Long-Term Progesterone Influence on Feed Efficiency, Body Composition, Non-Esterified Fatty Acids and Metabolic Hormones in Mature Rambouillet Ewes

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IMPACT STATEMENT

Our results indicate that systemic progesterone concentrations are not directly related to increased feed efficiency and changes in partitioning of nutrients over a 126-d period that in pregnant ewes. Changes in the partitioning of nutrients in pregnant ewes is probably related to fetal or placental interactions with maternal metabolism. However, maintaining progesterone may alter the homeostatic relationship between insulin and carbohydrate metabolism.

SUMMARY

The objectives of this study were to evaluate the effects of long-term progesterone (P4) treatment on changes in feed efficiency, BW, estimates of body composition, NEFA and metabolic hormones in mature Rambouillet ewes. Thirty, multiparous, 5- and 6-yr-old Rambouillet ewes were assigned randomly to receive long-term P4 administration using a sequential replacement every 14 d of either a P4-containing controlled internal drug release device (CIDR; n = 15) or non-P4-containing CIDR (CIDRX; n = 15) for 126 d. Serum samples were collected at time of CIDR or CIDRX replacement and were assayed for P4, NEFA, insulin (INS), triiodothyronine (T3) and thyroxine (T4). Individual feed intake was recorded using GrowSafe units. Ewes were fed a mixed grass hay diet ad libitum that met the nutrient requirements for maintenance. BW for each ewe was collected at time of CIDR or CIDRX replacement. Back fat (BF) and rib-eye area (REA) were measured for each ewe every 28 d using ultrasonography. BW, residual feed intake, BF, REA and estimates of body composition did not differ ($P > 0.10$) between CIDR- and CIDRX-treated ewes. NEFA, T3 and T4 concentrations did not differ ($P > 0.10$) between CIDR- and CIDRX-treated ewes. However, INS concentrations did differ ($P < 0.05$) between CIDR- and CIDRX-treated ewes. In conclusion, long-term P4 treatment did not appear to alter feed efficiency and partitioning of nutrients. However, maintaining P4 may alter the homeostatic relationship between INS and carbohydrate metabolism in ewes.

INTRODUCTION

Recently, Swartz et al. (2014) reported that the total kg of TDN consumed per ewe per kg of lamb born was 24% greater in Rambouillet ewes from lines selected high (HL) reproductive rate than in ewes selected for low (LL) reproductive rate. The only endocrinological difference between ewes of these lines was that systemic concentrations of P4 were greater in HL ewes than in LL ewes between 60 and 120 d of gestation. One could interpret these results to mean that the apparent increase in efficiency of nutrient utilization in HL ewes during gestation was the result of increased concentrations of P4 between d 60 and d 120 of gestation. Additionally, Parr et al., 1987 showed that the nutritional status of pregnant ewes can alter systemic P4 concentrations which in turn could alter metabolic process that impact maintenance of pregnancy.

Therefore, the objectives of this study were to evaluate the effects of long-term P4 treatment, independent of the influence of the placenta and fetus, on changes in feed efficiency, BW, estimates of body composition, NEFA and metabolic hormones in mature Rambouillet ewes for 126 d.

PROCEDURES

Thirty, multiparous, 5- and 6-yr-old commercial Rambouillet ewes from the Montana State University, Red Bluff Research Ranch flock in Norris, Montana were used for this study. Treatments were: 1) long-term P4 maintenance using CIDR (CIDR; n = 15) or 2) no long-term P4 maintenance using a CIDR backbone (CIDRX; n = 15). Ewes were synchronized for estrus using the 7-d CIDR and $PGF_{2\alpha}$ Twelve d (d = 0) after estrus each CIDR-treated and CIDRX-treated ewe received a CIDR or CIDRX, respectively. This event was the beginning of the feeding trial and d 0 of the experiment. P4 concentrations in each ewe were maintained by replacing a CIDR every 14 d with a new CIDR.

Blood samples were obtained from each ewe every 2 wk along with CIDR or CIDRX replacement. Serum samples were assayed for P4, NEFA, insulin (INS), triiodothyronine (T3) and thyroxine (T4). Body weights of each ewe were recorded every 14 d and estimates of BF and REA were obtained by ultrasonography every 28 d. Ewes were given ad libitum access to mixed grass hay, water, and mineralized salt blocks. The chemical composition of the mixed grass hay on an as fed basis met the NRC (NRC, 2006) nutrient requirements for maintenance of a 132 lb adult ewe. Daily intakes were computed for each of the ewes from the feed intakes derived from the GrowSafe Data software. Residual feed intake (RFI) and estimates of body composition were calculated for each ewe.

RESULTS DISCUSSION

We were able to confirm that long-term P4 can be sustained using sequential replacement of CIDRs. Progesterone concentrations on d 0 differed ($P < 0.05$) between those ewes that received a CIDR and those that received a CIDRX (Figure 1). The difference between CIDRX- and CIDR- treated ewes on day 0 (d 12 of the estrous cycle) may be due to individual ewe differences in time of ovulation relative to estrus. There was a treatment by day interaction ($P < 0.05$) for P4 concentrations over the 126- d experimental period. Progesterone concentrations in CIDR-treated ewes decreased by d 14 which reflects early regression of the corpus luteum (Ottobre et al., 1980) and inhibition of estrus and ovulation. Progesterone concentrations then remained constant until d 84 than increased and remained high from d 96 to d 126. In order to mimic pregnancy, two CIDRs were inserted at d 84 to increase P4 concentrations mimicking the change associated with pregnancy.

