A STUDY OF EARLY SEASON BREEDING PERFORMANCE IN WESTERN EWES

By

JOHN CALLAWAY GLENN

Bachelor of Science
Alabama Polytechnic Institute
Auburn, Alabama
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Master of Science
Mississippi State University
State University, Mississippi
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Thesis Approved:

Joe V. Whiteman
Thesis Advisor

J. A. Whatley Jr.

Elwynn Jones

J. C. Hillier

Hugh Reuber

Robert MacVicar
Dean of the Graduate School

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INTRODUCTION

Sheep in the wild state are thought to have only one or, at most, very few estrous cycles during the year. These normally occur in the late summer and early fall. This seasonality of breeding is probably a result of natural selection since lambs born from a fall breeding have a greater possibility of living and producing offspring. Most of these wild sheep also produce only one lamb per parturition; again, perhaps due to the selective advantage of these single lambs as well as the often times poor nutrition of the dam.

As our present day breeds have been developed they have been selected and managed in such a way as to promote a longer breeding season and greater prolificacy. Progress has been and is being made toward reaching these goals. There is still an anestrous period of varying length and intensity in most of our breeds of sheep, usually in the spring and early summer months.

This anestrous period is quite a problem to sheep producers who are located in areas of rather mild winters and summer temperatures are high enough to affect growth of lambs to a large extent.

Their system of management is such that it is desirable for lambs to be born in the fall and early winter. These lambs, then, can reach a market weight of around 100 pounds by the month of May.

In order for lambs to be born at the desired time, the breeding season must be in May, June and July. This is the period when many of our domestic breeds are in some degree of anestrous. A few ewes will come in heat at this time; but usually, the conception rate is low and/or embryonic death rate is high and the ewes seem to be less prolific than in the fall breeding season.

Various methods have been used in an effort to increase the percent of ewes lambing and their prolificacy. Most of these are mentioned in the review of literature. The particular studies being reported in this thesis were conducted to observe the early season breeding behavior (May, June and July matings) of Western ewes. They also were purposed to give some indication of the factors behind the better breeding performance of ewes shorn in May (late shorn) as compared to ewes shorn in April (early shorn). The main factors studied were ovulation and fertilization rate and early embryonic mortality.

REVIEW OF LITERATURE

In order for the farm flock production of sheep to be most economical, multiple lambs must be obtained from a ewe as frequently as possible. The ideal would be twins twice a year or three times in two years. The reproductive performance of the ewe, however, is not this high, due to various factors which act upon the ewe and upon the ram to which she is mated.

Reproduction in sheep is naturally influenced by the occurrence of estrus. Sheep are normally seasonal breeders, but a number of variables affect the occurrence as well as the length of the breeding season. Kammlade et al. (1952) studied the pituitary activity of sheep in the anestrous and estrous seasons. The gonadotropic activity of the pituitary was found to be constantly high in the non-breeding season. Gonadotropic hormone potency dropped to a low level when the ewe manifested estrus at the onset of the breeding season and gradually increased during the cycle until the seventeenth day when the level was about equal to that observed during anestrus. These workers found follicle activity during the non-breeding season to be as great as during the breeding season and that these follicles could be caused to rupture by injecting luteinizing hormone. These observations suggest that, possibly, the main pituitary activity during anestrous may be the production of the follicle stimulating hormone (FSH).

Quinlan and Mare (1931) reported that Merino ewes in South Africa showed estrus at regular intervals throughout the year. Marshall and Hammond (1932) noted that Merino and Dorset ewes are capable of producing two lamb crops yearly. McKenzie and Phillips (1930) when studying Hampshire, Shropshire and Southdown ewes found that the Hampshires started cycling the latter part of August, about ten days earlier than the other two breeds. Cole and Miller (1935) noted under California climatic conditions that Rambouillet ewes would breed in early July.

McKenzie and Terrill (1937) studied estrus in various medium wool breeds of sheep from July, 1929, to March, 1936. The onset of the breeding season showed considerable individual variation but with few exceptions started in late August or early September and ended in late December or January. The ewes which came in heat earlier in the season also tended to go into anestrum later. Underwood et al. (1944), working in Australia, studied the time of onset of estrus and the length of the breeding season in Merino, Merino-Border Leicester crosses and British breed ewes. The maximum number of ewes of these breeds exhibited the first estrus of the breeding season in November and December, December and

January, and February and March, respectively. Hafez (1951a) worked with Dorset, Welsh Mountain and crosses of these two breeds. The Dorsets started cycling in late July, Welsh Mountain in late October and the crossbreds in early October. The breeding season ceased about the same time for the three groups. Karam (1957) stated that fat tailed sheep in Egypt seemed to have no restricted ovarian activity.

Watson (1953), in Australia, divided 288 Merino ewes into three groups. Group one was mated during the period from April to June* (this corresponds to October, November and December in the United States). Group two was bred from August to October* and group three from December to February*. Ewes were cycling and there was a high incidence of mating from the start of the breeding season in groups one and two. A high incidence of mating was delayed about three weeks from the first exposure to the ram in group three. In group one, there were 87 ewes; 86 mated and 80 produced lambs. Similar figures for groups two and three were 116 ewes, 113 mated, 89 produced lambs, and 85 ewes, 85 mated, 79 lambed, respectively.

Williams _et al_. (1956b) observed a group of 100 Western cross ewes (fine wool type with Hampshire, Shropshire or Suffolk) for three years to determine onset of

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*Corresponds to a period six months later in the United States.

estrus and length of the estrous cycles. They found no tendency for individual ewes to be consistently early or late in onset of their breeding season from year to year. The initiation of the breeding season varied from July 8 to August 27 to September 1 for the years studied.

Chang and Raeside (1957) studied the estrous cycles of New Zealand Romney ewes in the fall and winter months over a two-year period. The onset of first estrus ranged over a three-month period with the highest incidence being in May. The average number of cycles in the breeding group was 2.7 in 1956 and 4.28 in 1957.

Various workers have noted that at the beginning of the breeding season, ewes tend to have one or more ovulations without estrus (Grant, 1933; Cole and Miller, 1935; McKenzie and Terrill, 1937.)

Yeates (1949) shortened or lengthened the hours of light in an effort to determine the effect of this variable on the occurrence of estrus in ewes. His control animals had a breeding season of from September 20 to March 27. In the experimental group, the ewes came into heat 13 to 16 weeks after a change from increasing to decreasing length of day. The breeding season ended 14 to 19 weeks after the change from decreasing to increasing day length. This cessation of cycling occurred whether the season ended in February, March or November.

Terry and Meites (1951) kept a group of ewes under constant dark, constant light or normal light between June 22 and August 29. Thyroid activity was generally decreased after constant light and increased after constant darkness. One of eight ewes lambed earlier than normal under constant light; four of eight under constant darkness. Robinson (1951b) concluded that there is an inverse relationship between pituitary activity and hours of daylight. He postulated that the threshold of activity required to initiate ovulation varies between breeds. Hafez (1951b) exposed a group of Suffolk ewes to light continuously from November first. All ewes were cycling normally at the beginning of the experiment. The ewes placed on the constant light treatment entered anestrus in about twelve weeks; this was eight weeks earlier than a control group. Hafez (1952a) reported that the daylight environment is responsible for the seasonal nature of the breeding season. In general, the incidence of estrus is inversely related to the length of daylight; that is, the peak of sexual activity corresponds to the shortest days. At the equator where there is no seasonal fluctuation in the daylight hours, it seems that seasonal activity is conditioned by factors other than daylight, probably rainfall or nutrition. This same worker noted that there is much less tendency for seasonal breeding at the equator.

Hafez (1952b) hastened the onset of the breeding season by 57 days in ewes treated daily with eight hours of light and sixteen hours of darkness. Ovulation started, in most cases, before the ewes exhibited the first estrus of the breeding season. When the amount of light and dark was reversed the onset of anestrus occurred 104 days earlier than in a control group.

In addition to light affecting the occurrence of estrus, temperature seems to be of some importance also. Elpatjevski (1934) stated that low temperature, especially below 15 degrees C., reduced the number of ewes coming in heat by about 25 percent. Yeates (1953) considered light to be clearly the dominant factor in regulating the seasonal incidence of estrus, although other factors may affect its expression. He did not find that exposure of a group of Romney ewes to 105 degrees F. for six hours a day, five days a week, caused any change in time of onset of estrus.

Dutt and Bush (1955) were able to change the date of first estrus by cooling a group of fine wool Hampshire cross ewes. They used 2- to 3-year old ewes, half of them being placed in an air conditioned room at 45 to 48 degrees F. on May 26, the other half being kept at normal environmental temperatures. The average date of first estrus for the cooled ewes was July 10 and for the controls September 2. All of the ewes in the former group had a cycle between May 31 and August 8 while the latter group delayed until the period from August 13 to September 22.

Morrison and Erb (1957) concluded that, in general, breeding efficiency in cattle is more affected by increased temperature than by variation in length of daylight, especially in areas where very high environmental temperatures are encountered.

