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Reproductive performance of ewe lambs from ewes from different selection practices with or without induced estrus

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Abstract

Three groups of ewe lambs born in May (experiment 1; $n = 211$) or April (experiment 2; $n = 174$) were used to evaluate the effects of selection line and induction of estrus on pregnancy rate. Experiment 1 was a single factor experiment with induction of estrus as the main effect. In early December, May-born Targhee ($n = 82$) and Rambouillet × Targhee ($n = 129$) ewes were randomly assigned within body weight to one of two treatment groups: control or induction of estrus. Experiment 2 was designed in a 2 × 2 factorial array with the main effects of induction of estrus or selection line. In early November, April-born Targhee lambs ($n = 174$) from two distinct selection lines were either treated as controls or received an estrus induction treatment. The two lines included an unselected control line of randomly bred ewes and a line that had been selected since 1976, based on the weight of lamb weaned. Ewes from each line were randomly assigned within body weight to one of the treatment groups. In experiments 1 and 2, estrus was induced using MAP pessaries. Pessaries were inserted for 12 days. At the time of pessary removal, ewe lambs received 400 IU eCG i.m. All ewe lambs were bred in multi-sire pens. Pregnancy rate and fetal numbers were determined either by lambing data or real-time ultrasound. Body weight, lambing date and fetal numbers were analyzed by GLM, and remaining variables were analyzed by CATMOD. For experiment 1, estrus induction increased ($P < 0.01$) pregnancy rates (61 versus 31%) and number of fetuses estimated by real-time ultrasound (79 versus 35%) compared to control ewe lambs. Pregnancy rate and fetal number were increased ($P < 0.01$) for the 1st year compared to the 2nd year. For experiment 2, estrus induction tended to increase ($P < 0.07$) pregnancy rate, and pregnancy rate differed ($P < 0.01$) between selection lines. Estrus induction increased ($P < 0.05$)

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fetal numbers (0.96) compared to controls (0.77). Fetal numbers were greater ($P < 0.01$) for the selected line (1.06) compared to random bred controls (0.67). Average date of lambing was earlier in both experiments for the estrus-induced ewe lambs compared to controls. These results indicate that induction of estrus can be recommended if increased reproduction is desired for ewe lambs.. Published by Elsevier Science B.V.

Keywords: Sheep; Ewe lambs; Pregnancy; Selection; Synchronization

1. Introduction

Ewes that are bred for the first time early in life (7–9 mo of age) achieve greater lifetime productivity than ewes that are bred for the first time later in life (18 mo of age) (Bowstead, 1930; Hulet et al., 1969; Dickerson and Glimp, 1975). Birthdate, plane of nutrition during rearing (Dyrmundsson, 1981) and breed (Quirke, 1978) are three major factors that affect onset of puberty for ewe lambs. Ewe lambs of later maturing breeds, such as the Targhee, which are born late in the spring (May/June) normally do not conceive until the following fall breeding period at 18 mo of age, which, reduces their lifetime productivity. Even Targhee ewe lambs that are born as early as April and exposed to rams in November to mid-December of that same year (9–10 mo of age) have reduced pregnancy rates, when compared with older Targhee ewes or ewe lambs of earlier maturing breeds (Westman, 1993). Therefore, it would be advantageous to increase pregnancy rate in ewe lambs of slower maturing breeds and in ewe lambs born late in the year. In order for the ewes of late maturing breeds or ewes born late in the spring to compete with ewes that are easily bred early in life, it is necessary to develop a successful breeding program for these ewes at 7–9 mo of age.

Induction of estrus increases pregnancy rates in ewe lambs bred out of season (50 versus 0%; Stellflug et al., 1993) and may also increase pregnancy rates in late maturing or ewe lambs born late in the year. Thus, the major objective of this study was to evaluate the effects of induction of estrus and selection line on pregnancy rate in spring-born ewe lambs at 7–8 mo of age.

