Long-term progesterone influence on feed efficiency, body composition, non-esterified fatty acids and metabolic hormones in mature Rambouillet ewes

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ABSTRACT

Long-term progesterone influence on feed efficiency, body composition, non-esterified fatty acids and metabolic hormones in mature Rambouillet ewes

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, long-term maintenance of P4 concentrations may alter the homeostatic relationship between INS and carbohydrate metabolism in ewes.

BACKGROUND

- Nutrition and metabolism are known to affect reproduction in livestock.
- Nutritional status of ewes has been shown to interact with systemic progesterone (P4) concentrations and influence the maintenance of pregnancy (Parr et al., 1987).
- Work at MSU: P4 concentrations greater in Rambouillet ewes selected for high reproductive rates than in ewes selected for low reproductive rate during pregnancy (Figure 1). *More importantly, HL ewes require ~25% less total digestible nutrients to produce 1 lb. than LL ewes, i.e., were ~25 more efficient!!*

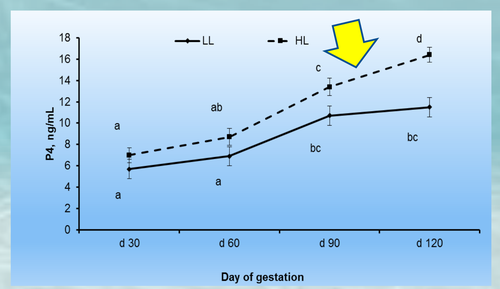

Figure 1. Least squares means of progesterone (P4) concentrations during gestation in Rambouillet ewes selected for high (HL; n = 20) and low (LL; n = 15) reproductive rate. Error bars represent ± SE of each mean. Line by d of gestation interaction; *P* = 0.04. Means with different superscripts differ (*P* < 0.05).

- *One could hypothesize that HL ewes were more efficient in partitioning nutrients into fetal growth and development.*

QUESTION

Does long-term P4 treatment, independent of the influence of the placenta and fetus, influence feed efficiency, BW, body composition, NEFA and metabolic hormones in mature Rambouillet ewes?

OBJECTIVE

To evaluate the effects of long-term P4 treatment, independent of the influence of the placenta and fetus, on changes in feed efficiency, BW, body composition, NEFA and metabolic hormones in mature Rambouillet ewes.

HYPOTHESIS

Feed efficiency, BW, back fat (BF), rib-eye area (REA), body composition, NEFA and metabolic hormones do not differ between Rambouillet ewes treated with a long-term P4 regimen, maintained with controlled intravaginal releasing devices (CIDR), or ewes not treated with the long-term P4 (CIDRX) regimen for 126 d.

METHODS & MATERIALS

Animals and Treatments. Thirty, multiparous, 5- and 6-yr-old Rambouillet ewes were stratified by age and metabolic BW and assigned randomly to receive long-term P4 administration using controlled intravaginal releasing devices (CIDR; n = 15) or no P4 (CIDRX; CIDR backbone only, n = 15).

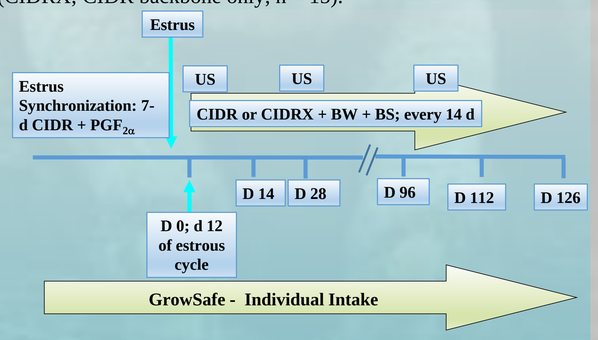

Figure 2. Experimental protocols and time course of study. These include BW and serum samples for each ewe collected every 2 weeks when CIDR or CIDRX were replaced. Back fat (BF) and rib-eye area (REA) were measured for each ewe every 28 d using ultrasonography.

Feed Intake. Individual feed intake was recorded using the GrowSafe units beginning at d 0 following a 3-wk adaptation period. Ewes were fed a mixed grass hay diet ad libitum that met the nutrient requirements for maintenance.

Table 1. Chemical composition of mixed-grass hay diet[1] throughout the 126 d experiment

Item	Mixed-grass hay diet
Nutrient analyses, %	
DM	86.8
CP[2]	7.77
TDN[2]	59.5

[1] Ewes had free access to the mixed-grass hay diet.
[2] CP and TDN are based on a percentage DM basis.

