OVARIAN CYCLICITY AND SERUM PROGESTERONE AND LUTEINIZING HORMONE IN FINE-WOOL EWES SUPPLEMENTED WITH ALFALFA OR PINTO BEANS

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ABSTRACT

Effects of season and supplementation on the incidence and rate of ovulation and hormone profiles in multiparous, nonlactating ewes were investigated under range and drylot conditions during anestrus (February through August). Ninety ewes received one of six nutritional treatments: 1) range forage, 2) range forage plus 0.33 $kg \cdot hd^{-1} \cdot d^{-1}$ pinto beans, 3) 0.45 $kg \cdot hd^{-1} \cdot d^{-1}$ alfalfa pellets, 4) dry lot plus 1.33 $kg \cdot hd^{-1} \cdot d^{-1}$ prairie hay only, 5) pinto beans or 6) alfalfa pellets at rates used on the range and prairie hay. Supplemented ewes were heavier ($P < 0.05$) than ewes fed range forage or prairie hay during most of the study. Seasonality of ovulation, in terms of incidence and rate, was not affected ($P > 0.40$) by supplementation in range ewes. The ovulation rate tended to be highest in prairie hay plus pinto bean drylot ewes in February ($P = 0.21$) and in prairie hay plus alfalfa pellet and prairie hay plus pinto bean ewes in March ($P = 0.13$) compared with prairie hay ewes. Generally, seasonality of ovulation was not influenced by supplementation ($P > 0.40$). The incidence of ovulation approached zero for drylot ewes in April, May, June and July, while it was 43, 27, 35 and 21% for range ewes, in those same months. Supplementation did not affect serum progesterone during the estrous cycle. Luteinizing hormone (LH) concentrations were similar ($P > 0.50$) among drylot treatment groups before a 50-ug gonadotropin releasing hormone (GnRH) challenge. Pinto bean supplementation enhanced serum LH response to GnRH ($P < 0.10$).

Key words: supplementation, ovulation, sheep, luteinizing hormone, progesterone

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INTRODUCTION

Profitability and efficiency of lamb and wool production can be enhanced by improving reproductive efficiency. The seasonal nature of sexual activity imposes a major constraint on improving the reproductive efficiency of sheep (1, 2). Apart from the well documented breed and latitude effects on the onset and duration of breeding activity, modifying influences, mainly nutrition, also exist (3, 4). Adequate nutrition and good body condition can extend the breeding season (5, 6) and increase ovulation rates of ewes (7, 8). Other studies report a lack of nutritional and body weight effects on the length of anestrus in ewes (9 - 11). Variations among responses to plane of nutrition may be related to type, quality and composition of feed, and the duration of feeding (12). Seasonal fertility of the ewe is controlled by neuroendocrine mechanisms. Anestrous ewes are unable to generate LH levels necessary to induce ovulation and sustain normal cyclic activity (13 - 15). Also, higher ovulation rates in ewes are associated with higher plasma gonadotropin concentrations (14, 16) and lower concentrations of steroids (17, 18). Research on the influence of increased feeding levels on the incidence of ovulation is limited. Our study was conducted to investigate the effects of long-term supplementation with alfalfa pellets and pinto beans on ovarian cyclicity and hormone profiles in fine-wool ewes that were allowed to graze on native range and those kept in confinement.

MATERIALS AND METHODS

In July 1984, 90 nonpregnant, nonlactating Rambouillet ewes (5 to 6 yr of age) were randomly allotted to two management groups. The first group, kept under native range conditions, was again randomly assigned to one of three nutritional treatments. One treatment group was maintained on range forage at the Jornada Experimental Range near Las Cruces, NM, at an elevation of 1,208 m above sea level. About 52% of the 230 mm average annual precipitation comes from intense local short-duration, convection thunderstorms between July 1 and September 30. The predominant grasses and forbs are burrowgrass (*Schleropogon boevifolius*), mesa dropseed (*Sporobolus flexuosus*), specticlepod (*Dithyrea wislizeni*), deer's tongue (*Cryptantha crissisepala*), woolly paperflower (*Psilostrophe togetinae*) and leatherwood croton (*Croton corymbulosus*). This arid range is typical of millions of hectares of land in the Southwest. The other two treatment groups were fed in addition to the first treatment either 0.33 $kg \cdot hd^{-1} \cdot d^{-1}$ of cracked pinto beans or 0.45 $kg \cdot hd^{-1} \cdot d^{-1}$ of alfalfa pellets. The supplements were fed at levels providing comparable energy and protein. These three treatment groups of ewes were kept on three large pastures (600 to 800 hectares each) and were rotated monthly to minimize pasture effects. Predation losses occurred throughout the study and were equally distributed across treatments, with 50% of the losses occurring during the last 3 mo (April to July 1985).

