The effect of flushing on reproductive performance of ewes managed under range conditions
by Arthur S Hoversland

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Animal Industry
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Abstract:
The trial reported herein was initiated to study the effect of supple mental feeding range ewes prior to and during breeding (flushing) on their subsequent reproductive performance and productivity. The experimental an imals consisted of a band of grade, whiteface ewes. Of a total of 2902 ewe-years, 2232 ewe-years are represented by mature ewes and 670 ewe-years are represented by two-year-old ewes. Supplemental feeding at the fate of one-half pound per head per day did not insure body weight gain. Significant differences in weight gain resulted due to treatment, years and year x treatment interaction. The weight advantage acquired by the flushed ewes during the flushing period was retained to a high degree during the entire pregnancy period.

On the average, over the three-year period flushing resulted in a reduced proportion of single births, an increased proportion of multiple births, an increased lambing percent based on ewes bred and alive at lambing and an increased lambing percent based on ewes lambing. This occurred in both age groups.

The increases and reductions in the factors aforementioned occurred consistently in Case of the mature ewes but not for the flushed two-year-old ewes. In addition, among the mature ewes, flushing consistently resulted in a decreased proportion of barren ewes. The frequency distribution of birth types among flushed two-year-old and mature ewes was significantly different than that of the controls. Ewes that gained weight during the experimental period reproduced at a higher rate in both age groupings as compared to the ewes that lost weight during this same period. Among mature ewes, the greater the gain in weight during the flushing period, the higher the reproductive fate the following spring. There was no indication that this phenomenon occurred among two-year-old ewes.

Flushing consistently Increased grease fleece weights in both age groupings in the amount of 0.30 and 0.28 pounds for the two-year-old and mature groupings, respectively. Flushing also increased the average pounds of lamb weaned per ewe bred in the amount of 3.6 and 4.9 pounds for the two-year-old and mature age groupings, respectively. This increase was consistent among the flushed mature ewes but not among the two-year-oId ewes. Flushing tended to hasten lambing, in both age groupings, resulting in an earlier average lambing date as compared to the controls. The data indicate that two-year-old ewes respond to a flushing program quite differently than do mature ewes. In addition, the reproductive fate and average lamb production of two-year-old ewes was considerably lower than for the mature ewes.

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THE EFFECT OF FLUSHING ON REPRODUCTIVE PERFORMANCE OF EWES MANAGED UNDER RANGE CONDITIONS

by

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ABSTRACT

The trial reported herein was initiated to study the effect of supplemental feeding range ewes prior to and during breeding (flushing) on their subsequent reproductive performance and productivity. The experimental animals consisted of a band of grade, whiteface ewes. Of a total of 2902 ewe-years, 2232 ewe-years are represented by mature ewes and 670 ewe-years are represented by two-year-old ewes. Supplemental feeding at the rate of one-half pound per head per day did not insure body weight gain. Significant differences in weight gain resulted due to treatment, years and year x treatment interaction. The weight advantage acquired by the flushed ewes during the flushing period was retained to a high degree during the entire pregnancy period.

On the average, over the three-year period flushing resulted in a reduced proportion of single births, an increased proportion of multiple births, an increased lambing percent based on ewes bred and alive at lambing and an increased lambing percent based on ewes lambing. This occurred in both age groups.

The increases and reductions in the factors aforementioned occurred consistently in case of the mature ewes but not for the flushed two-year-old ewes. In addition, among the mature ewes, flushing consistently resulted in a decreased proportion of barren ewes. The frequency distribution of birth types among flushed two-year-old and mature ewes was significantly different than that of the controls. Ewes that gained weight during the experimental period reproduced at a higher rate in both age groupings as compared to the ewes that lost weight during this same period. Among mature ewes, the greater the gain in weight during the flushing period, the higher the reproductive rate the following spring. There was no indication that this phenomenon occurred among two-year-old ewes.

Flushing consistently increased grease fleece weights in both age groupings in the amount of 0.30 and 0.28 pounds for the two-year-old and mature groupings, respectively. Flushing also increased the average pounds of lamb weaned per ewe bred in the amount of 3.6 and 4.9 pounds for the two-year-old and mature age groupings, respectively. This increase was consistent among the flushed mature ewes but not among the two-year-old ewes. Flushing tended to hasten lambing, in both age groupings, resulting in an earlier average lambing date as compared to the controls. The data indicate that two-year-old ewes respond to a flushing program quite differently than do mature ewes. In addition, the reproductive rate and average lamb production of two-year-old ewes was considerably lower than for the mature ewes.

INTRODUCTION

Range livestock production is a major industry in the western range area. Due to the peculiarities of soil, topography and limited precipitation, range livestock production will undoubtedly remain an important segment of the economy of this vast area.

