MODIFICATION OF THE MATING PATTERN OF EWES USING SYNTHETIC PROGESTOGENS

By

CHARLES W. NICHOLS

Bachelor of Science
Texas A. and M. University
College Station, Texas
1958

Master of Science
Colorado State University
Fort Collins, Colorado
1961

Submitted to the faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May, 1965

MODIFICATION OF THE MATING PATTERN OF

EWES USING SYNTHETIC PROGESTOGENS

Thesis Approved:

Joe V. Whiteman
Thesis Adviser

E. J. Turman

L. E. McDonald

I. D. Musgrave

James A. Whatley

J. H. Boggs
Dean of the Graduate School

ACKNOWLEDGMENT

The author wishes to express his appreciation to Dr. Joe V. Whiteman, Professor of Animal Science, for his counsel and guidance during the course of this study and in the preparation of this thesis.

Appreciation is also extended to Dr. E. J. Turman of the Animal Science Department, Dr. J. A. Whatley, Jr., Associate Director of the Agricultural Experiment Station, Dr. S. D. Musgrave, Head of the Dairy Science Department, and Dr. L. E. McDonald, Head of the Physiology and Pharmacology Department for their suggestions in the preparation of this thesis.

Further acknowledgment is due Mr. Gene Kennedy, Mr. Willie Basler, and Mr. Mike Gould, Sheep Herdsmen at the Ft. Reno Livestock Experiment Station, for their aid in obtaining the data used in this study.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The need for more intensive management practices in sheep production has made essential the investigation of methods of modifying the mating pattern of sheep. The development of more intensified lambing programs such as lambing twice yearly or three times in two years are sheep breeding-management programs of interest to workers in agricultural research and industry at the present time. These programs will necessitate having ewes bred at times other than their natural mating season and at unusually short intervals after lambing.

Both estrus synchronization, to reduce the length of the mating season, and the induction of estrus and ovulation during early lactation, to reduce the time interval from one lambing to the next, may be necessary for the successful implementation of such intensive sheep breeding practices. The use of progestational compounds, either alone or in combination with ovulation inducing hormones, has been investigated for the synchronization of estrus of ewes during the breeding season and for the induction of coincident estrus and ovulation during anestrous.

This study was conducted to investigate the use of a synthetic progestational compound, either alone or in combination with pregnant mare serum and under practical management conditions, for the synchronization of estrus during spring or late summer breeding seasons and for the initiation of estrus and ovulation during early lactation.

REVIEW OF LITERATURE

The Breeding Season of Sheep

Domestic sheep are generally considered to be seasonally polyestrous in nature, meaning that they have a sexually active period each year in which they ovulate and exhibit estrus and an anestrous period during which they do not normally exhibit estrus.

Many authors have mentioned that sheep generally have their most active breeding season in fall and winter and are in complete or partial anestrum in the spring and early summer, but few experiments designed to determine the actual breeding season of sheep have been reported in the literature.

McKenzie and Phillips (1930) checked 100 Shropshire, Southdown and Hampshire ewes for the onset of estrus during two years, using aproned teaser rams. In both years the breeding season began the last of August, with the Hampshire ewes being about ten days ahead of the Southdown and Shropshire ewes. No information was reported as to the end of the breeding season. McKenzie and Terrill (1937) investigated the occurrence of estrus in a total of 344 purebred Hampshire, Shropshire, Southdown and grade crossbred ewes over a seven year period. In general the breeding season extended from September to January with few individuals showing estrus outside this period.

Hammond (1944) observed that the breeding season of Suffolk X Border Leicester-Cheviot ewes, running with fertile rams the year around on the Cambridge University research farm, began in October and extended to late March most years. These observations would be affected by the fact that practically all the ewes would be pregnant during the winter and would lamb and be lactating in the spring of the year. Hafez (1952) used vasectomized rams to check small numbers of several breeds of ewes for the onset and cessation of estrus during two years on the Cambridge University research farm. Blackface Mountain, Border Leicester and Welsh Mountain ewes had a breeding season averaging 19 weeks during October to February. Romney Marsh and Suffolk ewes had a breeding season of 26 weeks average duration during October to March. Dorset Horn ewes had a breeding season averaging 32 weeks during July to March.

Thompson (1942), in Western Australia, checked 20 each of Merino, Merino X Dorset Horn, Merino X Border Leicester and Merino X Romney Marsh mature ewes for estrus three times daily for six months, from spring through fall, using teaser rams. The Merino X Dorset Horn and the Merino ewes exhibited estrus first in October (spring). Eighty-five percent of the Dorset X Merino ewes and 35 percent of the Merino ewes exhibited estrus during October. Most of the Merino X Border Leicester and Merino X Romney Marsh ewes did not show estrus until March (fall). Kelley and Shaw (1943), in Australia, studied the breeding seasons of Merino, Dorset Horn, Border Leicester and Merino X Border Leicester ewes run continuously with vasectomized rams over a six year period. All of the breed groups showed a definite period of reduced sexual activity in the spring and early summer. The Merinos and Dorset Horns had a relatively short inactive period, usually in October and November (late spring). The Border Leicester and Border Leicester X Merino ewes had a longer inactive period, usually from August through December (late winter to early summer). The greatest breeding activity for all breed groups was in late fall and winter.

Kelley (1946) observed the occurrence of estrus in 163 Merino ewes which were run continuously with vasectomized rams at several locations in Australia and Tasmania for four years. In all instances a high incidence of estrus was observed during the late summer, autumn and winter months and a low incidence, or complete absence, of estrus was observed during the spring and early summer. Underwood _et al_. (1944) used vasectomized rams to check 25 Merino and 25 Merino X Border Leicester ewes during two years and one other group of 25 Merino ewes during one year for the occurrence of estrus. The Merino ewes reached a maximum incidence of estrus by December (early summer) and were in anestrum from July to October (winter and early spring) the first year and August to October the second year. The crossbred ewes reached their maximum incidence of estrus by February (summer) and were in anestrum by July (winter). This report does not agree with that of Kelley and Shaw (1943) and Kelley (1946) as to the breeding season of the Australian Merino, but the observations made by Underwood and his coworkers were made in a more western part of Australia, nearer the equator.

Watson (1953), in Australia, divided a group of 288 Merino ewes into three groups and allowed each group to mate to fertile rams during different three-month periods of the year. The ewes mated readily from the beginning of the fall and winter periods. The group that was put with the rams in December (early summer) did not reach a high incidence of mating for about 3 weeks after the rams were introduced. This was interpreted to mean that the ewes were in anestrum when the rams were introduced in the late summer but not in the fall and winter.

Williams et al. (1956), in Illinois, checked a flock of 100 Western crossbred ewes for estrus daily for 3 years, using vasectomized rams. The earliest onset of estrus the first year was July 8, the second year August 27 and the third year September 1. The breeding season ended in either late February or early March all 3 years. No tendency for individual ewes to be consistently early or late in the onset of estrus was noted. The authors concluded that selection for a prolonged or continuous breeding season would not be effective with the ewes they studied.

Hormonal Modification of the Breeding Season

Progestogens have been used to inhibit ovulation in many species of animals since the early work of Selye et al. (1936) and Phillips (1937) demonstrated that injected progesterone would inhibit ovulation in the rat. Many workers have investigated the possibility of using progestogens to modify the estrual cycle of domestic animals. A large part of this work has been with sheep and only the literature concerned with sheep will be discussed in this review.

Injectable Progesterone

Dutt and Casida (1948) investigated the use of injectable crystalline progesterone for suppressing estrus in Shropshire ewes during the fall breeding season. Estrus was suppressed by injections of either 5 mg. or 10 mg. progesterone per head daily for 14 days, beginning on the fourth, eighth, and twelfth days after last estrus. For the ewes receiving 5 mg. progesterone daily the post-treatment ovulation rate was significantly ($P<.05$) lower than for the preceding estrual cycle in the same ewes. The post-treatment ovulation rate was slightly, but nonsignificantly, lower than the ovulation rate of the preceding cycle in the ewes that received 10 mg. progesterone per day. O'Mary _et al_. (1950) injected 19 of 39 grade and purebred ewes of several breeds with 10 mg. progesterone per head per day for 14 days at the beginning of the fall breeding season. Twenty percent of the treated ewes exhibited estrus during the treatment period and 89.5 percent of the control ewes exhibited estrus during the same period. All the treated ewes mated post-treatment and 16 of the 19 ewes conceived at the first post-treatment estrus. Fifteen of the 19 control ewes that mated conceived at their first estrus.

Lamond and Lambourne (1961) injected 90 adult Australian Merino ewes during the fall breeding season with mean doses of 5 mg., 10 mg. or 20 mg. progesterone given daily, every other day or every fourth day. The levels of progesterone and intervals of injection were tried in all combinations. Injections every fourth day were less successful in suppressing estrus. There was a tendency for ewes in late cycle at the time of the first injection to exhibit estrus at the expected time. Of 19 ewes that mated while on treatment only one lambed. Fifteen of the ewes that mated while on treatment mated again after the last injection of progesterone. Lamond and Bindon (1962) injected 112 adult Merino ewes during the summer and fall with varying levels of progesterone every day or every other day for 13 days. Injections were given at either 8 a.m. or 4 p.m. The period from the last injection of progesterone to estrus was found to vary with the amount of progesterone given, the interval between doses and the time of day of the last injection. The interval was greatest on the higher daily dosage levels. Variability in onset of estrus was least when the final injection was given in the morning. The authors offered no explanation for this phenomenon.

Foote and Matthews (1962) reported complete suppression of estrus in 22 Rambouillet, Columbia and Southdown ewes injected with 10 mg. progesterone daily for 17 days during August and September. Average time from end of treatment to estrus was 3.1 days for the treated ewes and was 8.2 days from the time of introduction of the ram in a comparable group of control ewes. A significantly ($P < .01$) greater number of the control ewes conceived at their first estrus than did the treated ewes at their first post-treatment estrus (92.0 percent vs. 26.7 percent). There appeared to be no effect due to breed of ewe. Fertility in the treated group appeared to be normal at the second estrus after treatment.

Hormones such as pregnant mare serum, human chorionic gonadotropin and gonadotropins of pituitary origin, which stimulate the ovary directly, have not generally been successful in the induction of estrus in the anestrous ewe. However, they can generally cause ovulation without estrus. The literature concerned with the use of these hormones in both cycling and anestrous ewes has been reviewed by Phillips et al. (1945), Robinson (1951) and Gordon (1958a). The successful induction of estrus and ovulation in ewes during anestrum has generally involved a period of progesterone administration followed by an injection of an ovulation inducing hormone, such as pregnant mare serum (PMS).

Dutt (1953) randomly divided 72 Hampshire X Western ewes into eight groups during May when all the ewes were in anestrum. Six of the groups received subcutaneous injections of 30 mg. progesterone every 3 days for from one to five injections. Each of the ewes in these groups received 500 I.U. PMS injected subcutaneously 3 days after the last progesterone injection. One group served as an untreated control, one group received only 500 I.U. PMS and one group received five injections of progesterone but no PMS. None of the ewes that received only PMS showed estrus, but all ovulated. Of the nine ewes that received one progesterone injection followed by PMS, three showed estrus and eight had ovulated. Of the ewes receiving two, three, four or five injections of progesterone followed by PMS, all had ovulated and at least six of each group exhibited estrus. All the ewes were slaughtered within 10 days post-treatment and 40 percent of the ova recovered from ewes that had shown estrus were found to be fertilized.