The second group of 45 ewes, maintained in confinement at two locations (15 ewes at New Mexico State University and 30 at the nearby Jornada Experimental Range headquarters), was randomly allotted to one of three nutritional treatments. One group was maintained on 1.33

$kg \cdot hd^{-1} \cdot d^{-1}$ prairie hay (4.2 kcal/g and 7.4% protein), while the remaining two groups received either hay plus pinto beans (24.6% protein) or hay plus alfalfa pellets (17.4% protein) at the same rates used in the range trial. However, the nutritional treatments in the New Mexico State University drylot group continued until after the GnRH challenge in October 1985. All ewes underwent an adaptation period of 30 d on their respective diets, and had free access to salt, mineral and water. All sheep were weighed at monthly intervals. Beginning August 12, a subset of 12 ewes from each group in both trials was examined by laparoscopy (19) and the number of corpora lutea (CL) was recorded. Thereafter, ovaries were monitored in all ewes at monthly intervals, except during the breeding season (September to January). An earlier study conducted at the same location over a 2-yr period indicated most ewes cycled during September to January (6).

Beginning September 1, 1984, estrual activity was monitored twice daily in all groups located at New Mexico State University using vasectomized rams. Beginning at the second observed estrus, daily jugular blood samples were collected from all 15 ewes through one estrous cycle to determine serum progesterone concentrations (20). The same procedure was repeated in the fall of 1985. The within- and between-assay coefficients of variation for the progesterone radioimmunoassays were 6.8 (n = 10) and 7.4% (n = 14), respectively. At the end of the trial (October 1985), all 15 ewes were challenged with 50 ug of GnRH[a] given intramuscularly on Day 11 (Day 0 = estrus) of an estrous cycle to assess the LH response. Day 11 was used to minimize any confounding effects of fluctuating steroids, which may influence the gonadotropin response to GnRH (18). Jugular blood samples were collected at 30-min intervals for 2 h before and 4 h after treatment. A sample was also taken immediately before the GnRH injection (Time 0). All blood samples were allowed to clot at room temperature for 30 min before the serum was separated by centrifugation (2,300 x g at 4°C). Serum was then harvested and stored at -20°C. Luteinizing hormone was quantified in all samples by radioimmunoassay (21) with inter- (n = 10) and intra- (n = 4) assay coefficients of variation of 4.6 and 5.8%, respectively.

Animal weights and total weight changes were analyzed by two-way analysis of variance for a randomized complete block design (22). Initial weights of animals were used as the covariate and the two locations (New Mexico State University and Jornada Experimental Range) were treated as blocks. The main treatment effect was tested against the treatment by block interaction (22). Categorical data, i.e., incidence of ovulation and ovulation rate, were analyzed by Chi-square procedure (23). Serum progesterone and LH concentrations were subjected to split-plot analysis of variance for repeated measurements (24). When treatment by time interactions occurred, treatment effects were evaluated within sampling time. When significant F values occurred, means were separated using the least significant difference test (22). Also, LH responses to GnRH were analyzed by one-way analysis of variance for differences in time to peak, peak level and total LH concentrations. Total LH was defined as the sum of LH

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[a]Cystorelin, CEVA Laboratories, Inc., Overland Park, KS.

concentrations between 30 and 240 min after GnRH for each ewe (25). Relationships between LH peak, total LH concentration, body weight and weight change were examined by computing correlation coefficients.