Our economy today demands efficient production. If livestock production is to compete with other agricultural enterprises it must increase efficiency of production. One means of increasing efficiency of production is to increase the reproductive rate of range livestock. The day is passing when the producer desires only one lamb per ewe. Farm flock producers have long recognized the economic importance of having high reproductive rates in their flocks. Range sheep producers are becoming more conscious of the necessity of high reproductive rates to offset high production costs.

It is assumed that with increased reproductive rates the nutritive demands of the ewe will become greater. Fortunately, man's knowledge of the nutritive value of native forages and feedstuffs, as well as the requirements of animals grazed on the range, has increased considerably the past decade. Considerable research is in progress throughout the west to determine the proper levels of supplementation of range livestock under various conditions.

Today's nutritional and industrial technology makes possible the manufacture of pelleted concentrates, formulated to include those in-

gredients which are known to be deficient in range forage and required by livestock. With these factors in mind, it is assumed that the problem of meeting the increased nutritive requirements resulting from increased reproductive rates is of minor importance when we consider the increased productive potential which could result.

With the new advances in science and industry in the field of nutrition, combined with our economy demanding efficient production, it seems logical that range sheep producers will become more and more interested in increasing the level of fertility of their flocks.

Considerable research on flushing has been conducted however, some results are contradictory. The majority of the research carried out to date has been done under farm conditions. The problem of maintaining high reproductive rates is not one that plagues the farm flock producer but the range producer. Therefore, it was deemed important to investigate the possibility of increasing reproductive rates of range ewes by supplemental feeding prior to and during breeding.

LITERATURE REVIEW

Reproductive performance of domestic livestock is influenced by many variables in a given environment. Due to the interactions of the various factors involved it is difficult to assess the influence of each individual one. The effect of nutrition alone on reproduction is a very comprehensive field. Asdell (1949) reports that one rarely finds a case of malnutrition due to one specific factor; usually a multiple deficiency exists. The influence of individual factors may be enhanced by either a deficiency or an excess of others.

The effect of some of the more important factors on reproductive performance are reviewed herein.

Flushing

Although there are varied definitions of the word "flushing", there is a great deal of similarity among them. The majority of the authorities indicate that flushing means increasing the level of nutrition prior to and during breeding (Reeve, 1953; Ballinger, 1956; Anderson, 1947; Lush, 1945; Hultz and Hill, 1931; Underwood and Shier, 1941; Spencer, 1939; Richards, 1942; Cooper, 1933; Watkins, 1955; Miller, 1913; Bray, 1925; Pope, et al., 1956).

Other authors define flushing as increasing the condition of the ewe previous to breeding or having the ewe in a rising condition at mating (Winters, 1949; McKenna, 1953; Shearer, 1932; Anderson, 1934; Griswold, 1936; Reed, 1927; Marshall, 1927; Miller, 1939; Darlow, undated).

Another definition of flushing found in the literature is feeding ewes so they are gaining weight at the time of breeding (Weir and Albaugh, 1954;

Morrison, 1949; Kammlade, 1947; Adams, 1936).

Other definitions of flushing are found in the literature. Marshall (1952) defines flushing as artificially stimulating the ewes by means of a special food at the approach of the tupping (breeding) season. Williams (1954) defines "nutritional flushing" as causing breeding sheep to fall in condition followed by increased feeding 2 to 3 weeks before breeding. Webster (1952) defines flushing as the response of sheep to the combined stimuli of shorter days, cooler temperatures, and improved pasture following autumn rains. Marshall and Potts (1921) indicate that flushing is feeding ewes at breeding to increase the number of twins produced. Kleinheinz (1920) indicates that flushing means bringing the ewe from a thin condition into a good strong condition in a short time.

It is reported that two conditions must be fulfilled for successful flushing; (1) flushing must result in a significant gain in weight over the unflushed ewes; (2) the nutritional plane before flushing must be below the level which permits the highest possible lamb crop for that particular breed (Friedman and Turner, 1939; Clark, 1934; Darlow and Hawkins, 1933; Marshall and Potts, 1924).

The foregoing definitions clearly point out the fact that the word "flushing" as it is used by producers and research workers, has varied interpretations.

Marshall (1908) made an investigation on the influence of flushing in Scotland. His data indicated that the percent of lambs born for flushed flocks was almost invariably in excess of the average percent for flocks

which received no flushing treatment. Marshall and Potts (1921) flushed Southdown ewes with grain and pasture and found both methods produced higher lamb crops. The average number of lambs dropped per 100 ewes lambing was 128.7 for the control ewes and 147.4 for the flushed ewes.

Table I summarizes the flushing trials conducted by the United States Department of Agriculture at Beltsville, Maryland and Middlebury, Vermont. At Beltsville the advantage of flushing is very consistent with one year producing no advantage and one year flushing reduced the lambing percent. At Middlebury the increase in lambing percent due to flushing was also consistent, however, one year flushing lowered the lambing percent. The data indicates in general that flushing increased the lambing percent a great deal more at the Beltsville station than at the Middlebury station.