Age is another factor which may affect the occurrence of estrus. Cole and Miller (1935) found the first estrus to occur at 8 to 10 months of age in late winter and spring born lambs. Mature ewes came in heat mainly in August and September as compared to September and October for the lambs. Asdell (1946) found that lambs usually begin to cycle during their first fall breeding season at a mean age of 213 days. Late born lambs often do not cycle this first year. Williams et al. (1956b) reported that the average beginning date of the breeding season for Hampshire-Western cross ewes as one, two or three year olds was July 8, August 27 and October 1, respectively. Kelly (1937) found no association between age and occurrence of estrus.

Hafez (1952b) noted that estrus occurred from 17 to 63 days post partum in sheep. Post mortem examinations revealed that the estrus was accompanied by ovulation. Barker and Wiggins (1958) found that the average interval from lambing to establishment of a regular cyclic pattern of estrual behavior was 72.8 days with a range of 12 to 212 days.

Williams _et al._ (1956) reported that estrus occurred after conception in 63 percent of 24 pregnant Rambouillet ewes and 22 percent of 103 Western ewes. Other workers have reported similar results.

Radford and Watson (1957), in Australia, placed vasectomized rams with Merino ewes at different times during the spring and early summer (anestrous period). Vaginal smears indicated estrus in almost all ewes placed with the ram on December 8 and in very few of the control ewes which were not exposed to a ram. There is considerable controversy as to the ability to differentiate the various stages of the estrous cycle with vaginal smears. Grant (1936), Cole and Miller (1935) and Darlow (1942) indicated that if a succession of smears are taken, they can be used as a diagnostic measure in detecting certain reproductive states. The smears were made December 8 to 14. Corpora lutea compatible with ovulation were found in the teased ewes, but not in controls.

Smith _et al._ (1958) obtained a significantly higher percentage of teased ewes lambing during the first two weeks of the lambing season when the breeding season started before August 1. Underwood _et al._ (1944) suggested that the presence of a ram has an effect on ewes causing them to cycle sooner than non-teased ewes.

Thompson and Schinkel (1952) placed vasectomized rams with a group of ewes for one estrous cycle before they were placed with fertile rams along with a control group. Significantly more teased ewes cycled in the first seven days of the breeding season. About the same number from both groups cycled the second seven-day period and in the third period significantly more non-teased ewes mated. The authors stated that teasing seemed to be more beneficial in ewes which started cycling during periods of increasing daylight hours and had little or no effect when the breeding season commenced during decreasing daylight hours.

Whiteman (1959) placed a vasectomized ram with three groups of ewes for four weeks prior to breeding. Using date of lambing as an indicator of breeding date, a group of one-half Dorset one-half Rambouillet, or one-half Dorset one-half Panama X Rambouillet which were teased lambed eight days earlier than a group of non-teased controls. Grade Rambouillet and grade Panama teased ewes lambed two and three days later than controls.

Henderson and Henneman (1957) sheared ewes just prior to breeding in August. These late sheared ewes lambed on the average 25.5 days earlier than ewes shorn at the regular time. Warren <u>et al</u>. (1957) sheared grade Hampshire ewes on about April 7 or May 21 for four years. The breeding season began July 1 and continued until ewes entered anestrus, except for one year when it was stopped on October 1. The average percentage of ewes lambing for the four years was 73 for the early sheared group and 86 for the late sheared ewes. The average date of lambing was seven days earlier in the late sheared group. Whiteman and Brown (1959) did not find any difference in the onset of the breeding season in ewes shorn in either April or May. This shearing treatment did affect lambing rate as will be reviewed later.

Darlow and Hawkins (1931) placed grade Rambouillet ewes on a high and low level of nutrition. In the high level 20 of 21 ewes came in heat between July 23 and October 28; whereas, only 12 of 20 low level ewes were found to be in estrus. Darlow (1942) concluded from later work that there was no significant difference in the time of the onset of the breeding season of ewes on a maintenance or a gaining ration. deBaca et al. (1954) found that nutrition played a major role in the onset of the breeding season. Ewes started cycling earlier in a year of good pasture conditions than when pastures were poor. Other factors could have been involved here also, as the authors pointed out.

In recent years much work has been done throughout the world on the use of exogenous hormones to stimulate the onset of the breeding season. Some of the more pertinent papers are reported here. Hammond (1941) found that the injection of pregnant mare serum (PMS) into anestrous ewes caused the maturing of large numbers of ovarian follicles. Robinson (1950) injected 800 international units (I.U.) of PMS into anestrus ewes and obtained ovulation without estrus in cases where the ewe did not have a waning corpus luteum. He stated that a wide range of responses could be expected since in most ewes anestrus is a relative, rather than absolute, quiescence of the ovary.

Dutt (1952-53) injected ewes during anestrous with PMS alone or with one to five doses of progesterone followed by PMS. None of the control ewes cycled during the experiment. Ewes injected with PMS alone ovulated, but did not exhibit estrus. Prior injection of the ewe with progesterone caused estrus and ovulation to occur. There was a tendency for better results with increased injections of progesterone up to five injections. Estrus and ovulation are not well synchronized as is indicated by the fact that only 49 percent of all ova recovered from the various groups were fertilized. Edgar (1958) injected 90 milligrams (mgms) of progesterone (three injections of 30 mgms on alternate days) followed in two days by 1,000 I.U. of PMS. Seventeen of the 25 anestrus ewes were marked by a teaser ram and 11 lambed to artificial insemination. Workers reporting the same general findings include Robinson (1954-1955), Raeside and Lamond (1956a,b), Gordon (1958b), and Hunter _et al._ (1959).

Ovulation

Reproductive efficiency is also affected by the ovulation rate. Under farm flock conditions it is desirable that ewes have two or more ovulations per estrus so that more production may be realized per ewe.

Much of the early data on differences in ovulation rate between breeds or various treatments is based on lambing data. Since embryonic mortality can influence this considerably some of the earlier findings may be misleading.

Asdell (1946) shows a wide range of ovulation rates in various breeds of sheep. The Cheviot has a reported fertility of 89 percent and the Romanov, 238 percent. Terrill and Stoehr (1939) reported the percent lamb crop of ewes mating to be 129, 127, 122 and 118 for the Targhee, Columbia, Rambouillet and Corriedale ewes, respectively. The first three of these differences are statistically significant.

Reddy _et al_. (1958a) and Baker _et al_. (1958) found significant differences between the ovulation rate of various breeds of swine.

Rendel (1956) calculated an average heritability of multiple births for all breeds studied of 0.113 and a repeatability of .094. Johannson and Hanson (1943) measured repeatability of performance by correlation and regression methods. The correlation between lambs produced by ewes as two-year olds and lambs produced by these as three-year olds was .208; the regression value was .180. This would indicate that ewes which produced twins at the first lambing would produce on the average .18 more lambs at the second lambing than would ewes which first produced a single. Their general conclusion was that the hereditary part of the total variance in size of litters within breeds is very small, probably not over 15 percent.

Belogradskii (1940) reported that selection of ewes from multiple litters was effective in increasing prolificacy. The number of lambs born per 100 ewes which were themselves born as a single, twin, triplet or quadruplet was 217, 236, 263 and 301, respectively. This work was with Romanov sheep. Smirnov (1936) selected ewes from multiple litters and decreased the percentage of singles from 24 to 16 and increased the triplets from 17 to 30 percent.

Roberts (1921) found that the percentage of multiple births in Shropshires increased up to four years of age. Johannson (1932) stated that in the Swedish breeds, there is an increased lamb crop from first to fourth lambing of about 22 percent. Terrill and Stoehr (1939) reported a steady increase in fertility up to five years of age. McKenzie and Terrill (1937) noted that the ovulation rate varied with age and that the ewes fell into three main groups. Lambs and yearlings averaged 1.21 ova, three and four year olds averaged 1.6 and five to seven year olds 1.46 ova per ewe. Other workers who have reported a peak of reproductive performance at about five years of age are: Bell (1912), Pearl (1913), Marshall and Potts (1924), Kennedy and Bettenay (1950), Williams (1954) and Karam (1957).

Grant (1934) and Cole and Miller (1935) discovered that there are one or more cycles of ovulation not accompanied by heat at the beginning and end of the breeding season. McKenzie and Terrill (1937) laparotomized 17 ewes at first estrus and found that 16 had one or more corpora lutea which were one cycle old. The average number of corpora lutea for these silent ovulations was 1.25 as compared to 1.6 for the first estrus ovulation. They also observed that there was a tendency for more multiple births, and, thus, possibly more ovulations early in the lambing season when ewes were bred in the normal season. Roberts (1921) reported that of 3,790 lambs born in January, February and March, 42.3 percent were twins as opposed to 36.1 percent of 4,617 lambs born in April, May and June. These results were obtained from material in the "American Shropshire Sheep Record".

Bezrukov (1957) found ovarian activity to be greater in autumn than in spring and summer; however, summer services were responsible for 47 percent twinning, autumn services for 30 percent. Hammond Jr. (1944) reported that ewes bred at the beginning of an estrus season generally increased in prolificacy up to a peak in November while Averill (1958) stated that the peak occurred between the first week in November and the last week in December. Watson (1953) indicated that the percent of ewes which produced multiple lambs decreased as the breeding season advanced. These workers were experimenting with various breeds of sheep, of different ages, and in widely separated areas. Any or all of these factors might account for the differences in their findings.

