REPRODUCTIVE MANAGEMENT IN THE EWE FLOCK BY INDUCTION OR SYNCHRONIZATION OF ESTRUS

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INTRODUCTION

For more than half a century attempts have been made to synchronize the period of sexual receptivity, or estrus, in farm animals. Synchronization of estrus can save labor and is a key component in artificial insemination (AI) programs. AI is not widely used in sheep in the US due to the low success rate with frozen ram semen and the lack of performance data to identify superior rams.

Despite the very low rate of adoption of AI, interest in synchronization of estrus remains high among sheep producers. Synchronized breeding results in synchronized lambing, thus concentrating and reducing the labor requirements at lambing. Synchronized lambing, in turn, results in a more uniform lamb crop, which facilitates both management and marketing of lambs. Marketing costs are reduced as a result of having fewer weight/age groups to market. Lower lamb mortality can be achieved due to greater observation during the first three days of life when the danger of mortality is highest.

The sheep industry in the US and in West Virginia has been on the decline for several years. Recently, both price and demand for lamb products have risen, but this has been associated with a simultaneous increase in the importation of lamb and lamb products. The survival and regrowth of the industry requires that producers increase their production efficiency with the use of improved technologies so that they are better poised to take advantage of the improved consumer demand for lamb products. Many of these technologies are used routinely by producers outside the US. However, limited usage of previously approved products by US producers, coupled with a long-term decline in sheep numbers in the US, have made pharmaceutical companies reluctant to seek approval for commercial use of synchronization products in this country.

Typically, farmers may expose their ewes to rams during the fall breeding season for the equivalent of two (35 days) or three estrous cycles (51 days). When exposed to rams for the equivalent of three estrous cycles, 90 to 95 percent of ewes lamb within a 60-day period. Synchronization of estrus results in a similar percentage of ewes that conceive and lamb as with random mating. However, lambing occurs in three shorter and more concentrated lambing periods of 7, 10 and 10 days, with approximately 10-day intervals between these periods. This is because ewes are bred initially in a short period of two or three days, and those that do not conceive to first service remain synchronized and return to estrus within another short interval of about 5 days, an average of 16 to 17 days after the first breeding. The breeding period can be shortened to y about 37 days, because the first service opportunity for all ewes occurs within the first three days.

Ewes of the same breed-type that were bred in a single day usually lamb in a 7-day period and those bred over a 3-day period lamb during a period of ten days or less. Therefore, knowing the average gestation length (146 days in most cross-bred flocks in West Virginia), the producer using synchronized estrus can predict the days when most lambs will be born and can schedule lambing to occur when it is most convenient. In addition, knowing expected lambing dates in advance allows producers to target specific markets.

Lamb production is a seasonal enterprise for most producers. Ewes are typically bred in the fall (when reproductive activity and ovulation rate are greatest) and lamb in the spring. As a result, there are wide monthly fluctuations in both the numbers of lamb available and in the prices received by producers. Seasonal lambing patterns will affect prices, as many producers are marketing lambs during the same time period. Further, the inconsistent supply reduces the efficiency of lamb processors and results in periods of low availability to the consumer.

Induction of estrus in ewes during the non-breeding season (spring/summer) to achieve lambing in the fall has been attempted with limited success. Such programs have been aimed at increasing the number of lambings per year (3 every 2 years), taking advantage of seasonally high prices, and (or) making more efficient use of labor and other resources.

REPRODUCTIVE PATTERN OF THE EWE

The ewe is a seasonally polyestrous animal, meaning that the ewe displays estrus (“heat”) every 16 to 18 days during a limited breeding season. The onset of the breeding season at this latitude is associated with decreasing day length (after summer solstice) and temperature. The peak of the breeding season in West Virginia, as represented by the highest proportion of the flock showing cyclic estrous activity or by the highest ovulation rate (and thus expected pregnancy rate and litter size) is in October and November.

Breed, age, and nutritional status affect the exact time of onset and duration of the breeding season. Among breeds, the Southdown and Cheviot exhibit a relatively short breeding season, while the Dorset, Rambouillet, Merino and Finn-sheep exhibit extended breeding seasons. The black-faced breeds typically found in West Virginia, Hampshire and Suffolk, have breeding seasons intermediate in length. Many of the hair sheep breed types, such as the Katahdin, Barbados Blackbelly, Virgin Island White and West African Hair Sheep are considered year- round breeders. The breeding seasons of ewe lambs start later and conclude earlier compared to adult ewes. Therefore, the first breeding season of the ewe lamb is shorter and it is more difficult to breed ewe lambs out of season. In general, ewes or ewe lambs that are not receiving an adequate plane of nutrition will initiate their breeding season later in the fall. Ewe lambs that have not achieved an appropriate weight or age will not be bred during their first year of life. A minimum age of 7 months and a minimum weight of 100 pounds would be reasonable recommendations for the most common breeds and crosses in West Virginia.