2. Materials and methods

Three groups of ewe lambs born in May (experiment 1; one group) or April (experiment 2; two groups) were used in two experiments to evaluate the effects of induction of estrus and selection line on pregnancy rate. The ewe management systems were different between experiments 1 and 2. Ewe lambs in experiment 1 were managed on a low impact sustainable agriculture program; whereas, ewe lambs in experiment 2 were more intensely managed.

2.1. Experiment 1

The aim of experiment 1 was to evaluate the effects of induction of estrus on pregnancy rates following breeding at 7–8 mo of age in May-born ewe lambs. Experiment 1 was a single factor experiment with induction of estrus as the main effect. In early December,

May-born Targhee ($n = 82$) and Rambouillet × Targhee ($n = 129$) ewes were randomly assigned within body weight to one of two treatment groups: control or induction of estrus. Ewe lambs were blocked by weaning weight, before they were assigned randomly to either of the two treatment groups. Two replicates of this experiment were conducted over 2 years (1995–1996). The ewe lambs were weighed at weaning, onset of breeding, and end of breeding.

Ewe lambs grazed intermountain sagebrush/bunch grass range under herded conditions until weaning. At weaning, the ewe lambs were separated from their dams for 7 d. After 7 d, they were put back with their dams and grazed small grain (barley or wheat) stubble and regrowth, and alfalfa aftermath, until they entered the feedlot for breeding. During the 7 d separation for weaning, ewe lambs were fed 1.13 kg alfalfa hay and 0.3 kg of whole barley daily. Management of ewe lambs in the feedlot was the same in experiments 1 and 2.

2.2. Statistical analyses

The CATMOD and GLM procedures of SAS (SAS Inst. Inc., Cary, NC) were used to determine the effect of induction of estrus on pregnancy rate, fetal numbers, body weight at end of breeding, and day of lambing. The initial model for the data set contained terms for the main effect (induction of estrus), a term for replicate (year), and all of the appropriate interactions. For all variables, the model was reduced to main effects and the variance associated with the two way interactions was absorbed into the error term, because no significant two way interactions were detected. Specifically, CATMOD was used to determine if induction of estrus affected pregnancy rate. The GLM procedures were used to determine whether treatment affected number of fetuses, date of lambing, or body weight at end of breeding.

2.3. Experiment 2

The aim of experiment 2 was to evaluate the effects of induction of estrus and selection line on pregnancy rates following breeding at 7–8 mo of age in April-born ewe lambs. In experiment 2, ewes ($n = 174$) were assigned to one of four treatment groups in a 2×2 factorial arrangement. The main effects were induction of estrus (no induction of estrus versus induction of estrus) and selection line (unselected versus selected). Ewe lambs were assigned to the following treatments: (1) unselected-no induction of estrus, (2) unselected-induction of estrus, (3) selected-no induction of estrus, and (4) selected-induction of estrus. Ewe lambs were blocked by weaning weight, before they were assigned randomly within selection lines to either induced estrus or no induced estrus treatment. Two replicates of this experiment were conducted. The first replicate was in 1995 ($n = 82$) and the second in 1996 ($n = 92$).

The two lines of ewe lambs were defined as unselected and selected. The unselected line consisted of ewe lambs born in April from a random-bred control line. The selected line consisted of ewe lambs born in April from a line of ewes selected since 1976 for weight of lamb weaned (Ercanbrack and Knight, 1998).

Ewe lambs in experiment 2 grazed intermountain sagebrush/bunch grass range until late June, then alpine range under herded conditions until weaning. After weaning, ewe lambs were grazed again on intermountain sagebrush/bunch grass range for 3 wk before they entered the feedlot. In the feedlot, lambs were started on 1.13 kg long stem alfalfa hay and

0.23 kg of whole barley per head per day. Feeding was increased to 1.90 kg alfalfa hay and 0.45 kg whole barley daily within 2–3 wk. The lambs were continued on this diet until spring lambing. At lambing, they were fed 2.27 kg alfalfa hay and 0.45 kg barley daily in the feedlot.