Table II summarizes the flushing trials on pasture conducted at Beltsville, Maryland by the United States Department of Agriculture. The increase in lambing percent due to flushing on lush pasture was consistently greater.

Okulicev (1934) fed four groups of ewes, each numbering 115, different rations before breeding. The number of lambs born per 100 ewes bred was 103.5 for the controls and 120.3, 112,7 and 110,2 for the ewes fed various supplements initiated prior to breeding. The increase of lambing rate was due to higher percent of multiple births and lower percent of barren ewes in the supplemented groups.

Nichols (1924) reported lambing rates of 150 and 125 lambs per 100 ewes flushed and non-flushed, respectively. Nichols (1926) reported a

Table I. Increase in percent lambs born of ewes lambing, due to flushing 1/

Year	Beltsville, Md.	Middlebury, Vt.
1916-1920	+ 25.9%	+ 8.6%
1923	+ -- 2/	+ -- 2/
1924	+ 27.0%	+ 16.4%
1925	+ 23.0%	+ 17.0%
1926	+ -- 2/	+ 18.8%
1927	- 5.1%	- 9.4%
1928	No Difference	+ 20.0%
1929	+ 20.0%	--
1930	+ 25.0%	--
1931	+ 9.0%	+ 13.0% 3/
1932 4/	+ 10.0%	--

1/ The flushing was accomplished by lush pasture or grain feeding prior to 1927. For the year 1927 and those years following, flushing was accomplished by supplemental grain feeding except where otherwise noted.

2/ Reported an increase but no specific amount.

3/ The ewes in this group were flushed on hay, silage and grain.

4/ The above data was obtained from the Report of the Chief of Bureau of Animal Industry, United States Department of Agriculture for years indicated.

Table II. Increase in percent lambs born of ewes lambing due to pasture flushing at Beltsville, Md.

Year	Lambing percent 1/		
	Control	Flushed on pasture	Increase due to flushing
1927	128.5	133.3	+ 4.7
1929	124.0	145.0	+ 21.0
1930	116.0	160.0	+ 44.0
1931	143.0	164.0	+ 21.0
1932 2/	126.0	140.0	+ 14.0

1/ Lambing percent is based on number of lambs born per ewe lambing.

2/ Data obtained from the Report of the Chief of Bureau of Animal Industry, United States Department of Agriculture for years indicated.

lamb crop of 154 percent for 1,033 ewes kept under farm-flock conditions that were flushed and 140 percent for 4,054 ewes that were not flushed. McKenzie and Terrill (1937) reported that flushing Rambouillet ewes increased the number of ovulations from 1,06 per ewe to 1.15.

Polovceva et al. (1938) concluded that feeding concentrates beginning 20 days prior to breeding and continued until lambing, increased the number of multiple follicles and number of lambs born. Flushed ewes had a lamb crop of 133 percent as compared to 119 percent for control ewes. The addition of phosphates in these trials had no influence on lambing rate. Vita (1951), working with Italian Varese sheep, conducted two flushing trials. In the trial conducted during the winter, the flushed group was given concentrate and hay and the lambing rate was 155 percent as compared to 120 percent for the control ewes. On a second trial, conducted during the summer, the flushed ewes were grazed on rich alpine pasture and it resulted in 156 lambs per 100 ewes as compared to 124 lambs per 100 ewes in the control group.

Underwood and Shier (1941) report increased lambing rates when the ewes were brought down in condition prior to the beginning of flushing, followed by placing the ewes on very desirable pasture the two weeks previous to breeding and while the rams were with the ewes. The control group was maintained at approximately the same weight the period previous to breeding and while the rams were with the ewes. The flushed group produced 109 lambs per 100 ewes and the control group produced 91 lambs per 100 ewes. Wallace (1951) conducted a flushing trial to determine the effect of flush-

ing and length of flushing period on lambing rate. The method of management was similar to that of Underwood and Shier (1941). Flushing had no effect in bringing the ewes into estrus earlier, but twinning was consistently higher in the flushed ewes. New Zealand workers (New Zealand Department of Agriculture, 1952) indicated that flushing should start 2 weeks before breeding to be most successful. Later work indicated that flushing should begin 3 weeks prior to breeding (Wallace, 1951; New Zealand Department of Agriculture, 1953).

Williams (1954) reported that ewes flushed during the two year period produced 163 and 152 percent lamb crop per ewe lambing as compared to 140 and 141 percent lamb crop for the non-flushed ewes the same two years. His results indicated that in 1950 flushing raised the fertility of the ewe by 11.5 percent in terms of ewes mated and 23.8 percent in terms of ewes lambed. During the following year the respective increases were 9.8 and 11.1 percent. The increase in fertility was due to a higher percent of multiple births with practically no difference in the percent of barren ewes.