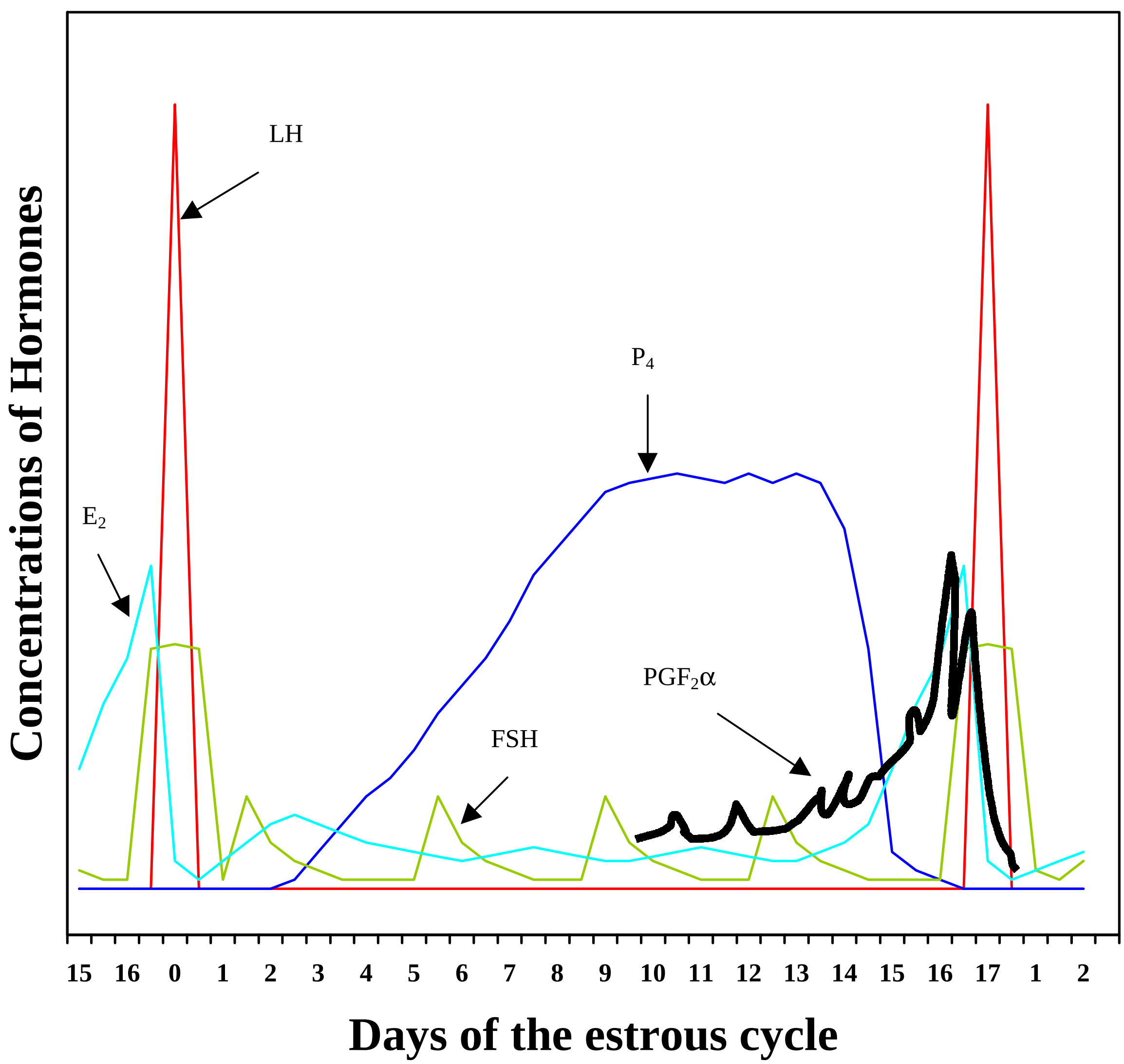

Figure 1. Patterns of concentrations of follicle stimulating hormone (FSH), luteinizing hormone (LH), estradiol-17β (E_2), progesterone (P_4), and prostaglandin $F_2\alpha$ in peripheral blood of the ewe during the estrous cycle.

HORMONAL REGULATION OF THE ESTROUS CYCLE

Just before the onset of estrus, the pituitary gland, under the control of the hypothalamus in the brain, releases increasing amounts of luteinizing hormone (LH, Figure 1). Luteinizing hormone stimulates the final maturation of the ovarian follicle(s) containing the egg(s) and stimulates the follicle to produce the hormone estrogen that brings the ewe into estrus. The rising concentration of estrogen (Figure 1) stimulates a surge in LH that causes ovulation (release of the egg) and stops further secretion of estrogen by the follicle.

Once an egg has been released, LH transforms the follicle into a corpus luteum (CL), which produces progesterone (Figure 1). Progesterone is necessary for the maintenance of pregnancy and it suppresses estrous behavior and further release of LH and ovulation. Progesterone prepares the uterus for pregnancy and stimulates the uterus to produce and secrete prostaglandin $F_2\alpha$ ($PGF_2\alpha$) beginning on about day 11 or 12 after estrus (Figure 1). If the ewe was not bred or failed to conceive, the $PGF_2\alpha$ causes the CL to stop secreting progesterone (regress) by day 14 or 15. The decrease in progesterone thus allows estrus (heat) and ovulation to occur again. If the ewe becomes pregnant, the CL is resistant to $PGF_2\alpha$ and does not regress, but continues to produce progesterone, which maintains pregnancy. An understanding of these events in the cycle has allowed us to develop tools for synchronizing estrus.

THE ANESTROUS PERIOD

As day length increases in late winter or early spring, the non-pregnant ewe ovulates the last egg(s) of the season. Upon regression of the CL and decline in progesterone, LH secretion fails to increase and estrus and ovulation do not occur. This failure to ovulate represents the entrance into the non-breeding season or anestrus. That period, which lasts until late summer, is associated with decreased secretion of LH, and an absence of estrus and ovulation (and as a result the absence of a CL and extremely low concentrations of progesterone).

As first noted in 1946 by Underwood in Western Australia and confirmed in 1954 by another Australian scientist (P.G. Schinckel), the sudden introduction of rams to a group of ewes that have been isolated from rams can interrupt the anestrous period and result in fertile matings. This phenomenon is known as the “ram effect”. In response to introduction of rams, the anestrous ewe secretes increasing amounts of LH and estrogen, which result in ovulation within 1 to 3 days (in some ewes, response may be slower, 4 to 7 days), but without the expression of estrus. The absence of estrus at this time, even in the face of rising estrogen, is thought to be due to the absence of progesterone during anestrus. Progesterone priming and withdrawal increase the sensitivity of the behavioral centers of the brain to estrogen. As illustrated in Figure 2 (panels 1 and 2), the

