COMPARATIVE VALUE OF CERTAIN FEEDS IN MEETING THE NUTRITIONAL REQUIREMENTS OF EWES DURING GESTATION AND LACTATION

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INTRODUCTION

In recent years a series of investigations were undertaken at the Oklahoma Agricultural Experiment Station in an attempt to determine the cause of cattle losses in the eastern part of the state. Preliminary data indicated that the losses were confined almost entirely to pregnant and lactating cows during the late winter and early spring. The most common symptoms exhibited were weakness, emaciation and digestive disturbances; death frequently resulted.

Experiments at the Oklahoma Station, in which hay from this area was fed to pregnant and lactating ewes, failed to associate the malady with a deficiency of minerals or vitamins. The results of these experiments led to the postulation that the disturbance was due primarily to a lack of protein in the ration and secondarily to a deficiency of energy.

Since protein is fundamentally essential, the critical shortage of the natural protein supplements, such as cottonseed meal and soybean oil meal, creates a problem for the livestock industry. Therefore, there is an increased interest in the utilization of urea as a protein extender for ruminants. It has been shown that urea can be utilized by growing and fattening cattle and sheep. However, only a limited amount of data is available on the utilization of urea by pregnant and lactating ewes. In the present era of high feed prices, if urea could partially replace the protein required by the cow or ewe, critical protein supplies could be extended and larger profits to cattle and sheep producers would result.

Also, it seemed desirable to study the relative value of conventional hydraulic-processed cottonseed meal and a new solvent-processed cottonseed meal of low fat content. Previous research has shown that so-called "stiff-lamb" disease is associated with rations low in fat and made up of low-grade feeds.

The research reported in this paper is a continuation of the study designed to determine the cause of livestock losses in eastern Oklahoma as well as a further test of the practical value of urea as a partial replacement for crude protein. Sheep were used as experimental animals because of economy, ease of handling and because they are believed to have requirements similar to cattle. Pregnant and lactating ewes were fed rations calculated to be adequate in energy but containing different sources of crude protein. The 3 supplements were hydraulic-processed cottonseed meal, a new solvent-processed cottonseed meal and urea. In addition, a poor quality native grass hay from eastern Oklahoma was compared to a good-quality prairie hay from the central part of the state. The results of the different treatments were measured by the gain or loss in body weight of the ewe during pregnancy and lactation, the fleece weight at shearing and the gain of the lamb from birth to 42 days.

LITERATURE REVIEW

Prior to 1945, research concerning the nutritive requirements of pregnant and lactating ewes was rather limited. Since that time, however, workers have realized the need for additional information as to the requirements of pregnant and lactating ewes for production of lambs, milk and wool.

Investigations Concerning the Eastern Oklahoma Disturbance

Since 1948 the Oklahoma Station has conducted a series of investigations in an attempt to determine the cause of livestock losses in eastern Oklahoma.

Clinical investigations in the field by Whitehair et. al. (1948) indicated that calcium, phosphorus, vitamin A and carotene blood values were normal even in the most severe cases. However, hematocrit and hemoglobin levels indicated that the affected animals were anemic. The disturbance was most frequent in cows at calving time, or while nursing calves, during the late winter and early spring when food nutrients supplied by the pastures are at their lowest level. Due to the nature of the disease, and the absense of infectious organisms, these investigators postulated that the disturbance was nutritional in nature.

Whitehair, Gallup and Ross (1949), using sheep as experimental animals, produced symptoms that resembled those of the afflicted cattle from the eastern Oklahoma area. These symptoms of weakness, emaciation and digestive disturbances, were produced by feeding native prairie hay from eastern Oklahoma without adequate supplementation. Ewes which received additional protein in the form of corn gluten meal reproduced normally.

Nash (1950) added energy in the form of starch to a basal ration of poor quality prairie hay and again produced symptoms of the disturbance in ewes. In the same trial, addition of corn gluten meal to a corn starch-prairie hay ration resulted in nearly normal reproduction. The addition of calcium, phosphorus, trace minerals or cod liver oil failed to produce an additional response. It was concluded that the disorder encountered was essentially caused by a protein deficiency.

Scott (1951) in a similar experiment divided 30 ewes into 5 lots. The ewes were fed the following rations:

Lot 1 - Prairie hay, corn, sorghum syrup and corn starch. (Basal).

Lot 2 - Prairie hay, corn and corn gluten meal.

Lot 3 - Prairie hay, corn and soybean oil meal.