Experimental data concerning supplementing or flushing range ewes prior to and during breeding is more limited. Smith (1933) and U.S.D.A. workers (U.S.D.A., 1932) reported that flushing increased the lamb crop by 7.4 percent in a group of Rambouillet ewes. Richards (1942) concluded that phosphorus rich supplements fed prior to and during breeding resulted in higher conception rates and more twins dropped. Darroch, Nordskog and Van Horn (1950) reported that flock fertility was increased 10 and 9 percent by feeding supplement during the pre-breeding and breeding periods, respectively.

Ballinger (1956) cites a flushing trial conducted at the Canterbury Agricultural College, New Zealand, approximately 25 years ago. Flushed ewes, receiving pasture plus 1/2 pound of fowl wheat per ewe per day for three weeks before and two weeks during breeding, produced 25 percent more lambs than the comparable group of ewes on pasture only. Serebrjakov and Taran (1950) studied the effect of grazing ewes on green barley pasture prior to and during breeding on multifoetation in Karakul sheep. Lambing rate per 100 ewes was 121.5 and 107.3 for the barley pastured and control groups, respectively. Markus and Gaal (1952) fed carrots to ewes on carotene deficient pasture to determine its effect on the fertility of ewes. As the ewes exhibited estrus they were artificially inseminated. The percent of ewes exhibiting heat was ten percent higher in the carrot supplemented group. The percent of ewes lambing based on ewes inseminated was 74.5 and 58.0 percent for the supplemented and control groups, respectively. Lambing percent based on ewes inseminated was 84.7 and 70.0 percent for the supplemented and control ewes, respectively.

Research workers in New Zealand (New Zealand Department of Agriculture, 1950) attributed the increased lambing percent obtained among the flushed ewes to increased ovulation rate. Laing (1955) states that flushing increased the number of follicles matured and the number of ova fertilized. Hammond (1957) makes the following statement, "In all breeds the number of eggs shed at tupping, and hence the lambing percentage, can be increased by flushing the ewes before the rams are put in."

Friedman and Turner (1939) state that the practice of flushing sheep

needs no defense by this time. Webster (1952) indicates that few sheep farmers are prepared to question the benefit of flushing ewes. Contrary to all the foregoing citations indicating that flushing increases lambing rate, Briggs et al. (1942) found no evidence over an eight year period that flushing increased lambing rate. Stoddart and Smith (1943) state, "Despite many unfavorable results in ewe flushing, the practice is widespread among sheep producers and is generally subscribed to by authorities." Darlow and Hawkins (1932) state, "The belief in flushing has had a firm hold on the minds of sheep men for so long that several well defined cases of poor results will not shake their belief in it." Unfortunately neither Stoddart and Smith (1943) nor Darlow and Hawkins (1932) cite any specific experiments to clarify their statements concerning "... many unfavorable results ..." and "... several well defined cases of poor results ..."

An extensive review of the literature indicates that flushing has not in all instances increased lambing rates; however, without doubt, the preponderance of the evidence indicates that flushing increases the ovulation rate and the number of lambs born per ewe lambing.

What to feed during flushing

A wide variety of feedstuffs have been recommended for flushing. Probably the most recommended and successful type of feed was green pasture (Friedman and Turner, 1939; Carlyle and Spencer, 1916; DuRant and Godley, 1955; Darlow, undated; Adams, 1936; Vita, 1951; Morrison, 1949; Hammond, 1941). Research workers of the United States Department of Agriculture (U.S.D.A., 1927) report, "Pasture is usually the cheapest and most effec-

tive means of securing larger yields of lambs."

Many authorities recommend specific pastures such as rape (Iddings, 1927; Marshall and Millin, 1927; Hislop, 1917; Carlyle and Spencer, 1916; Arkell and Ben, 1915; Shearer, 1932; Anderson, 1934; Miller, 1937; Woll, 1921). Timothy pastures were highly recommended for flushing (Marshall and Millin, 1927; Anderson, 1934; Miller, 1937), as well as blue grass pastures (Marshall and Millin, 1927; Shearer, 1932; Miller, 1937).

Grain pastures consisting of volunteer oats (Adams, 1936), wheat (Arkell and Ben, 1915) and rye, (Arkell and Ben, 1915) have been recommended for flushing. Other pasture crops recommended are soybean, (Anderson, 1934) cowpeas (Adams, 1936) clover (Arkell and Ben, 1915) (Shearer, 1932) (Anderson, 1934) and alfalfa (Arkell and Ben, 1915) (Cooper, 1933).

Grains have been reported useful for flushing ewes (Joseph, 1922; Anderson, 1934; Woll, 1921; Marshall and Potts, 1921). Some of the specific grains that have been recommended have been oats (Marshall and Millin, 1927; Iddings, 1917; Carlyle and Spencer, 1916; Shearer, 1932). The combination of oats and bran for flushing has been recommended (Iddings, 1917) as well as oats and corn (Shearer, 1932).