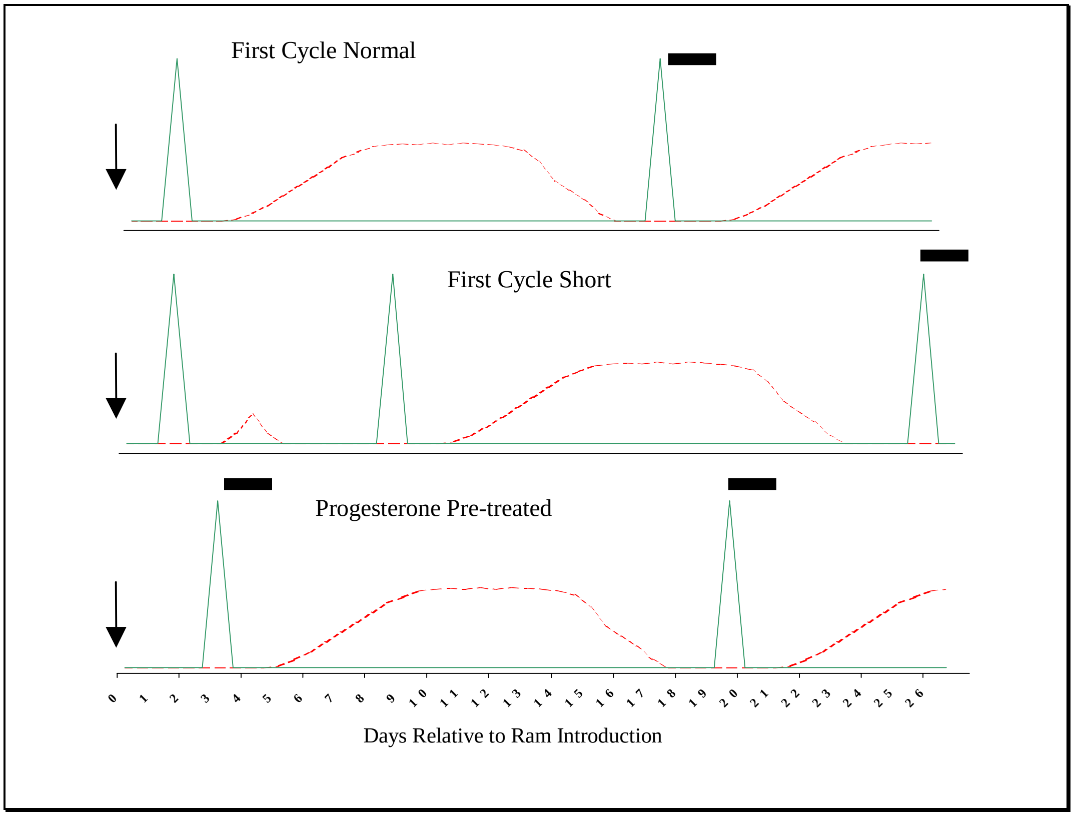

Figure 2. Types of Ovulatory and Estrous Cycles of Ewes in Response to Ram Introduction. Male symbol and arrow represent the time of ram introduction. Dashed line represents concentrations of progesterone indicating function of the corpus luteum after ovulation induced by the ram introduction or subsequent ovulation. Solid bars denote estrus and solid lines indicate surges of luteinizing hormone (LH).

CL that results from the first ram-induced ovulation has two possible fates that determine the actual day after the rams are first introduced that estrus occurs. If the CL has a normal life span (12 to 14 days) then upon its regression, estrus and ovulation occur around 16 to 17 days after introduction of rams, so fertile matings are possible at that time. However, in about 50% of ewes, the CL regresses early, and another ovulation without estrus occurs around 7 to 9 days after ram introduction. In this case, the first fertile mating can occur some 22 to 23 days following ram introduction.

A number of factors contribute to considerable variation in the percentage of ewes that are actually bred out-of-season in response to ram introduction. The breed of ewe and ram affects the response; in general, ewes and rams that have longer breeding seasons tend to breed more readily out-of-season. Further, within breeds, rams with greater sexual activity induce more ewes to respond. Ewes that have been separated from the rams, and from their lambs for at least a month also respond better, because ewes lose their ability to respond to rams or ram lambs with which they have been joined continuously. The postpartum interval and the nutritional and lactational status of the ewe also affect the response. More ewes ovulate in response to introduction of rams as the days from lambing increase, likewise the longer lambs have been weaned from the ewes, the better the response of the ewes. Ewes that are on a high plane of nutrition will respond better than ewes that are nutritionally stressed. Both postpartum interval and lactation affect nutritional status. As the postpartum and post-weaning interval increases, the nutritional status should improve and so too, should the percentage of ewes that ovulate in response to ram introduction.

The ratio of ewes to rams is critical. As the number of ewes each ram must stimulate and service decreases, the response increases. In general, a ewe to ram ratio of no more than 15 to 1 is best. Increasing the opportunity for contact amongst rams and ewes by keeping the animals in small paddocks for the first day or two can potentially increase the response. The introduction of the ram is a powerful tool and knowledge of the mechanisms underlying the ram effect has been used to develop approaches to breeding ewes out-of-season.

APPROACHES TO SYNCHRONIZING ESTRUS DURING THE NATURAL (FALL) BREEDING SEASON

Progesterone - based approaches. Progesterone prevents the ewe from returning to estrus and ovulating. Therefore supplementing the ewe with progesterone for a period equal to the duration of the life of the CL (so that all CL already present on the ovaries have regressed), then withdrawing it, will synchronize the release of LH, estrus and ovulation in a group of ewes. Progestogens (synthetic analogs of progesterone) can be provided by feeding (MGA; melengesterol acetate), implants under the skin (Norgestomet – Synchro-Mate B), sponges inserted into the vagina (FGA, flurogestone acetate; MAP, medroxyprogesterone acetate; progesterone), or plastic delivery devices such as the CIDR – G (controlled internal drug releasing device) inserted into the vagina. Progesterone, the natural hormone, is the most desirable of progestogens because it is cleared rapidly from the body after withdrawal. However, the ability to incorporate adequate amounts of progesterone into suitable delivery devices that can maintain high concentrations in the ewe throughout the treatment period has been a limiting factor.