RESULTS AND DISCUSSION

Body Weight of Ewes

In the range trial (Table 1), animals fed a supplemented diet were heavier ($P < 0.05$) in August, September, October, December, February, March, June and July. However, during November, April and May, range forage plus pinto bean ewes were heavier ($P < 0.05$) than range forage or range forage plus alfalfa pellet ewes. Only in January were range forage plus alfalfa pellet ewes heavier ($P < 0.05$) than range forage or range forage plus pinto bean ewes. Ewes maintained on range forage alone lost only 2.2 kg of weight during the study, indicating that the quantity and quality of range forage were essentially adequate for body weight maintenance. In the drylot trial (Table 2), ewes fed a supplemented diet were heavier ($P < 0.10$) in all months except September and October. However, the magnitude of weight gain resulting from the supplements (1.1 kg in prairie hay plus pinto bean ewes and 2.1 kg in prairie hay plus alfalfa pellet ewes and 3.9 kg weight loss observed in prairie hay ewes) indicated that the quality of prairie hay was not quite adequate for body weight maintenance. Ewes fed supplemented diets with cull pinto beans (both on range and drylot) had satisfactory weight gain, with no apparent ill effects. Satisfactory weight gain of adult ewes and feedlot lambs on cull pinto beans has been reported elsewhere (26, 27).

Incidence and Rate of Ovulation

The mean percentage of range ewes ovulating and the mean ovulation rate ranged from 20% and 0.2 in July to 75% and 1.0 in August, respectively (Table 3). Seasonality of ovulation, in terms of incidence and rate, was not affected ($P > 0.40$) by supplementation in range ewes. In the drylot trial (Table 3), ovulation rates tended to be higher in prairie hay plus pinto bean ewes ($P = 0.21$) in February and in prairie hay plus alfalfa pellet ewes ($P = 0.13$) in March compared with prairie hay ewes in those same months. The incidence of ovulation was similar ($P > 0.40$) in August, February and March, but it decreased markedly approaching zero in all groups in April, May, June and July. In contrast, 43, 27, 33 and 21% of range ewes ovulated during these same months. Abundant forage and availability of green forbs on the range may explain the difference in the depth of anestrus between range and drylot ewes.

The proportion of ewes ovulating in both trials followed the seasonal pattern reported for Rambouillet and fine-wool ewes (6, 28, 29), with an observed tendency toward nonseasonal breeding. Our study indicates that seasonal patterns of ovulation in Rambouillet ewes may not be consistently altered by the level of nutrition and its long-term effect on body weight.

Table 1. Body weights (kg) of ewes receiving range forage alone (R), range forage supplemented with pinto beans (RB) or range forage plus alfalfa pellets (RP)[a]

Month	Number of Animals	Treatment			
		R	RB	RP	SEM
July	45	48.6	47.4	48.7	
August	43	48.7^{b}	50.8^{c}	50.8^{c}	0.4
September	39	49.8^{b}	54.5^{c}	52.9^{c}	0.7
October	37	48.0^{b}	52.9^{c}	54.5^{c}	0.8
November	36	48.6^{b}	52.9^{c}	50.1^{b}	0.9
December	36	46.4^{b}	49.0^{c}	48.6^{c}	0.9
January	36	45.4^{b}	47.8^{b}	49.0^{c}	1.0
February	34	45.4^{b}	48.3^{c}	50.0^{c}	0.9
March	32	46.8^{b}	50.3^{c}	49.8^{c}	1.0
April	29	50.6^{b}	55.9^{c}	52.2^{b}	1.0
May	26	49.2^{b}	55.6^{c}	51.5^{b}	1.1
June	20	47.2^{b}	52.8^{c}	52.6^{c}	0.8
July	15	46.0^{b}	51.2^{c}	53.4^{c}	1.2
Overall body weight changes		-2.2^{b}	2.9^{c}	5.3^{c}	1.2

[a]Least-square means, adjusted for initial weight.
[b,c]Row means within month with different superscripts differ ($P < 0.05$).