The practice of placing ewes on lush feed prior to the breeding season is known as "flushing". There is rather general agreement that this practice can cause an increase in percent lamb crop if the ewes are not in high condition at the time of breeding.

Marshall and Potts (1924) compared the lambing percentages of ewes which were not flushed with ewes which were flushed. The former group produced a 128.8 percent lamb crop as compared to 146.9 percent for the flushed ewes. McKenzie and Terrill (1937) found that flushing increased the ovulation rate in a group of Western ewes (1.15 as compared to 1.06.)

Clark (1934) conducted two experiments with flushing. In one case he obtained rather large differences in double ovulations (8 versus 0) in favor of the flushed group. In the second experiment the unflushed group had a slightly higher ovulation rate. There were ten double and ten single ovulations in the flushed as compared to twelve double and eight single in the unflushed ewes. These ewes were in high condition before flushing, however. Other workers have indicated that ovulation rate is increased by flushing (Bell, 1912; Okulicev, 1934; Vita, 1951; Wallace, 1953; Gerring, 1954; El Sheikh *et al.* 1955; Foote *et al.* 1957; and Foote *et al.* 1959.)

Hauser (1939), Briggs *et al.* (1942) and Darlow (1942) reported a long time study with Rambouillet, Hampshire, Shropshire and native ewes. These ewes were on various nutritional planes and the effect of these levels of nutrition on reproduction were discussed. When the lots in which (1) ewes had gained more than seven pounds, in which (2) ewes had neither gained nor lost more than seven pounds, and in which (3) the ewes had lost more than seven pounds were compared, the ewes which gained the most were more productive than the middle group (108.18 as compared to 89.76 percent lamb crop); but the ewes which lost the most weight were the most productive (115.0 percent lamb crop).

When the rations fed were disregarded and each ewe was placed into the (1) flushed, (2) maintenance and (3) sub-maintenance groups as described above, the flushed group was the most productive; but not significantly more than the other two groups. They also found no significant effects of flushing on number of barren ewes or time of onset of the breeding season.

Whiteman and Brown (1959) reported data on April and May shearing of ewes and its effect on reproductive performance. The breeding season started about ten days after the May shearing and continued for 32 or 48 days. The April sheared group had 148 of 189 ewes lambing and these produced 195 lambs. The May sheared group had 170 of 194 ewes lambing and these produced 226 lambs. It has not been established if differences in ovulation or embryonic mortality accounted for these results.

Smirnov (1936) stated that prolificacy was dependent upon body weight. He found that the larger ewes in his experiment produced 2.5 to 2.6 lambs, while the smaller ones produced only 1.62 lambs per ewe. Terrill and Stoehr (1942) also noted an influence of body size on this trait. The body size within breed seemed to be more important than between breeds. Columbia, Rambouillet and Corriedale ranked in that order for percent lamb crop.

It has been shown that either anterior pituitary extract or PMS are effective in causing multiple ovulations in the ewe (Robinson, 1951b); but because of the greater availability and economy of PMS this compound has been used to a greater extent. Murphree et al. (1944) injected follicle stimulating pituitary extract subcutaneously for four days starting on day twelve after the beginning of the previous cycle plus one intravenous injection on the sixth day after treatment started. The ewes were inseminated on this and the following day. Twenty-four ewes treated in this way produced 576 corpora lutea. There were 357 eggs found and 153 were fertilized. Seven of the ewes had no fertilized eggs.

Hammond (1941) stated that the injection of PMS in the presence of a waning corpus luteum of diestrous results in multiple ovulations, presumably due to the fact that the corpus luteum prevents immediate rupturing of the first ripening follicle and gives time for many follicles to become mature before the trigger for ovulation is released.

Robinson (1951a), Wallace (1954), Averill (1958) and Gordon (1958a) used from 250 to 1000 international units of PMS on days 11-13 post-estrus to cause superovulation. These workers obtained good superovulation response, conception rate and lambing rate. Wallace (1954) found an average of 0.5 more embryos in the PMS treated ewes than in controls. Gordon (1958) reported 1.40 lambs per ewe surviving beyond one day post partum for PMS treated ewes as compared to 1.26 for controls. Robinson (1951a) obtained a 20 percent increase in lamb crop due to PMS treatment.

Fertilization

Nalbandov (1958) stated that if the timing is proper and a male with high semen quality is used, the fertilization rate of all polytocous animals approaches 100 percent. In pigs, if only individuals in which at least one egg is fertilized are considered, the fertilization rate approaches this level. Baker et al. (1958) established a fertilization rate of 95 percent in gilts bred by boars of established fertility.

Somewhat different results have been reported in monotocous and ditocous females than in polytocous females. Averill (1955) found that 70.8 percent of 130 ewes conceived to first service. In a group of ewes killed at three days post-breeding 14.2 percent of 53 ewes had unfertilized ova and 7.6 percent were found to have dead ova which had been fertilized. Three causes for failure of fertilization were listed in this paper -- the absence of sperm from the fertilization site, asynchronous estrus and ovulation, and death of the ovum prior to fertilization.

Alliston (1957) studying reproductive performance during the summer months, placed one group of ewes in a room at atmospheric temperature (84 degrees F.), another in a cooled room (65 degrees F.), and another in a heated room (92 degrees F.). The fertilization rates for these groups of ewes were 92.3, 96.5, and 71.4 percent, respectively. All ewes were bred to rams having high quality semen as evaluated by sperm concentration and percent motility.

Egli et al. (1956) obtained a first service conception rate of 57 percent when ewes were kept at 65 degrees F. for 17 days after breeding to a cooled ram; when bred to a non-cooled ram this conception dropped to 45 percent. When non-cooled ewes were bred to either cooled or non-cooled rams the conception rates were 44 and 17 percent, respectively. Dutt et al. (1956) placed sheared and unsheared ewes in a heated room (90 degrees F.) in November, on day twelve of the estrous cycle. A third group was kept under normal conditions as controls. All ewes were killed three days post-mating and fertilization rates for the three groups were 69.2, 42.9 and 92.9 percent, respectively.

Hulet et al. (1956) found that shearing rams just prior to the breeding season significantly increased fertilization rate. Dutt and Simpson (1957) worked with cooled (45 to 48 degrees F.) and non-cooled rams early in the fall breeding season and obtained 64.2 and 26.0 percent fertilization, respectively.

Hulet et al. (1956a) reported that fertilization rates increased significantly in each of four two-week periods from August 1 to October 1. Ram infertility accounted for fertilization failure in 47.6 percent of the ewes prior to

September 16 and for 31.4 percent after that time. Dutt (1954) placed a group of ewes with a fertile ram during the last week in August and in September. The fertilization rate was found to be 55.1 percent; 28.1 percent of the unfertilized ova were classified as abnormal. In this case the ewe and ram seemed to be about equally responsible for fertilization failure.

Robinson (1950) stated that ova from multiple ovulations are highly fertilizable except when the rates of ovulation exceed 15 per estrus. In these cases the recovery of ova and the percentage of ova fertilized is decreased due to the rapid passage of the ova through the oviduct.

Fertilization rate might not be as low in cattle as in sheep if the data reported by Kidder _et al_. (1954) and Bearden _et al_. (1956) can be assumed to be representative of normal cattle. These workers reported fertilization rates of 100 and 96.6 percent when cows were bred to highly fertile bulls. Comparable values for low fertility bulls were 71.9 and 76.9 percent.

Embryonic Mortality

The full importance of this aspect of reproductive loss is not known. Attachment, development of the fetal membranes, and the early nutrition of the embryo, especially in the first month of pregnancy, are far from being completely understood. Casida (1956) stated that the investigation of lowered fertility in a herd or flock is very complex since differentiation must be made between fertilization failure and embryonic death. If sperm fertility can be assured then prenatal mortality is the most likely reason for lowered fertility.

Hammond (1921) evidently felt that embryonic mortality was not too important since he concluded that the number of ova shed is more important in determining the rate of reproduction in sheep than is the occurrence of fetal atrophy.

Prenatal death can be traced either to defects inherent within the embryo or to adverse conditions within the maternal environment. In swine, it has been demonstrated rather conclusively that maternal environment has an effect on embryonic mortality. Gilts which consumed two-thirds as much feed as a full fed group failed to ovulate as many ova as the latter group, but had a lower incidence of embryonic mortality and, in most cases, farrowed more pigs per litter (Casida, 1956). This same conclusion may be drawn from the fact that inbred sows have a greater loss of early fetuses than outbred dams whether the sows are carrying inbred or outbred litters (Pomeroy, 1952; Casida, 1956).

Reddy *et al.* (1958b) stated that it is likely that defective internal environment, usually as a result of faulty implantation, is the primary cause of mortality in mammalian embryos. The possession of hereditary internal defects (lethals) may also be important.

