Factors Influencing The Initiation and Duration of the Breeding Season of the Ewe

HAL B. BARKER

Louisiana Polytechnic Institute

In many areas of the world there are numerour factors involving feeding, management and marketing of sheep which make it necessary to attempt to alter or extend their breeding season. Reports of variation in the time of onset and duration of the breeding season of ewes indicate that genetic, as well as several environmental factors, may affect her breeding behavior. This report has been prepared in an attempt to summarize a portion of the literature pertaining to the influencing factors of breed and strain, age, light, temperature, nutrition, hormones and the psychological effects of the ram.

Breed and Strain:

Estrual activity in sheep varies from the monestrual type exhibited by wild sheep (3) to the completely polyestrual type shown by some domestic sheep (4) (5) (3) (66) (70). However, most breeds of sheep are seasonally polyestrous in that they experience a series of diestrual cycles during a particular season of the year (25). Hafez (34) cited many references which indicated that this difference in sexual behavior among sheep is related to the geographical origin of the breed. In summarizing the literature on the breeding behavior of sheep, Hafez (34) listed thirty-two breeds which have been reported to be completely polyestrual. This extreme polyestrual condition has been observed at the equator and at latitudes varying from 35° N. to 35° S. The most widely recognized breed of sheep observed to manifest sexual activity throughout the year, in certain localities, is the Merino. Quinlan and Mare' (66) stated that Merino ewes, maintained at Cape Karoo in South Africa (latitude 25° S to 35° S) would breed at any season of the year. Similar sexual activity in the Merino breed has been reported by Anderson (cit. Hafez, 34) at Kenya, Africa in an area which is located on the equator. On the other hand Kupfer (46) presented evidence that the Merino and wooled - Persian breeds showed an anestraul period. Quinlan and Mare' (67) in a later study also reported that Merino ewes have an annual period of sexual inactivity. Roux (75) reported that Merino sheep in Eastern Transvaal of South Africa had a restricted breeding season, which commenced in February (summer) and terminated in late August (winter). Opperman (cit. Hafez, 34) reported that the Blackhead Persian breed maintained at Pretoria, South Africa, on a latitude of 26° S, showed year-long estrual activity. Thus it appears that, in certain areas of South Africa, sheep may breed throughout the year, whereas, in other areas of that continent, sexual behavior in the same breeds is restricted to certain seasons of the year.

Sexual activity throughout the year has also been reported for breeds of sheep maintained in other countries, namely the Romanov and Karakul breeds of Russia (34) and the Improved White-Face Mutton sheep of Germany (34) in which the latitude range (41° N to 58° N) exceeds that reported for South Africa where similar year-round breeding accurred. Thus, latitude does not appear to be the only factor which influences the breeding season of sheep. Genetic factors, as well as a host of environmental factors, acting singly, or in combination, have been reported to be at least partially responsible for the reproductive rhythm of sheep (75). Kelly (43) found that Merino ewes, even in seasons of high sexual activity, would often fail to show any external evidences of heat.

Kelly and Shaw (44) reported on the sexual activity in three different strains of Australian Merino ewes. Their data, based on observations made througout the year, showed that very few ewes came into heat during the summer months (late December to early March). Sexual activity increased from a minimal level in late summer to a maximal level within a period of one month.

Further investigation reported by these authors (45) substantiated their previous findings of a summer anestrus in Merino ewes. Underwood, **et al.** (84) stated that in the agricultural areas of Western Australia, the breeding season for Merino sheep commenced in November and December (late spring). This same breed was found to be in anestrus or in a very low state of sexual activity from July to October (mid-winter to early spring). All evidence presented by the Australian workers seems to indicate that Merino sheep show a relatively long estrous season followed by a short anestrous period.

Roberts (70), Marshall (52) and Marshall and Hammond (54) have also reported that in certain limited cases sexual activity in Merino ewes and Dorset Horn ewes is exhibited annually in two distinct sexual seasons.

Marshall (51) began in 1903 to investigate the sexual season of ewes in England. He concluded after several years of investigation that the British breeds exhibited an anestrual period of about 6 months (April through August). Studies conducted in the United States by McKenzie and Phillips (48), McKenzie and Terrill (50), Schott, **et al.** (79), Phillips, **et al.** (62) Sayed **et al.** (76), and de Baca **et al.** (18), also, revealed that the mutton breeds of sheep, which were developed in England, have a restricted breeding season in this country. Underwood and Shier 83) reported that the British breeds also have a restricted breeding season in Australia.