Lot 4 - Same as Lot 2 plus cobalt.

Lot 5 - Same as Lot 2 plus alfalfa ash.

The average weight loss of the ewes from the start of gestation to the 56th day of lactation in Lots 1, 2, 3, 4 and 5 were 38.0, 3.0, 9.3, 7.8 and 6.6 pounds, respectively. The birth weights of the lambs in Lot 1 averaged substantially less than the birth weights of the lambs from Lots 2, 3, 4 and 5. Lamb gains over a 56 day period also showed a similar trend. Single lambs gained an average of 7, 29.8, 22.8, 25.8 and 26.2 pounds in Lots 1, 2, 3, 4 and 5, respectively. It was concluded from this experiment that the disturbance found in eastern Oklahoma livestock was possibly due to a protein deficiency. Little benefit was observed when cobalt or alfalfa ash was added to the above rations.

That conditions similar to those reported in sheep are also common to cattle is indicated by the work of Rusoff and Seath (1947) who reported symptoms in dairy cattle, similar to those found among the cattle of eastern Oklahoma, in the upland piney woods areas of northwestern Louisiana. A series of mineral studies by these workers failed to indicate that a deficiency or an improper balance of minerals was the cause of the disturbance studied. They concluded that the disturbance of the dairy animals studied was due to improper feeding practices (primarily a lack of protein in the ration) and improper management.

Studies on the Nutritive Requirements of Ewes During Gestation and Lactation

Wallace (1948) made an extensive three-year study in which he attempted to establish the dietary needs of ewes for maintenance, weight gain during gestation and milk production. He also investigated the effect of different levels of nutrition during pregnancy on the birth weights of the lambs and the milk yield of the ewes.

During the first year, twenty ewes after parturition, were individually fed a ration of sanfoin hay and a concentrate mixture of crushed oats, bran, sugarbeet pulp, linseed cake and white fish meal. Each ewe was given 2.5 pounds of hay daily plus a sufficient amount of the concentrate mixture to maintain body weight. It was assumed that the feed consumed would be utilized only for purposes of maintenance and milk production. He was able to show that a large individual variation exists between ewes in nutritive requirements during lactation due to differences in body size and milk production.

In a second experiment, 15 ewes were allotted into three groups of five each and placed on experiment six weeks prior to lambing. The rations used were similar to those fed during the first trial. One group was fed a super-maintenance allowance sufficient to result in a satisfactory gain in live weight; the second group was so fed that each ewe maintained a constant live weight, while the third group was fed a sub-maintenance ration. After lambing, all ewes received a ration sufficient to maintain their body weight at the post-parturition level. Ewes on the super-maintenance ration gained an average of 30.7 pounds during the last 6 weeks of pregnancy, while ewes on the maintenance and sub-maintenance rations lost an average of 1.2 and 13.9 pounds, respectively. Mortality was 100 percent among the twin lambs in the sub-maintenance lot. Single lambs from ewes fed the super-maintenance ration were substantially heavier at birth than single lambs from the ewes fed the other rations.

In a third experiment, the same investigator fed 13 ewes a maintenance ration during the first 105 days of gestation. Following this period, they were divided into two lots. The first group (high-plane) was fed liberally to assure that each ewe would make considerable live-weight gain up to lambing. The second group (low-plane) was given a reduced feed intake to assure a loss in body weight over the same period. Following lambing, the ewes were fed to maintain their body weight at the post-parturition level. The high-plane ewes gained 40.4 pounds each up to lambing, while the low-plane group lost an average of 10.5 pounds. The average birth weights of the lambs from the two groups of ewes were 10.4 and 6.7 pounds, respectively.

Wallace concluded from these trials that the birth weight of the lamb and the milk production of the ewe were greatly affected by the level of nutrition during the last 6 weeks of pregnancy. By extreme low level feeding, the birth weight of the lambs may be reduced substantially, with a resulting decrease in the vigor of the lamb. Also, he found that the level of the maternal ration affects the degree of udder development and the resulting milk yield of the ewe which is reflected in the growth of the lamb after birth.