Such feedstuffs as aftermath in hay meadow have been reported useful for flushing ewes (Joseph, 1922) (Anderson, 1934). Similarly, grain stubble fields have been useful for flushing (Anderson, 1934) (Cooper, 1933). Other feedstuffs probably not so common but which have been recommended for flushing are silage (Darlow, undated), pumpkins (Marshall and Millin, 1927)

roots, (Iddings, 1917; Arkell and Ben, 1915), cabbage (Woll, 1921; Hammond, 1941) and young mustard (Hammond, 1941).

If hay is available a small amount could be fed each day during the flushing period (Bray, 1925; Joseph, 1922; Darlow, undated). When the sheep are on the range, cottonseed cake has been used or recommended for flushing (U.S.D.A., 1932; Bray, 1925). If no additional supplement is being fed, it is recommended to reserve pasture or range specifically for flushing (Moles, Koogler and Neale, 1924; Stoddart and Smith, 1943). Underwood and Shier (1941), as well as Wallace (1951), obtained good results from pasture management alone.

Marshall and Potts (1921) reported no difference in kind of feed used for flushing, pasture or grain. Darlow (undated) suggests simply increasing the ration the ewes are receiving or feed anything that tends to cause the ewes to gain in flesh. Any fodder that is of good quality and palatable is recommended for flushing (Geary, 1956; Bray, 1925).

Work by Richards (1942) indicates that the addition of phosphorus to a flushing supplement, fed to ewes bred on the range, increased lambing percent. Harris et al, (1956) found that the combination of phosphorus and protein added to a supplement for range feeding was beneficial in increasing lambing percent. If a gain in weight is the desired result during flushing, a high protein concentrate would tend to be the most desirable if weight gains during winter feed treatments can be used as an indicator (Van Horn, et al., 1952).

Nutrition and environment in general

Aristotle (1910) commented on the increased fertility of sheep in a favorable environment. Darwin (1905) states, "The amount of feed affects the fertility of the same individual, thus sheep which on mountains never produce more than one lamb at birth, when brought down to lowland pastures frequently bear twins." Heape (1899) found that the fertility of a flock depends greatly on its management and the quality and quantity of food supplied.

Marshall (1908) reported that the lambing percent of ewes bred in Scottish mountains varied from 80 percent to 100 percent in 12 flocks. The lambing percent of flocks bred on the lowlands during the same season varied from 140 percent to 190 percent. White and Roberts (1927) reported that Welsh ewes that remained on the mountains before breeding produced 90 lambs per 100 ewes, while those kept on the lowlands where the level of nutrition was more desirable, produced 123 lambs per 100 ewes.

Hawkins and Darlow (1935) stated that initial estrus in the ewe in a given breeding season may be inhibited by very unfavorable nutritional conditions. They further state that fertile matings are fewer among ewes which are reduced and retained in an emaciated condition, even though the ewes may come in heat.

Roux (1936) found that reduction of the ration reduced the duration of the sexual season of Merino sheep and it was particularly evident in younger sheep. Kelley (1937) reported that the plane of nutrition had no association with the failure of estrus to appear.

McKenzie and Terrill (1937) report that ewes kept on a low plane of nutrition had a shorter breeding season, longer estrual cycles and lower ovulation rates, but showed no differences in the duration of estrus when compared with similar ewes kept on a high plane of nutrition.

In comparing the reproductive performance of cattle kept on low and high nutritional planes, Joubert (1955) found that the low plane females required fewer services per conception. This phenomena had been reported earlier by Asdell (1952). Differences in the occurrence of post partum estrus in cattle due to plane of nutrition have been reported. High plane heifers came in heat only after weaning their calves but low plane heifers required nearly a year in addition to regain depleted body reserves before sexual activity was restored (Joubert, 1955).

Hammond (1955) reports that in sheep silent heats occur both under conditions of low plane of nutrition and also when the darkness-daylight ration begins to become unfavorable. Hafez (1952) reported that substantial reduction of live weight by underfeeding did not delay onset of the breeding season if the sub-maintenance diet was started two months before the expected onset. Estrus was inhibited after the normal onset with the occurrence of silent heats which were more frequent in yearlings than adult ewes. More than one service was generally required even at the peak of the breeding season in the under-fed ewes. Laing (1955) reports that starvation and heavy internal parasitism delays puberty in young animals and the estrus cycle is depressed in those that are older.

In cattle Eckles (1920) records that heifers fed heavily, experienced

their first heat earlier than those lightly fed; the difference for Jerseys was 65 days, for Ayrshires, 100 days, and for Holsteins, 126 days. Other work confirms this phenomena that underfed heifers are late experiencing their first estrus (Allen, 1943; Quinlan, 1929).