Prostaglandin $F_2\alpha$ - based approach. Prostaglandin $F_2\alpha$ is produced by the uterus beginning around day 11 or 12 after estrus and causes the regression of the CL in the non-pregnant ewe. Beginning in the late 1960's and early 1970's, workers around the world observed that synthetic $PGF_2\alpha$ could regress the CL and so synchronize estrus and ovulation. However, it was soon observed that the

CL did not regress as readily in ewes that were less than 5 days post-estrus, so that only a proportion of the flock was synchronized by treatment with $PGF_2\alpha$.

A 1980 study conducted in West Virginia compared the effectiveness of progestogen-containing (FGA) sponges to two injections of 20 mg $PGF_2\alpha$ given 12 days apart. In 1981, in an attempt to improve the cost effectiveness of $PGF_2\alpha$ treatments, a third treatment regimen, consisting of 2 injections of 5 mg $PGF_2\alpha$ given 3 hours apart, 3 or 4 days after introduction of rams, was evaluated. The results of these studies are presented in Table 1. The three treatments were equally effective in synchronizing estrus and resulted in similar levels of fertility. These studies showed that as little as 10 mg of $PGF_2\alpha$ (1/4 of the dose used in the other treatment) can be used to effectively synchronize estrus during the breeding season.

APPROACHES TO BREEDING EWES OUT-OF-SEASON

In addition to the use of the ram effect, several techniques have been used to breed ewes out-of-season. In 1981, studies were conducted during July through early September, just prior to the breeding season. These studies evaluated the effectiveness of a 12-day treatment with the progestogen FGA prior to ram introduction. Pre-treatment with progestogen stimulated estrus at the first ram-induced ovulation and therefore provided the opportunity for a fertile mating during the first 3 days that rams were present. Treatment with progestogen prevented the occurrence of CL with reduced life span and therefore synchronized the second service period 16 to 17 days later (Figure 2, third panel). Another treatment consisted of $PGF_2\alpha$ (5 mg, 2 X, 3 hours apart) given 12 days after introduction of rams. Both treatments resulted in 50% of the ewes lambing to two service periods.

In a series of experiments carried out in Spain and West Virginia, the timing of injection of $PGF_2\alpha$ after introduction of rams was examined in ewes that did or did not receive a single injection of progesterone at the time of ram introduction. A single injection of progesterone, although insufficient to facilitate estrous behavior, prevents the occurrence of CL with a reduced life span. When this treatment is combined with an injection of $PGF_2\alpha$ 12 to 16 days after ram introduction, a synchronized estrous response can be expected. In these experiments, $PGF_2\alpha$ was given to one group of ewes on either day 12, 14 or 16 after introduction of rams. In another group of ewes, a single injection of progesterone (25 mg) was given at introduction of rams and $PGF_2\alpha$ was given on day 14 or 16 after ram introduction. The results of these studies are presented in Table 2. Injection of prostaglandin 12 to 16 days after ram introduction increased the pregnancy rates to the first service and after two service periods over ram introduction alone. The highest pregnancy rates were obtained when progesterone was injected at ram introduction and $PGF_2\alpha$ was given 16 days after ram introduction.

Other approaches that have been used include treatment with melatonin, “the hormone of darkness”. Melatonin is secreted by the pineal gland during the night. Treatment with melatonin therefore mimics the short days of fall and

Table 1. Reproductive performance of ewes treated with FGA for 12 days (FGA), injected with $PGF_{2\alpha}$ 12 days apart (PGF; 20 mg/injection), or introduced to rams for 3 days, then injected with $PGF_{2\alpha}$ on day 4 (RPGF; 2 X 5 mg, 3h apart) in Fall, 1980 and 1981.

Variable	Treatments		
	FGA	PGF	RPGF
No. Ewes	330	334	300
Estrus (%)	94	93	94
Lambing (%)	72	73	72
Litter Size (First Service)	1.68	1.63	1.68

Table 2. Pregnancy rates of ewes exposed to rams (R), exposed to rams and injected with $PGF_{2\alpha}$ 12, 14 or 16 days later (RPG), or injected with progesterone (25 mg) at ram introduction and injected with $PGF_{2\alpha}$ 14 or 16 days later (PRPG) during the non-breeding season.

		Pregnancy Rate (%)	
Treatment	No. ewes	First service	After two services
R	60	35	45
RPG			
Day 12	220	40	67
Day 14	546	51	66
Day 16	481	51	62
PRPG			
Day 14	157	49	58
Day 16	219	71	75

induces estrous behavior after a minimum of approximately 35 days of treatment. The percentage of ewes bred out-of-season can be increased by selection of ewes with naturally long breeding seasons such as Dorsets, Finn and hair sheep breeds or by selection within breeds or crosses. For example, D. R. Notter of Virginia Tech was able to increase the percentage of ewes lambing in a flock of crossbred ewes (50% Dorset, 25% Rambouillet, 25% Finnsheep) from 33 to 76% over a five-year period. These latter approaches (melatonin treatment and selection) do not synchronize estrus and must be combined with other treatments if a synchronized lambing to out-of-season breeding is desired.

RECENT STUDIES ON FARMS IN WEST VIRGINIA

Intravaginal delivery devices for progestogens are easiest to use and have generated the most interest in recent years. The low amounts of progestogen incorporated into the original Synchro-Mate sponges marketed in the US in the 1970's (20 mg FGA) and in the CIDR-G (300 mg progesterone) appeared to have resulted in lower fertility at the synchronized estrus in some cases in larger American ewes. With the development of a newer delivery device that incorporated more than twice the amount of progesterone compared to the previous devices, it became of interest to evaluate its effectiveness for possible use in ewes during the non-breeding and breeding seasons. Because the release of progesterone from the intravaginal devices decline with time, short-term treatments might be beneficial.

Even when ewes are induced to ovulate and show estrus during the non-breeding season, ovulation rates and litter sizes (prolificacy) are lower than those observed during the breeding season. The hormone equine chorionic gonadotropin (eCG or PMSG), which has follicle stimulating hormone (FSH) activity in ruminants is widely used in other countries, but no eCG preparation is currently approved for use in livestock in the US. The natural hormone FSH is conditionally approved for use in super-ovulation protocols in cattle, thus it became of interest to evaluate the use of FSH in combination with progesterone pre-treatment and ram introduction for possible future use to increase litter size in ewes mated during the non-breeding season.