Robinson (1955), working with Romney Marsh ewes and Suffolk cross ewes in Australia, concluded that in anestrual ewes the commencement of progesterone pretreatment 4 days before PMS injection would give occasional expression of estrus, 7 days progesterone pretreatment would give fairly reliable results and 13 days progesterone pretreatment would almost certainly result in estrus.

McDonald (1961) investigated the use of various combinations of progesterone and PMS for inducing estrus and ovulation in New Zealand Romney Marsh ewes in deep seasonal anestrum. Four groups of 10 ewes each received twice daily injections of progesterone for 4, 6, 8 or 10 days. Ten ewes received progesterone twice daily for 4 days plus 750 I.U. PMS subcutaneously 40 hours after the last progesterone injection, five ewes received progesterone twice daily for 6 days plus the same dosage of PMS and 10 ewes received only 750 I.U. PMS. Of all the ewes treated, only one from the 6-day progesterone plus PMS group exhibited estrus. The ewes of each group were slaughtered 9 to 20 days after the PMS injection to determine if ovulations had occurred. Five of 10 ewes on the 4-day progesterone plus PMS treatment, four of five ewes on the 6-day progesterone plus PMS treatment and four of 10 ewes that received only PMS had ovulated. It was apparent in this experiment that the PMS dosage used was inadequate to consistently cause ovulation.

Denney and Hunter (1958), in South Africa, injected 12 ewes with 10 mg. progesterone per head per day for 20 days. One-half of the ewes received 500 I.U. PMS 24 hours after the last progesterone injection. All of the ewes but one exhibited estrus from 52 to 96 hours after the last progesterone injection. The time from last progesterone injection to estrus was significantly less in the group injected with

PMS. Lishman and Hunter (1961), in South Africa, injected 60 ewes with either 10 mg. progesterone per head per day or 30 mg. progesterone per head every 3 days for 21 days. One-half of each group of ewes received 500 I.U. PMS either 24 or 72 hours after the last progesterone injection. No ewes mated while on progesterone treatment. Seventy percent of the ewes mated between 27.5 and 107.5 hours after the last progesterone injection. An average first estrus conception rate of 40.5 percent was obtained with no significant differences between the various treatments.

Shimizu and Sakuma (1959) and Shimizu *et al*. (1962), working with a small number of Corriedale ewes in deep anestrum in Japan, were able to cause only a weak estrus response by injecting 12.5 mg. progesterone twice daily for three days followed by 1000 I.U. PMS, or by injecting 25 mg. progesterone once daily for three days followed by 1000 I.U. PMS. The ewes would not mate naturally, but when force-mated approximately one-half the ewes that received both progesterone and PMS lambed.

Both progesterone and PMS have been used during the breeding season in attempts to improve the breeding and lambing performance of cycling ewes. Robinson (1961) successfully suppressed ovulation and synchronized estrus in 72 Border Leicester X Merino yearling ewes by injecting 10 mg. progesterone per head daily or 20 mg. progesterone per head every 2 days for 16 days. One-half of each group received an injection of 500 I.U. PMS on the day following the last progesterone injection. The injection of PMS resulted in a highly significant ($P < .01$) increase in the number of ewes which ovulated and exhibited estrus.

Lamond (1964), in a series of rather extensive trials involving 234 Merino ewes and 43 Romney X Cheviot ewes, investigated the interaction between progesterone and PMS at varying levels and intervals of injection of each. The most important finding from these studies was that, for comparable dosage levels of PMS, the number of ovulations were greater after progesterone injections on alternate days than after daily injections.

Wagner et al. (1960) reported that a single injection of 70 mg. per ewe of a macrocrystalline suspension of progesterone would inhibit estrus for a period of 12 to 16 days in cycling ewes. Of 25 seasonally anestrous ewes that received a single injection of the progesterone suspension followed 14 to 20 days later by 1000 I.U. PMS per ewe, 45 percent had a post-treatment estrus and 37 percent of these ewes conceived. The addition of injections of 50 to 200 mcg. of the sodium salt of estradiol 30 hours after the PMS administration did not influence the incidence of estrus, but did seem to increase the conception rate of those ewes exhibiting estrus. Numbers of ewes per treatment in these trials were small and the ewes used had a rather heterogeneous background, possibly influencing these results.

In addition to PMS, which is predominantly follicle stimulating in its action, human chorionic gonadotropin (HCG), which has predominantly a luteinizing hormone-like effect, has been used in conjunction with progesterone in an attempt to improve the breeding performance of ewes.

Lamond (1962a) used 128 Merino ewes to investigate the use of four levels of PMS, 30 I.U. to 810 I.U., and four levels of HCG, 60 I.U. to 1620 I.U., in all combinations. The PMS and HCG were injected the first and second days following the last of 14 daily injections of 12.5 mg. progesterone per ewe. Estrus was inhibited in a large portion of the ewes receiving the two highest dosages of HCG (540 I.U. and 1620 I.U.), independent of the level of PMS. Less than 10 percent of the ewes in all treatment groups conceived. The authors proposed that the higher levels of HCG may have caused some premature luteinization of follicles, thus preventing ovulation. Control ewes receiving no HCG were not maintained. Lamond (1962b) further investigated the use of progesterone, PMS and HCG during different seasons of the year. Four trials were conducted using 48 mature Merino ewes each during July, October, January and April to determine if a seasonal effect existed. No significant differences in the number of ovulations were observed among the ewes treated in the different seasons. Ovulation was found to have occurred more often when HCG was given 48 hours after the PMS than when HCG was given 24 hours after PMS.

Oral Progestogens

The development of synthetic progestogens that can be administered orally has made progestational compounds much more practical for use in modifying the breeding pattern of farm animals. Several workers have reported the successful synchronization of estrus of cycling ewes using these synthetic progestogens. Combs et al. (1961) fed 81 cycling Rambouillet and Columbia ewes 120 mg. per head per day of 6-methyl-17-acetoxyprogesterone (MAP) for 13 days. Of the 81 ewes, 75 mated from the third to fifth days after the last feeding of MAP, four ewes mated on the sixth day and two did not mate. First estrus conception rate was 58 percent. The ewes not conceiving at the first synchronized estrus remained synchronized and all but five of the remaining ewes conceived at the second estrus. Lamb numbers from the treated ewes were normal and equal to nontreated ewes. The control ewes were apparently not maintained under the same conditions as the treated ewes.

Hinds et al. (1961) divided 88 cycling, grade ewes into four groups of 22 each. One group received 75 mg. MAP per head per day for 14 days in one-half pound of feed (actual consumption 58 mg. per ewe per day). Another group received 100 mg. MAP per head per day under the same conditions (actual consumption 75 mg. per ewe per day). The other two groups served as untreated controls. During the five days following the last feeding of MAP, 86 percent of the treated ewes mated as compared to 38 percent of the control ewes. Sixty-three percent of the ewes that received 75 mg. MAP and 84 percent of the ewes that received 100 mg. MAP lambed during the expected time, as compared to 35 percent and 26 percent of the two control groups. This would indicate that conception rate was about the same for the treated and control groups. Yearling ewes did not respond to the MAP treatment as consistently as did mature ewes.

Hogue et al. (1962) assigned 120 mature Western ewes to three equal groups for a study of estrus synchronization. One group was allowed to cycle normally and to mate naturally. One group was allowed to cycle normally and the ewes were artificially inseminated. The third group was fed 60 mg. MAP per head per day for 20 days, and one-half of the ewes were allowed to mate naturally and the other one-half were artificially inseminated. Of the 40 ewes fed MAP, 37 came into estrus between 50 and 64 hours following the last feeding of MAP. Eight of the 18 treated ewes mated naturally conceived. Four of these ewes showed a return estrus but lambed from the first synchronized mating. Of the 19 treated ewes artificially inseminated, four did not return to estrus and three of these lambed. The conception rate of the control ewes mated naturally at normal estrus was comparable to the treated ewes, but conception rate of the artificially inseminated control ewes was 49 percent compared to 4 of 19 or 16 percent for the treated ewes artificially inseminated. The authors explained that the differences in conception rates of the artificially inseminated ewes could have been due to ram differences.

Evans et al. (1962) investigated three levels of MAP feeding and treatment periods of three different lengths for synchronizing estrus of ewes during the fall breeding season. Seventy-five dark-faced Western ewes were used in two trials. After feeding 50 mg. MAP per head daily for 14 days, 26 of 35 ewes exhibited estrus within 4 days after the end of treatment and 29 exhibited estrus within 8 days. Two ewes showed estrus during the treatment period. Ovulation rate in ten ewes slaughtered was 1.27 with 70 percent of the ova cleaved. Eight of the 19 ewes retained for lambing data lambed as a result of mating at the first post-treatment estrus. In a second trial, 40 ewes were used in a factorially designed experiment in which four groups of 10 ewes each received 60 or 90 mg. MAP in their feed for either 15 or 18 days. None of the ewes came in estrus during treatment. Thirty-eight (95 percent) of these ewes exhibited estrus 2 to 5 days post-treatment. The ovulation rate for 19 ewes slaughtered was 1.42 with 63 percent of the ova cleaved. Of the 19 ewes retained for lambing data 16 (84.2 percent) lambed to mating at the first post-treatment estrus. The interval from end of treatment to estrus was significantly ($P < .01$) longer for the 90 mg. group (2.7 vs. 3.6 days) and for the 18-day group (2.9 vs. 3.6 days).

Roberts et al. (1963) administered MAP to four groups of cycling Merino ewes. Twenty ewes received 50 mg. MAP per head per day in their feed, 10 ewes received 50 mg. MAP per head per day in gelatin capsules, 10 ewes received 100 mg. MAP per head every other day by capsule and 10 ewes received 200 mg. MAP per head every fourth day by capsule. The first three treatments appeared equally effective in suppressing estrus but 200 mg. every fourth day was less effective. In the first three groups, 81 percent of the ewes mated from the third to fifth days after the last administration of MAP. The percent ewes lambing of those mating at the first synchronized estrus for the four groups, in the order named previously, was 65, 60, 86 and 22 percent. The only information given on the control ewes was that they were cycling regularly.

Addleman et al. (1963) synchronized estrus by feeding MAP at the rate of 50 to 60 mg. per head daily for 14 or 16 days to a total of 471 Suffolk and Willamette ewes during the fall breeding season of two different years. The two years results were very comparable. Combining both years results, 94 percent of the ewes mated by the fifth day after the last day of feeding MAP, while 71 ewes (35 percent) exhibited a second estrus and 14 ewes (7 percent) a third estrus. A total of 153 ewes (83 percent) lambed from mating at the first synchronized estrus, 28 ewes (15 percent) from the second estrus and four ewes (2 percent) from the third estrus. Ten percent of the Willamette ewes and 20 percent of the Suffolk ewes exhibited a second estrus but lambed from the mating at the first synchronized estrus. Breeding and lambing data from the control ewes were not presented.