Progesterone concentrations at d 14 in CIDRX ewes is consistent with a normal estrous cycle length and luteal function in the next cycle. For CIDRX- treated ewes, d 42 represents the periovulatory period, which is characterized by low concentrations of P4. Thereafter, P4 concentrations in CIDRX- treated ewes continue to decrease from d 56 to d 126 as a result of the change in photoperiod associated with the onset of the anestrus season. This is reflected in a progressive increase in the proportion of anestrus ewes from 25% at d 56, 57% at d 84, and 95% at d 126 (Figure 1).

Body weight, RFI, BF and REA did not differ between CIDR- and CIDRX-treated ewes (Table 1). Estimates of body composition did not differ between CIDR- and CIDRX-treated ewes. Non-esterified fatty acids, T3 and T4 concentrations did not differ between CIDR- and CIDRX-treated ewes (Table 2). Concentrations of INS were greater ($P < 0.05$) in CIDRX-treated ewes than in CIDR-treated ewes (Table 3). There is evidence that P4 increased INS resistance in rats (Kumagai et al., 1993), yet our results indicate that in sheep they are less INS resistant at higher P4 concentrations.

In conclusion, it appears that maintaining P4 concentrations that mimic those during pregnancy for 126 d does not alter BW, feed efficiency, body composition, NEFA, T3 or T4. Changes in the partitioning of nutrients in pregnant ewes is probably related to fetal or

placental interactions with maternal metabolism. However, it appears that long-term P4 treatment may alter the mechanism associated with carbohydrate metabolism.

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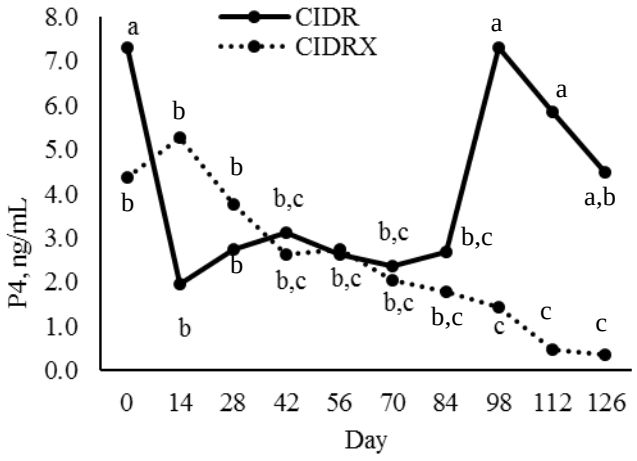

Figure 1. Progesterone (P4) concentrations at 14-d intervals in Rambouillet ewes given a P4-containing, controlled internal drug release devise (CIDR; n = 15) or a non-P4-containing CIDR (CIDRX; n = 15) beginning on d 12 (d 0 insertion of devises) of the estrous cycle relative to estrus. Interaction of treatment x d; $P < 0.05$. Different letters among points indicate differences at $P < 0.05$. Pooled SEM = 5.1 ng/mL.

Table 1. Body weight (BW), residual feed intake (RFI), back fat depth (BF), and rib-eye area (REA) in Rambouillet ewes that received a P4-containing controlled internal drug release device (CIDR) or a non-P4 containing CIDR backbone (CIDRX) for 126 d

	Treatment			
Item	CIDR	CIDRX	SEM	*P*-value
n	15	15		
BW, kg	57.8	58.7	8.4	0.70
RFI, kg/d	-0.03	0.02	0.2	0.50
BF, mm	1.9	2.0	0.2	0.46
REA, mm^2	26.4	26.8	0.5	0.60

Table 2. Non-esterified fatty acids (NEFA), thyroxine (T3) and triiodothyronine (T4) concentrations of Rambouillet ewes that received a P4-containing controlled internal drug release device (CIDR) or a non-P4 containing CIDR backbone (CIDRX) for 126 d

	Treatment			
Item	CIDR	CIDRX	SEM	*P*-value
n	15	15		
NEFA, mEq/L	0.029	0.030	0.03	0.13
T3, ng/mL	0.056	0.058	0.05	0.71
T4, ng/mL	36.4	35.2	24.9	0.69
T3:T4	0.001	0.001	0.001	0.77

Table 3. Insulin concentrations of Rambouillet ewes that received a P4-containing controlled internal drug release device (CIDR) or a non-P4 containing CIDR backbone (CIDRX) for 126 d

	Treatment		
Item	CIDR	CIDRX	Mean[1]
n	15	15	
0	0.13	0.23	0.18[a]
28	0.14	0.19	0.17[a]
56	0.13	0.20	0.17[a]
84	0.12	0.19	0.16[a]
126	0.20	0.27	0.23[b]
Mean[2]	0.14[a]	0.22[b]	

[a,b]Means within a column or row with different letters differ; $P < 0.05$.
[1]Pooled SEM = 0.005 ng/mL.
[2]Pooled SEM = 0.003 ng/mL.