Studies with Out-of-Season Breeding

<u>Experiment 1</u>. <u>Tests of a new intravaginal insert with and without FSH</u>. This study was conducted in 1998 with 382 ewes on six farms during the anestrous period (May to July). Eighty-four of these ewes were determined to have high progesterone in blood (thus these ewes had been undergoing estrous cycles) and were removed from the study. The remaining ewes were assigned to one of four groups. One group received progesterone from a new intravaginal releasing device (PCL; containing 800 mg. progesterone) for 12 days (P12) alone or with a single injection of FSH (55 mg) on day 11 (P12F). Another group of ewes was assigned to receive the PCL insert for 5 days with FSH on day 4 (P5F), while the fourth group was exposed to rams only (C). Fertile rams with painted briskets were introduced to ewes at the time of insert removal at a ewe to ram ratio of 15:1. Blood samples were collected throughout the treatment period, ewes were observed for estrus, and pregnancy rates and litter sizes were recorded.

The new PCL insert did not increase concentrations of progesterone in the blood of the ewe as high as concentrations seen during the luteal phase of the estrous cycle or those reported previously for the original CIDR-G. In ewes treated for 12 days, the concentration of progesterone declined rapidly after the first 4 days, and was not different from that of untreated ewes by day 12.

With progesterone treatment, 74% of ewes showed estrus during the first 5 days after ram introduction compared to 12% in ewes introduced to rams only (Table 3). The mean time from introduction of rams to estrus was 42 hours and did not differ with duration of treatment with progesterone.

The percentages of ewes lambing to the first (42%) and to both first and second service periods (64%) in progesterone-treated ewes were not affected by duration of progesterone treatment. In ewes introduced to rams only, the values were 0 and 41%, respectively (Table 3). Therefore, treatment with progesterone increased the overall proportion of ewes lambing by 23 percentage points.

Ewes lambing to the first service period that were treated with progesterone and given an injection of FSH had a larger litter size (0.2 to 0.3 more lambs born per ewe lambing) than ewes exposed to rams only (Table 3).
Treatment with progesterone resulted in ewes lambing earlier and in a more synchronized pattern (Figure 3). The majority (60 to 70%) of progesterone-treated ewes that lambed did so during the first 8 days of the lambing period. There was no lambing between days 9 and 15, but another period of lambing occurred between day 16 to 25. Ewes introduced to rams lambed continuously between days 14 and 29 of the lambing period.

Experiment 2. Examination of short-term treatment with the CIDR-G. In experiment 1, the new insert did not prove to deliver more progesterone than the original controlled internal drug releasing devices (CIDR-G; containing 300 mg. progesterone). Treatment for 5 days seemed to be equally effective as treatment for 12 days. Experiment 2 was aimed at testing the efficacy of a 5-day treatment with the original CIDR-G device with or without FSH given one day before removal of inserts compared to introduction of rams only. In this study, conducted in 1999, a total of 653 ewes on 7 farms were assigned to be controls (C; introduced to rams only), or to receive the CIDR-G device for 5 days, alone (P5) or in combination with an injection of FSH 1 day before insert removal (P5F).

The results of this study were similar to those obtained in experiment 1 (Table 3). More ewes treated with progesterone (P5 and P5F) were marked by rams during the first 3 days after ram introduction (77 vs 20%), and lambed to the first (46 vs 0%) or both services (63 to 67 vs 45%). Thus an additional 18 to 22% of the ewes treated lambed due to progesterone pre-treatment. Ewes that were treated with FSH and lambed to the first service tended to have a larger litter size than ewes not treated with FSH and control ewes.

Table 3. Reproductive performance of anestrous ewes in 1998 (Experiment 1) in response to ram introduction (C), or ram introduction + 12-d PCL treatment (P12), 12-d PCL treatment + FSH (P12F) or 5-d PCLtreatment +FSH (P5F) and in 1999 (Experiment 2) in response to ram introduction (C), or ram introduction + 5-d CIDR pre-treatment without (P5) or with FSH (P5F).

	Experiment 1,1998				Experiment 2, 1999		
	Treatment				Treatment		
Variables	C	P12	P12F	P5F	C	P5	P5F
Total Ewes	73	73	71	77	125	25	271
Ewes in Heat (%)	12	77	66	79	20	75	79
Conception Rate (%)	10	63	64	56	0	70	66
Percentage of Ewes Lambing:							
A) First Service Period.	0	45	39	42	0	46	46
B) Overall	41	66	64	63	45	63	67
Litter size:							
A) First Service Period.	-	1.6	1.9	1.8	-	1.5	1.7
B) Second Service Period	1.5	1.4	1.3	1.8	1.5	1.5	1.5
C) Overall.	1.5	1.5	1.6	1.8	1.5	1.5	1.6