Other studies made in this country have shown that ewes having some fine-wool ancestry will breed earlier in the season than will the mutton breeds (6) (14) (38) (41) (47) (56) (85). Henning and McKenzie (41) reported on the use of Merino, grade Merino, and Dorset X Merino for hot-house lamb production in Pennsylvania. Rams were turned with the ewes on June 18 in the first year and on June 11 in the second year. Schott **et al.** (79), on reworking

the data presented by Henning and MacKenzie, showed that of 100 ewes exposed to breeding, 44 conceived in June, 2 in July and eight ewes conceived in August, September, and October. Six ewes failed to lamb. The above distribution in dates of conception was based on lambing dates. Cole and Miller (14) of California presented data on the time of year at which the sexual season began in several medium-wool breeds and their crosses. Ewes of the mutton breeds were exposed to rams on August 1. Since the interval from exposure to rams to the first observed estrus was shorter than the length of a normal estrual cycle, it is possible that some ewes were cycling prior to the beginning of observations. This was particularly apparent in the Rambouillet ewes in which the ewes were exposed to rams on July 1. The earliest date of first estrus following exposure to the ram was July 6 with an average breeding date of July 18. Miller (56) further demonstrated that Rambouillet ewes were an important factor in early lambing production in California since they breed readily in July Leveck (47) reported that crosses produced from Corriedale (based on Lincoln X Merino breeding) mated with native ewes lambed 14 days earlier than Hampshire X Native and 28 days earlier than Southdown X Native in Mississippi. The average conception date for the three groups, based on birth date, was July 27 for the Corriedale X Native, August 11, for the Hampshire X Native and August 2 for the Southdown X Native. Williams, **et al.** (93) observed the onset of the estrual season on a flock of western ewes (crosses between fine-wool breeds and such breeds as Hampshire, Shropshire and Suffolk), over a 3-year period in Illinois. The flock showed a significantly earlier onset of the breeding season in 1951 (July 8) than in 1952 (August 27) or 1953 (September 1). There was no tendency any year for individual ewes to be consistently early or late in the onsets of their individual breeding seasons. This study, as well as many others (18) (34) (50) (75), lends support to the idea that genes affecting estraul onset are associated with genes for breed characteristics. Even though Williams **et al.** (93) used crossbred sheep only, the dates of estraul onset, as reported by these authors, were somewhat intermediate between those reported for parent bred by other workers (14) (18) (34) (38) located at the same general range of latitude.

Bell (6) published the results of an investigation designed to ascertain if Rambouillet ewes could be bred other than during the fall months in New Mexico. His data showed that over half of the mature ewes could have been bred as early as June. About three-fourths of them were in heat in July and more than 90 percent of them came into heat in August and were bred.

Harris **et al. (38)** presented data on occurrence of estrus in purebred Rambouillet, Columbia and Hampshire ewes during the spring and summer months in Utah. Some ewes of the Rambouillet breed were observed in estrus in May with a progressive increase in percentage of estrual activity during June and July. Ewes of the Columbia and Hampshire breeds showed no estrual activity in May. Only an occasional heat was observed in either of these breeds in June and July.

It appears from the literature examined for this review, that there are breed and strain differences in the onset and duration of the breeding season, and that the same breed may behave differently in different areas.

Age:

Several studies, designed to investigate the economic considerations of breeding ewe lambs also provide data on the age at breeding and the percentage of lambs born. Bowstead (10), in a report on the effect of breeding ewe lambs at 7 to 8 months of age, stated that 24.5 percent of the lambs selected for breeding failed to come in season, or following breeding, failed to produce a lamb. Griswold (29) in a five-year study which involved breeding ewe lambs of a Hampshire X Rambouillet cross, reported 85 percent of the young ewes conceived. A similar study on the effects of breeding ewe lambs by Briggs (8) showed that of 122 ewe lambs bred, approximately 66 percent dropped live lambs. Another 19 percent conceived but aborted or dropped dead lambs. Only 15 percent failed to conceive. Cole and Miller (14) reported that the sexual season in ewe lambs was much shorter than for mature ewes. In several cases the season consisted of only one estrus.