Botkin and Nelms (1963) fed MAP at levels varying from 50 mg. to 120 mg. per head per day for 14 days to 291 Rambouillet, Columbia and Suffolk ewes during either August or December of three different years. Thirty-four Columbia ewes were fed one-half mg. 6-chloro-17-acetoxyprogesterone (CAP) per head daily for 14 days to synchronize estrus. Over the three years, 94 percent of 52 Rambouillet ewes mated the first five days after the last feeding of MAP and 35 (67 percent) of these lambed. Of the 40 Suffolk ewes fed MAP, 45 percent mated during the same five-day period and 42.5 percent lambed from these matings. Ninety-four percent of the 244 Columbia ewes fed MAP mated during the five day period and 58 percent lambed from these matings, while 80 percent of the 40 Columbia ewes fed CAP mated during the five days after the end of the treatment and 47 percent lambed from these matings. A higher percent of the treated ewes conceived at the first synchronized estrus than did the control ewes at their first estrus of the breeding season; however, except for a small group of Rambouillet ewes the control ewes and treated ewes were not handled in the same manner.

Southcott <u>et al</u>. (1962) administered MAP at levels of 6.6 mg., 20 mg. and 60 mg. per head per day for 14 days to Merino ewes during the fall breeding season to synchronize estrus. The pure MAP was administered orally by gelatin capsules to insure a constant intake of the drug by the ewes. The two lower dosage levels of MAP did not completely inhibit estrus. Conception from mating at the first synchronized estrus was 60 percent for the groups receiving 20 mg. and 60 mg. MAP, and 70 percent for the group receiving 6.6 mg. and the untreated control group. In a second trial, 100 Merino ewes were allotted to five equal groups during the fall breeding season. Group one received 50 mg. MAP per head per day for 17 days, while group two received 50 mg. MAP per head per day plus 500 I.U. PMS 24 hours after the last MAP and 600 I.U. HCG 24 hours after the PMS. Groups three and four were treated the same as groups one and two except that 10 mg. progesterone in oil was injected daily in place of the orally administered MAP. The fifth group was a control group. No treatment completely stopped the occurrence of estrus during the treatment period. The number of ewes conceiving from matings at the first synchronized estrus was 9 of 15, 6 of 14, 6 of 17, and 5 of 12 for treatment groups one through four, respectively. During the first 17 days of the treatment period, 13 of the 19 control ewes mated with a resulting conception rate of 74 percent.

Brunner _et al_. (1964) reported that 60 mg. MAP per head daily and 30 mg. MAP per head daily for 16 days were both successful in synchronizing the estrus of Western ewes during the fall breeding season. Conception rates at the first synchronized estrus were 62 percent for the naturally mated ewes receiving 60 mg. MAP per head daily and 50 percent for the ewes receiving 30 mg. MAP per head daily. First estrus conception rate was 82 percent for the control ewes. Conception was very poor in the half of each group that was artificially inseminated. Nineteen mature Dorset ewes were fed 60 mg.

MAP per head per day during March. Fifteen of these 19 ewes had a synchronized estrus and 11 (73 percent) of these ewes lambed from mating at the synchronized estrus. Eighteen of 23 (78 percent) of the untreated control ewes lambed from first estrus matings during the same period.

Synthetic progestogens have been used, generally in conjunction with other hormones, by several workers to induce estrus and ovulation in seasonally anestrous ewes. Evans and Dutt (1962) fed 20 seasonally anestrous ewes 50 mg. MAP per head per day for 7 days and 20 additional ewes the same level of MAP for 14 days. Both treatments were followed on the second day after the last feeding of MAP with injections of 500 I.U. PMS per head. Twenty-five percent of the ewes that received MAP for 7 days, as compared to 65 percent of the ewes that received MAP for 14 days, exhibited a post-treatment estrus. In a second trial, using the same general procedure as in the preceding trial, 1 mg. per head daily of 6-chloro-17-acetoxyprogesterone (CAP) was fed to 10 anestrous ewes for 14 days followed by 500 I.U. PMS and the same level of CAP was fed to 10 additional ewes for 21 days followed by 1000 I.U. PMS. Seventy-five mg. MAP per head daily was fed to two groups of 10 ewes each using the same treatment periods and PMS levels as for the CAP treatments. One of the 10 ewes that received MAP for 14 days and four of the 10 ewes that received MAP for 21 days had post-treatment estruses. One of the 10 ewes that received CAP for 14 days and two of the 10 ewes that received CAP for 21 days exhibited estrus post-treatment. Length of treatment period was confounded with level of PMS in this trial. The ewes that received CAP had a significantly ($P<.05$)

higher ovulation rate than did the ewes receiving MAP, but fertility did not differ significantly between the two groups.

Wagner and Bush (1961), in three different trials, fed seasonally anestrous ewes levels of CAP varying from 1 mg. to over 25 mg. per head daily for 16 days. All ewes received injections of 1000 I.U. PMS on the day following the last feeding of CAP. One-half of each group received an injection of estradiol (500 mcg. or 750 mcg.) 36 hours after the PMS injection. None of the ewes receiving over 5 mg. CAP per head per day exhibited estrus nor did these ewes generally ovulate. Of the 50 ewes that received estradiol and 1, 2, 3, or 4 mg. CAP per head daily 45 exhibited estrus post-treatment, whereas 31 of 48 ewes that received these levels of CAP without estradiol exhibited estrus. No reference was made to the lambing performance of the ewes.

Pursel and Graham (1962) compared the use of injectable crystalline progesterone, injectable 17-hydroxyprogesterone-17-caproate and orally administered MAP as pretreatments followed by varying levels of a follicle stimulating pituitary extract (FSH) for inducing estrus and ovulation in anestrous ewes. In a trial designed to compare injectable progesterone and MAP, either fed or administered as a drench, it was found that 10 mg., 30 mg. or 60 mg. MAP per head per day was as successful as a pretreatment before FSH injection as 40 mg. progesterone per head injected every third day for 12 days. Of the 35 ewes that received MAP at the various levels, 28 had a post-treatment estrus and nine conceived. Five of eight ewes that received the progesterone had a post-treatment estrus and two conceived. In a separate trial, 15 anestrous ewes received one injection of 125 mg.

17-hydroxyprogesterone-17-caproate either 8, 10 or 12 days before an injection of 25 mg. FSH per ewe. Three of four ewes on the 12-day interval and one of six ewes on the 8-day interval had a post-treatment estrus and one of these ewes lambed. In these trials numbers were small for an adequate test of the treatment comparisons being made and untreated control ewes were apparently not maintained for comparison. Robinson (1962) concluded that 17-hydroxyprogesterone-17-caproate was not a good substitute for injectable crystalline progesterone for use with PMS or HCG in inducing estrus and ovulation in anestrous ewes.

Addleman and Bogart (1963) used various combinations of MAP and PMS in an attempt to induce estrus in yearling North Country Cheviot ewes during the early summer when these ewes are normally in deep anestrum. Ten ewes received 50 mg. MAP per head per day for 16 days plus an injection of 4 rat units of PMS per pound of body weight on the fourteenth day of the MAP feeding period. Six of these ewes exhibited a post-treatment estrus and three ewes lambed. Five of 10 additional ewes receiving the same MAP treatment and PMS at the same level on the last day of Map feeding mated post-treatment and two lambed. Two of 10 ewes receiving the same MAP treatment and no PMS mated post-treatment and none lambed. None of the 10 control ewes exhibited estrus.

Brunner _et al_. (1964) fed 15 anestrous Hampshire and Corriedale ewes 60 mg. MAP per head daily for 20 days during May. Thirteen ewes of the same breeding and age received 60 mg. MAP per head daily for 8 days, 750 I.U. PMS per ewe on day 9, 60 mg. MAP per ewe per day on days 15 through 22 and 750 I.U. PMS on day 23. Fifteen ewes were maintained as untreated controls. None of the control ewes nor the ewes that received only MAP exhibited estrus. Of the ewes that received both MAP and PMS 11 exhibited estrus and five lambed from mating at the synchronized estrus. The same MAP-PMS treatment, using 50 mg. MAP instead of 60 mg. as used in the preceding trial, was administered to 75 anestrous Hampshire, Corriedale and whiteface crossbred ewes in May. By the sixth day following the last PMS injection 44 of 56 ewes (79 percent) had mated. Eleven of 19 ewes mated naturally lambed. None of the 20 control ewes exhibited estrus.

During July and August, a period of marginal anestrum, Brunner et al. (1964) allotted 30 Hampshire and 35 Corriedale ewes to four treatment groups and a control group. One group of 16 ewes received 60 mg. MAP per head per day for 20 days in their feed. Thirteen of these 16 ewes (81 percent) exhibited a synchronized estrus and 8 of these 13 ewes (62 percent) conceived. The second group received 60 mg. MAP per head daily for 8 days followed on the ninth day by injections of 750 I.U. PMS per head. Eighty-eight percent of this group had a synchronized estrus and 62 percent conceived. The ewes of the third group received injections of 750 I.U. PMS per head on the first day of the treatment period and 60 mg. MAP per head daily on days 7 through 14. Eighty-one percent of these ewes had a synchronized estrus and 62 percent conceived. The fourth group received the same treatment as group three plus 750 I.U. PMS per head on day 15. All 16 of these ewes had a synchronized estrus and 14 of the 16 ewes (88 percent) conceived. Twenty-three of the 30 control ewes exhibited estrus during the 21 day treatment period. Lambing rates were higher, although not significantly so, in the groups receiving PMS after MAP treatment, suggesting an increase in ovulation rate due to the PMS.

Few workers have reported the results of experiments investigating the use of hormones in the induction of estrus and ovulation in ewes during lactational anestrous. Gassner (1952) divided 560 ewes with lambs ranging in age from one to four weeks into four groups according to the age of their lambs. All ewes were injected with 250 rat units of PMS per head. Twenty-five ewes with lambs one week old were kept as untreated controls. All ewes that mated were given 100 I.U. HCG 24 hours after mating. At weekly intervals the ewes that had not mated were again given 250 rat units PMS. Of 75 ewes with lambs one to two weeks old 36 percent mated and 69 percent of these conceived. Fifth-three percent of 155 ewes with lambs two to three weeks old mated and 35 percent of these conceived. Sixty-nine percent of 212 ewes with lambs three to four weeks old mated and 24 percent of these conceived. Five of the twenty-five control ewes mated and one of these lambed. The author proposed that the decrease in conception rate that occurred as the post-partum interval increased was due to the uterus approaching a state of anestrous dormancy. The author did not state the time of year during which this trial was conducted, but it would appear to have been early spring lambing.

Gordon (1958b), in a rather extensive series of trials, treated 357 lactating ewes and 216 non-lactating ewes with various levels of progesterone followed two days after the last progesterone injection by 700 I.U. PMS per ewe. Of the 357 lactating ewes treated with both progesterone and PMS 75.6 percent mated and 26.6 percent of these conceived. Of the 216 non-lactating ewes treated 80.1 percent mated and 44.3 percent conceived. The length of the interval from lambing to treatment and mating was not discussed.

Gordon (1963) injected five different flocks (140 ewes total) of lactating Clun, Scotch Half-Bred, Shropshire and Kerry ewes with 50 mg. progesterone three times over a 7 day period followed by 750 I.U. PMS. The treatments were applied in April and May 2 to 16 weeks after the ewes had lambed. In two flocks of ewes having lambs 2 to 4 weeks of age none of the ewes mated. In the three other flocks of ewes having lambs 4 to 16 weeks of age 20, 44 and 90 percent of the ewes mated and none, 11 percent and 24 percent of the ewes conceived.

