

# Effect of Parenteral Vitamin E and/or A on Reproductive Performance of Ewes Mated on Pasture or in Drylot

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### Summary

Forty-four Hampshire (H) and 41 Suffolk (S) ewes were allotted within breed to one of four treatment groups (VitA, VitE, VitAE, and Control) to evaluate the effect of supplemental vitamin E and A on reproductive performance of ewes mated on pasture or in drylot. Beginning two weeks before the mating period, ewes received 0 or 300 IU of vitamin E every 14 days and 0 or 250,000 IU of vitamin A every 28 days. Hampshire ewes remained on pasture during the mating period, whereas S ewes were moved to drylot. Treatment did not affect ovulation rate (OR), embryonic loss (EL), fetal loss (FL) or litter size (LS) of H ewes. Embryonic loss was higher ( $P < .05$ ) in the H yearlings and two-year olds than in older ewes. Litter size was lower ( $P < .01$ ) for H yearlings compared with other age groups. Suffolk ewes in the VitE group exhibited a lower ( $P < .01$ ) OR than S ewes in other treatment groups, but no effect of treatment was observed for EL, FL, or LS. Although S yearling ewes did not differ from ewes of other age groups for OR and EL, they did produce fewer ( $P < .05$ ) lambs. Analysis of serum samples revealed that H yearling ewes exhibited lower ( $P < .05$ ) serum  $\alpha$ -tocopherol levels than older H ewes. In addition, H ewes had a higher ( $P < .05$ ) serum  $\alpha$ -tocopherol level than S ewes at the beginning of study when they were managed as one group. Even though age and breed influenced certain reproductive parameters, results of this study indicate little effect of supplemental vitamin E and A on the overall reproductive efficiency of ewes mated on pasture or in drylot.

### Introduction

Researchers have been interested in the ability of vitamin E and A to enhance female reproductive performance since the 1920's when those vitamins were implicated in the process of fetal resorption and maintenance of pregnancy in rats. In sheep, the importance of vitamin A for reproduction was clearly shown in a study with ewe lambs fed a diet deficient in vitamin A and carotene for three months. Only eight of 31 females exposed for mating conceived (26% conception rate), and none of the offspring produced by the ewe lambs survived beyond five days of age. A later study conducted by a different research group showed that none of the ewe lambs fed a

diet devoid of vitamin E for four months conceived compared with an 83% conception rate for ewe lambs provided the identical diet supplemented with vitamin E.

Despite the adverse consequences of feeding diets deficient in vitamin E or A on reproduction, researchers have not had consistent success increasing reproductive rate by supplementing standard diets with vitamins. For example, one research group was unable to increase lamb production of ewes grazing green pasture (an abundant source of vitamin A) by administering capsules of shark liver oil (100,000 IU of vitamin A per capsule) on a weekly basis throughout pregnancy. However, these same researchers observed that ewes grazing dry wheat pasture (a poor source of vitamin A) during the breeding season had a higher lamb crop (200%) when supplemented with vitamin A versus when they were unsupplemented (117%).

The number of lambs born per ewe is the single most important factor affecting profitability of commercial sheep enterprises. The ability to obtain an 83% boost in lamb crop percentage by providing supplemental vitamins raises an important practical and economic issue for sheep producers to consider. Do ewes require vitamin supplementation in order to realize their maximum reproductive potential when they are removed from summer pasture and placed into drylot for breeding?

Previous experiments with sheep made no attempt to quantify the effect of supplemental vitamin E and A on the specific components of reproduction (ovulation rate, embryo survival, etc.), except for the number of lambs born. In addition, no information is available that describes the vitamin status of the ewe at relatively frequent intervals during pre-mating/flushing, mating, and early gestation. Without this information, few conclusions can be drawn regarding the specific effects of supplemental vitamin E and A on reproductive events.

The objective of this study was to evaluate the effect of supplemental vitamin E and/or A on ovulation rate, embryonic loss, fetal loss, litter size, and serum vitamin levels in ewes maintained during the mating period under two different management systems (drylot versus pasture) commonly utilized in the United States sheep industry.