Corner (1923) studied embryonic mortality in the pig and classified the various possibilities which might account for the occurrence of embryonic abnormalities in mammals. They are:

A. Defects of zygosis

1. Failure of fertilization
2. Irregular fertilization

B. Defects of maternal environment

1. Mechanical disorder of the uterus
2. Infection of the reproductive tract
3. Toxicity of the uterine environment
4. Nutritional defect of the uterine environment
5. Disorders of uterine peristalsis and other disorders of the implantation mechanism

C. Defects of the gametes and the zygote

1. Non-genetic defects of the germ cells
2. Genetic defects of the germ cells

Dutt (1954) estimated embryonic mortality during the fall breeding season to be 32 to 37 percent with most of the deaths occurring before 16 to 20 days post-breeding. Hulet <u>et al</u>. (1956a) also noted that embryonic death occurred early, mainly in the first 18 days of gestation. They also estimated the percent of ewes in which fertilization occurred and was followed by prenatal mortality of all embryos to be 28.6 percent for ewes bred prior to

September 16 and 9.9 percent for ewes bred from that date to October 25.

Laing (1949; 1952) stated that the incidence of embryonic mortality in commercial cattle may be about 20 to 30 percent and that it occurs at all seasons in the year. The incidence seems to be higher in the winter months from October to March.

High air temperatures also seem to affect the rate of embryonic mortality. Cameron (1943) found that an artificially produced fever in does that had been bred for 22 to 80 hours resulted in a poor reproductive performance. Seventeen of 18 does subjected to a water bath temperature of 113 degrees F. for 20 minutes failed to produce any offspring. One doe was removed from the water bath at ten minutes and another was subjected to a temperature of 107 degrees F. for 20 minutes. Both had normal litters.

Shah (1956) subjected a group of does to an environmental temperature of 96 degrees F. six days after breeding. The does had a total prenatal death loss of 96.2 percent. When developing blastocysts were transplanted from heat treated to non-heat treated does or from non-heat treated to heat treated does, it was found that more blastocysts survived in the former type transplant than in the latter. It was concluded that heat adversely affected the maternal tissues rather than the ova or embryos. Ragsdale (1948) reported that two Holstein cows aborted four and a half and six month fetuses two days following exposure to a temperature of 100 degrees F. for 27 hours.

Yeates (1953) placed ewes in a heated room for seven hours daily during the entire, last two-thirds or last one-third of gestation and found a decrease in the number of ewes lambing as well as in the birth weight of lambs for those ewes which did produce an offspring. The longer the exposure, the more drastic the results appeared to be.

Dutt *et al.* (1956) placed a group of ewes in a heated room (90 degrees F.) eight days after breeding in November and kept them there for 16 days. One-half of the ewes were shorn; the others were not. At 32 to 35 days post-breeding, the controls outside the room were all pregnant as well as all of the hot room sheared and 90 percent of the hot room non-sheared. He concluded from this and earlier work that heat affects fertility and normalcy of the ova more than it does survival of young embryos. Alliston and Ulberg (1957) had ewes under three different environmental temperatures. Ewes kept outside under existing summer temperature in Mississippi had twelve normal embryos from 24 corpora lutea in 18 ewes. Ewes at 65 degrees F. had 28 normal embryos from 34 corpora in 21 ewes and at 95 degrees F., one normal embryo from eight corpora in five ewes. All ewes were killed two and a half to fourteen and one half days after breeding.

That the ram has an effect on embryonic mortality was shown by Dutt and Simpson (1957) and Hulet et al. (1956b). Ewes bred to cooled or sheared rams had lower embryonic death loss than ewes bred to rams under normal atmospheric conditions.

El-Sheikh et al. (1955) compared embryonic death to 40 days in ewes fed hay alone or hay plus two pounds of grain for six to eight months prior to and after breeding. The average number of corpora lutea for the low level ewes was 1.2 and for the high level 1.6. Embryo survival was lower in ewes on grain by 9.26 percent in one year and 74.03 percent in another year.

Henning (1939) and Brambell (1948) concluded that the proportion of mortality of fetuses increases as the number of ova ovulated increases. Spalding et al. (1955) studied the development and maturation of follicular and oviduct ova which were produced under natural conditions and due to injection of gonadotropins. All except one of the ova produced under gonadotropin stimulation were normal just prior to and after ovulation. The exception was found in the oviduct in an immature state.

Robinson (1950) found that up to the ovulation of 15 ova in sheep the fertilization and attachment rates were high. However, embryonic mortality within the first three weeks of pregnancy reduced the number of survivals to a mean of 2.5. Casida et al. (1944) found that 74 percent of multiple ovulated ova (mean ovulation rate was 20.8) recovered from a group of ewes were cleaving at two to five days post-breeding. Eight similar ewes examined at 14 to 27 days post-insemination had only 3.4 normal embryos with an average of 23.2 corpora lutea. Only five of eight ewes examined at 30 to 37 days were pregnant. No ewe had more than one normal embryo and the average number per pregnant ewe was 0.8. There was an average of 3.8 abnormal embryos found. These workers suggested two possible reasons for this high embryonic mortality. The rapid maturation of the follicles may induce abnormalities in the ova which do not prevent fertilization and early cleavage, but which are not capable of producing viable young, or the female reproductive tract may be incapable of supporting such a large number of embryos.

It is easy for one to see that many problems remain to be solved relative to reproductive performance in sheep. Much of the research must be of the basic type in order to determine exactly why and in what way a certain treatment or management technique causes increased reproductive capacity. We must learn the various ways in which reproduction is affected by definite factors such as genetic differences, temperature, humidity and light.

The results reported here do not indicate that we can consistently improve the performance of sheep by the use of hormones to cause estrus and/or ovulation. These techniques are also not easily adaptable to general farm conditions. The author believes, from the results of work reviewed here that it is possible by using the proper breeds or combinations of breeds along with certain alterations in the environment of the ewe and ram to produce a larger number of fall born lambs, as desired in Oklahoma and other states with rather mild winter climate.

One needs to read very little concerning embryonic mortality to realize that it is one of the biggest deterrents to greater prolificacy in sheep breeding. This fact is pointed out in the review along with methods which have been and are being used to reduce the occurrence of embryonic mortality.

All of these factors mentioned directly affect the economics of sheep production under a fall lambing program and must be considered when setting up research aimed at improving the efficiency of reproduction of sheep under these conditions.

EXPERIMENTAL

These studies were designed to answer two questions. (1) What is the reproductive performance of Western (predominantly fine wool) ewes bred in the summer months? The answer to this question and the perfection of methods whereby we might measure reproductive performance would aid in the development and study of management techniques to improve the reproductive performance of the ewes. (2) What is the reason for the improved reproductive efficiency of ewes shorn in May as compared to those shorn in April? The latter month is the normal shearing time in Oklahoma. This question was important due to results of earlier research at this and other stations. (Whiteman and Brown, 1959; Henderson and Henneman, 1957; Warren *et al.* 1957) If an answer is obtainable to this latter question, then other management systems might be suggested which would further increase the productivity of ewes bred for fall lambs.

The study is divided into three trials; the last two were designed to answer the same question. Ewes of different ages were used in these last two trials.

The sheep used in this study were furnished by the Oklahoma Agriculture Experiment Station and were located at the Fort Reno Experiment Station. The work was in cooperation with the Sheep, Goat and Fiber research section, Animal and Poultry Branch, A.R.S., U.S.D.A. The ewes were purchased in two separate groups. Their time of acquisition, management and treatment will be described separately.

Trial I

Materials and Methods

In October of 1957, 100 aged Western ewes, predominantly of Rambouillet breeding, were purchased from New Mexico. These ewes were all multi-parous and probably were sold from various flocks due to their advanced age. The teeth of the ewes indicated that they were six to nine years old, although some might have been older. There is no evidence that they were poor or non-breeders unless their level of reproductive performance might be affected by advanced age. The important thing to this study, however, is not so much their average productivity as their response to the treatments involved.

The traits to be observed in this study necessitated recovery of the ova and embryos from the ewes after breeding. Much previous work has been reported on this technique; but, in most cases, the recovery was made almost immediately after slaughter. Various factors made it necessary for these ewes to be slaughtered in Oklahoma City and the reproductive tracts transported to Stillwater before they could be flushed for ova or dissected to observe the embryos. This involved a considerable delay and it was not known what effect this delay might have on the results.

In order to determine if this procedure could be followed, a group of twelve ewes were slaughtered in November to study this problem. On November 21, a fertile ram was placed with all of the ewes for two nights which was the time required to get twelve ewes bred. One-half of these was designated to be slaughtered at 3 to 5 days post-breeding and the other half at 16 to 19 days post-breeding.

Three ewes from each of these two groups were killed at the meat laboratory on the campus; the others were killed by Wilson and Company at their packing plant in Oklahoma City. The reproductive tracts of the ewes killed at the meat laboratory were removed after slaughter and flushed immediately. At the packing plant the reproductive tracts were removed as the ewes passed down the processing line. The tracts were tagged and placed in a plastic bag. These, in turn, were placed in ice water in an insulated chest and returned to Stillwater for flushing. A period of from four to ten hours elapsed between slaughter and examination. The tracts remained in the ice water until each was examined.

The ova or embryos were recovered from the reproductive tract by flushing with a physiological saline (.85 percent) solution. Recovery was made from both the oviduct and the uterine horns; but the former was found to be much easier with less chance of ovum or embryo loss. Ova and embryos were found in the uterine horn as early as three days after breeding, so that our observations indicated the ewes should be slaughtered as soon as possible in the two to five day post-breeding period to facilitate recovery.