Summary of the Review of Literature

Domestic sheep have been shown to normally have an active breeding season in the fall and winter and an anestrous period in the spring and early summer during which breeding activity is reduced. Different breeds of sheep vary considerably in the length and intensity of the anestrous period.

Injectable progesterone and orally active synthetic progestogens generally have been very effective in suppressing estrus and ovulation during the breeding season, thus allowing estrus synchronization. The induction of coincident estrus and ovulation during the anestrous period generally has depended upon an adequate period of progestogen administration followed by an ovulation inducing hormone. During deep seasonal or lactational anestrous estrus has been more difficult to induce than has ovulation.

Oral synthetic progestogens generally have been adequate substitutes for injectable progesterone during either the breeding season or during anestrum.

The hormonal induction of coincident estrus and ovulation during lactational anestrous has not been thoroughly investigated. The few experiments that have been reported have indicated rather variable results in the induction of fertile estrus during lactation.

GENERAL MATERIALS AND METHODS

This study is composed of a series of six separate trials, all of which have some materials and procedures which are generally the same. The materials and methods which all trials have in common will be presented in this section. All materials and methods specific to the individual trials will be presented in the following sections in conjunction with the results and discussion for each trial.

The sheep used in this series of experiments were part of the experimental sheep flock at the Ft. Reno Livestock Research Station at El Reno, Oklahoma. The ewes used in all trials were either Dorset X Western, 3/4 Dorset-1/4 Western, 3/4 Western-1/4 Dorset or Western ewes. The Dorset crossbred ewes were in all cases produced in the Ft. Reno flock and saved as flock replacements. The Western ewes (predominantly Rambouillet) were purchased as yearlings from various sources in Texas, New Mexico, and Oklahoma.

The flock was managed according to the usual practices of commercial sheep producers in Oklahoma. The ewes ran on wheat pasture with their lambs during the fall and winter and were grazed on native or bermuda grass pasture during the remainder of the year. Supplemental grain and alfalfa hay generally were given to the ewes for a short period of time before lambing and for approximately two months after lambing.

The ewes were usually shorn shortly before the beginning of the spring breeding season. The usual breeding schedule was to have a 40 day spring breeding season in late May and June with the ewes lambing in October and November. A 30 day cleanup breeding season was conducted in late August and September with the ewes conceiving during this time lambing in January and February. The ewes were routinely exposed to fertile rams during the late summer breeding season, whether or not they conceived during the spring breeding season. The fall born replacement ewe lambs were first exposed to fertile rams during the late summer breeding season when they were approximately 10 months of age. In this study these general management practices may have been modified slightly as will be discussed for each specific trial.

The 6-methyl-17-acetoxyprogesterone[1] (MAP) was in all cases administered in a daily feed ration, group fed to all ewes receiving the same treatment. The MAP was received from the pharmaceutical company premixed in soybean meal, either at the rate of 33 mg. MAP per gram of soybean meal or 7.14 mg. MAP per gram of soybean meal. The total amount of MAP premix to be administered to a treatment group of ewes during a treatment period was mixed in a large feed mixer with the total amount of feed to be fed during that treatment period. For convenience and accuracy in feeding, the feed containing MAP was weighed and sacked into individual sacks containing the amount to be fed to the treatment group daily. The ewes were fed once daily in a group with adequate trough space so that all ewes could eat without crowding. The ewes were usually fed in the morning after being in a lot at night; consequently, in no case was difficulty encountered with

[1]Repromix, The Upjohn Company, Kalamazoo, Michigan.

any of the ewes not eating. The fed mixture with which the MAP was fed in all trials was 45 percent ground sorghum grain, 5 percent molasses and 50 percent ground alfalfa hay.

The pregnant mare serum[2] (PMS) used was a commercial preparation containing 50 I.U. per ml. The PMS was injected subcutaneously behind the shoulder.

Laparotomies were performed using the median line procedure as discussed by Casida (A.S.A.P., 1960). General anesthesia was induced by injecting pentobarbital sodium[3] intravenously, usually into the jugular vein. Approximately 50 mg. pentobarbital sodium per 10 lb. body weight was given each ewe, although individual variation in sensitivity to the drug was quite high. The anesthetic was injected slowly until the interdigital reflex was just lost or until the corneal reflex was very weak but still present. The duration of surgical anesthesia was usually from 15 to 20 minutes. The ovaries were visually observed and the number of corpora lutea were recorded as were observations on the number and size of follicles present.

Breeding records were maintained by equipping all the rams used, either fertile or vasectomized, with marking harnesses and checking the ewes either once or twice daily for the presence of chalk marks on their rumps, indicating mating. The detection of matings by the use of marking harnesses is fairly reliable, but is subject to some error. When ewes lambed, but did not have a mating recorded, the

---

[2]Gonadin, Cutter Laboratories, Berkeley, California.

[3]Diabutal, Diamond Laboratories, Inc., Des Moines, Iowa.

probable date of conception was computed by subtracting an average gestation period (Tilton, 1964) for the age and breed of ewe concerned from the lambing date.

Conception rate, as used in this study, is defined as the number of ewes lambing expressed as a percent of the number of ewes mating. Lambing rate is defined as the number of lambs produced by a given group of ewes expressed as a percent of the total number of ewes in the group, whether they mated or not. Lambing records, including the date of lambing and the number of lambs born, were kept for each ewe.

All the ewes had permanent identification numbers on ear tags as well as paint brand numbers on their backs to aid in easy identification.

TRIAL I

Materials and Methods

Prior to the 1962 spring breeding season 24 two-year old Dorset X Western ewes and 22 three-year old Merino X Rambouillet ewes were allotted at random within breed of ewe to a treatment group and a control group to investigate various aspects of the use of MAP to synchronize estrus.

The Dorset X Western ewes were reared in the Ft. Reno Experiment Station flock and were from either grade Rambouillet ewes or 3/4 Rambouillet-1/4 Panama ewes and purebred Dorset rams. The Merino X Rambouillet ewes were purchased as yearlings from a ranch near Roswell, New Mexico.

Beginning May 20, MAP was fed at the rate of 60 mg. per ewe daily in one-half pound of feed to 12 of the Dorset X Western ewes and 11 of the Merino X Rambouillet ewes for 15 consecutive days. The control ewes received the same amount of feed daily as did the treated ewes. Both groups of ewes ran together on pasture during the day and were penned in the same lot at night. The ewes were separated for approximately one hour in the morning to be fed. Beginning May 22, two fertile rams were alternated, one every other day, with the ewes for 40 days. Matings were recorded twice daily.

The Dorset X Western ewes, both treated and control, were laparotomized approximately 5 days after they mated to determine if the ewes had ovulated and to determine the number of ovulations.

The difference in ovulation rate between the MAP treated ewes and the control ewes was tested for significance using chi-square. Bartlett's test for homogeniety of variance (Steel and Torrie, 1960) was used to test for the effect of MAP treatment on the variation in the time of occurrence of first estrus during the breeding season.

Results and Discussion

The breeding and lambing performance of the ewes in this trial is summarized in Table I. Seven of the 12 Dorset X Western ewes receiving MAP mated from days 4 to 7 of the 15 day MAP feeding period. One additional ewe mated on day 13 of the treatment period and four of the seven ewes that first mated during the treatment period mated again on day 15 of the treatment period. One of the ewes that mated on day 5 of the treatment period was laparotomized 6 days later and was found to have not ovulated. None of the ewes lambed from matings during the treatment period. All 12 of the Dorset X Western ewes that received MAP mated on the third to fifth days post-treatment. None of the 11 Merino X Rambouillet ewes mated during the MAP treatment period. Ten of these ewes mated on the third and fourth days and one ewe mated on the sixth day after the end of MAP feeding.

Two of the control ewes, one of each breed group, did not mate during the 40 day breeding period. The remainder of the control ewes had their first estrus over a 24 day period. The variance in the

TABLE I

BREEDING AND LAMBING PERFORMANCE OF THE EWES IN TRIAL I WITHIN BREED AND TREATMENT GROUP

	Dorset X Western		Merino X Rambouillet	
	MAP Group	Control Group	MAP Group	Control Group
No. of ewes beginning trial	12	12	11	11
Range of first estruses in days[a]	3	24	4	24[b]
No. first estrus conceptions	5	2	5	6
No. lambs from first estrus conceptions	7	2	5	8
No. second estrus conceptions	1	6	4	3
No. lambs from second estrus conceptions	1	8	4	4
No. ewes not mating	0	1	0	1
No. ewes not lambing	3	3	2	2
No. ewes alive at lambing	9	11	11	11

[a]For the MAP groups the range in days refer to the first synchronized estruses following the MAP treatment period.

[b]The variance significantly ($P < .005$) less for the MAP treated ewes.

occurrence of first estrus during the breeding season was significantly ($P < .005$) less for the MAP treated ewes than for the control ewes.

All the Dorset X Western ewes were laparotomized either 5 or 6 days post-mating except for the one ewe previously laparotomized during the treatment period. The MAP fed ewes were laparotomized after their first estrus of the breeding season. None of the Merino X Rambouillet ewes were laparotomized.

Of the 11 MAP treated Dorset X Western ewes laparotomized post-treatment two had not ovulated. The nine ewes that had ovulated had an average ovulation rate of 1.33 ovulations per ewe. All of the Dorset X Western control ewes had ovulated at their first estrus with an average ovulation rate of 1.55 ovulations per ewe. This difference in ovulation rate was not significant. The effect of mating during the treatment period, particularly if ovulation had occurred, may have influenced the ovulation rate of the treated ewes.

Three of the MAP treated Dorset X Western ewes and one of the control Dorset X Western ewes died as a result of the laparotomies, consequently no lambing information was obtained on these ewes.

Five of the MAP treated Dorset X Western ewes conceived from mating at their first synchronized estrus and produced seven lambs, while one ewe conceived at a second estrus and produced a single lamb and three ewes did not lamb. Two of the 10 Dorset X Western control ewes, that mated and lived until lambing, conceived at their first estrus and produced two lambs. Six control group ewes conceived at a second estrus and produced eight lambs and three ewes did not lamb.

The effect of the laparotomies upon lambing performance is not known, but it is possible that the operation could increase embryonic mortality. This might explain the low first estrus conception rate shown by the Dorset X Western control ewes.

Of the 11 MAP treated Merino X Rambouillet ewes, five conceived at their first post-treatment estrus and subsequently produced five lambs. Four of the six remaining ewes conceived at their second estrus and produced four lambs, while the other two ewes did not lamb. Six of the 11 Merino X Rambouillet control ewes conceived at their first estrus of the breeding season and produced eight lambs. Three of the remaining ewes conceived at their second estrus and produced four lambs, while two ewes did not lamb.