### Materials and Methods

#### *Animals and Diet*

Forty-four Hampshire and 41 Suffolk mixed age (1 to 5 years) ewes had been maintained as one flock on a grass/legume pasture during the summer months. A teaser ram was introduced on August 26 (21 days prior to the introduction of fertile rams) to stimulate and enhance ewe reproductive activity. Flushing with 454 g. corn/head/day began on September 2 (14 days before

joining) and continued until removal of the fertile rams. Body weight (BW) and body condition score (BCS; on a scale of 1 [emaciated] to 5 [obese]) were recorded 14 days before the start of the mating period (Hampshires: BW of  $71.1 \pm 1.4$  kg. and BCS of  $2.4 \pm .1$ ; Suffolks: BW of  $68.8 \pm 1.5$  kg. and BCS of  $2.5 \pm .1$ ) and at monthly intervals thereafter over the next four months.

On September 16, a 35-day mating period began. The flock was divided by breed to permit single-sire purebred matings. Hampshires remained on pasture, and Suffolks were moved to drylot. One Hampshire and one Suffolk ram that had passed a thorough breeding soundness examination were fitted with a marking harness before being joined with the ewes. Raddle marks were recorded twice daily during the mating period.

Table 1 shows the nutrient analyses for feedstuffs fed during the flushing and mating periods. After the end of the mating period, ewes were managed as one flock and were allowed to graze stockpiled grasses and other crop residue while being supplemented with grass hay and corn as needed.

#### *Treatment Groups*

Ewes were allotted by age within breed to treatment groups in a 2 x 2 factorial arrangement. The commercial vitamin preparations used in this study were Vital-E™-300 (Schering-Plough, Kenilworth, NJ) containing 300 IU/ml. vitamin E (as d-a-tocopherol) in a nonaqueous solution and vitamin AD<sub>3</sub> AgriLabs® (Agri Laboratories, Ltd., St. Joseph, MO.) consisting of 500,000 IU vitamin A (as vitamin A propionate), 75,000 IU vitamin D<sub>3</sub>, and 5 IU vitamin E (included as an antioxidant) per ml. in an emulsifiable solution. No commercial products were available that contained solely vitamin A.

The product label of Vital-E™-300 recommended a 1200 to 1500 IU dose for ewes in late gestation; however, the vitamin AD<sub>3</sub> AgriLabs® label had no recommendation for sheep, but suggested a 500,000 to 1,000,000 IU dose for breeding cattle. The treatment dosages for the present experiment were based upon the concentration of the vitamin preparations, label recommendations, and daily vitamin requirements of ewes (NRC, 1985). Ewes received 0 or 300 IU of vitamin E (1.0 ml. vital-E™-300 given every 14 days) and 0 or 250,000 IU of vitamin A (.5 ml. vitamin AD<sub>3</sub> AgriLabs® given every 28 days) in order to provide a typical therapeutic dose yet avoid possible toxicosis. All treatments began 14 days prior to the mating period and were administered intramuscularly in the gluteus muscle.

#### *Serum Collection and Analysis*

A total of nine blood samples was collected from each ewe via jugular venipuncture at 14-day intervals over a period of 16 weeks. Samples were collected prior to vitamin administration into non-heparinized 15 ml. vacutainer tubes and were allowed to sit in the dark for one hour at room temperature (to aid in serum separation) before centrifugation (30 min., 3,000 rpm, 6°C). Serum was transferred to glass vials for storage at -

20°C until analysis.

Serum samples were analyzed by high performance liquid chromatography using a modification of published methods. Duplicate samples were analyzed, and any sample with concentrations that differed by more than 10% was reanalyzed. The duplicate concentrations were averaged to obtain the final sample concentration.

Due to extreme cost, no serum samples were analyzed for retinol concentration. However, reproductive data were analyzed to assess the potential effects of vitamin A administration on components of ewe reproduction.

#### *Ovulation Rate*

Laparoscopic ovarian examinations were performed between days four and 10 of gestation (day 0 = day of first observed raddle mark) to determine the number of corpora lutea (CL). It was assumed that each CL represented the ovulation of one oocyte. Any ewe that returned to estrus during the mating period was re-examined at the same stage of gestation following the subsequent mating(s).