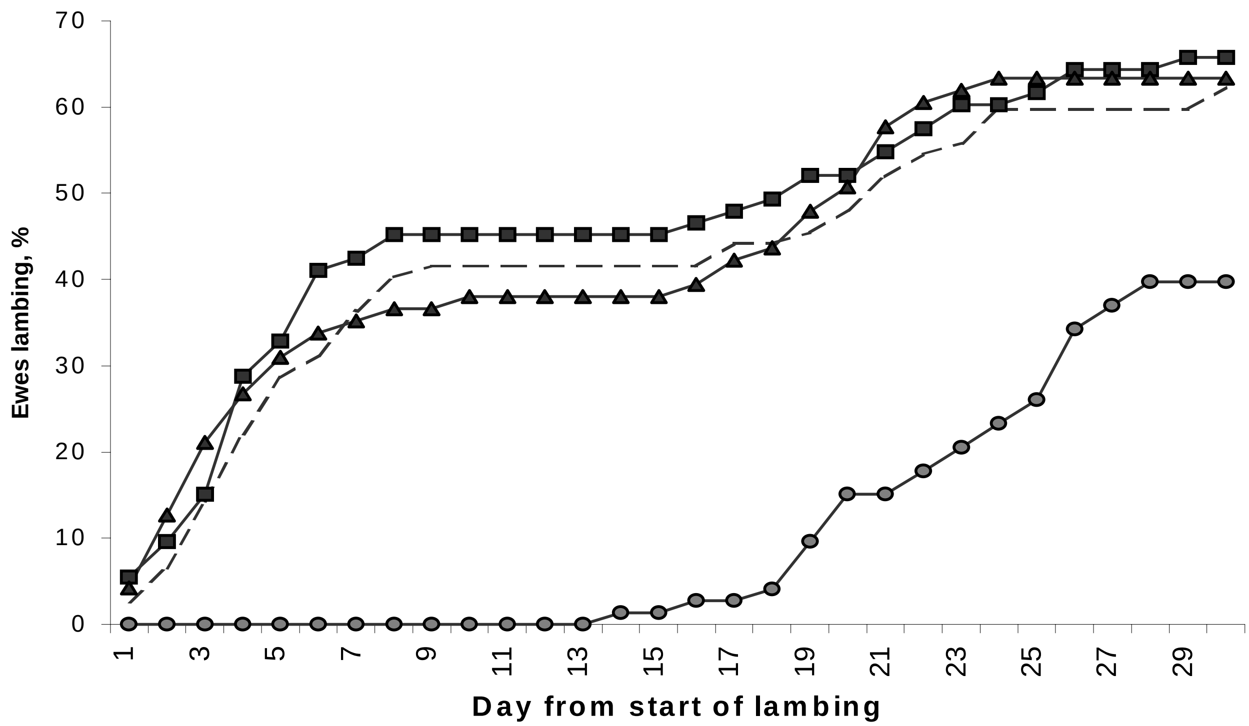

Figure 3. Cumulative percentages of ewes lambing in control ewes (C,), ewes pre-treated with PCL inserts for 12 d without (P12,), or with FSH 24 h before insert removal (P12F,) and ewes treated with PCL inserts for 5 d with FSH 24 h before insert removal (P5F,).

In both studies, the response varied among farms and to a limited extent with the face color of the ewe (Table 4). The greatest responses in terms of overall ewes lambing were observed in white-faced ewes (69%) other than North Country Cheviots. Although only a few North Country Cheviot ewes were studied, none of these ewes lambed in response to treatment.

<u>Experiment 3.</u> <u>Effects of dosage, vehicle, and injection time on the response to FSH</u>. In a third experiment, conducted during 2000, different dosages of FSH, vehicles for the FSH and times that FSH was injected relative to removal of the intravaginal insert were examined. Although dosages of FSH of 42 or 68 mg increased ovulation rate slightly when given 12 hours before insert removal, numbers of lambs born were not increased in most flocks. Vehicle did not affect the response, but injection of FSH 36 hours before insert removal was ineffective.

Overall, it was concluded that progesterone treatment before ram introduction can be used to induce a synchronized fall lambing in the majority of ewes, which can allow producers to take advantage of seasonally higher lamb prices. Increases in litter size were not sufficient to justify the addition of FSH to the treatment regimen of progesterone and ram introduction.

Table 4. Distribution and some reproductive characteristics of ewes by farm and face color.

	No. of Ewes Per Face Color/Breed Type[a]					PR 1st service (%)[b]	Ewes Lambing (%)[c]	Prolificacy[d]
Variable	Tot	B	M	W	Ch			
Farm:								
1	52	9	15	28	0	40	52	1.7
2	47	33	8	6	0	40	87	1.8
3	75	60	14	1	0	44	72	1.7
4	34	13	8	3	10	21	24	1.4
5	15	15	0	0	0	60	47	1
6	67	51	11	4	1	16	43	1.5
Face Color:								
Black (B)			181			43	59	1.6
Mottled (M)			56			49	61	1.8
White (W)			42			60	69	1.6
Cheviot (Ch)			11			0	0	-

[a]The only breed identified specifically was North Country Cheviot(Ch). Black-faced ewes (B) on farm 5 were 100% Suffolk, but other black-faced ewes were grade and included Hampshire and Suffolk breeding. White-faced ewes (W) included Dorset and other breeding. Mottled-faced ewes (M) were crosses of black- and white-faced ewes.
[b] PR=pregnancy rate, number of ewes pregnant on d 26 to 31 as a percentage of all ewes in groups treated with progesterone.
[c] Ewes lambing to first or second service period of all ewes exposed and alive at lambing, including both progesterone treated and control ewes.
[d] Lambs born per ewe lambing.

Lactating Ewes: A Limiting Factor During Anestrus

Lactation has little or no inhibitory effect on the ability of ewes to exhibit reproductive cycles during the breeding season. Estrus accompanied by ovulation occurs about 35 days after parturition in fall-lambing ewes, regardless of whether they are suckling lambs or non-lactating. However during anestrus, lactating ewes usually respond poorly to attempts to induce breeding activity by ram introduction or treatment with progestogens. In recent studies, effects of lactation on response to treatment with progesterone were examined in ewes that were treated in early July. The lambs had been weaned from ewes in one group and ewes in the other group were in the second and third month of lactation. All ewes received CIDR devices (that had been used previously for 5 days) for 5 days before introduction of rams.

In experiment 1, 105 weaned ewes and 53 lactating ewes were studied. Half of each group received an additional treatment of 30 micrograms of estradiol benzoate in 1 mL corn oil 24 hours after insert removal and ram introduction. The other half received 1 mL corn oil. Weaned ewes had higher pregnancy rates by ultrasonography at 26 to 30 days after first (59%) or second service (74%) periods than the lactating ewes (38 and 44%, respectively). Thus 81% of the weaned ewes, but only 44% of the lactating ewes lambed. Lambs born per ewe exposed (lambing rate) averaged 1.26 and 0.61, respectively. Lambing rate was higher in ewes treated with estrogen, (1.1) than in ewes receiving corn oil (0.8).