It was apparent in this trial that the Dorset X Western ewes did not receive enough MAP to completely suppress estrus during the treatment period. Inadequate mixing of the MAP with the feed, thus causing variation in the daily intake of MAP, could be one explanation. This seems unlikely since none of the Merino X Rambouillet ewes exhibited estrus during the treatment period. Another possibility could be that the 60 mg. per ewe per day level of MAP was not adequate to suppress estrus in the Dorset X Western ewes at this time of year. Past breeding performance has indicated that the Dorset X Western ewes are more sexually active in the spring than are the Merino X Rambouillet ewes. If this is true a higher level of progestogen should be required to supress estrus and ovulation in the Dorset X Western ewes. Both Southcott _et al_. (1962) and Evans _et al_. (1962) reported that 50 mg. MAP per ewe daily did not suppress estrus in all ewes during the fall breeding season.

TRIAL II

Materials and Methods

Twenty yearling (12-month old) Dorset X Western ewes and 17 yearling (12-month old) Rambouillet ewes were used during the fall of 1962 to investigate the synchronization of estrus using MAP alone and in combination with PMS.

The Dorset X Western ewes were produced in the Ft. Reno Experiment Station flock and were from either Rambouillet ewes or 3/4 Rambouillet-1/4 Panama ewes and purebred Dorset rams. The Rambouillet ewes were purchased as yearlings from the Texas Agricultural Experiment Station at McGregor, Texas.

All the ewes received 60 mg. MAP per ewe daily for 15 days in one-half pound of feed, beginning October 5. One-half of each breed group was selected at random to receive 500 I.U. PMS 36 hours after the last feeding of MAP. The PMS was injected subcutaneously behind the shoulder.

Two fertile rams equipped with marking harnesses were alternated with the ewes, one during the day and one at night, for 25 days beginning the last day that MAP was fed. The ewes were checked twice daily for marks indicating mating. The difference between the lambing rate of the MAP treated ewes and the MAP plus PMS treated ewes was tested for significance using chi-square.

Results and Discussion

The breeding and lambing performance of the ewes in this trial is summarized in Table II. All 18 of the ewes of both breeds that received MAP for 15 days and no PMS mated within 5 days after the last feeding of MAP. Eighteen of the 19 ewes that received MAP for 15 days followed by 500 I.U. PMS mated within the same 5 day period and one ewe mated 20 days post-treatment.

Eight of the 10 Dorset X Western ewes in both the group receiving only MAP and the group receiving MAP and PMS lambed from mating at the first synchronized estrus. The eight ewes within each group produced 11 lambs. The remaining two ewes in each group conceived at their second estrus and each produced a single lamb. Six of the nine Rambouillet ewes that received only MAP conceived at their first synchronized estrus and produced six lambs while the remaining three ewes did not lamb. Four of the eight Rambouillet ewes that received both MAP and PMS conceived at their first synchronized estrus and produced six lambs, while one ewe conceived at a second estrus and produced a single lamb and three ewes did not lamb.

The injection of 500 I.U. PMS per ewe did not significantly increase the number of lambs born from matings at the first synchronized estrus. Fourteen ewes that received only MAP had 17 lambs and 12 ewes that received MAP and PMS had 17 lambs. The PMS did not appear to influence the occurrence of estrus after the end of the MAP feeding period, although one ewe that received both MAP and PMS did not mate until 20 days post-treatment.

TABLE II

BREEDING AND LAMBING PERFORMANCE OF THE EWES IN TRIAL II WITHIN BREED AND TREATMENT GROUP

	Dorset X Western		Rambouillet	
	MAP Group	MAP-PMS Group	MAP Group	MAP-PMS Group
No. of ewes	10	10	9	8
No. ewes mating 1 to 5 days post-treatment	10	9	9	8
No. ewes conceiving at first estrus	8	8	6	4
No. lambs from first estrus conceptions	11	11	6	6
No. ewes conceiving at second estrus	2	2	0	1
No. lambs from second estrus conceptions	2	2	0	1
No. ewes not lambing	0	0	3	3

Five of the ewes that received only MAP and four of the ewes that received MAP and PMS showed a second synchronized estrus but lambed from mating at the first synchronized estrus. This phenomenon will be discussed further in the Results and Discussion section of Trial V of this study.

TRIAL III

Materials and Methods

To investigate the possible effects of MAP upon lactation and upon the occurrence of post-partum estrus 24 two to four-year old Dorset X Western and 24 two to five-year old Western ewes, that had lambed from November 4 to 10, were allotted at random within breed of ewe, age of lamb and type of birth (single or twin) to two groups.

The Dorset X Western ewes were raised in the Ft. Reno Experiment Station flock from either Rambouillet or 3/4 Rambouillet-1/4 Panama ewes and purebred Dorset rams. The Western ewes were predominantly of Rambouillet breeding and were purchased as yearlings from various sources in Texas, New Mexico, and Oklahoma.

One group of 24 ewes was fed 70 mg. MAP per ewe daily in one pound of feed for 17 days beginning November 21 when their lambs averaged 15 days of age. The other group of 24 ewes received the same feed ration without MAP. The two groups of ewes were run on separate but similar wheat pastures during the day with their lambs and were penned in separate adjacent lots at night. The ewes were fed each morning before going back to pasture. After the end of the MAP feeding period the two groups of ewes were run together on wheat pasture.

Vasectomized rams equipped with marking harnesses were run with the ewes and matings were recorded daily for 69 days, beginning the first day of the MAP feeding period.

Using the lamb weight change method described by Harrington (1963), milk production of the ewes was measured the day before the MAP feeding period began, at the end of the first week of the MAP feeding period and at the end of the second week of the MAP feeding period.

The difference between the milk production of the two groups and the post-partum interval to mating of the two groups was tested for significance using the "t" test. Bartlett's test for homogeniety of variance (Steel and Torrie, 1960) was used to test for the effect of MAP treatment on the variation in the time of occurrence of first estrus during the breeding season.

Results and Discussion

The milk production of the MAP fed ewes and the control ewes was the same for the 24 hour test period before the MAP feeding started (2.70 pounds per ewe). At the 24 hour test period at the end of the first week of MAP feeding the MAP group produced an average of 3.44 ± .34[4] pounds of milk per ewe as compared to 3.30 ± .24 pounds for the control group. During the test period at the end of the second week of MAP feeding the MAP fed ewes produced an average of 2.64 ± .21 pounds of milk and the control ewes produced an average of 2.85 ± .23 pounds per ewe. The average milk production of the two groups of ewes was not significantly different at any of the test periods. In agreement with these results Ferin _et al_. (1964) reported that the administration

[4]Mean ± standard error of the mean.

of a synthetic progestogen to women beginning the sixth week of lactation had no significant effect on their milk production.

None of the ewes fed MAP mated until 17 days after the end of the treatment period. Fourteen of the 24 MAP group ewes mated within 17 to 24 days post-treatment and three other ewes mated 35, 38 and 44 days post-treatment. The average post-partum interval to mating for the 17 MAP fed ewes was 55.2 days. Eleven of the control ewes mated from 39 to 69 days post-partum with an average post-partum interval to mating of 52.8 days. The variance in the day of occurrence of first estrus was not significantly different for the two groups. The post-partum interval to mating was significantly ($P < .05$) longer for the MAP fed ewes than for the control ewes. This reflects the delay of at least 17 days after the end of the MAP feeding period until the first treated ewes mated. This can be explained in that ewes normally do not exhibit estrus at their first ovulation of the breeding season, since a regressing corpus luteum generally is necessary for the expression of estrus (Grant, 1934; Cole and Miller, 1935; and McKenzie and Terrill, 1937). Apparently feeding 70 mg. MAP per ewe daily for 17 days did not sufficiently substitute for the presence of corpora lutea from previous ovulations. Foote et al. (1960) and Fosgate et al. (1962) reported that a period of progestogen treatment shortly after calving increased the post-partum interval to first estrus in beef cattle.

TRIAL IV

Materials and Methods

The same Dorset X Western and Rambouillet ewes previously discussed in Trial II were allotted at random within breed, lambing performance (single, twin or no lamb) and age of lamb into two groups to study the effect of MAP and PMS on the breeding and subsequent lambing performance of lactating ewes. Both groups of ewes were fed 60 mg. MAP per head for 13 days, beginning April 1 when the oldest lambs were 17 days old. When the MAP feeding period began three of the ewes had not lambed. These ewes were added to the group receiving MAP when their lambs were 2 days old. The ewes of one group received 500 I.U. PMS subcutaneously 24 hours after the last feeding of MAP.

A fertile ram equipped with a marking harness was run with the ewes continuously for 90 days beginning the first day of the MAP treatment period and matings were recorded daily.

The 17 Rambouillet ewes were laparotomized one week after the end of the MAP treatment period.

Results and Discussion

None of the ewes exhibited estrus within a 22 day period immediately following the end of the MAP treatment period. Three Dorset

X Western ewes, two that received only MAP and one that received both MAP and PMS, and one Rambouillet ewe that received both MAP and PMS mated within 22 to 25 days after the end of the MAP treatment period. The Dorset X Western ewe that had received both MAP and PMS lambed from this mating and produced a single lamb. All four of the ewes that mated were lactating. No additional matings were recorded during the 90 day breeding season, although one Rambouillet ewe lambed from an unrecorded mating near the end of the breeding season.

When examined at laparotomy one week after the end of the MAP treatment period all the Rambouillet ewes that had received PMS had ovulated. The average ovulation rate for the PMS-treated Rambouillet ewes was 3.0 ovulations per ewe with a range of one to five ovulations per ewe. Of the MAP treated Rambouillet ewes only one dry ewe had ovulated. In general the ewes that did not receive PMS, both lactating and non-lactating, had rather inactive ovaries containing only small follicles. This would indicate that the ewes were in deep seasonal or lactational anestrous.

The results of this trial agree with the previously discussed results of Trial III in that the ewes receiving only MAP during lactation did not exhibit estrus at the end of the treatment period. It is difficult to explain why more ewes did not mate during the 90 day breeding season, although there were probably several contributing causes. These were young ewes raising their first lamb crop; consequently, it was difficult to keep the ewes in good condition during lactation. The breeding season began in April which is probably the least active breeding season during the year, which might explain why the six Rambouillet ewes that had not lambed did not mate.

That the non-lactating ewes receiving MAP and PMS did not exhibit an estrus does not agree with the results of Dutt (1953) and Robinson (1955), who reported that most ewes in seasonal anestrous would ovulate and exhibit estrus after a progestogen treatment period followed by PMS injections. In contrast, McDonald (1961), Shimizu and Sakuma (1959) and Shimizu *et al*. (1962) reported that ewes in deep seasonal anestrous did not consistently exhibit estrus after progesterone and PMS treatment.

TRIAL V

Materials and Methods

Two-hundred and five mature Dorset X Western and Western ewes were allotted to two groups before the 1963 spring breeding season to determine the degree of estrus synchronization and the conception rate of ewes mated at the second synchronized estrus after receiving MAP.

The Dorset X Western ewes were from 4 to 6 years of age and were raised in the Ft. Reno Experiment Station flock from Rambouillet and 3/4 Rambouillet-1/4 Panama ewes and purebred Dorset rams. The Western ewes were 4 to 6 years old, predominantly of Rambouillet breeding and were purchased as yearlings from various sources in Texas, New Mexico, and Oklahoma.