#### *Fetal Numbers*

Real-time ultrasound scanning began one day after the end of the mating period and continued at weekly intervals for nine weeks to encompass days 35 to 98 of gestation for ewes that conceived on the first day of the mating period, and days 0 to 63 of gestation for ewes that conceived on the last day of the mating period. Thus, all experimental ewes were scanned between days 35 and 63 of gestation, irrespective of the actual day of mating. Ultrasonography was performed by a commercial technician using a VETSCAN 2® sector scanner (BFC Technology, Ltd., Livingston, West Lothian, Scotland) equipped with a 3.5 MHz transducer. Ewes were held off feed for 18 hours (but were allowed access to water) before being scanned twice on each day. The technician was asked to provide a count of the number of fetuses present in utero or, if that was not possible, to provide an assessment of fluid accumulation and/or presence of cotyledons as an indicator of pregnancy. If the result of the first scan did not match the result of the second scan, a third scan was performed to obtain two scans in agreement. At lambing time, ewes were separated into small groups and were closely monitored to facilitate accurate recording of the number of lambs born for the assessment of litter size.

#### *Statistical Analysis*

The records of each ewe were reviewed before performing analyses to determine the effect of vitamin administration on ovulation rate (OR), embryonic loss (EL), fetal loss (FL), and litter size (LS). Ovulation rate was not assessed on 11 ewes due to the absence of detectable breeding marks. Although these ewes were subsequently found to be pregnant (with a calculated day of conception that fell within the 35-day mating period), they were removed from the data set to avoid inaccurate assumptions regarding OR and EL. Ovulation rate was

adjusted from one to two in two ewes which consistently had fetal counts of two, had two lambs born, and whose records included a notation of incomplete observation of the ovaries during laparoscopy.

Ovulation rate was calculated as the sum of the CL present on the left and right ovary. The CL count that corresponded with the breeding date which yielded a gestation length of approximately 147 days was used as the OR for ewes that lamb. For ewes that had a confirmed pregnancy by real-time ultrasound (RTU) but which did not lamb, the CL count consistent with the first potential detection of pregnancy by RTU ( $\approx$  26 to 33 days) was used as OR. The last observed CL count was utilized for the OR of ewes not lambing nor having a pregnancy confirmed by RTU.

Embryonic loss was calculated for each ewe using the formula:  $EL = [(OR - \text{first fetal count}) / OR]$ . Fetal loss was calculated for each ewe using the formula:  $FL = [(\text{first fetal count} - \text{number born}) / \text{first fetal count}]$ . Three records of BW and BCS were taken during the time which encompassed the mating period; therefore, the pre-mating changes in BW and BCS were defined as the change from the first to the second record for ewes mated prior to the second record or as the change between the second and third record for ewes mated after the second record. The change in pre-mating serum a-tocopherol level was defined as the change between the two serum samples immediately preceding a fertile mating. Data were analyzed utilizing analysis of variance and correlation analysis procedures.

## Results

### *Reproductive Traits*

The OR of Hampshire ewes was not affected by treatment or age group (Table 2). Similarly, no significant correlations were observed between OR of Hampshire ewes and the pre-mating serum a-tocopherol level or the changes in pre-mating BW, BCS or serum a-tocopherol level, irrespective of analysis within or across treatment groups.

Treatment did not affect EL, FL, or LS of H ewes, although age group was an important effect. Yearling ewes experienced greater ( $P < .05$ ) EL and produced fewer ( $P < .01$ ) lambs than two year old ewes, while older ewes were intermediate. Only two H ewes exhibited FL, so data were too few for statistical analysis. One yearling ewe lost her single fetus in the seven-day period ending on day 46 of gestation (i.e., the fetus was present on day 39, but was not present when scanned one week later on day 46 of gestation). One mature ewe lost both of her fetuses -- one in the week ending on day 63 and the second in the week ending on day 70 of gestation.

Analysis of data from Suffolk ewes revealed contrasting results (Table 3). Age group did not influence OR, although yearling ewes tended to have lower OR than older ewes. Neither the pre-mating serum a-tocopherol level nor any of the pre-mating changes in BW, BCS, or serum a-tocopherol level influenced OR. No correlation was observed between OR and pre-mating serum a-

tocopherol, the change in pre-mating serum a-tocopherol level, BW, or BCS. However, ewes treated with VitE exhibited a decreased ( $P < .05$ ) OR.