Snell (1936) fed two groups of ewes differently to determine the effect of nutrition on productivity. One group was full fed and the other limited to one-third the amount of the full fed group. The full fed ewes had a higher percent of ewes lambing, higher lambing percent born, higher percent of lambs raised, higher milk production and greater wool production.

Whitehair and Gallup (1955) reported on a study of disorders in cows and ewes associated with the feeding of low quality roughage during pregnancy. Ewes fed only the low quality roughage lost as high as 50 percent of their body weight, had a high death loss, had a high incidence of pregnancy toxemia, lacked maternal instinct and poor milking ability at lambing time and had a high rate of lamb mortality.

Specific nutrients

Montana grasses are reported to be deficient in protein and phosphorus eight to nine months of the year (Payne, 1952). Carotene was abundant 6 to 7 months of the year and not seriously deficient the remainder of the year. These foregoing deficiencies are based on National Research Council recommendation for breeding cows and estimated forage intake of known chemical analysis for the nutrients in question.

One of the earliest accounts indicating that phosphorus deficiency was a factor in reproductive disorders, is that of Tuff (1923) in Norway.

Phosphorus has been reported an important nutrient associated with fertility in cattle. Asdell (1949) indicates that phosphorus deficiency tends to occur when diets low in protein are fed or under conditions resembling those found on the range when the grass is dry. Deficiency symptoms also occur when the soil is definitely deficient in phosphorus and in borderline areas when the cows are lactating but are not fed an adequate protein and mineral supplement (Asdell, 1949). Eckles et al. (1926), working with cattle in Minnesota, reported considerable breeding troubles which were corrected by phosphate supplementation. On many farms one calf crop was obtained every two years and heifers sometimes did not come in heat until they were past two years of age. Normal reproduction occurred after supplementation was practiced.

Eckles et al. (1932) reported that phosphorus deficient cows tended to have one or two heat periods after they calve. If they became pregnant at this time, the calves were carried to term; if not, they tended to show anestrum for the remainder of their lactation. After weaning, heat periods returned and they had a normal chance of conception.

Palmer et al. (1941) found phosphorus deficiency delayed first heat in heifers, followed by ovulations without heat which occurred at normal intervals. Riddell et al. (1934) also reported absence of heat in cows on a phosphorus deficient ration. Theiler et al. (1918) reported a calf crop of 51 percent in phosphorus deficient herds, and this was restored to 80 percent in herds with a phosphate supplement. Laing (1955) reports phosphorus deficiency reduces fertility in older animals and delays puberty in

young ones.

Keith et al. (1955) reported that ewes fed low phosphorus rations during pregnancy and lactation had a greater loss in body weight during pregnancy and lactation and had higher lamb mortality the first 48 hours of the lamb's life.

Asdell (1949) in a review of literature concluded that from all the data available, it appeared that phosphorus deficiency interferes with ovarian function, causing probably a lower estrogen secretion. In more severe conditions, follicular development is interferred with. If pregnancy occurs, little effect is seen until the end of gestation, when parturition may be difficult and the calves may be born weak or dead.

Vitamin A deficiency is reported to have no affect on the estrual cycle or ovulation in sheep but will cause death in utero late in pregnancy or lambs often die shortly after birth (Hart and Miller, 1937). Ewes grazed on green grass in California during the growing season stored sufficient vitamin A in their bodies so that the lamb crop was not affected even though the ewes were kept on a low vitamin A ration for 4 or 5 months. Other work also indicates that sheep apparently have a slow depletion rate of stored vitamin A (Cunha et al., 1946; Weir et al., 1949; Pierce, 1954).

Limiting the protein intake of adult ewes during the breading season had little effect on the number of lambs produced (Hart and Miller, 1937). Rations low in both protein and phosphorus lowered the fertility of ewes (Hart and Miller, 1937; Miller, Hart and Cole, 1942).

Gain in weight prior to and during breeding

Millin (1924) indicates that it is a well known fact among observing sheep men the world over that ewes that are gaining during the breeding season produce a heavier percentage of lambs than those that are just holding their own or those that are losing in condition.

Terrill and Stoehr (1939) reported a highly significant correlation (.38) between gain or loss during breeding and the percent of lambs born of ewes having lambs born at full gestation. The ewes in their study which gained weight during the breeding season produced about 6 per cent more twins than those which lost weight during the same period.

In summarizing the flushing trials conducted on the range by the U.S. Department of Agriculture (U.S.D.A., 1932) it was reported that ewes which gained weight during the breeding season produced 122 lambs per 100 ewes, whereas, the ewes not gaining weight during this period produced 108 lambs per 100 ewes.

Marshall and Potts (1921) divided their ewes into three catagories based on the amount of weight gain during the flushing period. Their data indicates that the ewes that gained the most weight produced the greater proportion of twins. This was not confirmed by Briggs et al. (1942).