Table 2. Body weights (kg) of ewes maintained on prairie hay (H), or supplemented with pinto beans (HB) or alfalfa pellets (HP)[a]

Month	Number of Animals	Treatment			
		H	HB	HP	SEM
July	45	51.2	52.7	53.7	
August	45	52.8^{b}	52.7^{b}	53.9^{c}	0.4
September	45	52.0	51.9	52.2	1.1
October	45	52.1	54.7	53.7	1.7
November	45	49.4^{b}	51.5^{c}	52.9^{c}	0.9
December	45	50.1^{b}	53.3^{c}	53.9^{c}	1.3
January	45	49.7^{b}	53.0^{c}	54.0^{c}	0.9
February	45	49.2^{b}	53.0^{c}	54.0^{c}	0.9
March	45	49.0^{b}	54.2^{c}	55.5^{c}	1.0
April	45	48.2^{b}	54.1^{c}	54.7^{c}	0.5
May	45	47.8^{b}	52.8^{c}	53.7^{c}	0.7
June	43	47.9^{b}	52.9^{c}	54.1^{c}	0.9
July	43	47.5^{b}	53.3^{c}	54.5^{c}	0.9
Overall body weight changes		-4.0^{b}	1.1^{c}	2.1^{c}	0.6

[a]Least-square means, adjusted for initial weight.
[b,c]Row means within month with different superscripts differ ($P < 0.10$).

Table 3. Ewes ovulating (%) and corpora lutea (CL) per ewe in range (free grazing) and drylot (1.33 kg prairie hay) managed ewes supplemented with pinto beans or alfalfa pellets[a,b]

	Number of animals		Range						Drylot					
			Ewes ovulating, %			Number of CL/ewe			Ewes ovulating, %			Number of CL/ewe		
Month	Range	Drylot	R	RB	RP	R	RB	RP	H	HB	HP	H	HB	HP
August	34	38	75	80	75	1.0	1.0	1.1	92	92	77	1.0	1.2	1.0
February	30	38	70	80	60	0.8	1.0	0.7	55	73	67	0.5	1.0	0.7
March	30	45	50	40	60	0.7	0.6	0.7	13	27	27	0.1	0.3	0.4
April	28	45	33	67	30	0.4	0.7	0.3	7	7	0	0.1	0.1	0
May	26	43	22	33	25	0.2	0.3	0.2	0	7	0	0	0.1	0
June	20	43	22	60	33	0.2	0.8	0.3	0	0	0	0	0	0
July	14	43	20	33	17	0.2	0.3	0.2	0	7	13	0	0.1	0.2

[a]R = range, RB = range plus 0.33 kg·hd^{-1}·d^{-1} pinto beans, RP = range plus 0.45 kg alfalfa pellets·hd^{-1}·d^{-1}, H = prairie hay, HB = hay plus beans, HP = hay plus alfalfa pellets (same levels as on range).

[b]Row values within category do not differ (P > 0.20).

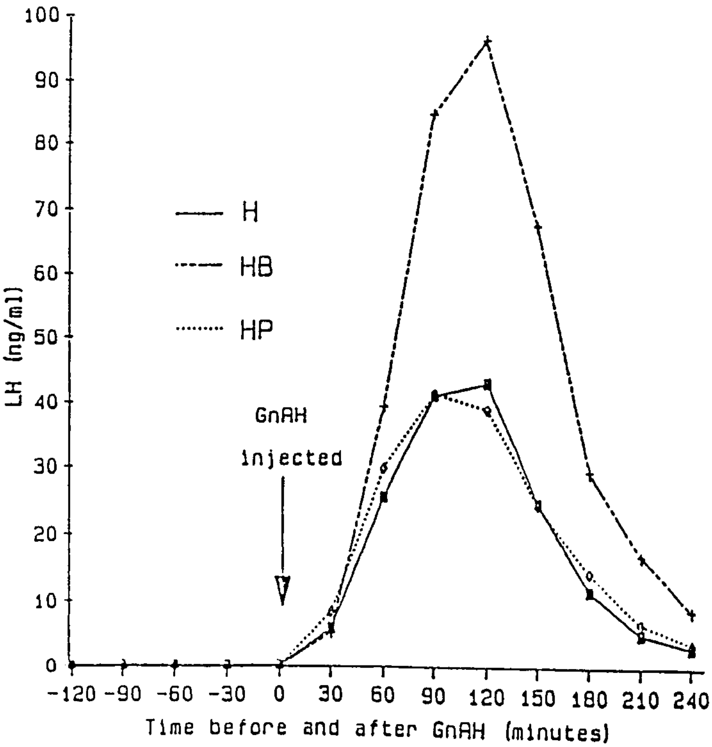

Figure 1. Serum luteinizing hormone (ng/ml) 2 h before and 4 h after intramuscular injection of 50 ug GnRH in ewes receiving prairie hay (H), prairie hay plus pinto beans (HB) or alfalfa pellets (HP).