Embryonic loss was higher ( $P < .01$ ) for the VitA Suffolk ewes, but age effects were not significant (Table 3). The frequency of FL was also low within the Suffolk breed, so the effects of treatment or age could not be analyzed statistically. One mature ewe and one yearling ewe each lost their single fetus in the seven-day period ending on day 43 and 46 of gestation, respectively. Fewer ( $P < .05$ ) lambs were born to yearling ewes compared with three-year old and older ewes, and VitA and VitE ewes produced fewer ( $P < .05$ ) lambs than control ewes.

### *Serum Levels*

Within the Hampshire ewes, analysis of serum a-tocopherol level at the initial sample (i.e., prior to any vitamin treatment) revealed a significant effect of age. Yearling ewes exhibited a lower ( $P < .05$ ) serum a-tocopherol level than older ewes (Table 4). Age group was also important ( $P < .05$ ) at the second (i.e., after the first vitamin treatment) but not at subsequent samples, even though the trend for yearling ewes to have a lower serum a-tocopherol level continued (data not shown). Despite the age effect at the first two samples, the magnitude of change in a-tocopherol serum level between these samples was similar across age groups. Treatment with vitamin E (VitE, VitAE) caused serum a-tocopherol levels to be higher than levels in ewes not treated with vitamin E (VitA, Control) at the fifth sample (Figure 1).

In contrast, no effect of age group was found in Suffolk ewes, although a trend for yearling ewes to have a lower serum a-tocopherol level than older ewes existed at the first two samples (Table 4). The serum a-tocopherol level of Suffolk ewes treated with vitamin E became higher ( $P < .05$ ) than non-vitamin E treated ewes by the third sample and remained higher throughout the experiment (Figure 2).

Even though a dietary difference during the mating period prevented a direct breed comparison of all serum a-tocopherol samples, the first two serum samples were collected when both breeds were being managed together. Analysis of these data revealed an effect of breed ( $P < .05$ ) with Hampshires having higher levels than Suffolks at both the first ( $3.2 \pm .1$  vs  $2.7 \pm .1$  ppm) and second sample ( $2.1 \pm .1$  vs  $1.9 \pm .1$  ppm). The effect of age group that had been observed previously in H ewes also existed ( $P < .05$ ) in the combined data set.

## Discussion

### *Reproductive Traits*

Suffolk VitE ewes had a suppressed OR, and all seven VitE ewes ovulated only a single oocyte. Reasons for the reduced OR, however, are not clear. Timing of vitamin E administration was investigated as a possible cause, but no correlation existed between OR and the interval from vitamin E administration to the ensuing ovulation. Increasing body weight was not correlated with improved OR, but VitE ewes did exhibit the lowest BW

(64.3 ± 4.2 kg.) and the lowest BCS (2.3 ± .2) among the four treatment groups. Ewes in all treatment groups were below average in BCS, indicating that ewes could have been near a minimum BCS threshold to support normal ovulation rates. The small number of observations, combined with the low BW and low BCS, provide reasonable grounds to propose that the reduced OR may not be due solely (or at all) to vitamin E treatment. In a subsequent follow-up study, we saw no evidence that a 300 IU parenteral dose of vitamin E suppressed OR in either Hampshire or Suffolk ewes of average BCS (3.0) and substantially higher BW (86.5 kg.).

Vitamin A treatment increased OR of S ewes, but these data should be viewed with caution because only six observations comprised the mean. In addition, the low OR of the VitE group undoubtedly accentuated the difference between ewes that did and did not receive vitamin A treatment, despite the lack of a significant interaction among vitamin A and vitamin E treatments.

With two exceptions, the level of EL recorded in the present experiment generally fits the 20 to 30% range typically observed. First, the Suffolk VitA ewes exceeded the expected range of EL by more than two-fold. Reasons for this response are not clear, but the potential of vitamin A toxicity to embryos should be considered even though data analysis revealed no relationship between EL and the day of gestation on which vitamin A was administered. An alternative explanation is that the increased EL was associated with higher OR. These ewes exhibited an OR considerably greater than their breed average, and this provided more opportunities for EL to occur.

Secondly, yearling ewes of both breeds exhibited high EL regardless of whether they were mated on pasture (Hampshires) or in drylot (Suffolks). Increased EL of yearling ewes was not expected, as they are more often thought to possess lower OR and hence fewer opportunities for embryo death. One explanation for this high EL may be related to the combined social/nutritional stresses incurred by the smaller yearling ewes as they co-mingled with the larger older ewes. Reducing the stress of yearling ewes by providing separate management during the mating and early gestation periods may result in lower EL and higher LS.