Barton (1955) states that for flushing to be successful it is imperative that the ewe be rapidly gaining weight for 3 weeks before mating. Contrary to this statement, Miller, Hart and Cole (1942) concluded that gain in weight during the breeding season is not essential for high fecundity in ewes that are in good condition. Terrill and Stoehr (1939) found

that regardless of whether range ewes gained or lost weight during breeding there was practically no affect upon the percent of ewes lambing.

Condition of the ewe

Clark (1934) reported higher ovulation rates resulted from flushing thin wester ewes, however, flushing did not increase the ovulation rate in a group of Shropshire ewes in good condition. Darroch, Nordskog and Van Horn (1950) found that flushing white face range ewes only during the period 14 days before breeding result in 15.8 and 2.8 percent more lambs born for poor and good condition ewes, respectively. Of all ewes lambing, the ewes in good condition at breeding averaged 11 percent more lambs born and also 11 percent more lambs weaned than those in poor condition.

Hammond (1940) states "On the condition of the flock at tupping (breeding) depends the fall of lambs the following season." Ballinger (1956) reports that the most important factor which influences lambing percent is the condition of the ewes. Darroch, Nordskog and Van Horn (1950) concluded that ewe condition appeared to be the most important factor determining the number of lambs born and weaned. Miller, Hart and Cole (1942) concluded "The results of various investigators seem uniformly to indicate that flushing is beneficial to ewes if they are thin. No one has yet ascertained whether it is better to keep the ewes relatively thin and then allow them to gain rapidly during the breeding season, or to keep them uniformly in good condition." Kelley (1943) states that ewes should be deliberately brought down in condition and then changes to a highly nutri-

tious, succulent diet about a month before mating.

It is not recommended to flush the overfat ewe as it will only make a bad matter worse (Griswold, 1936). Miller (1937) recommends special treatment for overfat ewes and stresses the desirability of preventing this condition by proper management. The author suggested gradually reducing body weight prior to breeding by controlling feed intake. Weir and Albaugh (1954) suggest keeping ewes on poor feed from the time of weaning until flushing begins.

Age

Goot (1951) reported that age of ewe is by far the most important factor responsible for the variations in the fertility of ewes. The biggest rise in fertility takes place between age of 2 and 3 years and gradually increased up to 5 years of age and decline in certain components of fertility thereafter. The percent of ewes lambing of ewes bred was 82.1 and 91.4 for ewes of 2 years and 5 years of age respectively. The lambing percent of ewes lambing was 123.5 percent and 148.2 percent of ewes 2 years and 5 years of age respectively. Terrill and Stoehr (1939) found there was a steady increase in percent of ewes lambing, percent of lambs born of ewes having mature lambs at birth and in percent of live lambs born per ewe bred, as the age increased up to 5 years of age. The breeds in this study included Rambouillet, Columbia, Targhee and Corriedale ewes.

Many workers are in general agreement that there is a rise in prolificacy until the 5th or 6th year and then a gradual decline (Smirnov, 1935;

Hammond, 1948; Beigert, 1938; Marshall and Potts, 1921; Carlyle and McConnell, 1902; Nozdracev, 1939; Harris, et al., 1956; Humphrey and Kleinheinz, 1907; Nichols, 1924; Johansson 1932; Roberts, 1921; Jones and Rouse, 1920; Langlet, 1933). In Ossimi sheep it is reported that the highest reproductive rate occurred at 6 to 7 years of age indicating breed differences (Asker and Ragab, 1954). In early maturing breeds of sheep the maximum fertility may be attained at 3 years of age while in late maturing breeds it is not attained until 5 to 6 years of age (Lopyrin, 1938). Johanson (1932) indicates that the increase in lambs per 100 ewes from the first lambing to the fourth is about 22 percent.

In hogs, Lush and Molln (1942) concluded that the number of pigs farrowed rises to about 2 years of age, remains at a high level until about 4 ½ years of age after which it slowly declines. In range cattle, Lassley and Bogart (1943) reported that fertility was lowest in 2 year old heifers, highest in cows 5 to 7 years of age and declines again in cows 9 to 10 years of age.

McKenzie and Terrill (1937) found ovulation rate increased to 3 or 4 years of age (at breeding) with slight decrease as age increased beyond this point. Lambs and yearlings had shorter estrual periods and lower ovulation rates as compared to mature ewes. McKenzie and Phillips (1930) reported the period of estrus was longer for yearling ewes than for ewe lambs.

Schott, Phillips and Spencer (1939) found that yearlings tended to

come in heat later than mature ewes. deBaca et al. (1954) reported that age had no effect on expression of heat in purebred ewes on irrigated pastures; however, this was not true in a group of cross bred ewes on native pasture.

Breed

Johansson (1932) states that the differences in lamb yield between Swedish breeds are small and possibly due to environmental influences. The breeds studied by Johansson were Oxford Downs which produced 153.2 lambs per 100 ewes and the Cheviots which produced 140.9 lambs per 100 ewes. It is assumed this data is based only on ewes lambing. It is stated by the author that the two breeds were not maintained under the same environmental conditions.