2.4. Statistical analyses

The CATMOD and GLM procedures of SAS were used to determine the effect of selection line and induction of estrus on pregnancy rate, fetal numbers, body weight at end of breeding, and day of lambing. The initial model for the data set contained terms for the main effects (selection line and induction of estrus), a term for replicate (year), and all of the appropriate interactions. For all variables, the model was reduced to main effects and the variance associated with the two and three way interactions was absorbed into the error term, because no significant two way or three way interactions were detected. Specifically, CATMOD was used to determine whether selection line, induction of estrus, or the selection line × induction of estrus interaction affected pregnancy rate. The GLM procedures were used to determine whether treatment affected number of fetuses, or date of lambing.

2.5. Induction of estrus and breeding

The same estrus induction protocol was used throughout experiments 1 and 2 with the exception of the month of treatment. Administration of the induction of estrus protocol was consistent with the age of ewe lambs across both experiments. Ewe lambs were treated in early December (7 mo of age) in experiment 1 and in early November (7 mo of age) in experiment 2. Estrous cycles were induced with 60 mg medroxyprogesterone acetate (MAP) — impregnated pessaries inserted for 12 d.

Two breeding pens were used for the ewe lambs in experiment 1. The selected and unselected ewe lambs in experiment 2 were randomly distributed within selection group between two pens each year for breeding. All treatment groups were represented in each pen at all times throughout both experiments. In order to avoid overwhelming the breeding capacity of the rams, induction of estrus was staggered. Ewe lambs assigned to induction of estrus were divided into the two groups, and estrus was induced 2 d apart. At pessary removal, each ewe received an i.m. injection of eCG (400 IU). The ewe lambs that did not undergo induction of estrus were introduced to intact rams at the same time as the first group of estrus-induced ewe lambs received pessaries. The control and treated ewe lambs were exposed to the same intact rams.

Three, 18-mo-old rams were used in each breeding pen. Rams were tested for libido with ewes in estrus according to previously reported procedures (Perkins et al., 1992). Only rams with average to high libido were used. All rams tested free from *Brucella ovis*. All rams were acceptable for sperm motility and morphology.

2.6. Pregnancy diagnosis and lambing

Real-time ultrasound pregnancy diagnosis was used to estimate pregnancy rate and fetal numbers in ewe lambs in experiments 1 and 2 at approximately 50 d after the end of breeding. Estimated pregnancy rate and fetal numbers were analyzed for the ewe lambs

in experiment 1, because these data were more accurate for estimating reproductive rates than lambing data which was collected during the extensive range lambing. In experiment 2, pregnancy rates and fetal numbers were confirmed by lambing data collected in a shed lambing environment providing more reliable lambing data than what could be achieved during range lambing.

Day of lambing period lambed is defined as the Julian date of lambing minus Julian date of the calculated 1st day of lambing for the respective groups (1st day of lambing = 0). The Julian date for the 1st day of lambing was calculated by adding the average gestation length of those lambing to induced estrus to the Julian date for the 1st day of breeding for the respective group. These calculated dates were only relevant in experiment 2.

Actual data on day of lambing was recorded in experiments 1 and 2. In experiment 1, ewes with new lambs were identified on the range within 24 h of parturition. In experiment 1, lambing estimates had also been calculated following pregnancy diagnosis by ultrasound. At the time of pregnancy diagnosis, the age of the fetus and therefore, lambing date were calculated.

3. Results

3.1. Experiment 1

Induction of estrus increased pregnancy rates ($P < 0.01$; Table 1). Number of fetuses counted by real-time ultrasound was greater ($P < 0.01$) in ewes that received the induction of estrus protocol than in controls ($P < 0.01$). Average lambing date was earlier ($P < 0.01$) in ewes that received the induction of estrus protocol than in control ewes. Pregnancy rates and number of fetuses were greater in the 1st year (1996) than in the 2nd year (1997; $P < 0.01$). Average lambing date was earlier in the 1st year than in the 2nd year ($P < 0.01$). Body weights did not differ at end of breeding between treatments ($P = 0.96$). However, ewe lambs were heavier ($P < 0.01$) at all weigh times in 1996.