RFI and Body Composition. Daily intakes were computed for each of the ewes which were used to calculate individual residual feed intakes (RFI; Redden et al., 2011). Where RFI is the difference between dry matter intake and expected feed intake based on the herd. Estimates of body composition were modeled using regression equations reported by Silva et al. (2006) and Sanson et al. (1993) for mature ewes.

Metabolites and Hormones. Serum samples were assayed for P4, insulin (INS), triiodothyronine (T3) and thyroxine (T4) using a radioimmunoassay. Concentrations of non-esterified fatty acids (NEFA) were quantified using an enzymatic colorimetric assay.

Statistical Analysis. Data for BW, RFI, BF, and REA were analyzed by ANOVA for completely randomized design using PROC ANOVA of SAS. The model included treatment (CIDR and CIDRX). Data for estimated body composition were analyzed by ANOVA using separate PROC MIXED models for repeated measures of SAS. The model included treatment (CIDR and CIDRX), day (ultrasound day), and the treatment by day interaction. Data for P4, T3, T4, I and NEFA concentrations, and the T3:T4 ration were analyzed by ANOVA using separate PROC MIXED models for repeated measures of SAS (SAS, Cary, NC). The model included treatment (CIDR and CIDRX), day (ultrasound day), and the treatment by day interaction. Ewe within treatment was the subject and d of ultrasound was the repeated measure. Means were separated using Bonferroni's multiple comparison adjustment.

RESULTS

- Treatment by day interaction ($P < 0.05$; Figure 3) for P4 concentrations over the 126- d experimental period. P4 concentrations decreased from d 14 to 126 in CIDRX-treated ewes; whereas, P4 concentrations were maintained in CIDR-treated ewes from d 14 to 84.
- From d 84 to 98 P4 concentrations increased in CIDR-treated ewes, while P4 concentrations fell to their lowest concentrations in CIDRX-treated ewes (Figure 3).

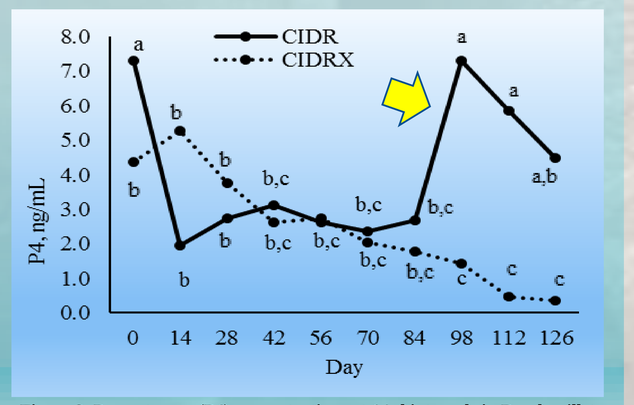

Figure 3. Progesterone (P4) concentrations at 14-d intervals in Rambouillet ewes given a P4-containing, controlled internal drug release devise (CIDR; n = 15) or a non-P4-containing CIDR (CIDRX; n = 15) beginning on d 12 (d 0 insertion of devises) of the estrous cycle relative to estrus. Interaction of treatment x d; *P* < 0.05. Different letters among points indicate differences at *P* < 0.05. Pooled SEM = 5.1 ng/mL.

- Body weight, RFI, BF, REA (Table 2) **did not differ** between CIDR- and CIDRX-treated ewes.
- 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. 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 intravaginal releasing device (CIDR) or a CIDR backbone (no P4; 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

- Concentrations of INS were greater ($P < 0.05$) in CIDRX-treated ewes than in CIDR-treated ewes (Table 3).

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.

INTERPRETATION

- Long-term P4 can be sustained using sequential replacement of CIDRs. Two CIDRs were inserted at d 84 to mimic increased P4 associated with pregnancy, similar to data reported by Swartz et al. 2012.
- For CIDRX- treated ewes, d 42 represents the peri-ovulatory 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 3).
- 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.

CONCLUSIONS

The most important result of this study is that long-term systemic progesterone concentrations that mimics those during pregnancy are not directly related to increases in feed efficiency or to changes in the partitioning of nutrients over a 126-d period. 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.

ACKNOWLEDGEMENTS

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