Thomson and Frasier (1939) in a study of the cause of pregnancy disease fed three groups of 14 ewes each a ration of concentrates, turnips and hay in quantities to induce various weight changes during pregnancy. One group was fed sufficient ration to allow an average gain of approximately 8 pounds per ewe while in-lamb. The second group which was fed the same ration <u>ad lib</u>. gained 50 pounds per ewe during pregnancy. The third group was placed on a restricted ration until the last month of pregnancy, at which time they were fed <u>ad lib</u>. Ewes of this group gained an average of 20 pounds during the pregnancy period. The lambs produced by ewes of the latter two groups were comparable in birth weight and vigor, and averaged more than 2.2 pounds heavier at birth than the lambs from the first group. Many of the lambs from the first group lacked vigor at birth and in most instances twins needed assistance while nursing. Some of the ewes in the first group produced very little milk. It was concluded that heavy feeding during the entire pregnancy period had little advantage over heavy feeding during the last month of pregnancy.

Thomson and Thomson (1949) used 81 Sutherlandshire-Cheviot ewes to study their reproductive performance in relation to the diet during pregnancy. The ewes were all treated alike for the first 10 weeks of pregnancy, and fed so each ewe would attain the same degree of "condition". After the 10th week of pregnancy, the ewes were divided into two groups. The "high-plane" group was fed a high-protein ration with the intake regulated to produce a body weight increase of about 30 percent. The "low-plane" group was fed a low-protein ration so restricted in amount to cause a 5 percent decrease in body weight. The ewes were continued at these levels of nutrition during lactation. The average birth weights of the lambs showed a distinct relationship to the maternal weight change during the second half of pregnancy. The twin lambs from the "low-plane" ewes lacked the vigor and vitality of those from the "high-plane" ewes, and many died. The lack of vitality at birth, together with starvation due to an insufficient milk supply, were the major causes of the high lamb mortality rate. It was concluded that the most important effects of under-feeding ewes during late pregnancy were on udder development and subsequent milk flow. Cases of inadequate milk supply were associated with nervousness and a lack of maternal instinct which occurred frequently in the "low-plane" group.

Klosterman (1950 and 1951) compared the lamb production of ewes on a low-protein ration with that of ewes on a high-protein ration. The rations were equalized in total digestible nutrients and varied only in the source and amount of protein. The sources of protein in this study were linseed meal and dried skim milk. The results of four experiments indicated that there were no consistent differences in lamb production when ewes received equal amounts of T.D.N. with the total protein of the ration varying from

6.8 to 11 percent. No significant difference was noted between lambs from ewes fed the two sources of protein supplements. It was found that a 135-pound Shropshire ewe, when fed a ration containing 0.10 pound digestible protein, remained in a positive nitrogen balance, gained approximately 28 pounds during pregnancy and gave birth to thrifty lambs. Blood analysis showed that when the digestible protein of the daily ewe ration was reduced from 0.33 to 0.19 pound, a significant lowering of oxyhemoglobin and serum albumin resulted

Whiting (1950) and Slen (1952) reported on lamb production as affected by the level of protein in the ration of mature ewes. The rations were composed of native prairie hay, oats, molasses, starch, corn oil, and a mineral mixture. Linseed oilmeal was used to vary the protein content of the rations. Protein levels of 7, 10 and 13 percent were fed to three different groups of 27 range ewes. These rations which were equal in T.D.N., consisted of 70 percent roughage and 30 percent concentrates; they were fed in pelleted form. The data from this experiment showed that the weight gains of the ewes were about the same until late pregnancy, at which time the low-level protein group failed to gain as rapidly as ewes of the other groups. The birth weights of the lambs (singles and twins) from ewes receiving the 7 percent protein ration were significantly lower than the birth weights of the lambs of the other lots. The lambs from ewes fed the two higher levels of protein gained more weight during the first 6 weeks after birth than lambs from ewes receiving the low protein ration. The same trend was noted in milk and wool production. As a result, it was concluded that 7 percent crude protein was not sufficient to produce satisfactory results with pregnant and lactating ewes, but that there was little advantage in feeding a ration containing more than 10 percent crude protein, providing the energy supply was adequate.

Williams and associates (1950), with the cooperation of 5 separate Canadian Stations, investigated the value of legume and non-legume hays and vitamin A as supplemental feeds for pregnant ewes. They also studied the effect of concentrate supplementation during the last half of pregnancy. Results showed that the lambs produced by the ewes receiving only legume hay during pregnancy made gains equal to those of lambs produced by ewes fed a non-legume hay for the first 100 days of gestation followed by a legume hay plus a concentrate supplement. In all tests, the ewes fed only legume hay maintained a greater body weight and produced heavier and more vigorous lambs than ewes fed only non-legume hay.