Table 1
Body weights (BW) and reproductive performance of May-born ewe lambs from a with (IE) or without (NIE) induction of estrus[a] at the start of the breeding period

	Treatment		*P*-value	Year		*P*-value
	IE	NIE		1996	1997	
N	103	108	–	111	100	–
Post-breeding (BW) (kg)						
L.S.M. ± S.E.	41.5 ± 0.3	41.6 ± 0.4	0.96	43.0 ± 0.4	40.1 ± 0.5	0.01
Pregnancy rate (%)						
Approximately ±S.E.M.	61 ± 5	31 ± 4	0.01	61 ± 5	29 ± 5	0.01
Fetal number						
L.S.M. ± S.E.	0.79 ± 0.06	0.35 ± 0.06	0.01	0.77 ± 0.06	0.37 ± 0.06	0.01
Lambing date (day of lambing period) L.S.M. + S.E.	6.3 ± 1.0	19.7 ± 1.4	0.01	10.0 ± 1.0	16.0 ± 1.0	0.01

[a] Estrus was induced with medroxyprogesterone acetate (MAP) pessaries for 12 d and 400 IU eCG at MAP removal.

3.2. Experiment 2

Pregnancy rate tended to increase ($P < 0.07$) after induction of estrus from 65 to 77% and a difference ($P < 0.01$) of 23% was noted between selection lines (Table 2). Fetal numbers were increased ($P < 0.01$) in ewes that received the induction of estrus treatment (0.96) compared to the control ewes (0.77) and also differed ($P < 0.01$) by selection line. Lambing date was earlier ($P < 0.01$) in ewes that received the induction of estrus treatment than in control ewes, but did not differ ($P = 0.27$) by selection lines. Body weights, which were blocked at weaning before assignment of animals to estrus induction treatments, did not differ ($P = 0.15$) at onset of breeding and approached significance ($P < 0.06$) by the end of breeding. There were year differences ($P < 0.01$) in favor of 1997 for the rest of the variables measured with the exception of pregnancy rate, where it approached a significant ($P < 0.06$) improvement in 1997.

4. Discussion

Estrus induction improved reproductive performance of ewe lambs in experiments 1 and 2. In experiment 2, pregnancy rate tended to increase, fetal numbers were increased and the lambing occurred earlier in the lambing period. More dramatically, in experiment 1, ewe lambs responded to induced estrus by almost doubling their pregnancy rate, more than doubling fetal numbers and lambing earlier in the lambing period. Thus, there was a consistent improvement in reproductive performance by induction of estrus across the two diverse selection lines and two different management systems. Although, it was not possible to directly compare the management systems represented in experiments 1 and 2, the diverseness of the ewe lambs that were treated and still responded positively in such a consistent manner underscores the usefulness of the induction of estrus treatment.

In experiment 2, a unique factor was the selection pressure that had been imposed on the dams of selected ewe lambs for 20 years and how this population responded to induced estrus treatments similarly to the unselected ewe lambs. Reproductive performance for ewe lambs from ewes selected for weight of lamb weaned has been reported to increase by 21% compared to ewe lambs from the random-bred controls (Ercanbrack and Knight, 1998; Hatfield and Stellflug, 1996). Results in the present study indicated a similar difference between the selected and unselected ewes for pregnancy rates (23% difference; 83 versus 60%, respectively). Fetal numbers in the present study also differed ($P < 0.01$) between selected and unselected ewe lambs (1.06 versus 0.67, respectively). Lambing date was not different ($P = 0.27$) for the selected and unselected ewe lambs, but induction treatments clearly stimulated an earlier ($P < 0.01$) lambing date. However, the lines responded similarly to the induction treatments as indicated by lack ($P = 0.27$) of treatment $\times$ line interactions. The present results support findings by Hatfield and Stellflug (1996) because the ewe lambs from these same lines did not differ in their response to induction of estrus either, but the induction of estrus treatment had no effect on pregnancy rate within the lines. A possible explanation for the apparent discrepancy between the two studies may be related to year differences. The fact that the present study was a more powerful test because of the factorial design including multiple years tends to favor the results of the present study. In the