The recovery technique involved separation of the oviduct and uterine horn at their point of junction and cutting the membrane attached to the oviduct so that the oviduct could be straightened. The oviduct was flushed by inserting a small tipped glass pipette into the infundibulum of the oviduct (or at the opposite end of the duct if entry could not be obtained here) and forcing the saline through the duct by means of a rubber bulb on the opposite end of the pipette. The saline was collected in a watch glass. Usually, two to three washings into separate watch glasses were made before the pipette was removed.

The watch glasses were shaken gently so that tissue and ova or embryos in them would concentrate in the central portion and, thus, reduce the area to be searched. These were then placed under a Bausch and Lomb microprojector and a search was made at 43X magnification for the ovum or embryo which could be easily differentiated from the tissue in the solution.

When the ovum or embryo was found it was observed and, if normal, no further study was made. If the ovum or embryo appeared to be abnormal in any way or was not dividing it was transferred by means of a micropipette or a white blood cell pipette to a clean solution for further study under the microprojector (100X magnification) or to a slide for study under a microscope (430X). In the event that the ovum was not found in the oviduct the uterine horn was flushed.

The horn was separated from the rest of the tract at the junction with the body of the uterus. The supporting tissue surrounding the horn was removed to allow the horn to be straightened. The pipette was then inserted into the large end (next to the body of the uterus) of the horn and saline forced through the horn and again collected in watch glasses and the washings examined. As stated earlier, recovery of the ovum or embryo from the uterine horn was more difficult, this being caused by the large amount of saline required and the fact that much more tissue was generally present in this washing.

The embryo recovery was much less difficult after 15 days post-mating. The reproductive tracts for 16 to 19 days post-breeding were handled in the same way as those for pre-implantation observations, in the preliminary study, except that the horns only were flushed. Actually, a loose implantation had taken place, but the elongated blastocyst present at this time was more easily flushed out than dissected out. In the later work the post-implantation studies were made at 21 to 39 days post-breeding. At these later stages a bulge was evident in the gravid horn of the ewe. This horn was dissected carefully and the normalcy of the embryo was observed and recorded. Because of the delay in recovery there was no heart beat in these embryos; but it was assumed that the healthy, normal appearance of the embryo and embryonic and maternal membranes was a good indication that the embryo was alive and normal at the time the ewe was slaughtered.

The remainder of the ewes in this first part of the study were maintained throughout the winter on dry grass supplemented with prairie hay and some small amount of alfalfa hay. Earlier workers have reported that the presence of a ram in some way affects the return of the ewe to normal estrous cycles after anestrous (Radford and Watson, 1957; Smith et al., 1958; Underwood et al., 1944; Thompson and Schinkel, 1952). To study what effect this might have on May and July breeding and to determine the nature of the estrous cycles of these ewes in March and April, 41 ewes were placed with a vasectomized ram from March 18 to May 1.

The ram was fitted with a marking harness and was left with the ewes continuously. The ewes which were marked by the ram were considered to be in estrus and the dates of estrus were recorded. The remaining 43 were continued on pasture without a teaser ram.

The ewes were shorn April 10, 1958. On May 2, the 84 ewes remaining were weighed, condition scored and allotted to treatment groups. Allottment was stratified according to previous treatment (teased or non-teased), weight and condition score. Within these strata the ewes were allotted at random into either a May or July breeding group.

The May breeding group was placed with a fertile ram from May 3 to May 25. The rams used for breeding were kept in a refrigerated room at 69 to 78 degrees F. during the daytime and placed with the ewes at night. As the ewes were bred, alternate ones were designated for pre- or post-implantation study. The ewes were taken to the Wilson and Company plant on the day of slaughter which was 2 to 7 or 15 to 39 days post-breeding. The reproductive tracts were removed and observations made as described earlier.

The July breeding group was placed with a fertile ram on July 1. Due to a series of cool days on July 4, 5, 6, and 7, the fertile rams were taken out on July 8. Teaser rams were placed with the ewes at night in order that a record could be kept of ewes which cycled during this period. The fertile ram was again placed with the ewes on July 15 and the breeding season continued to August 1. Alternate ewes were designated for pre- and post-implantation study. These were killed at 3 or 6 days and 16 to 28 days post-breeding. The same data were collected from these tracts as from those of the May bred group.

The remaining ewes which had failed to mate in either the May or July breeding were placed with a teaser ram on August 1 and the occurrence of estrus was recorded until October 7. They were then sold without further observation due to the fact that killing facilities were no longer available locally.

Results and Discussion

In the preliminary study in the fall of 1957, the following results were obtained. The three ewes killed at three or four days post-mating had four corpora lutea total. No ova were found upon flushing the reproductive tracts. It is probable that poor technique was responsible for this failure, this being the author's first experience with the technique. The next day three ewes were slaughtered at Oklahoma City and, again, four corpora lutea were found. An ovum was found for each of the corpora. From previous observations of ova from sows and microphotographs of sheep ova furnished by Alliston (1957), three of these ova were classified as normal and one as degenerate. Fertilization had occurred in all four.

The 6 ewes killed 16 to 19 days post-breeding were found to have the same ovulation rate (1.33) as the ewes killed at an earlier stage. The four corpora in the ewes killed at the meat laboratory were represented by four normal elongated blastocysts while only three blastocysts were found in the ewes killed at Oklahoma City. These ewes also had four corpora. The one corpus luteum for which no embryo was found appeared to be more like a forming corpus than a mid-cycle corpus luteum. This indicated that the ewe had ovulated again after failing to conceive or after embryonic death and resorption had occurred.

As a result of observations made in this preliminary study it was decided that as long as detailed studies were not to be made of the ova or embryos, the transport of the reproductive tracts from Oklahoma City, and the delay incurred therein, would not materially affect the findings. It was noted that more tissue was present in the watch glass when the tracts were flushed after this delay but not enough to interfere with the process of locating the ova or embryos.

Of the 41 ewes placed with a teaser ram on March 18, 32 were in estrus at least once during the teasing period. Estrus was recorded twice in 21 of the ewes and 3 were marked by the ram three times during the 43-day period. The cycles ranged from 13 to 20 days in length with a mean of 17.9 and a standard deviation of 1.7. There were three cycles longer than 20 days (26, 29, 37); these were omitted from these calculations because of the possibility that the ram had not marked these ewes at an intervening estrus.

No estrus was recorded on nine of the ewes, two of which lambed in April as a result of non-recorded matings shortly after arriving at the research station. The lambs were taken from these ewes immediately after lambing; but they still failed to cycle during the remainder of the teasing period.

A fertile ram was placed with the ewes on May 3. The average date of estrus for the teased ewes was May 11 and for the non-teased ewes was May 12. Thus, it was concluded that the presence of a teaser ram had no effect on the estrual behavior of these ewes. There was also no indication of a real difference in the proportion of ewes mating in May, since 16 of 19 teased ewes and 19 of 23 non-teased ewes came in estrus. Ovulation rate and normal embryos (both pre- and post-implantation) are shown in Table I.

TABLE I

REPRODUCTIVE PERFORMANCE OF TEASED AND NON-TEASED EWES WHEN BRED STARTING AT FOUR WEEKS AFTER THE BEGINNING OF TEASING

	Number	Ovulation Rate	Percent Normal Ova or Embryos
Teased			
Pre-implantation	8	1.25	80.0
Post-implantation	8	1.38	81.8
Total or Average	16	1.32	80.9
Non-Teased			
Pre-implantation	8	1.50	75.0
Post-implantation	11	1.09	83.0
Total or Average	19	1.16	78.3

A total of 36 of the 41 ewes in the May breeding group were marked by the ram during the 25-day period. This is slightly lower than that obtained for mature but younger ewes bred in May and June at the Fort Reno Station in 1957 and 1958 (88 percent for experimental ewes, 93 percent average for younger ewes). From this group 16 ewes were removed for slaughter at 2 to 7 days post-mating and 19 were killed at 15 to 39 days. The results from this group are shown in Table II.

TABLE II

OVULATION AND EMBRYONIC SURVIVAL IN MAY BRED EWES

	Pre-implantation	Post-implantation
Number	16	19
Corpora Lutea	22	23
Ovulation Rate	1.38	1.21
Normal Ova or Embryos	17	19
Percent Survival	77.3	81.3

All of the ova or embryos recovered in the pre-implantation studies were fertilized, 2 of the 16 ewes did not yield any ova or embryos from 3 corpora. These ewes were killed at six and seven days post-breeding. There are four possible reasons for failure to recover an ovum: (1) failure of the ovum to escape the ovarian tissue, (2) failure of the ovum to enter the oviduct, (3) complete degeneration of the ovum or embryo, and (4) faulty recovery technique. The first two reasons mentioned are least likely to be responsible for the failure, while the latter two are the most likely causes. In either case, the loss of these pointed out the need for earlier slaughter of the ewes to facilitate recovery of the ovum or embryo.