McKenzie and Terrill (50) reported significant differences in the onset and duration of estrus between ewe lambs and yearling ewes of Hampshire and Shropshire breeding. The mean date of onset of the breeding season for the same year (1934) for Hampshire lambs was October 23, as compared to September 12 for mature Hampshire ewes. The mean date for the end of the breeding season for the two groups were, ewe lambs, December 21 and mature ewes, February 7. The average date of onset of the breeding season for Shropshire lambs was October as compared with September 11 for mature Shropshire ewes. No dates on the termination of the breeding season were given for these groups of Shropshires. Schott, **et al.** (79) presented a comparison of the average date of first estrus in mature and yearling ewes of several breeds. In all breeds the yearling ewes tended to show the first estrus approximately one week later than the mature ewes. Spencer, **et al.** (81)reported that during an eight-year period, 1929-1936, 119 Hampshire ewes were exposed to breeding as lambs. Approximately 70 percent produced lambs. The breeding season began in December when the lambs were 9 to 10 months of age.

Quinlan and Mare (66) reported that Merino sheep maintained in the southern part of the union of South Africa were observed to exhibit sexual activity at 9 to 10 months of age. Roux (75) presented information on the age of puberty of Border Liecester X Merino crossbreds and Merino in the Transvaal, a northeastern area, of South Africa. Ninety percent of the Border Liecester X Merino crossbreds were sexually mature at 19 months of age. Only 40 percent of the Merino of comparable

age were sexually mature. Both groups experienced a restricted sexual season of 50 to 75 days. Hammand (35) found that in lambs 300 days of age the breeding season began about the same time as in mature ewes. In those that were younger, the season began later. The breeding season in lambs younger than 180 days was delayed until the next season. Bell (6) found that the appearance of the first heat in 20 Rambouillet ewe lambs that were born in January occurred in August. All ewe lambs in this study had come in heat by the end of November. Hafez (34) also reported that there was a relationship between the month of birth and estrous performance. Ewes born early in the season showed more sexual activity than those born late in the season. Limited estrual activity occurred in range ewe lambs from September to February as reported by Wiggins (92). In a three-year period of observation, 15 percent of April and May-born lambs were observed to be in heat. Of the total number observed approximately 62 percent exhibited one heat; 25 percent, two heats; and 3½ percent, three heats.

Light:

Evidence has been presented which indicates that length of daylight may be a contributing environmental factor in controlling the breeding season of sheep. Marshall (53) observed that sheep transported from one hemisphere to another reversed their seasonal breeding pattern. Several groups of investigators, Sykes and Cole (82), Yeates (95), (97, and Hart (39), have reported that the sheep can be brought into estrus by a reduction in amount of light.

Yeates (95) found that in Suffolk ewes the breeding season started 10 to 14 weeks after the longest day and that the season ended 14 to 19 weeks after the length of day began to increase. Hart (39) was able to initiate the breeding season in ewes through a ration of one part light to two parts dark wihout employing any gradual decreasing scheme. Hammond, Jr., (35) reported that there was a variation from year to year among several British breeds in the onset and termination of the estrual season but generally the season was evenly spaced from the shortest day of the year (December 21).

Eaton and Simmons (22) introduced Karakul sheep into an experiment with goats designed to determine the effect of length of day on the estrous periods of these animals and thereby explore the possibility of fall lamb production. The sheep were subjected to long days of light (18 hours) beginning in December or January. In February or March they were shifted to short days of light (6-10 hours). The percentage of ewes subjected to controlled lighting that were bred during the months of April, May and June was 85.7. In the control group the percentage of breeding was 44.7.

Watson (91) reported that Merino ewes in Australia do not always show a complete anestrual period. However, with some of those which do, the behavior is different from that of Suffolks and similar British breeds. Watson's observations made in Queensland and Western Australia on the onset of estrus showed that it occurred some time before December 22 (the longest day in Australia). He further stated that if the duration of daylight in the current season was the influence which controlled the annual rhythm, the regime must be entirely different from that which controlled the activity of the British breeds reported by Yeates (95), Hart (39) and Hafez (33) and the Karakul breed reported by Eaton and Simmons (22)

Hafez (32) presented data on the occurrence of estrus in a group of Dorset Horn ewes, in England, which were run continuously with vasectomized rams for a period of three years. None of the ewes exhibited estrus during May, but some began to do so in June. Apparently sexual activity began to rise in ewes of this breed close to the longest day.