Table 2
Body weights (BW) and reproductive performance of ewe lambs from a line selected for kg of lamb weaned (selected) and a random-bred control line (unselected)[a]

	Treatment		*P*-value	Line		*P*-value	Year		*P*-value
	IE[b]	NIE		Selected	Unselected		1996	1997	
N	88	86	–	87	87	–	82	92	–
Post-breeding (BW) (kg)									
L.S.M. ± S.E.	48.2 ± 0.5	49.6 ± 0.5	0.06	53.3 ± 0.5	44.6 ± 0.5	0.01	45.9 ± 0.5	52.0 ± 0.5	0.01
Pregnancy rate (%)									
Approximately ±S.E.M.	77 ± 6	65 ± 7	0.07	83 ± 6	60 ± 8	0.01	65 ± 7	77 ± 6	0.06
Fetal number									
L.S.M. ± S.E.	0.96 ± 0.07	0.77 ± 0.07	0.05	1.06 ± 0.07	0.67 ± 0.07	0.01	0.74 ± 0.07	0.99 ± 0.07	0.01
Lambing date (day of lambing period) L.S.M. ± S.E.	5.9 ± 1.0	18.6 ± 1.1	0.01	11.4 ± 1.0	13.0 ± 1.2	0.27	15.3 ± 1.1	9.1 ± 1.0	0.01

[a] Ewes were bred after induction of estrus (IE) at start of breeding period or without induction of estrus (NIE).
[b] Estrus was induced with medroxyprogesterone acetate (MAP) pessaries for 12 d and 400 IU eCG at MAP removal.

previous study (Hatfield and Stellflug, 1996), synchronization did improve pregnancy rates in pen-mated ewe lambs compared to range-mated ewe lambs. This was attributed to the inexperience of ewe lambs to seek out the ram and the ram's efficiency in finding ewe lambs in estrus in the more extensive range breeding pastures. This phenomenon also may have contributed to the difference observed between the present study and the previous one.

Selection for the composite trait appears to be the main factor contributing to consistently high reproductive performance of these ewe lambs, although body weight was also the highest in this group. However, direct selection for weaning weight (Lasslo et al., 1985) or litter size (Li et al., 1992) did not result in comparable improvement of reproductive performance of ewe lambs. In contrast, daughters of rams from a high litter size line of Romney, selected since 1947, showed a greater incidence of estrus in their 1st year and earlier onset of estrus in their 2nd year compared with daughters from the low litter size line (Meyer and Clarke, 1983). Our study supports the concept that selection for litter weight weaned resulted in a balanced biological system (Snowder et al., 1996) and this selection pressure did not alter how they responded to induction of estrus treatment. What did appear to affect the response to estrus induction in ewe lambs was the significant difference in body weights between years, because we noted that the highest reproductive performance in all three selection groups across experiments 1 and 2 corresponded with the year when BW were greater. Another factor that may have contributed to the low reproductive rate in ewe lambs in experiment 1 is the May birth date, because lambs born late in the year tend to fail to reproduce the first fall of life.

These experiments indicate that estrus induction consisting of progestagen followed by a source of gonadotrophins (eCG) can improve pregnancy rates and fetal numbers in diverse management conditions and the greatest increase in reproduction of ewe lambs appears to result from a combination of estrus induction and selection for increased litter weight weaned.

4.1. Conclusions/implications

The greatest benefit of estrus induction for improving reproductive performance of ewe lambs appears to be in systems where nutrient availability has restricted growth rate and presumably reproductive performance. However, even where total litter weight weaned has been selected for over 20 years resulting in a balanced biological system, induced estrus still had a beneficial effect increasing reproductive performance of ewe lambs and stimulating an earlier lambing date just as it did in the random bred control ewe lambs. Consequently, induction of estrus can be recommended in most production systems, where increased reproductive performance is desired in ewe lambs.

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