In experiment 2, 106 weaned ewes and 44 lactating ewes received either 0, 15 or 30 micrograms of estradiol benzoate 24 hours after insert removal and ram introduction. Again, more weaned (76%) than lactating (27%) ewes were pregnant to first service. More weaned (82%) than lactating (27%)ewes lambed, and lambs born per ewe exposed averaged 1.25 and 0.31, respectively. Treatment with estrogen increased pregnancy rate to first service and ewes lambing in weaned, but not in lactating ewes.

In conclusion, currently available methods are not suitable for induction of breeding out-of-season in lactating ewes. During March or April through July, it is recommended that lambs be weaned for at least 10 days before initiation of treatments to induce a fertile estrus.

Studies on Synchronizing Estrus during the Breeding Season.

Synchronizing estrus during the normal breeding season provides a means for producers to schedule the lambing period, concentrating labor needs into a short time-frame. Estrous synchronization also can help in improving the uniformity of the lamb crop for market.

The use of intravaginal progesterone inserts for a period equivalent to the lifespan of the CL (12 to14 days) has resulted in reduced fertility in some studies. The low amount of progesterone released by a single device was unable to completely maintain a low frequency of release of LH towards the end of the treatment period. A higher frequency of release of LH leads to an earlier increase in estrogen in relation to the time of ovulation. The result is ovulation of an older follicle, in which the egg may have begun to undergo degenerative changes, based upon studies in cattle and one study in ewes (however, a recent study in Ireland did not find decreased fertility in ewes treated with a lower dosage of progesterone).

A single CIDR-G device had been shown earlier to be unable to completely suppress LH secretion for a duration equal to the normal lifespan of the CL. Therefore, we investigated the effect of two (2) CIDR-G devices for 12 days on fertility at the synchronized estrus.

Experiment 1. Effect of two CIDR's for 12 days. A total of 401 ewes on three farms were used in this experiment in 1998. Nearly half of the ewes received 2 CIDR-G devices for 12 days, while the others acted as controls. Blood samples were collected every 2 days to monitor the concentration of progesterone. At insert removal, rams were joined at a ewe to ram ratio of 25 to 1 (remember that only a portion of the control ewes would be expected to show estrus during the period of synchronized estrus for treated ewes). Observations for estrus were done every 12 h from 24 to 60 h after introduction of rams. At estrus, the diameters of the two largest ovarian follicles were measured in 20 ewes in each group using ultrasonography, and pregnancy rate, lambing date and litter size were recorded in all flocks.

The use of 2 CIDR-G devices maintained high circulating concentrations of progesterone throughout the 12-day treatment period. In the first 60 h after removal of the CIDR devices, 94% of ewes treated with 2 CIDR-G devices were in heat compared to 36% in control ewes (Table 5). The majority of ewes treated with 2 CIDR-G devices came into estrus between 24 and 48 h after device removal. The conception rates (percentage of ewes detected in estrus during the first 60 h that lambed during the first 10 days of the lambing period; 68 and 73%), and the pregnancy rates for control and treated ewes (percentage of all ewes lambing; 91 and 93 %) did not differ. The litter sizes for the two groups, 1.86 and 1.95, did not differ (Table 5). It was concluded that use of 2-CIDR-G inserts was effective in synchronizing estrus and maintained high fertility in fall-bred ewes.

Experiment 2. Effect of a single CIDR for 5 days. The use of 2 CIDR-G devices synchronized estrus without any deleterious effects on fertility. However, such a system may be costly; further, the smaller reproductive tract of ewe lambs may not be able to accommodate 2 devices. We therefore compared ewes given prostaglandin alone to ewes given a single CIDR-G device for 5 days before injection of $PGF_{2}\alpha$. The 5-day treatment with CIDR-G plus $PGF_{2}\alpha$ should synchronize estrus without decreasing fertility, because this treatment should maintain high circulating concentrations of progesterone during the short treatment period. At the same time it should block ovulation so that ewes will possess either no functional CL or CL that are susceptible to $PGF_{2}\alpha$ (more than 5 days old).

Table 5. Reproductive performance of ewes during the breeding season in response to ram introduction (C), or ram introduction following a 12-d treatment with 2-CIDR-G inserts (2-CIDR; Experiment 1, 1998), and in response to $PGF_{2}\alpha$ alone (PGF), or a single CIDR-G device given for 5-d with $PGF_{2}\alpha$ given 18 h before (CIDR + PGF –18) or at insert removal (CIDR + PGF –0; Experiment 2, 1999).

	Experiment 1, 1998		Experiment 2, 1999		
	Treatment		Treatment		
Variables	C	2-CIDR	PGF	CIDR + PGF -18	CIDR + PGF-0
Total Ewes	185	216	211	83	166
Ewes in Heat (%)	36	94	72	84	93
Diameter of Largest Follicle (MM)	5.7	5.8	-	-	-
First Service Conception Rate (%)	68	73	52	66	75
Overall Pregnancy Rate (%)	91	93	87	81	91
Litter size	1.86	1.95	1.62	1.69	1.69

Four hundred and sixty (460) ewes on 4 farms were used in this study conducted between late August and December, 1999. Ewes were given a CIDR –G device for 5 days and given an injection of prostaglandin (Lutalyse 20 mg) 18 hours before or at insert removal. A third group of ewes were given a single injection of prostaglandin only.

The results from this experiment are presented in table 5. The estrous response was highest in ewes given a CIDR-G device and $PGF_2\alpha$ at insert removal (93%), lowest in ewes given prostaglandin only (72%) and intermediate in ewes treated with CIDR-G devices and given $PGF_2\alpha$ 18 h before insert removal.

The conception rate to first service was lower in the ewes given prostaglandin alone (52%) than in the ewes receiving a CIDR-G device and $PGF_2\alpha$ at insert removal (75%), while the conception rate was intermediate in ewes receiving $PGF_2\alpha$ 18 h before insert removal (66%). The overall pregnancy ratefrom the two service periods was 86% and was not different among the 3 treatment groups. The litter size averaged 1.68 and did not differ among groups.