Yeates (95) reported on the effect of light on the breeding season of Peppin strain Merino sheep in Australia. These sheep exhibited definite seasonal differences in incidence of estrus. Although less decisively, the estrual pattern resembles that of the British breeds. He was able to reverse the pattern of breeding by artificially reversing the seasonal trend in amount of daylight.

Means **et al.** (55) reported that the reduction of daylight to 10 hours during the non-breeding season (March 15 to July 15) was effective in the induction of estrus but that fertility as measured by actual lambing was low. Similar results were obtained when day length was reduced during the early part of the normal breeding season (July 15 to September 17).

Wilson, **et al.** (94) presented data which indicated that ewes receiving treatments of light reduction, temperature reduction and combinations of the two exhibited a higher degree of estrual activity than did control ewes.

It appears in many cases that variation in length and intensity of daylight which occurs in the different seasons has been a factor involved in the onset of the breeding season. However, with the change in season there is also fluctuations in other environmental factors such as temperature, humidity and rainfall which in some cases have been shown to influence reproductive activity, directly or indirectly. Consequently, as suggested by Nalbandov (59) it is very difficult to measure the direct influence that light alone might have on initiating the breeding season and controlling its duration.

Temperature:

The onset of the breeding season of the ewe may be influenced by temperature.

McKenzie and Phillips (49) placed seven ewes in an ice cellar, in which the temperature ranged from 44° F to 48° F, during the first ten days of August. Outside temperatures ranged from 70° F at night to 95° F during the day. As compared with controls, there were no significant differences in the time of estrual onset between the two groups. The experiment was repeated in September and the same results were reported.

Yeates (96) reported on studies involving the effect of high air temperatures on pregnancy and

birth weight in Romney and Merino ewes. Even though he showed pregnancy to be adversely affected by extremely high atmospheric temperature, all ewes in the heated chambers showed estrus at the same time of the year as those of the non-heated controls.

Dutt and Bush (21), in a temperature-controlled experiment, placed 20 Hampshire X Western cross bred ewes in a 45° to 48° F temperature room on May 26. A control group was placed in a room of similar size and subjected to natural temperature. Both groups remained in their respective rooms until October 8. The average date of first estrus for the treated ewes was July 10 (range May 31 - August 8) as compared with September 2 (range August 13 - Stepember (22) for the control ewes. All ewes in the experimental group came in heat before there was any evidence of sexual activity in the control group. There was a definite pattern of normal sexual activity among ewes in the air-conditioned room since it was noted that estrus occurred regularly in ewes that did not conceive. Wilson **et al.** (94), reported that a greater number of ewes exhibited estrus when maintained in an air-conditioned room than a similar group of control ewes. The temperature at the beginning of the experimental period was 70° F and was dropped 1° F every five days to a 60° F temperature.

Nutrition:

The literature regarding the effect of nutrition on the onset and duration of the breeding season in sheep is somewhat conflicting. Heape (40) and Marshall (52) based upon surveys from English flockmasters reported that an improvement in the plane of nutrition induced estrus. McKenzie and Phillips (49) reported that nutrition seemed to influence markedly the onset of the breeding season in several of the Down breeds. Ewes were maintained on very poor dry pasture from early July to mid-August, after which, the ewes were placed on an increasing plane of nutrition, first, on improved pasture and then on grain. Over 97 percent of the ewes had exhibited estrus by mid-September. These authors further reported that a day's starvation period during early part of the breeding season had no noticeable effect on the onset of the first estrus of the season.

Darlow and Hawkins (16), (17) in early reports of a long study designed to investigate the influence of nutrition on the reproduction of ewes, presented evidence indicating that ewes fed green feed began their breeding season sooner than a comparable group of ewes fed Prairie hay. This work was continued over a nine-year period and was reported by Briggs, **et al.** (9). These authors concluded that there was no difference between flushed and unflushed lots as to the time of the first estrus period of the season. Visual signs of heat were not apparent in a few ewes that had reached an emaciated condition but in some cases a low level of nutrition apparently caused a doubling of heat periods.

Grant (27), in a study of the physiology of reproduction, presented evidence that flushing hastened the onset of the breeding season by changing silent heats at the beginning of the breeding season into true heats.