One ewe which was killed at the early slaughter time had been marked by the vasectomized ram on April 21 and by the fertile ram on May 3. At slaughter on May 7, she was found to have a regressing corpus luteum on the left ovary. Evidently, she had a normal ovulation before the breeding season started and the May 3 marking was due to either a false heat or an over-agressive ram. This ewe was not included in the calculations of ovulation rate or embryo survival.

The remaining 14 ewes which were slaughtered for pre-implantation study at two to seven days post-breeding were found to have embryos ranging from the two cell to the morula stage.

In the post-implantation studies it was desired to kill all ewes at 24 or more days post-breeding in order to have the embryos firmly implanted. There is some degree of primary implantation which takes place before this time, but, to get a true estimate of post-implantation embryo survival, the later slaughter time was selected. There were 3 of the 19 ewes slaughtered earlier than 24 days (15, 15 and 20 days), but their breeding behavior seemed to make this desirable. They were originally scheduled to be killed at a later time but all three returned to estrus or, at least, were marked by the ram before their scheduled date of slaughter. These ewes were killed earlier so the actual time of ovulation could be determined. All three were found to have ovulated and conceived at the first mating. Such a false estrus has been reported to occur rather frequently in pregnant ewes (Williams *et al.* 1956).

All corpora lutea were represented by either a normal or degenerate embryo except in one ewe which had failed to conceive to the recorded mating and had ovulated since this mating. For the purpose of calculating embryo survival, this ewe was assumed to have ovulated one ovum.

The ovulation rate for the early killed ewes compares favorably with that of the 12 ewes killed in the preliminary study. There was a drop in ovulation rate in the ewes killed post-implantation. The small number of ewes involved would allow this to occur due to chance approximately 70 percent of the time (chi square = .154). Practically all of this decrease was due to the non-teased post-implantation ewes. The chi square value for the test for interaction between time of shearing and time of slaughter was .055 ($P < .99$). The differance in ovulation rate within the non-teased ewes was not significant (chi square = .61 $P < .45$). Even though these differences were not significant, there might be a trend indicated. One explanation for this decrease in ovulation rate would be corpus luteum regression.

It has been reported in swine that all of the corpora lutea are maintained on the ovaries throughout gestation, as long as one embryo or fetus survives. The author was unable to find any such statement pertaining to sheep except in some superovulation studies (Casida, 1944). If a ewe produced two ovulations and one of the embryos dies perhaps one of the corpora regresses. The physiological mechanism whereby this might occur is not apparent. The mechanism for the maintenance of the corpus luteum after conception has not been explained either so the proposal cannot be rejected because of this difficulty.

This possibility is proposed here for two reasons. First, except for chance sampling error, one would not find the post-implantation embryo survival to be higher than pre-implantation. For this sample a difference this large could occur due to chance 60 percent of the time. If the estimated ovulation rate is not the true one and is too low this would cause the embryo survival estimate to be too high. When the ovulation rate of the early killed ewes is assumed to be the true sample ovulation rate, then an embryo survival rate of 73.1 percent is calculated for the late killed ewes (1.38 times 19 ewes equals 26 ova, divided into 19 normal embryos found). This seems to be a more reasonable figure than the 81.3 percent obtained in the original calculations using the ovulation rate of 1.21.

The second possibility is that in all late killed ewes except one, there was either a normal or degenerate embryo found for each corpus luteum. This exceptional ewe had failed to conceive to the recorded service and had ovulated at a later date which was a few days prior to slaughter. Unless the loss of one embryo from a double ovulation causes loss of both, one would expect to find cases in which only one of the embryos remained. If there is a perfect correlation between the fates of these embryos it seems that more of the ewes should have been without any embryos. If the death of one of the twins is followed by regression of the corpus, however, this could account for both the lowered ovulation rate recorded for these ewes and the failure to find a case in which a double ovulation was represented by less than two embryos.

There were 41 ewes in the original July breeding group, 2 of which died before breeding started. The five ewes which did not mate in May were exposed to the ram during this period, but, again, none of them mated. Only 13 of the other 39 ewes mated during the 31-day period in which they were exposed to a ram. Two of these were mated by the vasectomized ram during the week that he was with the ewes. The remaining 11 mated by the fertile ram were slaughtered, four for pre-implantation studies and seven for post-implantation studies.

The vasectomized ram was used following the cool days since earlier work (Dutt and Bush, 1955) had shown that cooling caused ewes to cycle earlier than normal. Since we were interested in studying normal breeding behavior in July, it was thought that if the ewes were bred during this period that their ovulation and conception rate might be abnormal. Actually the cooler weather did not seem to affect cycling performance.

With the extremely small number of ewes killed it was probable that a reliable estimate of the traits being studied was not obtained. The findings are shown in Table III.

TABLE III

OVULATION AND EMBRYONIC SURVIVAL IN JULY BRED EWES

	Pre-implantation	Post-implantation
Number	4	7
Corpora Lutea	6	9
Ovulation Rate	1.5	1.43
Normal Ova or Embryos	3	7
Percent Survival	50.0	77.8

In the early killed ewes no ova were recovered from one ewe with a double ovulation; for the other four corpora, one unfertilized ovum and three normal embryos were found.

Of the ewes killed post-implantation one had failed to conceive to the recorded mating and had ovulated at a later date but without being in heat or without being mated. Another ewe with a double ovulation had no embryos at 16 days. The remaining corpora were represented by either a normal or degenerating embryo.

In studying the results from the May and July breeding groups it seems that the only valid comparison to be made here is between the mating performance of these ewes. As pointed out earlier, the small number of ewes slaughtered in July to gain an estimate of ovulation and fertilization rate and embryonic mortality prevented any comparison of these factors from being meaningful. Further research is needed to establish these factors since there is little information available applicable to this particular part of the year.

As for the mating performance, these data suggest that some factor or factors acting on these Western ewes or on the rams to which they were mated, caused a period of high reproductive performance in the late spring and early summer followed by a period of decreased activity in the middle of the summer. This is deduced from the percentage of ewes exposed to a ram which were mated; that is, 78 percent (32 of 41 ewes) were in estrus during period one (March 18 to April 30); 88 percent (36 of 41) during period two (May 3 to May 25); but only 33 percent (13 of 39) during period three (July 1 to July 31). The 35 ewes which had not mated in May or July evidently were not cycling normally in August, September or the first part of October (period four) since only 17 of these were marked by the ram in the 69-day period (48.3 percent). Chi square values for differences are shown in Table IV.

TABLE IV

COMPARISON OF MATING RESULTS OF AGED EWES IN FOUR PERIODS IN THE SUMMER OF 1958

Comparison of Mating Periods	Chi-Square Values	Degrees of Freedom	Probability
All four periods	12.13	3	.02
1 versus 2	.194	1	.69
1 versus 3	7.20	1	.01
1 versus 4*	2.58	1	.10
2 versus 3	9.70	1	.01
2 versus 4*	4.15	1	.05
3 versus 4*	1.05	1	.35

* Biased due to accumulation of poor breeders in this period.

A total of ten ewes had no mating recorded in any of the dates of mating. Of these, nine were in the July breeding group, seven of the ten were non-teased. Only two of the nine not mated in the July group would have had estrus recorded if they had been cycling prior to that time. This is due to the fact that the other seven ewes were in the non-teased group and had not been checked for estrus prior to July.

In comparing the results of the matings in the last mating period with those prior to this it should be remembered that this group contains a strong bias in that all of the ewes would be grouped together, which, for reasons such as advanced age or disease, were poor breeders or non-breeders. These ewes were randomly allotted to the early season teased and to the May and July breeding groups.

It was originally intended that these ewes would be slaughtered and their reproductive tracts studied in an effort to find the reason for their not breeding. The lack of slaughter facilities following suspension of the sheep slaughter at the Wilson and Company plant made this impossible.

As far as the comparison of the May and July breeding performance is concerned there are about four main factors which might have caused these results: (1) the increased heat during June and July in some way affected the reproductive performance of these ewes and caused them to be abnormal in their cycling behavior, (2) the increased heat affected the rams, decreasing their libido so that they did not mate all ewes which were in heat, (3) there is a normal period of relative anestrous in these midsummer months which is due to changing light and/or temperature, and (4) the ewes were losing weight during this period and they could have reached a low condition which interfered with normal reproductive performance.

(1) There is definitely a normal increase in average daily temperature from May to July. Dutt, 1956, stated that heat affected fertility and normality of the ovum more than embryonic mortality. Other researchers have reported

similar indications but none of them have studied the effect of heat on mating performance. It is possible that the occurrence and/or the degree of estrus are also affected by heat.

(2) It has been shown rather conclusively that rams kept in a cooler environment will mate with more ewes than non-cooled rams in the May breeding season (Whiteman and Brown, 1959). While it is true that the rams used in the July breeding were kept in a cooled room, the air conditioner was not in perfect working order and the temperature in the room rose to above 85 degrees F. on some occasions. During the July breeding, it was also warmer during the night when the ram was with the ewes. This slightly higher average 24-hour temperature may have been enough to reduce the ram's libido to a low level.

(3) There has been too little research done on the occurrence of relative anestrus in the particular period of the year involved here to properly evaluate this possibility.