Unexpected Findings: Late Embryonic and Fetal Mortality

During the recent studies in out-of-season breeding, pregnancy was diagnosed by ultrasonography of the reproductive tract of the ewes at 26 to 30 days after first and second service periods. In combination with the data for lambing, the data for pregnancy status at 26 to 30 days allowed us to estimate pregnancy retention. In out-of-season experiment 1, 91% of pregnancies to first service were retained to lambing and 73% of pregnancies resulting from the second service period were retained. Similarly, in out-of-season experiment 2, pregnancy retention rates were 88 and 80%, for first and second service periods, respectively.

These findings stimulated further studies of the numbers of embryos or fetuses present at 25, 45, 65 and 85 days after breeding and numbers of lambs born in both the breeding and non-breeding seasons. In 2000 and 2001, a total of 957 pregnant, non-lactating ewes of mixed breeding on 9 cooperating farms, bred either in early May and June (anestrus, season 1) or in late July, August or September (transition, season 2), were examined by ultrasonography. Late embryonic and fetal mortality was determined from these counts and numbers of lambs born. Breeding season and service period did not affect losses at any stage of pregnancy.

Individual embryos or fetuses were lost from multiple pregnancies, as well as complete losses of either single or multiple pregnancies. In fact, more ewes lost one or more, but not all, embryos/fetuses from day 25 to term than experienced complete loss of a pregnancy (Figure 4). Losses of potential offspring were continuous throughout gestation, with 4.3% of ewes experiencing

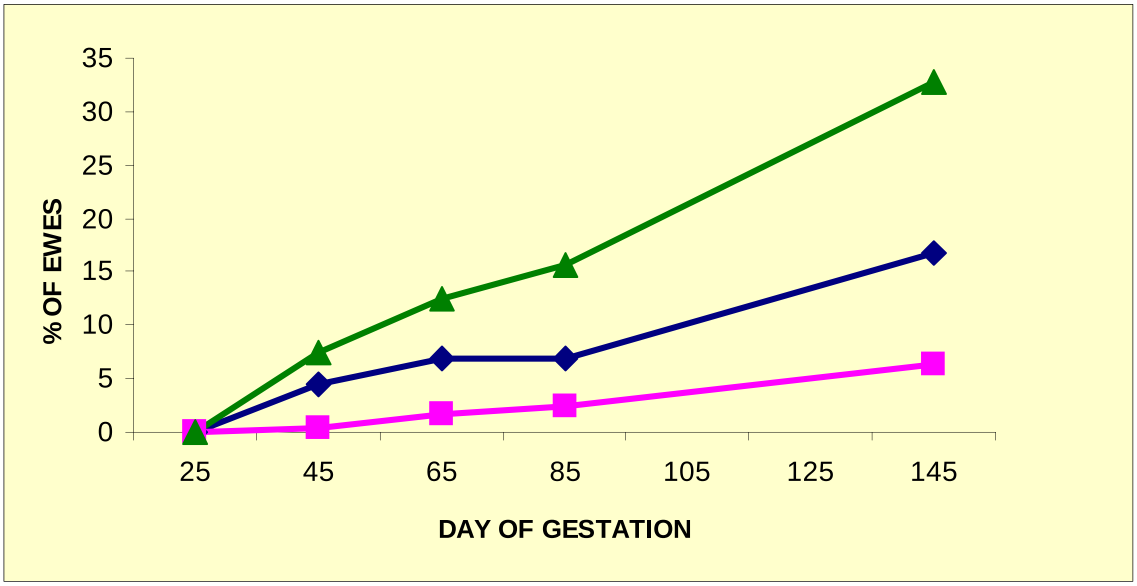

Figure 4. Proportions of ewes not retaining embryos present at day 25 (%) by type of loss, single pregnancies lost (♦), multiple pregnancies with complete loss ( ), and multiple pregnancies with partial loss ( ).

loss of one or more embryos from day 25 to 45, 5.1% losing one or more fetuses from day 45 to 65, and 10.2% from day 65 to term. Mean losses of embryos or fetuses averaged 3.3% from day 25 to 45, 2.7% from day 45 to 65, 2.3% from day 65 to 85, and 8.5% from day 85 to term.

Treatment with FSH increased the proportion of potential offspring (number of corpora lutea) not represented by lambs born (0.25, 0.55 and 0.71 for 0, 42 and 62 mg of FSH, respectively). Late embryonic or fetal mortality totaled 18.5% from day 25 to term in the current study. Estimated total loss of potential offspring from determination of ovulation rate to lambing was 22.4%. By difference, only approximately 4% of potential offspring were lost from ovulation to day 25 of gestation in those ewes that were pregnant at day 25. Thus fertilization failure and/or early embryonic death were more important in total failures of pregnancy that occurred before day 25 than in later losses. Overall, it is important to realize that ovulation rate is not the only factor limiting litter size in sheep.

CONCLUSIONS:

Treatment of ewes during the anestrous period with progesterone for as little as 5 days before ram introduction can result in synchronized fall lambing in greater than 65% of ewes treated, an improvement of 20 percentage points over ram introduction alone. Treatment with FSH one (1) day before progesterone removal, will sometimes yield a small increase in litter size in ewes bred out-of-season, but only in flocks with naturally low ovulation rates, and FSH increased embryonic and fetal mortality. Therefore, general use of FSH cannot be recommended.

The use of 2 CIDR-G devices for 12 days synchronized estrus during the breeding season with high fertility. The use of a single device for 5 days with $PGF_2\alpha$, given at insert removal, seemed to be as effective as using 2 CIDR-G devices for 12 days and should be a more acceptable treatment program. This treatment synchronized estrus more efficiently and with greater fertility than $PGF_2\alpha$ alone.

Once CIDR-G devices and $PGF_2\alpha$ are approved for use in the US sheep industry and marketed in this country, treatment with a CIDR device for 5 days before ram introduction can be used to induce out-of-season breeding. This regimen can allow producers to target lamb markets when prices are highest. Its utilization in the industry could help to ensure a consistent supply of lamb. Likewise, treatment with a CIDR device for 5 days, with $PGF_2\alpha$ at device removal, can allow producers to plan lambing dates and concentrate labor at lambing time for ewes bred in season.

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