Roux (75) reported on rather extensive studies concerning the influence of nutrition upon the sexual activity of non-pregnant Merino ewes. Sheep maintained on low-level rations of maize, teff hay and salt did not show marked decrease in sexual activity during the first 7 to 12 months of treatment. They declined in sexual activity after 19 to 24 months on such a feeding plan. The addition of bone meal prevented a marked reducation in the duration of the sexual season, but its inclusion in the ration did not insure sexual activity. The sexual activity of mature ewes on low-level rations was not as readily affected as it was in younger ewes. Roux also reported that when sheep were permitted green grazing throughout the year that an almost constant body weight was maintained. These ewes showed more sexual activity than under drought conditions. Even though improved nutrition tended to induce greater sexual activity and to shorten the duration of the anestrus period, all ewes under conditions of the Transvaal area of the Union of South Africa had a restricted breeding season. Miller, **et al.** (57) stated that advanced stages of Vitamin A deficiency were necessary before a supression of estrus and ovulation occurred.

The results of work reported by Esplin, **et al.** (24) Phillips, **et al.** (63) indicate that the diet of the ewe lamb during the first winter is a critical factor in determining the reproductive capacity during the following year.

Esplin, **et al. (24)** reported that 77 percent of ewes that had been lot-fed as lambs gave birth to lambs whereas only 64 percent of the ewes grazed on range as lambs gave birth to lambs. The authors suggested that the feeding which ended six or seven months before breeding must have been the factor which accounted for the difference in lambing rate. Phillips, **et al.** (63) reported similar findings. In addition to information on lambing percentages, more detailed information on estrual activity was presented. Four out of seventeen ewes carried on range during the first winter failed to show estrus during the succeeding fall season as compared with one out of sixteen ewes that received extra feed during the first winter. On the contrary, DeBaca (18) found that ewe lambs fed during their first *winter* did not exhibit estrus any earlier during their yearling breeding season than did a similar non-fed group.

Underwood and Davenport (84) stated that a high plane of nutrition did not hasten the onset of the breeding season. Hafez (34) reported that the onset of the breeding season was not delayed as a result of a sub-maintenance ration, if this were started two months before the expected onset. However, estrus was inhibited by sub-maintenance rations after the normally expected onset as evidenced by the occurrences of silent heats. The sub-maintenance diet resulted in a greater depression of estrus in yearlings than in adult ewes. Changing the ration to an above-maintenance requirement resulted in a rapid recovery. Regular estrus also fol-

lowed after the administration of Pregnant Mare Serum (PMS) which, according to the author, indicated that under sub-maintenance conditions that the pituitary activity was below the threshold for estrus or that the ovaries are less sensitive to the level of circulating hormones.

According to Ershoff (23), who reviewed the literature on nutrition and the secretory rate of the anterior pituitary, considerable data are available to indicate that the function of the anterior pituitary and the target organs of its secretion are largely dependent on the nutritional state and the composition of the diet fed in many different groups of experimental animals. He further stated that with laboratory animals the nutritional status, resulting either from an excess or a deficiency, may profoundly affect (1) the synthesis and secretions of hormones, (2) the response of the target organs and peripheral tissues and (3) the metabolism and excretion of hormonal substances. Since there is much indication of temporary fluctuations in endocrine balance within the ewe's body, it seems as though the role exerted by nutritional factors on the level of hormone production, as well as responses by target organs, needs further investigation.

HORMONES:

The possibility of stimulating estrus and ovulation in the anestrous ewe through the use of hormones has received much attention. In the ewe the onset of the breeding season appears in many cases to be a gradual process. It appears that the level of endocrine activity might be partly responsible for this phenomenon.

The subject of hormonal stimuation of estrus and ovulation in sheep was reviewed by Phillips, **et al.** (62) and Robinson (72) who pointed out extremely variable results from the use of hormones to induce preganancy in the anestrual ewe.

The use of gonadotrophins and steroid sex hormones to initiate estrual activity in the anestrual ewe has met with varying degrees of success with many different breeds that vary somewhat in their natural breeding seasons. In the ewe ovulation that is unaccompanied by estrus (silent heat) has been shown to occur prior to the beginning of seasonal breeding activity. Grant (27), Cole and Miller (14), McKenzie and Terrill (50), Parkes and Hammond (61).

