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Effects of body weight loss on serum progesterone concentrations of non-lactating dairy cows

R.O. Rodrigues[a], C. Trevisanuto[a], R.F. Cooke[b], J.L.M. Vasconcelos[a,*]

[a] São Paulo State University, Department of Animal Production, Botucatu 18168-000, Brazil
[b] Oregon State University, Eastern Oregon Agricultural Research Center, Burns, OR 97720

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Abstract

The objective was to evaluate serum concentrations of nonesterified fatty acids (NEFA), cortisol, insulin, and progesterone (P4) of dairy cows maintaining or mobilizing body weight (BW). Eleven non-lactating, non-pregnant, and ovariectomized Gir × Holstein cows were stratified by BW and body condition score (BCS), and randomly assigned to: 1) BW loss (six cows; LOSS) and 2) BW maintenance (five cows; MAINT). Treatments were achieved through a grazing schedule using three pastures. From Days −7 to 1 of the study, all cows were maintained in Pasture A (12 kg of dry matter/cow daily). From Days 2 to 30, LOSS cows were maintained in Pasture B (less than 1.0 kg of dry matter/cow daily), whereas MAINT cows were maintained in Pasture C (12 kg of dry matter/cow daily). However, from Days 3 to 30 of the study, cows from both treatments were regrouped daily into Pasture A from 0600 to 1200 h to allow LOSS cows to consume, on average, 4.5 kg/d of forage dry matter. On Day −66 of the study, all cows received an intravaginal drug releasing device containing 1.9 g of P4 (replaced every 14 d and removed on Day 3). Cow BW and BCS were assessed on Day 0 and 30 and blood samples were collected daily from Days 0 to 30 at 0600 and 1200 h. Changes in BW and BCS were greater ($P \leq 0.05$) in LOSS cows compared to MAINT cows. Within samples collected at 0600 h, serum NEFA concentrations were often greater ($P < 0.05$) in LOSS cows compared to MAINT after Day 14. Serum P4 concentrations were greater ($P < 0.05$) on Days 21 and 22, and tended ($P < 0.10$) to be greater on Days 16, 23, and 24 of the study in LOSS cows compared to MAINT. In conclusion, BW loss was associated with increased circulating concentrations of P4 in non-lactating ovariectomized dairy cows; this was mainly attributed to fat mobilization and consequent release of P4 stored in adipose tissues.

Keywords: Adipose tissues; Weight loss; Body condition score; Dairy cows; Progesterone

1. Introduction

Negative energy balance is highly associated with reduced reproductive performance of postpartum lactating dairy cows [1–3]. In addition to the well-documented detrimental effects of inadequate nutritional status on estrus resumption, fertility, and pregnancy maintenance [4], mobilization of fat can also have direct consequences on reproductive function of cattle. More specifically, substantial quantities of progesterone (P4) can be stored in adipose tissues of cows, and released into the circulation if these tissues are mobilized [5]. In fact, fat tissues in mid-estrous dairy cows may contain up to 10 times more P4 compared with equivalent weight amounts of plasma [6].

Progesterone is an integral hormone in many reproductive processes including attainment of puberty, resumption of estrous cycles, and also establishment and

* Corresponding author. Tel: +55 14 3811 7185; fax: +55 14 3811 7180.
E-mail address: vasconcelos@fca.unesp.br (J.L.M. Vasconcelos).

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maintenance of pregnancy [7–9]. Several researchers have reported that blood P4 concentrations in cattle before or after breeding have been positively associated with conception rates [10–12]. However, elevated P4 before first postpartum ovulation can impair GnRH secretion and thus prevent the LH peak, potentially leading to failed ovulation and formation of ovarian cysts [13–15]. Development of follicular cysts is a common reproductive disorder in the dairy industry [16], affecting up to 19% of dairy cows [17–19], and impairing their reproductive performance by increasing the service period from 22 to 64 d [20,21].