#### *Nutrition/Serum Level*

Serum levels of a-tocopherol in sheep are known to fluctuate with dietary intake, and some changes in serum a-tocopherol level were expected during the course of the experiment. However, the extreme changes of serum a-tocopherol level experienced by the ewes in this study were not expected.

Three intriguing changes in serum a-tocopherol level occurred: 1) a decline between the first and second serum sample while ewes of both breeds were co-mingled on the same pasture, 2) a decline between the first and the fourth serum sample (which encompassed the flushing and mating periods), and 3) an increase and then decline during the fourth, fifth, and sixth serum samples. The decline between the first and second samples

suggests that the a-tocopherol content of the pasture was changing rapidly during the 14-day time span prior to the mating period in this experiment--a time when many shepherds typically begin the fall mating period. The decline from the first to the fourth sample indicates that maintaining ewes under drylot conditions further reduced the serum a-tocopherol level during the mating period. This is in contrast to ewes maintained on pasture whose serum a-tocopherol level declined to a lesser extent. The serum a-tocopherol change between the fourth and sixth samples occurred during the time of early conceptus development and likely reflected the fact that ewes had access to alfalfa aftermath before their diet reverted to harvested feeds. Snow on November 19 required drylot feeding (corn and *ad libitum* grass hay) of all ewes for the remainder of the experiment. During this time the serum a-tocopherol levels of non-treated and vitamin E-treated ewes clearly diverged, displaying the effectiveness of injectable vitamin E to maintain serum levels during prolonged periods of drylotting.

Breed and age group differences of serum a-tocopherol level were not anticipated prior to the beginning of the experiment. One could rationalize the age group difference to be caused by differing feed intakes, particularly when considering competition at the feed bunk between older and younger ewes. The breed difference observed in serum a-tocopherol levels is more difficult to explain, but may be due to differing body type and conformation. A selection emphasis for heavier boned and larger framed ewes had occurred in the Hampshires, whereas Suffolk replacements had been selected on maternal traits, which resulted in a narrower, lighter boned body type.

#### **Implications**

**Reproductive traits are difficult to influence with injectable vitamin E and A when ewes are maintained on pasture during the mating period; however, ewes mated in drylot may be more easily influenced. Although these preliminary data suggest that vitamin E administration lowers ovulation rate and that vitamin A administration enhances ovulation rate when ewes are mated under drylot conditions, these effects may be circumstantial to this experiment and further evidence is necessary to support this finding. Overall, losses of the potential lamb crop were similar for ewes maintained on pasture or in drylot during the mating period. Embryonic loss was a major contributor toward reduced lamb production of yearling ewes in both production systems, implying that yearling ewes may require more specific management to avoid high levels of embryonic loss. Repeated parenteral administration of vitamin E will sustain serum a-tocopherol levels, but diet, breed, and age are also important determinants of serum a-tocopherol levels. The serum a-tocopherol level of ewes managed under two typical management systems utilized during the mating**

**period by the United States sheep industry was documented, and these findings provide important information on which future studies investigating the potential of supplemental vitamin E and A to enhance sheep reproductive performance may be based.**

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**Table 1. Diet analysis on a dry matter basis<sup>a</sup>.**

Nutrient	Pasture	Hay	Corn
Crude protein (%)	15.1	10.3	8.2
Metabolizable energy (kcal/kg)	971	882	1406
Vitamin E (IU/kg) <sup>b</sup>	< 1.4	2.2	2.5
β-carotene (mg/kg)	40.9	9.6	2.7
Selenium (ppm) <sup>c</sup>	< .11	.16	< .11

<sup>a</sup>All samples were analyzed at a commercial laboratory using industry-approved methods.

<sup>b</sup>Expressed as total tocopherol.

<sup>c</sup>Assay detection limit of .11 ppm.