Cole and Miller (13) reported that ovulation could be produced in the quiescent ovary of the anestrual ewe. A single dose of PMS caused ovulation with considerable regularity; however, neither a single injection nor a series of daily injections were adequate to produce heat. A second injection following an interval of time approximately equal to the length of a normal cycle produced heat. A further report by Cole and Miller (14) indicated that heat could be induced concurrently with ovulation in recently suckled ewes when PMS was given followed two days later with an estrogen treatment. McKenzie and Terrill (50) treated 11 ewes during anestrus (April, May and June) with 300 to 400 r.u. of PMS. Ovulation took place in 5 ewes but only one ewe came into heat. Thus they failed to achieve the hormonal control of estrus and concurrent ovulation with any degree of regularity.

In a more extensive study covering an eleven year period and involving more than 300 ewes, Cole **et al.** (15) concluded that hormonal control of estrus in the anestrus ewe could not be recommended since only 7 per cent of the ewes came in heat after one injection of 125-700 i. u. of PMS and none conceived. Following two injections 34 percent exhibited estrus but only one-third of these (about 11 percent of the total) conceived. Throughout the period of experimentation a complete response of estrus and ovulation was not produced with any degree of regularity.

Phillips **et al.** (62) cited a report on the field use of PMS on anestrous ewes of Rambouillet X Lincoln breeding. Of 430 ewes receiving a single injection of 250 r. u. of PMS in early May, 97.2 percent lambed before January 31. Another group of 40 ewes received 2 injections of PMS at sixteen-day intervals during May, resulting in a lambing percentage of 75 per cent. In a control group of 296 ewes, 26 per cent had lambed by the end of January indicating that not all the ewes were in anestrus at the time of PMS administration. Further evidence that the effect of gonadotrophic preparations to stimulate estrus and ovulation in the anestrual ewe depends upon the relative state of activity of the ovary was presented by Kelly and Shaw (45), who reported relatively successful results in inducing heat in Merino ewes with a single gonadotrophic treatment. These ewes were exhibiting limited natural estraul activity or were in the early period of anestrus. Casida **et al.** (12) reported that gonadotropic extract, when administered to ewes at three different stages of the estrual cycle, was not very effective in controlling the time of estrus. Wallace (88) suggested that breed and strain differences might be of considerable importance in governing the extent of the response from PMS treatment. Despite the few isolated reports that a single gonadotrophic treatment will produce concurrent heat and ovulation, the general experience of all investigators mentioned as well as that of Bell **et al.** (7), Underwood and Shier (83), Frank and Appleby (25), Quin and Van Der Wath (65), several Russian investigators (as cited by Phillips **et al.** (62) and van der Nott **et al.** (86) has been that a single injection of gonadotrophin produces ovulation without heat. Murphree **et al.** (58) treated anestrual ewes with follicle-stimulating-hormone extract or pregnant mare serum to determine the possibility of producing fertilized eggs. The proportion of corpora lutea was lower in anestrual ewes than in follicular ewes in which treatment was initiated 12 days after the beginning of an estrus period.

The steriod sex hormones, estrogen, and progesterone have been used in various combinations with the gonadotropins in attempts to produce physiologically normal heat and ovulation. Estrogen alone will, in general, cause heat without ovulation.

McKenzie and Terrill (50) produced estrus in 23 of 44 anestraul ewes with a single injection of 800 r. u. of estradiol benzoate (progynon-B). Anderson

(1) treated high-grade Merino ewes with estradiol benzoate and produced estrus in approximately 74 percent of those treated. Estrus was not always accompanied by ovulation. He further reported ovulation without estrus in untreated ewes during the anestrual period. Phillips **et. al.** (62) cited work by August who treated over 4,000 anestrual ewes with 10,000 to 15,000 I. u. of estradiol benzoate which resulted in 72.5 percent mating which occurred 3 to 7 days after hormone injection.

Less favorable results on the use of estrogenic hormones in causing estrus and ovulation in anestrual ewes have been reported by Cole and Miller (15), Hammond, **et. al.** (36), (37), Quin and Van Der Wath (65), Van der Noot **et. al.** (86).