(4) The fourth possibility mentioned as a cause of lowered reproductive performance is specific for this group of ewes. The mean weights and dates of weighing were: 121.5 on March 5, 120.0 on May 2, 115.4 on June 27 and 115.1 on July 8. The 13 ewes which mated in July lost an average of 2.5 pounds from March 5 to July 8. The corresponding loss in those 26 ewes which did not mate was 4.96 pounds. These

ewes were shorn in April so the weight of the wool would more than offset the decrease in weight. Even with the wool weight being considered, it would have been desirable for the ewes to have increased in weight considerably during the spring season in order that their condition would have been less of a possibility when seeking to explain their breeding performance. However, from June 27 to July 8, the mated ewes lost an average of 1.08 pounds as compared to an average gain of .44 pounds in the non-mated ewes. All of the ewes were in a rather low condition throughout the trial; but results from the May breeding did not indicate that this interfered with their breeding performance.

Thus, it seems that aged ewes, such as were used in this sample, are apparently normal in their reproductive performance in May. The average ovulation rate of 1.29 for these ewes compares favorably with an estimated ovulation rate of 1.34 for the mature ewes in the Fort Reno flock in 1957 and 1958. The July performance of these ewes is low as compared to May but this may be normal for any age ewe at this time of the year. More work is needed to determine if this is a general occurrence or if it was true only for this sample.

It is apparent that the slaughter of larger numbers of ewes and/or the refinement of the technique for ovum and embryo recovery is necessary in order to obtain a more valid estimate of reproductive performance. Even with the numbers used in this trial, the loss of one ovum or embryo will greatly affect the estimated embryo survival rate.

Trial II

Materials and Methods

In the fall of 1958, 70 aged Western ewes, much like the first group, were purchased. These were from the McGee Ranch of Roswell, New Mexico. These ewes were managed the same as the group of the previous year throughout the winter.

On April 1, there were 67 of these ewes remaining. These were randomly allotted to either an early or late shearing group. The 33 ewes in the early shearing group were shorn on April 4 and the 34 in the late shearing group were shorn on May 15. Both groups of ewes were kept on the same pasture.

On May 18, all of the ewes were weighed and scored for condition and then allotted into four breeding groups at random within treatment group. Breeding started May 20 and the ewes were then exposed to a fertile ram each night until June 29. Beginning on June 10, 20 of these ewes (12 early and 8 late shorn) were killed in the meat laboratory at Stillwater. One-half of the early shorn and one-half of the late shorn ewes were transported to Stillwater and slaughtered within three to five days after breeding. Removing only one-half of the individuals bred at a particular time allowed ewes bred during the same period to be in both the early and late killed groups. The ova and embryos were recovered and their condition observed. The remainder of the ewes were taken to the Swift and Company packing plant in Kansas City, Kansas, on July 3 and slaughtered. All reproductive tracts were tagged, placed in ice water and returned to Stillwater for examination. The reproductive tracts which obviously contained an embryo were dissected. Tracts of ewes within 20 days of mating and those in which pregnancy was not evident, but a corpus luteum was present, were flushed in an effort to recover the embryo. The presence or absence of embryos was recorded, along with the number of corpora lutea.

Results and Discussion

The results of this trial are shown in Tables V, VI and VII. There was no difference in the number of ewes mating in the early and late shorn groups. The ewes which did not mate were quite evenly distributed throughout the four breeding groups (five, one, five and four in lots one through four, respectively). This indicates that failure to mate was probably due to the failure of the ewe to be in estrus and not to different rams.

TABLE V

MATING PERFORMANCE OF MAY AND JUNE BRED AGED EWES SHORN IN APRIL OR MAY

	Early Shorn	Late Shorn
Number of Ewes	33	34
Ewes Mated	26	26
Percent Ewes Mated	79	76
Average Date of Breeding	June 9	June 10
Average Weight Change 12-4-58 to 5-18-59*	-19.2	-17.1

* Ewes shorn during this time. These losses are not entirely body weight.

One interesting observation was made on ram behavior toward these aged ewes. These ewes were included in breeding lots with younger ewes; on nights when some of the younger ewes were mated, the aged ewes very seldom were marked. As the breeding season progressed and most of the younger ewes had cycled and been bred, more and more of the old ewes were marked. At slaughter it was observed that 13 of 20 old ewes had corpora albicantia which indicated that they had been in estrus at some earlier time, but were not mated or they were mated, without the mating being recorded, and did not conceive. If these ewes did actually enter estrus and were not mated, the estrus was either of such a low intensity that the rams did not find them or that the rams did not have any interest in these old ewes until most of the younger ewes were bred.

The results obtained from 20 ewes slaughtered in the meat laboratory at Stillwater are shown in Table VI. Both early shorn ewes which had not ovulated had a large follicle on one of their ovaries. Since one of these was killed at two days and one at four days post-breeding it is doubtful that either of these ewes was going to ovulate in that estrous cycle. In each case it is possible that the follicle matured and estrogen was produced, but ovulation did not occur.

In the group of early shorn ewes three embryos were not recovered, and in the late shorn ewes two embryos were not found. As indicated in the previous years' study, it is not possible to know if the failure to recover these ova or embryos was due to poor technique or some other factor. The fact that these ewes were slaughtered three or four days post-breeding indicated that the technique might be at fault. Ova or embryo degeneration should not have occurred at this early stage. If it is assumed that the ratio of normal to abnormal is the same for the embryos lost as for those found, then there would have been six normal and four abnormal embryos in the early shorn and eight normal with one abnormal in the late shorn. On this assumption, the embryo survival would have been 60 and 80 percent for the early and late shorn ewes, respectively. (Chi-square equals .538 $P < 0.5$).

TABLE VI

REPRODUCTIVE PERFORMANCE OF AGED EWES KILLED TWO TO FIVE DAYS POST-BREEDING IN MAY AND JUNE

	Early Shorn	Late Shorn
Number of Ewes Killed	12	8
Number of Ewes with Corpora Lutea	10	8
Total Number of Corpora Lutea	10	9
Ovulation Rate	1.0	1.12
Total Number of Ova and Embryos Recovered	7	7
Abnormal Ova and Embryos Recovered	3	1
Percent of Corpora Lutea Resulting in Normal Embryos	40.0	66.7

There was essentially no difference in the ovulation rate between early and late shorn ewes or between times of slaughter. Only 4 ewes of the 42 from which ovulation rate was calculated had doubled ovulations, two being found in each of the treatment groups.

The chi square for differences between abnormal embryos recovered from the two groups is 1.00 ($P < .30$). Larger numbers would be required to show significance if this difference is actually due to treatment differences.

TABLE VII

REPRODUCTIVE PERFORMANCE OF EWES KILLED 11 TO 42 DAYS POST-BREEDING. 1959.

	Early Shorn	Late Shorn
Number of Ewes Killed	21	25
Ewes with Recorded Matings	14	17
Ewes with no Recorded Mating which Contained Embryos	0	2
Ewes with Normal or Abnormal Embryos	11	13
Normal Embryos Recovered	12	13
Ewes Mated which Failed to Produce an Embryo	3	6
Number of Corpora Lutea in Ewes with Embryos	13	14
Ovulation Rate	1.08	1.07

Of the ewes killed in Kansas City, 11 early shorn and 13 late shorn were found to have at least one embryo. Two late shorn ewes for which no mating was recorded were found to be pregnant. In each group one corpus luteum was not represented by a live embryo. This would indicate a tremendously high embryo survival rate except for the fact that three early shorn and six late shorn ewes had either failed to conceive or embryonic mortality had occurred and complete resorption had taken place prior to slaughter. The condition of the ovaries indicated that at least one ewe in each of the groups had ovulated at some time later than the recorded mating, but without being mated. The chi square value for the difference between early and late shorn ewes which mated but had no embryos post-implantation is 0.51. $P < 0.50$.

If the ovulation rate of those ewes with embryos is assumed to be the true ovulation rate of all the ewes in this group and all ewes are assumed to have ovulated and their ova fertilized, then the estimated embryo survival at 11 to 42 days for the early shorn ewes is 75 percent and 62 percent for the late shorn group. This difference was not significant.

Trial III

Materials and Methods

This group of ewes was also purchased in the fall of 1958 from the McGee Ranch of Roswell, New Mexico. These were 30 fine wool ewe lambs. They were kept with the aged ewes and received the same feed through the winter months.

In the spring of 1959 these ewes, along with the aged ewes, were placed on the best grass available since they had come through the winter in a low condition. Nineteen of these ewes were shorn on April 4 and the remaining 11 on May 15.

The ewes were placed on Johnson grass pasture May 20 and a fertile Dorset ram was placed with them at night from that date until June 29. The ram was fitted with a marking harness and ewes which were clearly marked were considered to have been in estrus.

At two to three days post-breeding the ewes were laparotomized and the ovaries examined for corpora lutea and for follicle activity. The procedure used was as follows:

The ewes were taken off feed and water approximately 18 hours prior to surgery. In preparation for surgery the wool was clipped as closely as possible from the para-lumbar fossa on the left side of the ewes. This area is bounded by the last rib, the hook bone, and the transverse processes of the lumbar vertebrae.