Throughout pregnancy, cows are exposed to elevated circulating P4 concentrations. A considerable portion of this P4 may be sequestered by adipose tissue [5] and released into the bloodstream as body fat is mobilized in response to negative energy balance early postpartum. The resulting circulating P4 could inhibit ovulation and lead to the formation of ovarian follicular cysts [15]. To our knowledge, no in vivo studies have investigated the effects of body fat mobilization on circulating P4 concentrations. A better understanding of this mechanism will provide important information toward the enhancement of reproductive efficiency in dairy cattle. Based on this rationale, we hypothesized that dairy cows experiencing body weight (BW) loss would have increased circulating P4 from adipose tissues compared to cohorts maintaining BW. To test this hypothesis, we compared serum concentrations of non-esterified fatty acids (NEFA), cortisol, insulin, and P4 of non-lactating, ovariectomized dairy cows maintaining or losing BW.

2. Materials and methods

This study was conducted at the São Paulo State University—Lageado Experimental Station, located in Botucatu, São Paulo, Brazil. The cows were cared for in accordance with the practices outlined in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching [22].

2.1. Animals and diets

Eleven non-lactating, non-pregnant, and ovariectomized Gir × Holstein cows (BW = 653 ± 23.3 kg; body condition score [BCS] = 4.3 ± 0.07) were stratified by BW and BCS, and randomly assigned to one of two treatments on Day −7 of the study: 1) BW loss (6 cows; LOSS) and 2) BW maintenance (5 cows; MAINT). Cows were evaluated for BCS in a 1–5 scale with 0.25 increments [23]. Treatments were achieved through a grazing schedule using three pastures (A, B and C), and designed according to the Cornell Net Carbohydrate and Protein System model [24] to induce BW loss (−0.9 kg/d) in LOSS cows, and BW maintenance in MAINT cows. From Days −7 to 1 of the study, all cows were maintained in Pasture A, a 4.5-ha *Brachiaria brizantha* pasture with adequate forage quality (average of 53% total digestible nutrients, 7.1% crude protein, and 76.4% neutral-detergent fiber; dry matter [DM] basis) and availability (average of 12 kg of DM/cow daily). From Days 2 to 30 of the study, LOSS cows were maintained on Pasture B, a 0.5 ha *B. brizantha* pasture with minimal forage availability (less than 1.0 kg of DM/cow daily), whereas MAINT cows were maintained in Pasture C, a 6.9 ha *B. brizantha* pasture with similar forage quality and availability compared to Pasture A. However, from Days 3 to 30, cows from both treatments were re-grouped daily into Pasture A from 0600 to 1200 h to allow LOSS cows to consume, on average, 4.5 kg/d of forage DM.

Both groups received a complete commercial mineral and vitamin mix (7.7% Ca, 4.0% P, 3.0% Na, 0.20% K, 0.20% Mg, 2.0% S, 0.002% Co, 0.03% Cu, 0.002% I, 0.02% Mn, 0.13% Zn, and 0.02% F) and water ad libitum throughout the study. From Days −7 to 30, forage mass from each pasture was evaluated once a week before and after grazing, based on techniques previously described [25] but using six 1 m^2 quadrats\ha. Forage intake was estimated by comparing forage mass before and after grazing, whereas forage samples were collected weekly and analyzed for nutritional content by a bromatology laboratory (São Paulo State University—Botucatu, SP, Brazil).

2.2. Progesterone implants

All cows received an intravaginal progesterone releasing device (CIDR, containing 1.9 g of P4; Pfizer Animal Health, Sao Paulo, SP, Brazil) on Day −66. The CIDRs were replaced at 14 d intervals to elevate circulating P4 concentrations and stimulate P4 uptake by adipose tissues. On Day 3, CIDRs were removed, and cows remained without an exogenous P4 source until the end of the study.

2.3. Sampling and blood analysis

Both BW and BCS were assessed on Days 0, 9, 16, 23, and 30 of the study to evaluate treatment effects on these variables. Values obtained on Days 0 and 30 were used to calculate BW and BCS change. Blood samples were collected daily, from Days 0 to 30, at 0600 and 1200 h, to determine serum concentrations of NEFA,