Underwood and Shier (1942) found that ewes grazing clover and grass pastures and fed a supplement of silage and 0.5 pound of wheat per head, daily, had a low lamb mortality rate at birth and losses from pregnancy disease were negligible.

Underwood <u>et</u>. <u>al</u>. (1943) reported two similar investigations in which high levels of prenatal feeding resulted in highly significant differences in birth weights and lamb gains when compared to the control group. Large reductions in ewe losses due to pregnancy disease and lamb losses at birth were noted. These workers found a high correlation between the birth weight of the lamb and the subsequent rate of gain. However, this view is not in agreement with the results of other workers who attribute considerable credit for lamb gains to the increased milk production of the ewe.

Jordon (1950) conducted feeding trials with pregnant ewes over a three year period, designed to determine the practicability and economy of feeding alfalfa alone, brome hay alone, an alfalfa-brome mixture alone and brome hay supplemented with soybean oil meal at two different levels. The results of these trials demonstrated the excellence of alfalfa hay as a roughage for ewes. Brome hay fed alone did not furnish adequate protein. The ewes fed brome hay alone actually lost weight during gestation and their fleece weights averaged approximately one pound less than those of the other lots. Brome hay supplemented with 0.25 pound soybean oil meal resulted in production performance equal to that of ewes fed the alfalfa-brome ration. The rations fed in these trials did not significantly affect mortality rate or the rate of gain of the lambs.

Wilson et. al. (1948) conducted a 5 year test to study the effect of the level of nutrition on the ewe during reproduction and lactation and its effect on the birth weight and growth of the lamb. They state that rations producing gains of 30 to 40 pounds per ewe during pregnancy are satisfactory for reproduction and lactation and will result in satisfactory lamb growth. Ewes gaining less than 20 pounds during pregnancy may actually be losing body weight.

The result of these studies point out the importance of proper nutrition of the ewe during the last 4 to 6 weeks of gestation and during lactation. The increased rate of development of the fetus and the demands associated with udder development and milk production necessitate an increased level of feeding during these two periods. Failure to provide the extra nutrients needed may result in a serious impairment of lamb growth and leave the ewe in a weakened, unhealthy condition.

Urea as a Partial Substitute for Protein

The use of urea in ruminant rations has been studied for nearly three-quarters of a century. Mitchell and Hamilton (1928) and Owen (1941) have reviewed the early work concerning the utilization of non-protein-nitrogen by ruminants. These workers have concluded that certain forms of non-protein-nitrogen, such as urea, can be utilized to a certain extent, by ruminants for maintenance, growth and possibly for lactation. However, these reviews indicate that more information is needed regarding the practical use of urea in feeding cattle and sheep. Many workers have found evidence which indicates that a ruminant is able to utilize small amounts of urea for protein synthesis, without harmful effects to the animal or its products. For optimum efficiency in protein synthesis it is necessary that the rumen microorganisms be supplied with a readily available source of carbohydrate such as found in corn. The best utilization seems to occur when a ration is high in carbohydrates and relatively low in natural feed protein.

Evidence that non-protein forms of nitrogen can be utilized was published by Wegner et. al. (1940) at the Wisconsin Station. These workers first studied the "in vitro" conversion of inorganic nitrogen to protein by microorganisms from a cow's rumen. Their results indicated that this conversion was brought about by the action of bacteria present in the paunch. They concluded that bacterial activity and the conversion of nitrogen to protein is dependent on the pH of the medium, a pH range of 5.5 to 7.0 being ideal.

Wegner and co-workers (1941) continued the study of urea utilization by means of the rumen fistula technique. They found that urea and ammonia nitrogen, when present in amounts varying from 1 to 5 percent of the dry matter of the ration, had disappeared from the rumen 4 to 6 hours after feeding. The addition of 5 percent urea to a low-nitrogen basal ration definitely increased the percentage of protein nitrogen in the rumen ingesta. It was found that the rate of conversion of non-protein nitrogen to protein nitrogen in the rumen decreased as the level of protein in the ration was increased.

Pearson and Smith (1943) also studied the conversion of urea nitrogen to protein, "in vitro". These workers found that urea was first converted to ammonia and carbon dioxide. This conversion took place in their "in vitro" experiments largely within one hour after the urea was introduced into the media. They observed that synthesis of protein appeared to take place during the incubation of rumen ingesta.