Pre-treatment with progesterone has revealed more promising results in synchronizing estrus and ovulation. The first attempt by Hammond (36) was ineffectual probably due to very low doses (2-5 mg) used. This observation was also made by Robinson (71). Subsequently, Robinson (72), (73) reported estrus with concurrent ovulation in anestrous ewes He suggested in the latter report that a short three-day period of progesterone pre-treatment prior to injection of PMS on the fourth day was necessary to induce both estrus and ovulation. The author suggested that progesterone was necessary to condition the animal to respond to ovarian estrogen. Robinson (72) cited work by Polovceva and Judovic in which it was demonstrated that tonic uterine contractions normally present at estrus were absent at PMS-induced ovulations without estrus. Robinson suggested the possibility that uterine motility may play a role in sexual receptivity and offered this as a possible mode of action of progesterone. O'Mary **et al.** (60) reported that variation in the breeding time of ewes could be reduced when progesterone was administered for 14 days of the estrual period.

Dutt (19) (20) presented data on the effects of progesterone and PMS, alone and in combination, on producing concurrent heat and ovulation in the anestrual ewe. None of the ewes came into estrus when PMS was injected without previous progesterone treatment. When progesterone was injected for a period of 10 days prior to PMS, synchronous estrus and ovulation occurred in all ewes. Synchronous estrus and ovulation occurred in some ewes injected with progesterone for shorter periods before PMS injection. Treatment with progesterone alone for a period of 15 days resulted in synchronous estrus and ovulation in 4 out of 9 ewes. Robinson concluded that an alternate progesterone—estrogen influence was necessary for regular cyclic estrous behavior in the ewe. Following the investigations by Dutt (19) and Robinson (17) on progesterone - PMS therapy as a possible practical way of controlling the breeding season of the ewe. Gordon (30) (31) presented data on experiments involving 189 ewes over four non-breeding seasons on estrus and ovulation response in relation to treatment with various combinations of progesterone and PMS. He reported no difference in estrual response in ewes receiving progesterone over a 13-day period as compared with those treated over a five-day period. Of 172 reproductive tracts which were examined for ovulation, all had ovulated. Forty-one of the ewes which came into estrus were slaughtered 41-121 hours after estimated onset of estrus. Seventy-six of the 92 ova shed by the animals were recovered of which approximately 81 percent were cleaved. Forty-eight of the ewes which came into estrus following progesterone—PMS treatment were slaughtered 20-22 days after mating. Sixty-seven percent of these ewes possessed one or more apparently viable embryos. Averill (2) injected progesterone and PMS during anestrus into 94 ewes of various breeds. Estrus and ovulation occurred in 74 percent of the ewes, estrus without ovulation in 5 percent and ovulation without estrus in 21 percent. Wagner **et. al** (87) reported that in the anestrous ewe the optimum interval necessary between injection of progesterone and PMS to induce follicular growth, ovulation, and estrus was 16 days. Braden **et al.** (11) presented data indicating that estrus and ovulation were synchronized by a 14-day course of progesterone injection followed by injections of pregnant mare serum and human chorionic gonadotrophin.

Several investigations have been reported in an attempt to associate the breeding and non-breeding seasons of sheep and the results of hormone administrations with the gonodotrophic secretory activity of the anterior pituitary gland. Warbritton and McKenzie (89) concluded from a cytological study of pituitary glands from sixty ewes in different phases of the estrual cycle that variations in the rate of synthesis of FSH might be the cause of the seasonal breeding behavior. Robinson (72) believed that the anestrus period was due to a decrease in secretary activity. On the other hand Cole and Miller (15) compared pituitary potency of sheep in different reproductive states and stated that pituitary potency did not vary significantly during the anestrous period, the estrual cycle or pregnancy.

Warwick and McKenzie (90) presented data showing that the pituitary gland of anestrual ewe was comparable to the breeding season in content of the gonodotrophic hormone complex. In the study reported by Warwick the gondotrphic potency of pituitary glands from crossbred Lincoln-Rambouillet ewes was significantly higher than that of pituitaries from purebred Hampshire ewes. The gonadotrophic potency of both breeds increased markedly during a ninety day period following spaying whether during the breeding season or during anestrus.