Serum Progesterone Concentrations

Serum progesterone profiles during an estrous cycle did not differ ($P > 0.10$) among treatments in confined ewes during the two consecutive breeding seasons (1984 and 1985). Other studies showed no effect of nutrition on progesterone concentration in ewes (30, 31). However, Cumming (32) and Lamond (10) reported lower plasma progesterone in ewes on restricted energy intake.

Serum LH Response to GnRH Challenge

The dosage of GnRH (50 ug) used to assess the functional response of the neuroendocrine system in ewes resulted in elevated concentrations of LH and satisfactory peaks comparable to those obtained with higher dosages in other studies (33, 34). Mean levels of LH for each treatment group at different sampling times before and after GnRH injection are shown in Figure 1. Split-plot analysis of LH revealed no treatment by time interaction ($P > 0.10$) or difference among treatments ($P > 0.50$) in baseline levels of LH (.23 ng/ml) before GnRH injection. Similar lack of response of basal LH secretions to the plane of nutrition have been reported by other researchers (30, 33). Serum LH in prairie hay plus pinto bean ewes was higher ($P < 0.10$) at 120, 210 and 240 min after GnRH injection than in prairie hay or prairie hay plus alfalfa pellet ewes. A large variation among ewes within treatments made significant differences among treatments at 90, 150 and 180 min after challenge undetectable. Serum LH concentration increased dramatically following GnRH injection, reaching peak levels after a mean time of 98 min. Serum LH levels declined sharply thereafter to approach basal levels 4 h after injection. Similar LH patterns to GnRH stimulation during the estrous cycle were reported (34), with the LH pattern being modulated by GnRH dosage. Peak levels tended to be higher ($P < 0.15$) in prairie hay plus pinto bean ewes (96.6 ng/ml) than in prairie hay (49.2 ng/ml) or prairie hay plus alfalfa pellet ewes (41.7 ng/ml). Peaks were achieved at a comparable time ($P > 0.20$) after injection in all groups. Total LH concentrations, which may give a better indication of total LH release than do other variables separately, tended to be higher ($P = 0.14$) in prairie hay plus pinto bean than in prairie hay or prairie hay plus alfalfa pellet ewes (350.5, 157.7 and 168.9 ng/4 h, respectively). Responsiveness of LH to GnRH stimulation was reported to be influenced by nutrition in ewe lambs (25) and in ewes (33). In the latter study, chronically underfed ewes had higher LH concentrations in response to GnRH injection than ewes fed a maintenance ration. Both chronic undernutrition and overnutrition may enhance LH response to GnRH stimulation by different mechanisms. Undernourished ewes may compensate with increased pituitary responses (33). Although prairie hay plus pinto beans and prairie hay plus alfalfa pellet ewes had similar body weights ($P > 0.40$), and gained weight at similar rates ($P > 0.30$), their LH response to GnRH differed. In addition, neither LH peak levels nor total LH concentrations were correlated ($P > 0.40$) with body weight or overall weight change. However, these variables were positively correlated ($r = 0.62$; $P < 0.02$) with weight change occurring during the month before the challenge. This finding may indicate a dynamic effect of nutrition on LH secretion in ewes which is independent of body weight or long-term body weight changes. Also, pinto beans had more available nitrogen (3.6%) than alfalfa pellets (2.5%). A high protein level is thought to be associated with increasing levels of steroid-clearing enzymes and, thus of increasing secretions of gonadotropin (8).

The results of our study indicate that long-term supplementation of pinto beans or alfalfa pellets can improve the body weight of Rambouillet ewes managed on native range or in confinement. However, supplementation did not consistently influence the seasonal pattern of ovulation in ewes. Seasonal anestrus was less complete in range ewes compared with confined ewes. Progesterone level during the estrous cycle was not affected by nutritional treatment. Sensitivity of ewes to GnRH challenge was altered by the type of supplement used independent of body weight. Ewes fed pinto bean supplements had the highest level of LH release ($P < 0.10$) following GnRH administration.

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