**Table 2. Reproductive performance of Hampshire ewes mated on pasture.**

	n	Ovulation rate <sup>1</sup>	Embryonic loss (%)	Fetal loss (%)	Litter size
Overall mean	43	1.8 ± .1	22.1 ± 6.1	4.7 ± 3.2	1.3 ± .1
Age Group					
yearling	17	1.7 ± .1	41.2 ± 1.0a	5.9 ± 5.9	.8 ± .2a
2	12	1.8 ± .2	.0 ± .0 <sup>b</sup>	8.3 ± 8.3	1.8 ± .2 <sup>b</sup>
> 3	14	2.0 ± .1	17.9 ± 10.0 <sup>a,b</sup>	.0 ± .0	1.5 ± .3 <sup>a,b</sup>
Treatment					
VitA	12	1.8 ± .2	25.0 ± 13.1	8.3 ± 8.3	1.2 ± .3
VitE	9	1.9 ± .2	16.7 ± 11.8	.0 ± .0	1.7 ± .3
VitAE	11	1.8 ± .2	18.2 ± 10.2	9.1 ± 9.1	1.2 ± .3
Control	11	1.8 ± .1	27.3 ± 14.1	.0 ± .0	1.2 ± .3

<sup>1</sup>A breeding mark was not detected for one ewe. Although this ewe became pregnant during the breeding season, she was removed from the data set due to lack of an ovulation rate record.

<sup>a,b</sup> Means within a column having unlike superscripts are different (P<.01).

**Table 3. Reproductive performance of Suffolk ewes mated in drylot.**

	n	Ovulation rate <sup>1</sup>	Embryonic loss (%)	Fetal loss (%)	Litter size
Overall mean	31	1.8 ± .1	24.2 ± 6.9	6.5 ± 4.5	1.2 ± .2
Age Group					
yearling	16	1.6 ± .2	31.3 ± 11.1	6.3 ± 6.3	.8 ± .2 <sup>c</sup>
2	7	2.0 ± .4	28.6 ± 14.9	14.3 ± 14.3	1.3 ± .4 <sup>c,d</sup>
≥ 3	8	1.9 ± .3	6.3 ± 6.3	.0 ± .0	1.8 ± .3 <sup>d</sup>
Treatment					
VitA	6	2.3 ± .4 <sup>a</sup>	75.0 ± 17.1 <sup>a</sup>	.0 ± .0	.7 ± .4 <sup>c</sup>
VitE	7	1.0 ± .0 <sup>b</sup>	.0 ± .0 <sup>b</sup>	28.6 ± 18.4	.7 ± .2 <sup>c</sup>
VitAE	9	1.8 ± .1 <sup>a</sup>	27.8 ± 12.1 <sup>b</sup>	.0 ± .0	1.3 ± .2 <sup>c,d</sup>
Control	9	2.0 ± .2 <sup>a</sup>	5.6 ± 5.6 <sup>b</sup>	.0 ± .0	1.7 ± .3 <sup>d</sup>

<sup>1</sup>Breeding marks were not detected for 10 ewes. Although these ewes became pregnant, they were removed from the data set due to lack of an ovulation rate record.

<sup>a,b</sup> Means within a column having unlike superscripts are different (P<.01).

<sup>c,d</sup> Means within a column having unlike superscripts are different (P<.05).

**Table 4. Serum a-tocopherol level (ppm) of Hampshire and Suffolk ewes co-mingled on pasture.**

	n	Sample 1	Sample 2	Decline	
				amount	%
<b>HAMPSHIRE</b>					
Age Group					
yearling	17	2.9 ± .2 <sup>a</sup>	1.9 ± .1	1.0	34
2	12	3.3 ± .2 <sup>a,b</sup>	2.1 ± .1 <sup>a,b</sup>	1.2	36
>3	15	3.6 ± .2 <sup>b</sup>	2.3 ± .1 <sup>b</sup>	1.3	36
Treatment					
VitA	12	3.0 ± .1	1.9 ± .1	1.1	37
VitE	10	3.2 ± .2	2.2 ± .2	1.0	31
VitAE	11	3.4 ± .3	2.2 ± .1	1.2	35
Control	11	3.3 ± .2	2.1 ± .1	1.2	36
<b>SUFFOLK</b>					
Age Group					
yearling	17	2.6 ± .1	1.7 ± .1	.9	35
2	13	2.8 ± .2	2.1 ± .1	.7	25
>3	11	2.8 ± .1	2.0 ± .1	.8	29
Treatment					
VitA	10	2.8 ± .2	1.8 ± .2	1.0	36
VitE	10	2.9 ± .2	2.0 ± .1	.9	31
VitAE	11	2.4 ± .1	2.0 ± .1	.4	17
Control	10	2.8 ± .2	1.8 ± .1	1.0	36

<sup>a,b</sup> Means within a column and breed group having unlike superscripts are different (P<.05).