The ewes were allotted to the two groups at random within breed, age, lambing performance the previous year (single, twins or no lamb) and the time of lambing the previous year (fall or winter). The treatment group of 103 ewes, 48 Dorset X Western and 55 Western ewes, were fed 70 mg. MAP per head daily in one-half pound of feed for 16 days, beginning 32 days before the regular spring breeding season (May 20 to June 29). The control group of 102 ewes, 50 Dorset X Western and 52 Western, received the same feed ration without MAP. The ewes received feed for 17 days, beginning the day before the MAP treatment.

The MAP treatment group and the control group were each divided into two groups as equal in size as possible. These four groups were then assigned at random to four adjacent pastures for the 17 day feeding period.

Vasectomized rams were run with the ewes after the end of the feeding period and before the regular breeding season began. No attempt was made to completely record individual matings but the general breeding activity within the groups was noted.

The ewes were sheared on May 9 and 10 before going into the breeding pastures.

Before the regular breeding season the ewes were allotted at random, within breed of ewe and treatment group, to four breeding groups. Two fertile rams were assigned to each group. One Dorset and one Hampshire ram were assigned to each of two breeding groups and one Dorset ram and one Suffolk ram were assigned to each of the other two breeding groups. The rams were rotated with their respective group of ewes every other day. Matings were recorded twice daily.

The objective in having the MAP feeding period end 16 days before the regular breeding season was to allow the ewes to mate to fertile rams at their second synchronized estrus. Foote and Matthews (1962) and Brunner et al. (1964) have reported a lower conception rate from ewes mated at the first synchronized estrus after progestogen treatment than for untreated ewes.

The differences in conception rate and lambing rate between breeds and treatment groups and the difference in number of pregnant ewes mating between treatment groups were tested for significance using chi-square. Bartlett's test for homogeniety of variance (Steel and

Torrie, 1960) was used to test for the effect of MAP treatment on variation in the time of occurrence of first estrus during the breeding season. To test the difference between the average day of occurrence of first estrus for the MAP group and control group the method described by Steel and Torrie (1960) for testing means with unpaired observations and unequal variances using the "t" test was used.

Results and Discussion

During the week following the MAP feeding period the ewes that had received MAP showed a considerable amount of mating activity to the vasectomized rams, indicating that many of the ewes were exhibiting a synchronized estrus. Mating activity was much less in the control group of ewes.

The number of matings for each week of the breeding season and the number of resulting conceptions for both groups of ewes are shown in Table III. Estrus synchronization was very effective with 95 of the 103 MAP group ewes mating during the first week of the breeding season. This indicates that the ewes remained synchronized very well through their second post-treatment estrus. Four additional MAP group ewes mated the second week, making a total of 99 of the 103 ewes mating the first two weeks of the breeding season. Three of the MAP group ewes mated the fourth week and one ewe did not have a recorded mating during the breeding season. Thirty-seven of the 102 control group ewes mated the first week and 49 additional ewes mated the second week for a total of 86 of the 102 ewes mating the first two weeks. Nine of the control group ewes mated the third week and three

TABLE III

NUMBER OF MATINGS AND CONCEPTIONS BY PERIODS OF THE BREEDING SEASON FOR THE 103 MAP TREATED EWES AND THE 102 CONTROL EWES

	MAP Group		Control Group	
	No. Matings	No. Conceptions	No. Matings	No. Conceptions
First estrus				
First week[a]	95[c]	77	37[c]	34
Second week	4	3	49	44
Third week	0	0	9	8
Fourth week	3	3	3	2
Last 12 days	0	0	0	0
Total	102	83	98	88
Second estrus[b]	12	8	6	4
Third estrus[b]	1	1	1	1

[a]Periods of the 40 day breeding season May 20 to June 29.

[b]Matings that could have resulted in conception.

[c]Significantly different ($P < .005$).

mated the fourth week, while four ewes did not have a recorded mating. None of the ewes from either group mated for the first time during the last 12 days of the breeding season.

A significantly ($P < .005$) greater number of the MAP treated ewes than control ewes mated the first week of the breeding season (95 vs. 37), although the difference in the number mating the first two weeks was not significant (99 MAP group ewes vs. 86 control group ewes).

The MAP treatment significantly ($P < .01$) reduced the variation in the occurrence of first estrus during the breeding season. The average interval from the beginning of the breeding season to first estrus was significantly ($P < .001$) shorter for the MAP treated ewes than for the control ewes (4.8 days vs. 8.4 days).

In comparison with past years breeding performance the control group ewes mated unusually well at the beginning of the breeding season. Figure 1 compares the percent of ewes, of ages comparable with the ewes in this trial, that mated by weeks for the first four weeks of the 1959, 1960, 1961 and 1962 breeding seasons with the breeding performance of the MAP treated ewes and the control ewes of this trial in 1963.

Since the ewes received one-half pound of feed per head daily for 17 days, beginning 33 days before the breeding season, it is possible that this supplemental feed in some way contributed to the better than expected breeding performance of the control ewes early in the breeding season. As an indication that such a feeding period could have an effect during the breeding season, Hulet _et al_. (1961) reported that flushing ewes with a 17 day feeding period, ending 17 days before

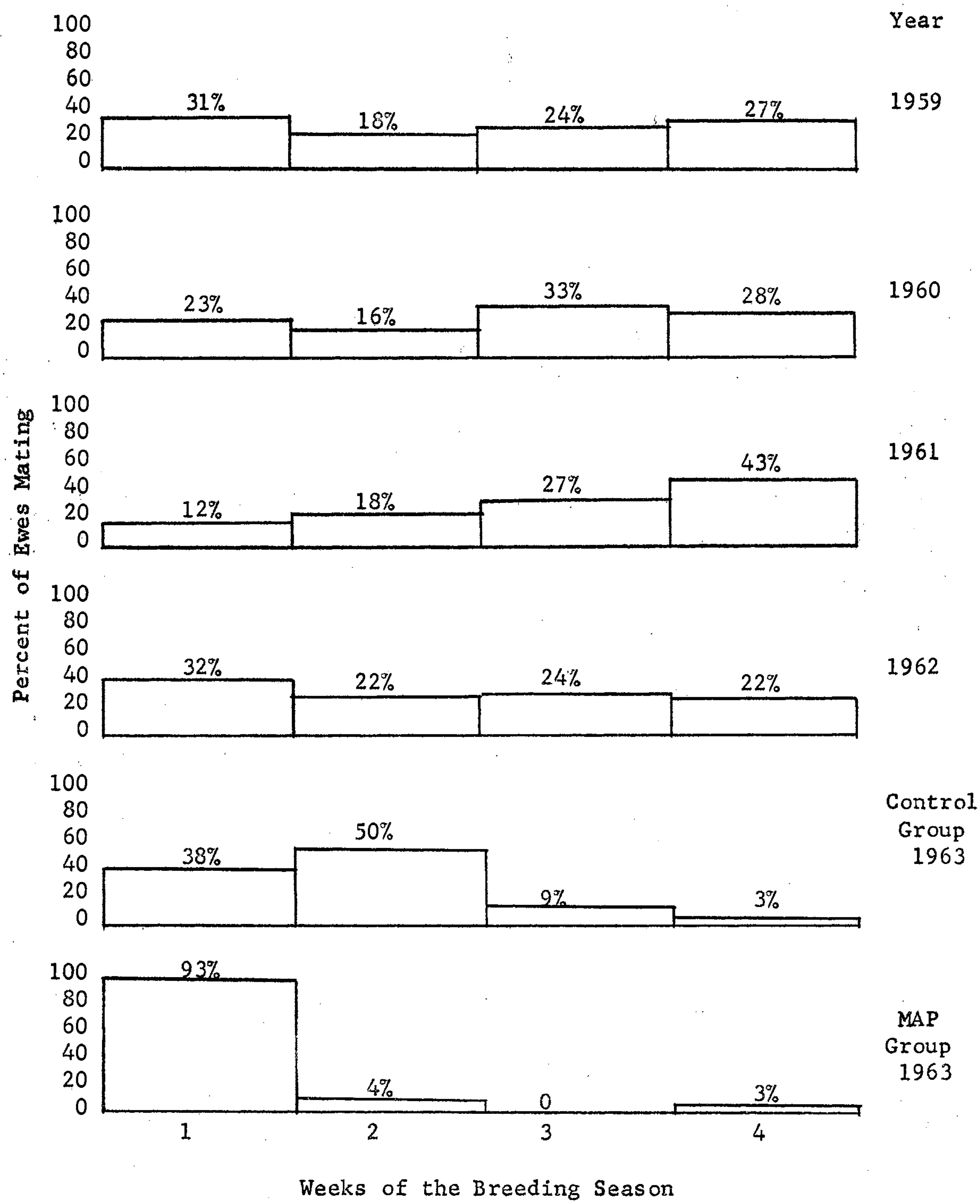

Figure 1. Percent of Mature Ewes Exhibiting First Estrus Each of the First Four Weeks of the Breeding Seasons 1959 to 1963.

the breeding season, significantly increased the number of lambs born as compared to control ewes not receiving feed.

The introduction of the vasectomized rams 16 days before the regular breeding season could also have contributed to the large proportion of the control ewes mating early in the breeding season. Previous observations at the Ft. Reno Experiment Station with similar ewes (Whiteman, unpublished data) have indicated little modification of the breeding pattern of ewes by introducing teaser rams before the regular spring breeding season. However, Shinckel (1954a), Shinckel (1954b), Riches and Watson (1954) and Watson and Radford (1960), in Australia, have reported that the introduction of rams with the ewes, at about the time they come out of seasonal anestrous in the late spring, caused many of the ewes to ovulate and begin regular estrual cycles.

No ewes mated for the first time during the last 12 days of the breeding season and few return matings were recorded during this period. This is difficult to explain since 11 of the MAP treated ewes and nine of the control ewes did not lamb. It is possible that some of these ewes had conceived and embryonic mortality occurred after the breeding season.

The number of first estrus conceptions for each week of the breeding season and the number of second and third estrus conceptions, with the number of lambs resulting from each, are presented in Table IV. Of the 95 MAP group ewes that mated the first week of the breeding season 77 (81 percent) conceived. Thirty-seven control ewes mated the first week and 34 (92 percent) conceived. Over the breeding season first estrus conception rate was 81 percent for the MAP treated ewes and 90

TABLE IV

NUMBER OF CONCEPTIONS AND NUMBER OF LAMBS BORN FOR THE 103 MAP TREATED EWES AND THE 102 CONTROL EWES

	MAP Group		Control Group	
	No. Conceptions	No. Lambs Born	No. Conceptions	No. Lambs Born
First estrus				
First week[a]	77	113	34	52
Second week	3	4	44	65
Third week	0	0	8	11
Fourth week	3	5	2	2
Last 12 days	0	0	0	0
Total	83	121	88	131
Second estrus	8	10	4	6
Third estrus	1	1	1	1
Treatment group Totals	92	133	93	137

[a]Periods of the 40 day breeding season May 20 to June 29.

percent for the control ewes. These conception rates were rather high and were not significantly different. As a comparison with previous years results at the Ft. Reno Experiment Station, the first estrus conception rates for ewes of a comparable age were 73, 75, 80 and 65 percent for 1959, 1960, 1961 and 1962, respectively.

Eight of the MAP treated ewes conceived to second estrus matings and one to a third estrus mating. Four of the control group ewes conceived to second estrus matings and one to a third estrus mating.