Terrill and Stoehr (1939) made an extensive study on reproduction of range ewes. Their data was collected over a 10 year period at the U. S. Sheep Breeding Laboratory at Dubois, Idaho. During this period, there were 8000 matings among the 4 breeds represented; namely, Rambouillet, Targhee, Columbia and Corriedale.

The percentage of lambs born per ewe lambing was 129, 127, 122 and 118 for the Targhee, Columbia, Rambouillet and Corriedale ewes respectively. The percentage of live lambs born per ewe bred was 102, 92, 92 and 93 for Targhee, Corriedale, Rambouillet and Columbia ewes respectively. Breed differences in percent of ewes producing lambs were 88, 88, 85 and 85 for Corriedale, Targhee, Columbia and Rambouillet ewes respectively.

Smirnov (1935), in working with Russian Romanov ewes, reported that the average number of lambs born for 6030 ewes was 2,38. In one district, 5.45 percent of the births were singles and 90.16 percent were multiple births. Nichols (1924) found that Suffolk ewes produced fewer lambs when bred to rams of different breed; however, Dorset horn ewes were more prolific when mated to the down breeds. Carlyle and McConnell (1902) reported increased lambing percent due to cross breeding. Marshall and Potts (1921) found breed differences in lambing percent born. The Rambouillet 2-year-old ewes as well as the mature ewes showed the lowest percent lamb crop born of the 9 breeds studied. The Dorset two-year-old ewes as well as the Dorset mature ewes had the highest lambing percent born. Nichols (1924) found that the lambing percent varied with the breeds studied. The highest lambing percent in his study occurred among the Border Leicester ewes and the lowest occurred among the Hampshire ewes.

McKenzie and Terrill (1937) found that Hampshires had longer estrual periods than Shropshires, Southdowns and Rambouillets. Hampshires also had higher ovulation rates than Rambouillets. deBaca, et al. (1954) reported breed difference in average date of first heat among the purebred ewes with the following rank, Hampshire earliest, Romney Marsh intermediate, and Southdown latest.

Time of breeding

Grant (1934) found the first estrus of the season tended to be shorter than succeeding periods. Grant (1933) also noted that the first estrus of

the season was preceded by one or more cycles of ovulation which were unaccompanied by estrus. Cole and Miller (1935) and Laing (1955) confirmed this phenomena. Cole and Miller (1935) reported a similar situation following the close of the breeding season.

Asker and Ragab (1954) conducted their work south of the equator and found that ewes bred in May had the highest lambing percent. The corresponding month in the northern hemisphere would be November. Marshall and Potts (1921), Beigert (1938), Johansson and Hansson (1943), and Hammond (1944) report similar results indicating that in the northern hemisphere the most opportune time to breed to insure a high lambing percent is near November 1.

Johansson (1932) presented data from Sweden indicating that mating during September and October, when the environmental temperature is falling, tended to increase multiple pregnancy in sheep. Pregnancies initiated prior to and following these two months produced fewer multiple births. McKenzie and Terrill (1937) found that as the breeding season progressed there was an increase in the length of the estrual cycle. Ovulation rate tended to be lower early in the breeding season then rise to a peak during mid season and fall off again during the latter part of the season. In the trials of McKenzie and Terrill (1935) the monthly interval with the highest ovulation rate was September 16 to October 15. During the next monthly interval, the ovulation rate declined considerably in Rambouillets but remained approximately the same for the mature Hampshire ewes.

Nozdracev (1951) reported that the lambing percent of ewes mated during September and October was 153 percent as compared to 127 percent for ewes mated in November and December.

Body weight of ewe

Johansson and Hansson (1943) found a significant increase in average litter size in sheep with an increase in body weight within breeds. Nozdracev (1939) also found a positive correlation between body weight and fertility in Merino ewes. Ewes in this study that weighed 62-68 kilograms gave 26.8 percent more twins than ewes 42-46 kilograms in body weight. Smirnov (1935), working with Russian Romanov ewes, found that on one farm ewes weighing 55-65 kilograms produced 2.6 lambs per lambing and ewes weighing 25-30 kilograms produced 1.62 lambs per lambing.

Terrill and Stoehr (1942) found that the number of lambs per 100 ewes lambing rises with an increase in body weight. Joseph (1931) states "Preliminary results on the inheritance of lamb producing ability indicate that the size of a ewe is a more accurate measure of her ability to raise heavy lamb crops than is the lamb producing ability of her dam."

Climatic factors associated with reproduction

Meteorlogical factors have been shown to have a marked influence on the occurrence and the length of the heat period in sheep (Epaljevski, 1934). Low temperature, especially below 15° C., reduced the number of sheep exhibiting estrus by 25.8 percent. This effect of cold was enhanced by windy weather with North, Northwest and East winds being the most detri-