Figure 1. Alpha-tocopherol serum level profile of pasture-mated Hampshire ewes.

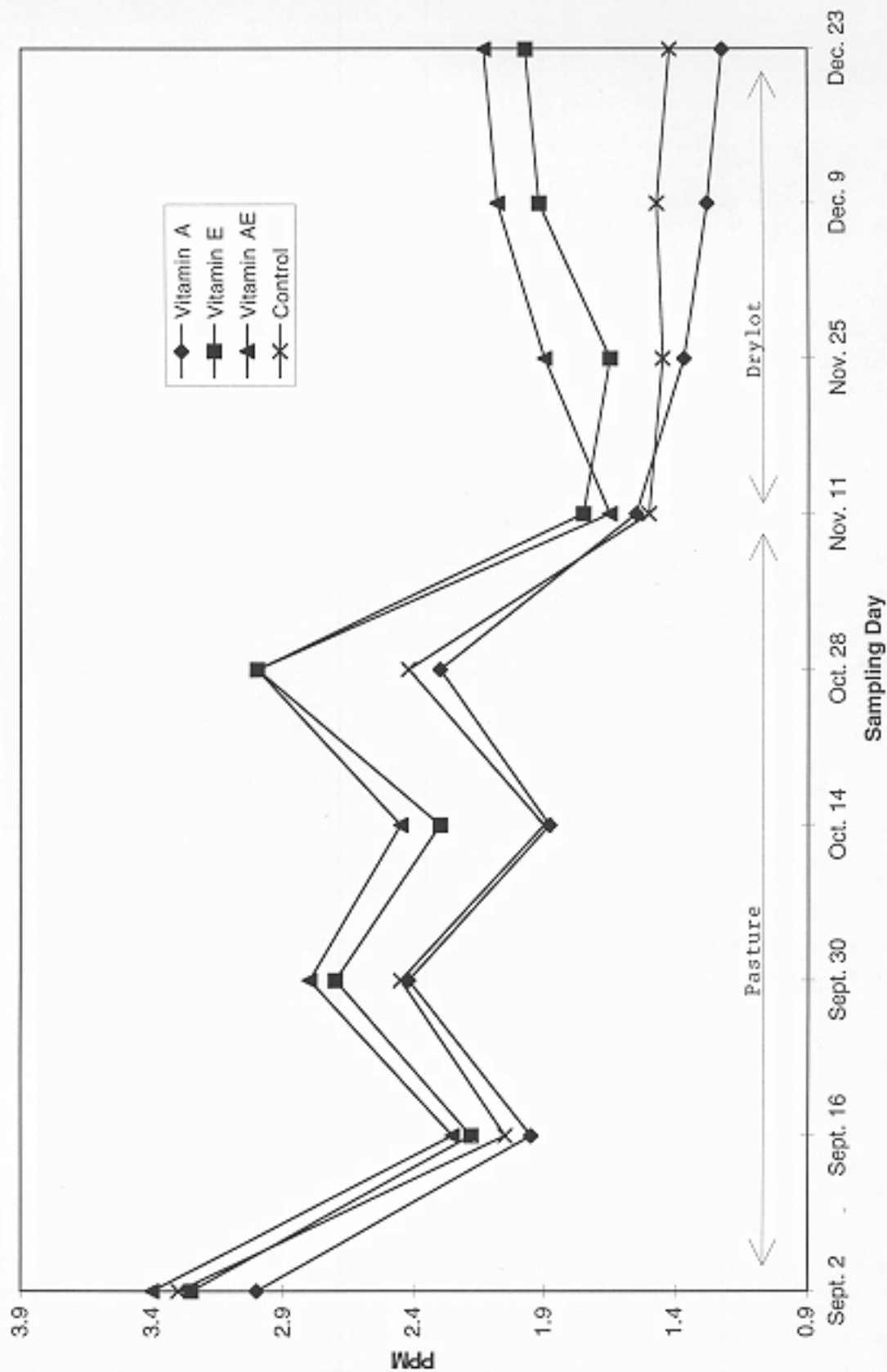


Figure 2. Alpha-tocopherol serum level profile of Suffolk ewes mated in drylot.