Table V presents the lambing results within breed of ewe and treatment group. Table VI contains the results of chi-square tests of significance for differences between the lambing rates of both breeds of ewe, both treatment groups and breed X treatment interaction. Lambing rates were not significantly different between the MAP fed group and the control group. The 103 MAP treated ewes produced 133 lambs (129 percent lambing rate) and the 102 control ewes produced 137 lambs (134 percent lambing rate). Eleven of the MAP treated ewes and 9 of the control ewes did not lamb. The 98 Dorset X Western ewes, both MAP treated and control, produced 141 lambs (144 percent lambing rate) and the 107 Western ewes produced 129 lambs (121 percent lambing rate). This difference was statistically significant ($P < .05$).

The MAP treatment appeared to reduce the lambing rate of the Dorset X Western ewes and increase the lambing rate of the Western ewes. The chi-square test indicated that a deviation of this magnitude would occur by chance about 19 times in 100 if there was truly no interaction between breed of ewe and MAP treatment. Further investigation would be necessary to determine if this interaction is real.

TABLE V

LAMBING PERFORMANCE OF THE EWES IN TRIAL V BY BREED OF EWE AND TREATMENT GROUP

	MAP Group	Control Group	Total by Breed of Ewe
Dorset X Western ewes			
No. of ewes	48	50	98
No. of lambs	64	77	141[a]
Western ewes			
No. of ewes	55	52	107
No. of lambs	69	60	129[a]
Total by treatment			
No. of ewes	103	102	205
No. of lambs	133	137	270

[a]Lambing rate of the two breeds significantly ($P < .05$) different.

TABLE VI

CHI-SQUARE ANALYSIS TO TEST DIFFERENCES IN LAMBING RATE

Comparison	d.f.	Chi-square Value	Probability Level
Total	3	6.245	$P < .10$
Dorset X Western vs. Western	1	4.191	$P < .05$
MAP vs. control	1	.230	$P < .66$
Breed X treatment interaction	1	1.824	$P < .19$

Fifty-three of the 207 ewes (25.6 percent) mated again at least five days after the mating at which they conceived during the spring breeding season. Twenty-four of these ewes mated once later during the spring breeding season and 23 mated once during the summer breeding season (August 20 to September 19). Both spring and summer matings were recorded for six ewes which had conceived earlier during the spring breeding season. Twenty-six of the 53 ewes were Dorset X Western; whereas, 27 were Western ewes. A significantly ($P < .025$) greater number of control ewes than MAP treated ewes mated during pregnancy (35 vs. 18). Addleman _et al._ (1963) reported that 10 percent of one breed group of ewes and 20 percent of another breed group of ewes showed a second synchronized estrus after receiving MAP, but lambed from the first synchronized estrus. Observations were not reported on ewes receiving no MAP. Williams _et al._ (1956) reported that 22 percent of 103 Western ewes and 15 of 24 Rambouillet ewes (62.5 percent) exhibited an estrus and mated during their gestation period. These ewes had received no hormonal treatment.

The mechanism by which the MAP treatment could reduce the number of matings occurring during pregnancy is not clear, particularly during the summer breeding season approximately four months after the MAP treatment period. Possibly, the difference observed in this trial was not real, but the chi-square test indicated that a difference of the observed magnitude would be expected to occur by chance only one time in 40 if there was truly no difference.

TRIAL VI

Materials and Methods

Prior to the 1963 summer breeding season (August 20 to September 19) 40 fall born ewe lambs were allotted, within breed and age groups, to a treatment group and a control group to investigate the effect of a MAP feeding period on the synchronization of estrus and the number of ewes mating and lambing.

The ewe lambs were saved as replacements from the Ft. Reno Experiment Station flock. Twenty of the ewe lambs were Dorset X Western from Western ewes of predominantly Rambouillet breeding and from purebred Dorset rams. Ten of the ewe lambs were 3/4 Dorset-1/4 Western from Dorset X Western ewes and purebred Dorset rams and the remaining 10 ewe lambs were 3/4 Rambouillet-1/4 Dorset from Dorset X Rambouillet ewes and purebred Rambouillet rams.

Beginning July 30 the 20 treatment group ewes received 50 mg. MAP per head daily for 12 days in one-half pound of feed. The 20 control ewes received the same feed ration without the MAP. During the feeding period the two groups of ewes were maintained in separate but similar pastures.

Two vasectomized rams were run with the 40 ewes for three weeks before the MAP treatment period began and individual matings were recorded daily. Two fertile rams were alternated one every other day with the ewes, beginning 10 days after the end of the MAP feeding period, for a 30 day breeding period (August 20 to September 19). This allowed the MAP treated ewes to mate to the fertile rams at their second synchronized estrus.

Bartlett's test for homogeniety of variance (Steel and Torrie, 1960) was used to test for the effect of MAP treatment on the variation in the time of occurrence of the first estrus during the breeding season. The difference between the average day of occurrence of first estrus for the MAP treated group and the control group was tested for significance by the method described by Steel and Torrie (1960) for testing means with unpaired observations and unequal variances using the "t" test. The differences between the number of ewes lambing and the first estrus conception rate for the two groups was tested for significance using chi-square.

Results and Discussion

The 20 MAP treated ewes all mated during the 30 day breeding period, but estrus synchronization was rather ineffective with first estruses occurring over a 19 day period. First estruses of the control group ewes occurred over a 29 day period. The MAP treatment did not significantly reduce the variation in occurrence of first estrus as compared to the control group, although the difference approached significance ($P < .07$). The average interval from beginning of the breeding season to first estrus was less, but not significantly so, for the MAP treated ewes (10.8 days vs. 8.8 days). It is possible that some of the ewes were not having regular estrual cycles, since only 12 of the 20 control group ewes and 17 of the 20 MAP group ewes had recorded matings to the teaser rams the 3 weeks prior to the MAP treatment period. If the ewes were not having regular estrual cycles much of the synchronization effect might have been lost by the second estrus post-treatment. Hinds et al. (1961) reported that yearling ewes did not respond as consistently to MAP treatment as did mature ewes.

Neither the number of ewes lambing nor the first estrus conception rates were significantly different between the two groups. Fifteen of the 20 MAP treated ewes lambed, 10 (67 percent) from first estrus conceptions and five from second estrus conceptions. Thirteen of the control ewes lambed, eight (62 percent) from first estrus conceptions and five from second estrus conceptions. All of the ewes that lambed produced single lambs.

SUMMARY AND CONCLUSIONS

A series of six trials were conducted to investigate the use of 6-methyl-17-acetoxyprogesterone (MAP) in modifying the mating pattern of ewes. Four trials were conducted with non-lactating ewes during spring, late summer and fall breeding seasons and two trials were conducted with lactating ewes during spring and fall. The MAP treatment periods were followed by pregnant mare serum (PMS) injections in one trial with lactating ewes and one trial with non-lactating ewes.

In Trial I feeding 60 mg. MAP per ewe daily did not completely suppress estrus in Dorset X Western ewes during a 15 day treatment period preceding the spring breeding season. The same treatment completely suppressed estrus in Merino X Rambouillet ewes during the same period. Even though some of the ewes mated during the treatment period, estrus was effectively synchronized. All the MAP treated ewes mated during a 4 day period as compared to a 24 day period for the control ewes. The variance in occurrence of first estrus was significantly ($P < .005$) less for the MAP treated ewes than for the control ewes. Numbers of ewes were not large enough in this trial to draw firm conclusions from the conception and lambing data.

In Trial II estrus was effectively synchronized in yearling Dorset X Western and Rambouillet ewes after the administration of 60 mg. MAP per ewe daily for 15 days, beginning in October. All the ewes exhibited estrus within 5 days after the last feeding of MAP.

The subcutaneous injection of 500 I.U. PMS per ewe 36 hours after the last feeding of MAP did not significantly increase the number of lambs born from matings which occurred at the first synchronized estrus.

In Trial III the administration of 70 mg. MAP per ewe daily for 17 days to mature ewes, in November during their third and fourth week of lactation, did not significantly influence the variation in occurrence of first post-partum estrus. The average interval from lambing to first estrus was significantly ($P < .05$) longer for the MAP treated ewes than for the control ewes (55.2 days vs. 52.8 days). None of the MAP treated ewes exhibited estrus until 17 days after the end of the treatment period, indicating that ovulation without estrus may have occurred in some of the ewes at the end of the MAP treatment. The MAP treatment did not significantly influence the milk production of the ewes.

The results of Trial IV agreed with those of Trial III in that ewes receiving 60 mg. MAP per ewe daily for 13 days during the first to third week of lactation did not exhibit estrus immediately after the treatment period. Four of 37 ewes mated 22 to 25 days after the end of the MAP treatment period, which began in April. The subcutaneous injection of 500 I.U. PMS per ewe 24 hours after the last MAP feeding did not influence the occurrence of estrus after the MAP treatment. Nine Rambouillet ewes that received both MAP and PMS had ovulated when examined at laparotomy one week after the end of the MAP treatment period. Of eight Rambouillet ewes that received only MAP only one non-lactating ewe ovulated. From the results of this trial April would appear to be a rather inactive breeding period.

In Trial V with 205 mature non-lactating ewes a treatment consisting of 70 mg. MAP per head daily for 16 days during the spring breeding season significantly ($P < .01$) reduced the variation in the occurrence of first estrus during the breeding season, even though the ewes were not allowed to mate until the second synchronized estrus. The average interval from the beginning of the breeding season to first estrus was significantly ($P < .001$) less for the MAP treated ewes. There was no significant difference between the first estrus conception rate nor the lambing rate of the MAP treated and control ewes. The MAP treatment appeared to reduce the lambing rate of the Dorset X Western ewes and increase the lambing rate of the Western ewes, but this interaction was not statistically significant. Fifty-three of the 207 ewes (25.6 percent) in Trial V mated during pregnancy. Significantly ($P < .025$) more of the control ewes than MAP treated ewes mated during pregnancy (35 vs. 18).

In Trial VI feeding 60 mg. MAP per head daily for 12 days to fall born ewe lambs did not significantly reduce the variation in occurrence of first estrus nor significantly shorten the average interval from beginning of the breeding season to first mating during the late summer breeding season.

Estrus synchronization was very effective in three of four trials with non-lactating ewes, at either the first or second estrus following a MAP treatment period. In one trial with 10-month old ewe lambs during the late summer breeding season, estrus synchronization was ineffective at the second post-treatment estrus. A MAP treatment period was not followed by the occurrence of estrus until approximately three weeks post-treatment in two trials with lactating ewes. Although MAP treatment would not appear to be detrimental to lactation, treatments other than those used in this study would appear to be necessary to effectively initiate and synchronize estrus in ewes during early lactation.

LITERATURE CITED

Addleman, Duane and Ralph Bogart. 1963. Hormone treatment for bringing ewes into estrus in early summer. Proc. Western Section Am. Soc. An. Sci. 14:XLVII-1.

Addleman, Duane, Ralph Bogart and Lloyd Wescott. 1963. Synchronization of estrus in ewes by hormone treatment. Proc. Western Section Am. Soc. An. Sci. 14:XLVI-1.

A.S.A.P. 1960. Techniques and Procedures in Animal Production Research. American Society of Animal Production.

Botkin, M. P. and G. E. Nelms. 1963. Synchronization of estrus and lambing in ewes. Proc. Western Section Am. Soc. An. Sci. 14:XLIX-1.