All except the first five ewes were injected with a small dose of one of two different tranquilizers (.25 milligrams per pound of body weight of Diquel or Frenquil) intravenously. The clipped area was then scrubbed with an antiseptic soap and either 70 percent alcohol or 7 per-cent iodine was applied. A local anesthetic (two or four percent procaine) was injectected subcutaneously and intra-muscularly for a distance of about six inches in a ventro-lateral direction beginning at a point approximately one inch below the loin and about two-thirds of the distance from the last rib to the tuber cocci.

An incision was then made along the anesthetized area through the skin, muscle and peritoneum. The muscle and peritoneum were torn, rather than cut, as much as possible to avoid excessive bleeding.

The operator then inserted his hand into the peritoneal cavity and the uterus and ovaries were located. The ovaries were palpated for follicles and corpora lutea. In most cases the ovaries were also pulled close enough to the exterior so that visual observations could be made. However, in the non-parous ewe the reproductive tract is very small and closely attached and since these ewes were to be retained in the flock it was not considered a good practice to put unnecessary pressure on the ovaries or the uterus to enable visual observation in all cases.

When the observations were completed, the peritoneum and muscle were sutured with catgut and the skin with nylon suture. The nylon suture was removed after 7 to 14 days.

If ewes returned to heat after the operation a second laparotomy was performed on the right side.

Results and Discussion

A total of 21 yearling ewes mated of the 30 exposed to the fertile ram. The results of this trial are shown in Table VIII.

TABLE VIII

RESULTS OF EARLY AND LATE SHEARING ON MATING PERFORMANCE AND OVULATION RATE IN YEARLING FINE WOOL EWES

	Early Shorn	Late Shorn
Number of Ewes	19	11
Average Breeding Date	May 26	May 31
Number of Ewes Ovulating	8	4
Number of Corpora Lutea	9	5
Ovulation Rate	1.12	1.25
Number of Ewes Mated Without Ovulating	4	5
Number of Ewes Not Mating	7	2
Percent of Ewes Mating	63	82

Four of the ewes died as a result of the laparotomies. There were four ewes which returned to estrus after the first laparotomy. This return to estrus could well have been the result of the stress of surgery causing death of the embryo. The ovulation rate of these four ewes at the second laparotomy was the same as that for the late shorn ewes (1.25).

The number of ewes from which an estimated ovulation rate was obtained is very small in both treatment groups, although a good estimate of the ovulation rate in this particular sample of ewes should have been obtained. The difference in ovulation rate between the early and late shorn ewes (1.12 versus 1.25) is not significant (chi square equals .0072 $P < .90$).

In the early shorn group, 33.3 percent of the ewes which mated failed to ovulate while 55.5 percent of the late shorn ewes had no corpora lutea when laparotomized. The chi square value for differences in proportion of ewes mating is .865 ($P < .85$). Eight of the nine ewes which did not ovulate had some follicle activity on their ovaries but in only one case was there a follicle near mature size.

Assuming that all ewes marked were in estrus, and not the result of an over aggressive ram, these percentages of non-ovulation seem rather high. Past research has indicated that as ewes are ending the anestrous period there are one or more cycles of ovulation not accompanied by estrus. No reports were found by the author in which there was estrus without ovulation except in pregnant ewes. Further research is needed to determine if this failure to ovulate is characteristic of other ewes in different years. In the event that further work shows similar results, this would indicate that estrus without ovulation may be one factor in the unusual breeding behavior often observed in replacement yearling ewes the first year of breeding.

The difference between percentage of ewes mating is not significant (chi square equals .447. $P < .50$). This failure to show significance could well be due to the small number of ewes involved. There appears to be a trend here which might well be investigated further with larger numbers.

With 30 percent of the ewes not mating and 30 percent not ovulating at the recorded mating, it is indicated that a very small percentage of yearling ewes bred in May and June will produce lambs in October and November. The lambing results should not be as poor as indicated here since the 30 percent which did not ovulate might have a normal estrus and ovulation at the next cycle and this would reduce the expected number of barran ewes. Actually a low percentage of replacement ewes have lambed in October and November at Fort Reno. In 1957, a year similar to 1959 in that cool weather persisted into the breeding season, four groups of yearlings or approaching yearling ewes were bred in May and June. The percentages of ewes mating in the four groups were 53, 65, 95 and 100. The percentage of ewes lambing which mated were 36, 46, 32 and 20.

In this experiment six of the nine ewes which had not ovulated failed to return to estrus and be laparotomized a second time although sufficient time elapsed before the end of the breeding season to allow them to do so. It is likely that the stress of the laparotomy and the subsequent healing (accompanied by varying amounts of infection) caused irregularity in the next estrous cycle.

GENERAL DISCUSSION

This research was undertaken with the desire to obtain answers to two questions which were mentioned earlier. It can be safely concluded that the results simply raise more questions. It is not possible to state specifically why the results were not as expected.

The two main factors which the author feels must be adjusted in order to produce more logical findings are the numbers of animals and the measurement techniques used. It has been pointed out that the loss of one embryo or ovum in a treatment group the size of those used here can considerably influence the overall results.

Improved technique would seem to furnish the quickest answer to the problem. If all ewes could be killed at two to three days post-breeding for pre-implantation study of the embryo, the probability of recovering all ova or embryos would be increased. If the post-implantation slaughter date could be within two days of the same stage for all ewes (24 to 26 days), then comparison between the two groups would be more meaningful. Also slaughter at this time would give a better indication of whether the embryo had died during the implantation process or at an earlier period. When slaughter is delayed until 35 to 40 days, for example, it is not possible to know how far back embryonic loss occurred if an embryo is missing. This procedure is not possible with the present conditions. This might be possible in the future if the ewes could be kept at Stillwater and full-time slaughter facilities can become available at the meat laboratory.

There are other advantages to be gained from having the ewes close enough so that the researcher could keep a more constant check on their condition and behavior. It would also be possible to take other measurements which might suggest some explanation as to why certain results were obtained.

A factor which makes year to year comparisons difficult besides being different sheep and treatments is that it is not known how minor or major changes in weather conditions affect sheep. Some summers are hot and dry during the breeding season while others are humid and hot; still others are cool and humid. The use of uniformity trials to study these effects, although time consuming, might be well worth while.

An important consideration in this particular research is the use of aged ewes as experimental units. The main advantage to using these is that the cost of research is reduced. Results from the two years do not indicate any great disadvantage to their use. It is very hard to maintain body condition during the winter months; but in the May and June breeding season of both years the percentage of ewes mated was satisfactory (88 and 81 percent for 1958 and 1959, respectively). Perhaps the question as to whether the reaction of these old ewes to the treatments applied can be assumed to be the same reactions that would occur in other age groups is no more pertinent here than it would be with any other age group of ewes.

The use of the laparotomy technique for determining ovulation rate, although time consuming, appears to be the only satisfactory way of obtaining this information. The weakest point in the trial in which this technique was used was in the recording of estrus. It is not known whether those ewes which were marked by the ram but did not have a corpus luteum were actually in estrus. Here, again, as with the aged ewe, it would be possible to refine the technique by having the ewes at a location where the ram could be observed while in with the ewes and in that way one could more effectively determine if estrus actually occurs.

SUMMARY

Three trials were conducted to determine the reproductive performance of Western ewes of two different age groups. The animals were either aged ewes bought from New Mexico range flocks or yearlings. Comparisons were made between reproductive performance of April and May shorn ewes.

There was no significant difference in the pre-implantation and post-implantation embryo survival rate of May bred ewes. There were 88 percent of the May bred ewes mated; whereas, only 33 percent of the July bred ewes did so. This difference was highly significant. Not enough July ewes mated to get a good estimate of embryo survival.

In the second trial aged ewes were shorn in April or May and slaughtered at 2 to 5 or 14 to 42 days post-breeding. The ovulation rate for all groups was approximately the same -- slightly above 1.0. There were no significant differences in embryo survival between the early and late shorn ewes, either pre- or post-implantation. There was no significant difference in breeding date or percent of ewes mating.

The yearling ewes which were laparotomized to determine ovulation rate were also shorn in April or May. There was no significant difference in ovulation rate. The difference between the number of ewes not mating in the two groups was not significant; but there was a trend toward a higher percentage of late shorn ewes being mated. Several of the ewes in both groups (4 of 19 early shorn and 5 of 11 late shorn) were marked by the ram but had not ovulated when laparotomized.

Larger numbers and/or refined techniques are needed to determine if some of the trends established in the three trials were differences actually due to the treatment applied.

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VITA

John Callaway Glenn

Candidate for the Degree of

Doctor of Philosophy

Thesis: A STUDY OF EARLY SEASON BREEDING PERFORMANCE IN WESTERN EWES.

Major Field: Animal Breeding

Biographical:

Personal Data: Born in Birmingham, Alabama, August 7, 1932, the son of Lester and Evelyn Glenn.

Education: Received the Bachelor of Science degree from the Alabama Polytechnic Institute, with a major in Animal Husbandry in August, 1953; received the Master of Science degree from Mississippi State University, with a major in Animal Husbandry, August, 1954; completed requirements for the Doctor of Philosophy degree in August, 1959.

Professional experience: Instructor of Animal Husbandry at Midwestern University, Wichita Falls, Texas, in 1955-56.

Date of Degree: August 8, 1959.