Kammlade **et al.** (42) measured the total gonadotrophic potency of pituitaries of sheep during the non-breeding and the breeding season. They assayed the pituitaries from one hundred and ten black-face-cross-bred western ewes for gonadotrophic hormone, and found the pituitaries contained more gonadotrophic hormone during the anestrual season than they did during the estrual season. An increase in hormonal potency of a gland might result either from increased production of a hormone or decreased secretion. This cannot be determined by any biological assay method. The assay method

employed by Kammlade **et al.** did not distinguish between the different components of the gonadotrophic complex. These authors suggested that the anestrous condition in sheep is caused by a shift in the ratio of FSH and LH with greater FSH as manifested by a cyclic pattern of follicular growth during anestrus. Evidence for this belief was ovarian activity. In spite of this follicular growth heat and ovulation did not occur spontaneously but could be caused to occur with exogenous LH.

Based on the literature reviewed it appears that the sexual cycle of the ewe involves the action and interaction of a number of hormones, the balance of which is exceedingly critical. Greater success will come with knowledge of quantitative relationships of various hormones and their interactions with one another. By use of combinations of hormones administered in physiological amounts, and at physiological time intervals, the problem of the seasonal breeding of the ewe may ultimately be solved.

Psychological Effect:

It has been shown that the sudden association of the sexes which occurred when Merino ewes were mated in late spring and early summer (November and December) in Australia led to the synchronization of estrus in a high proportion of ewes (26) (84).

Schnikel (77) studied the effects of the presence of the ram on ovarian activity in the ewe and concluded that the primary action was to stimulate ovulation without estrus in the majority of those ewes that had already commenced cyclic breeding activity. This effect occurred six days after joining the rams with the ewes. In a later paper Schnikel (78) suggested that the presence of the ram led to the synchronization of estrus cycles when ewes were mated early during the breeding season. Later in the season the presence of the ram had no effect. Teasing ewes with vasectonized rams prior to joining them with fertile rams did not increase conception rate.

Two series of observations were reported on the effect of the presence of the ram on the incidence of estrus in Merino ewes by Riches and Watson (69). One group was designated as the continuous group which were run continuously with vasectomized rams and another group as the changing group, the ewes of which had been held separate from rams except for a period of one month only. In all except the spring months most of the ewes of both the continuous and changing group exhibited estrus. In one year most of the ewes of the changing group exhibited estrus but many in the continuous group failed to do so. In another year most ewes of both groups failed to exhibit estrus during the spring months but the percentage of estrual activity in the changing group was significantly higher than for those in the continuous group. The authors suggested that this behavior must be attributed to the difference in the previous associations with rams.

Radford and Watson (68) reported on estrus and ovulation in Merino ewes, following the introduction of vasectomized rams at various times during the spring and early summer. The ewes were in anestrus when the observations were commenced.

Except in occasional ewes estrus did not appear until early December (late spring). It had occurred in most ewes by early January (early summer). In most ewes among which rams were introduced on October 26 or November 18, estrus occurred one week earlier than in ewes among which rams were not introduced until December 8, and ewes among which rams had been running continuously.

The authors further reported massive desquamation of the vaginal epithelium between 3 and 6 days after the introduction of rams on December 8 although estrus did not occur until 2-4 weeks later. They concluded that the introduction of the ram had an immediate stimulating influence on activity in the reproductive tract.

Smith **et. al.** (80) also presented evidence to indicate that the presence of the ram stimulated reproductive activity in the ewe at the time of transition from the non-breeding to the breeding season.

The manner in which the presence of the ram acts to initiate such sexual behavior has not been elucidated. Schinckel (78) suggested that the presence of the ram may take the form of an exteroceptive factor which stimulates the hypothalmus and hypophysial portal vessels in the anterior pituitary leading to the production of sufficient gonadotrophins to bring about maturation and ovulation in the more advanced follicles.

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EDITOR'S NOTE: This comprehensive literature review has been prepared as a basis for future publication based on research by the author at La. Polytechnic Institute on some of the specific problems in sheep breeding.

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Ralph Vorhies, Instructor
Fruit Production, Crops Department
Cal Poly, San Luis Obispo

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For Whatever It Is Worth

The following is quoted from ACTA DIURNA, Vol 12, Number 9, University of Houston, November 1, 1961.

> **"Changes in Programs offered at UH announced.** The discontinuation of nine programs in the College of Technology and the Department of Agricultural Economics in the College of Business Administration has been announced by Dr. Philip G. Hoffman ,president of the University of Houston. The changes will be effective by September 1, 1963.