 2011; McNamara, 2012). However, significant unresolved variation in metabolism remains that defines the summative energy efficiencies (McNamara, 2012).

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Variations in fat mobilization in high-yielding dairy cows during early lactation differentially affects lipid and glucose metabolism (Weber et al., 2013). We previously reported differential responses to metabolic stress during the transition period, as insulin signaling in adipose tissue was altered in a subgroup of cows that lost more BW postpartum and a correlation between BW loss and insulin responsiveness in adipose tissue was also observed (Zachut et al., 2013). Our recent finding of differential biomarker protein abundances in adipose tissues of peripartum dairy cows, which are related to individual responses to metabolic stress (Zachut, 2015), is further evidence of cow-to-cow variability.

The interspecies variation and repeatability of the response to metabolic stress was recently investigated in dairy cows (Gross and Bruckmaier, 2015) and goats (Friggens et al., 2016); however, in those studies, the response was tested in the same lactation. Automatically generated BW records, which are objective and quantitative (as compared with BCS), are now available in many farms over lactations. A consistent pattern of BW loss in 8 cows across lactations was found in our previous study (Zachut et al., 2013). Therefore, the aims of the present work were (1) to test the hypothesis that the magnitude of BW loss is an intrinsic trait in animals by using a data set of automatically generated daily BW measurements across lactations and examining their relation to milk production, health disorders, and reproductive performance; and (2) to examine, in an intensive study, the possible physiological mechanism underlying the variation between animals in the degree of BW loss postpartum.

## MATERIALS AND METHODS

### *Cows and Data Collection*

Data were collected from the dairy farm at the Volcani Center (Rishon LeZion, Israel), which has automatically generated daily records of milk yield and BW data for the last 15 yr. Thus, a data set of consecutive lactations of adult cows in the herd could be analyzed. For the current analysis, we randomly selected 92 Israeli Holstein cows that had had at least 4 full lactations in recent years. We excluded all data from >5 lactations due to the low number of cows with this many lactations.

All cows were milked 3 times a day, yields were recorded electronically by the Afimilk system (SAE Afikim, Kibbutz Afikim, Israel), and milk solids (protein, fat, and lactose contents) were determined once a month according to International Dairy Federation Standard 141C (International Dairy Federation, 2000)

by infrared analysis at the Israeli Cattle Breeders Association (Caesarea, Israel) laboratories.

Body weight was measured electronically by a walking scale in the milking parlor (SAE Afikim) 3 times a day, and average daily BW was calculated automatically and recorded. In general, cows were fed a typical Israeli dairy cow ration that contained, per kilogram of DM, 1.78 Mcal of NE<sub>L</sub>, 16.5 to 16.8% CP, and 30 to 33% NDF. The NE<sub>L</sub> values for feedstuffs in rations were determined according to NRC (1989). The concentrate-to-forage ratio in diets was 64 to 67% concentrate and 33 to 36% forage. The main forage were wheat and corn silages and the overall diet composition was changed from year to year depending on feedstuff availability.

### *Calculations of BW Loss*

The average BW during the first and fifth week of each cow for every lactation was calculated, and the percentage of BW change from wk 1 to 5 was calculated. Use of these time points was based on our previous work that showed a consistent pattern of BW loss in wk 1 to 5 across lactations in 8 cows (Zachut et al., 2013). As our objective was to determine whether a consistent pattern of BW loss exists in early lactation, cows were divided into 2 groups according to the magnitude of the BW loss in their last lactation; this value was used to calculate the average percentage BW loss among all cows (7%). Cows losing more than the average BW loss were regarded as high weight loss (**HWL**; range 7 to 17%; n = 55), whereas cows losing less than the average were considered low weight loss (**LWL**; range -3 to 6%; n = 37). This definition was valid for each cow across all lactations. The predicted transmitting ability values of these cows was collected and found not different between groups, at 212.8 and 198.7 kg for the HWL and LWL groups, respectively (SEM = 40.1; *P* = 0.8).

### *Reproductive and Health Data*

Cows were routinely examined by a veterinarian 7 to 10 d after calving, treated according to the farm's routine management, and clinical events and treatments were recorded. The BCS of cows (scale 1–5; Edmonson et al., 1989) was also determined by the veterinarian at this visit. All data on postpartum health disorders and reproductive performance (inseminations, date of conception) were taken from the dairy farm database (NOA, Israeli Cattle Breeders Association). Open days, interval between calvings, number of AI per conception, conception rates (**CR**) at first, second, and third AI, as well as health disorders (ketosis, retained placenta, metritis, and milk fever) were calculated individually for

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