Brunner, M. A., William Hansel and D. E. Hogue. 1964. Use of 6-methyl-17-acetoxyprogesterone and pregnant mare serum to induce and synchronize estrus in ewes. J. Animal Sci. 23:32.

Cole, H. H. and R. F. Miller. 1935. Changes in the reproductive organs of the ewe with some data bearing on their control. Am. J. Anat. 57:39.

Combs, Weslie, M. P. Botkin and G. E. Nelms. 1961. Synchronization of estrus and lambing in ewes fed 6-methyl-17-acetoxyprogesterone. J. Animal Sci. 20:968. (Abstr.).

Denny, J. E. F. M. and G. L. Hunter. 1958. Synchronization of the oestrous cycle in sheep. South African J. Agr. Sci. 1:381.

Dutt, R. H. 1953. Induction of estrus and ovulation in anestrual ewes by use of progesterone and pregnant mare serum. J. Animal Sci. 12:515.

Dutt, R. H., and L. E. Casida. 1948. Alteration of the estrual cycle in sheep by use of progesterone and its effect upon subsequent ovulation and fertility. Endocr. 43:208.

Evans, J. S. and R. H. Dutt. 1962. Induction of reproductive activity in anestrous ewes by use of oral progesterones and pregnant mare serum. J. Animal Sci. 21:1022. (Abstr.).

Evans, J. S., R. H. Dutt and E. C. Simpson. 1962. Breeding performance in ewes after synchronizing estrus by feeding 6-methyl-17-acetoxyprogesterone. J. Animal Sci. 21:804.

Ferin, J., J. Charles, G. Rommelart and A. Benselinck. 1964. Ovarian inhibition during lactation. Int. J. Fert. 9:41.

Foote, W. D., E. R. Hauser and L. E. Casida. 1960. Influence of progesterone treatment on post-partum reproductive activity in beef cattle. J. Animal Sci. 19:674.

Foote, W. C. and Doyle J. Matthews. 1962. Effects of progesterone injection on synchronization of estrus and on subsequent fertility in the ewe. Proc. Western Section Am. Soc. An. Sci. 13:VII-1.

Fosgate, O. T., N. W. Cameron and R. J. McLeod. 1962. Influence of 17-alpha-hydroxyprogesterone-n-caproate upon post-partum reproductive activity in the bovine. J. Animal Sci. 21:791.

Gassner, Frank X. 1952. Some physiological and medical aspects of the gonadal cycle of domestic animals. Rec. Prog. Hor. Res. 7:165.

Gordon, I. 1958a. Hormones and sheep fertility. II. Out of season breeding. Agr. Rev. 3:12.

Gordon, I. 1958b. The use of progesterone and serum gonadotrophin (P.M.S.) in the control of fertility in sheep. II. Studies in the extra-seasonal production of lambs. J. Agr. Sci. 50:152.

Gordon, I. 1963. The induction of pregnancy in the anoestrous ewe by hormonal therapy. II. Progesterone-pregnant mare's serum applications in anoestrus. J. Agr. Sci. 60:43.

Grant, R. 1934. Studies on the physiology of reproduction in the ewe. I. The symptoms, periodicity, and duration of oestrus. Trans. Royal Soc. Edinburgh. 58:1.

Hafez, E. S. E. 1952. Studies on the breeding season and reproduction of the ewe. Part II. The breeding season in one locality. J. Agr. Sci. 42:189.

Hammond, J., Jr. 1944. On the breeding season in the sheep. J. Agr. Sci. 34:97.

Harrington, Rodney B. 1963. A study of some of the relationships between ewes and the growth of their lambs. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Hinds, F. C., P. J. Dziuk and J. M. Lewis. 1961. The synchronization of estrus in sheep. J. Animal Sci. 20:972. (Abstr.).

Hogue, D. E., Wm. Hansel and R. W. Bratton. 1962. Fertility of ewes bred naturally and artificially after estrous cycle synchronization with an oral progestational agent. J. Animal Sci. 21:625.

Hulet, C. V., R. L. Blackwell, S. K. Ercanbrack, D. A. Price and R. D. Humphrey. 1961. Effects of feed and length of flushing period on lamb production in range ewes. Proc. Western Section Am. Soc. An. Sci. 12:LXXV-1.

Kelley, R. B. 1946. Studies on the breeding performance of ewes. Australian Council Sci. Ind. Res. Bul. 205.

Kelley, R. B. and H. E. B. Shaw. 1943. Fertility in sheep. Australian Council Sci. Ind. Res. Bul. 166.

Lamond, D. R. 1962a. Oestrus and ovulation following administration of placental gonadotrophins to Merino ewes. Australian J. Agr. Res. 13:707.

Lamond, D. R. 1962b. Effect of season on hormonally induced ovulation in Merino ewes. J. Reprod. Fert. 4:111.

Lamond, D. R. 1964. Quantitative studies of the interaction between progesterone and pregnant mare serum on ovarian function in the ewe. J. Reprod. Fert. 7:171.

Lamond, D. R. and B. M. Bindon. 1962. Oestrus, ovulation and fertility following suppression of ovarian cycles in Merino ewes by progesterone. J. Reprod. Fert. 4:57.

Lamond, D. R. and L. J. Lambourne. 1961. Suppression of oestrus in sheep with progesterone. Australian J. Agr. Res. 12:154.

Lishman, A. W. and G. L. Hunter. 1961. Synchronization of the oestrus cycle of sheep. II. Administration of progesterone daily or at three-day intervals. South African J. Agr. Sci. 4:35.

McDonald, M. F. 1961. Studies of the response of the anoestrous ewe treated with progesterone and pregnant mare serum. J. Agr. Sci. 56:397.

McKenzie, Fred F. and Ralph W. Phillips. 1930. Some observations on the estrual cycle in the sheep. Proc. Am. Soc. An. Prod. 23:138.

McKenzie, Fred F. and Clair E. Terrill. 1937. Estrus, ovulation and related phenomena in the ewe. Mo. Agr. Exp. Sta. Res. Bul. 264.

O'Mary, C. C., A. L. Pope and L. E. Casida. 1950. The use of progesterone in the synchronization of the estrual periods in a group of ewes and the effect on their subsequent lambing records. J. Animal Sci. 9:499.

Phillips, R. W., R. M. Fraps and A. H. Frank. 1945. Hormonal stimulation of estrus and ovulation in sheep and goats. Am. J. Vet. Res. 6:165.

Phillips, William A. 1937. The inhibition of estrous cycles in the albino rat by progesterone. Am. J. Physio. 119:623.

Pursel, V. G. and E. F. Graham. 1962. Induced estrus in anestrous ewes by use of progestogens and follicle stimulating hormone. J. Animal Sci. 21:132.

Riches, J. H., and R. H. Watson. 1954. The influence of the introduction of rams on the incidence of oestrus in Merino ewes. Australian J. Agr. Res. 5:141.

Roberts, E. M., B. M. Bindon and P. M. Houlahan. 1963. A preliminary report on regulation of oestrous and fertility in cyclic ewes by an oral administration of 6-methyl-17-acetoxyprogesterone. Australian J. Exp. Agr. An. Husb. 3:78.

Robinson, T. J. 1951. Reproduction in the ewe. Biol. Rev. 26:121.

Robinson, T. J. 1955. Endocrine relationships in the induction of oestrus and ovulation in the anoestrous ewe. J. Agr. Sci. 46:37.

Robinson, T. J. 1961. The time of ovulation and efficiency of fertilization following progesterone and pregnant mare serum treatment in the cyclic ewe. J. Agr. Sci. 37:129.

Robinson, T. J. 1962. Comparative studies of several gonadotrophin, progestin and oestrogen treatments in the anestrous ewe. J. Endocr. 24:33.

Schinckel, P. G. 1954a. The effect of the presence of the ram on ovarian activity in the ewe. Australian J. Agr. Res. 5:465.

Schinckel, P. G. 1954b. The effect of the ram on the incidence and occurrence of oestrus in ewes. Australian Vet. J. 30:189.

Selye, H., J. S. L. Browne and J. B. Collip. 1936. Effect of large doeses of progesterone in the female rat. Proc. Soc. Exp. Bio. Med. 34:472.

Shimizu, Hirokazu and Yuzi Sakuma. 1959. On the out-seasonal production of lambs. I. Hormonal inducing fertility in the anoestrous ewes. Tohoku J. Agr. Res. 10:289.

Shimizu, H., M. Sato and S. Takeuchi. 1962. On the out-seasonal production of lambs. II. Further experiments on the hormaonal induction of fertility in the anoestrous ewes, compared with those of oestrous cycle in breeding season. Tohoku J. Agr. Res. 13:119.

Southcott, W. H., A. W. H. Braden and G. R. Moule. 1962. Synchronization of oestrus in sheep by an orally active progesterone derivative. Australian J. Agr. Res. 13:901.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Thompson, D. S. 1942. A study of the breeding seasons of a group of Merinos and three groups of half-breds at Roseworthy Agricultural College. J. Dept. Agr. South Australia. 45:478.

Tilton, James E. 1964. Factors influencing length of gestation in sheep. M. S. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Underwood, E. J., F. L. Shier and N. Davenport. 1944. Studies in sheep husbandry in Western Australia. V. The breeding season of Merino, crossbred and British breed ewes in the agricultural districts. J. Dept. Agr. Western Australia. 21:135.

Wagner, J. F. and Leon F. Bush. 1961. Orally active progestin in the hormonal control of reproductive activity in the cycling and anestrous ewe. J. Animal Sci. 20:980. (Abstr.).

Wagner, J. F., E. P. Reineke, J. E. Nellor and H. A. Henneman. 1960. Hormonal control of reproductive activity in the cycling and anestrous ewe. J. Animal Sci. 19:607.

Watson, R. H. 1953. Studies on seasonal variation in the level of fertility in Merino ewes. Australian J. Agr. Res. 4:349.

Watson, R. H. and H. M. Radford. 1960. The influence of rams on onset of oestrus in Merino ewes in the spring. Australian J. Agr. Res. 11:65.

Whiteman, J. V. Unpublished data.

Williams, S. M., U. S. Garrigus, H. W. Norton and A. V. Nalbandov. 1956. Variations in the length of estrus cycles and the breeding season in ewes. J. Animal Sci. 15:984.

VITA

Charles W. Nichols

Candidate for the Degree of

Doctor of Philosophy

Thesis: MODIFICATION OF THE MATING PATTERN OF EWES USING SYNTHETIC PROGESTOGENS

Major Field: Animal Breeding

Biographical:

Personal Data: Born near Leakey, Texas, July 10, 1936, the son of Leroy and Susie Nichols.

Education: Received the Bachelor of Science degree, with a major in Animal Husbandry, from Texas A. and M. University, in May, 1958. Received the Master of Science degree, with a major in Animal Science, from Colorado State University, in June, 1961.

Experience: Raised on a ranch in Southwest Texas. Graduate Assistant at Colorado State University, 1958-59; Instructor in Animal Science at Colorado State University, 1959-61; Graduate Assistant at Oklahoma State University, 1961-64.

Professional Organizations: Member of American Society of Animal Science and Associate Member of Society of the Sigma Xi.

Date of Final Examination: September 11, 1964