Hilston and co-workers (1951) divided 81 bred range ewes into four lots to study the relative value of soybean meal and urea as nitrogen supplements during pregnancy and lactation. Lot 1 (basal group) received a ration adequate in T.D.N. but low in protein. Lot 2 received the same ration with the addition of urea in amounts to meet the National Research Council's recommendation for protein. Lot 3 was fed the same as Lot 2 except one-half the protein was furnished by soybean oil meal. The ration fed to Lot 4 was the same as Lot 1 plus enough soybean oil meal to meet the N.R.C. recommendations for protein. The basal ration consisted of low-protein prairie hay, molasses and corn. These same feed stuffs were used for all lots with varying amounts of corn to equalize the energy content of the rations. After 2 months the ewes in Lot 1 showed signs of a protein deficiency. Additional protein was, therefore, included in their ration. The ewes remained on experiment 134 days. At the end of this time no differences in gains or fleece weights were found among the various lots of ewes. Birth weights and vigor of the lambs from the urea-soybean oil meal lot were equally as satisfactory as those of lambs in the soybean oil meal lot. The lambs from the ewes receiving urea as a protein supplement had significantly lower birth weights and more were dead at birth than the lambs from the other lots. Following completion of the dry lot feeding, all ewes and lambs were moved to the open range. There were no apparent differences in the weaning weights of the lambs.

Jordon (1950) divided 60 ewes into five lots and supplemented brome hay with various sources of protein, including two levels of urea. The data from this trial showed that pregnant ewes receiving brome hay supplemented with a concentrate containing 5 to 10 percent urea (fed over a 100 day gestation period) made as good or better gains than ewes fed brome hay supplemented with only soybean oil meal. Three parts of alfalfa in the protein supplement increased the average gain made by ewes during the feeding period. The fleeces from ewes receiving urea were equally as heavy as the fleeces from the ewes in the positive control lot. Rasmussen (1951) reported that ewes receiving brome hay and soybean oil meal gained more weight during the 102-day gestation period than any of the other lots. The ewes receiving a protein concentrate containing 5 percent urea ranked close to the soybean oil meal lot in body weight gains. In this trial there seemed to be a trend indicating that the ewes receiving 10 percent urea in their concentrate mixture made less satisfactory gains than ewes of the other lots.

Pope et. al. (1952) in a gestation and lactation study, compared ewes which received a ration of prairie hay supplemented with a concentrate mixture containing urea with ewes receiving prairie hay and a concentrate mixture containing cottonseed meal. The concentrate mixtures were equal in crude protein. Only small differences were noted between the ewes and the lambs from the ewes receiving these two rations.

Influence of Minerals on Roughage Digestion

In a series of digestion trials with steers, Burroughs and co-workers (1950) added alfalfa ash and alfalfa water extract separately to a basal ration of corn cobs, starch, dried skim milk, bone meal, salt and vitamin A and D feeding oil. Addition of either alfalfa ash or alfalfa water extract to rations high in corn cobs, increased the digestibility of dry matter and organic matter significantly. The apparent digestibility of corn cob organic matter in the basal ration averaged 35 percent, as compared to 50 percent when either of the alfalfa components was added to the ration. From these studies, Burroughs postulated that the increase obtained in digestibility was due to unknown factor(s) associated with the inorganic nutrients in alfalfa hay.

Swift and co-workers (1950) also determined the effect of alfalfa ash on the digestibility of a ration in which corn cobs were the chief source of crude fiber. The addition of alfalfa ash increased significantly the digestibility of the crude fiber from 43 percent to 53 percent. Smaller increases in the digestibility of dry matter, protein and nitrogen-free extract were noted.

EXPERIMENTAL

Objectives

This trial was designed to study the value of different rations for ewes during gestation and lactation as measured by the gain or loss of body weight, wool production and lamb gain to 42 days. The experiment was initiated to determine:

1. The comparative value of urea and hydraulic-processed cottonseed meal as crude protein supplements to a prairie hay ration.

2. The relative value of a new solvent-processed cottonseed meal as compared to hydraulic cottonseed meal.

3. The comparative value of a prairie hay grown in central Oklahoma to one grown in the eastern part of the state.

4. The effect of adding alfalfa ash to a ration containing urea.

5. The effect of these sources of protein and roughage on hemoglobin and hematocrit levels.

Procedure

Sixty-six solid mouthed, fine-wool ewes of Texas origin, which had been used in a previous experiment, were secured for this study. The ewes had been pastured in a wooded area during the summer of 1951 and in October were moved to the Animal Husbandry experimental barn. After arrival at the experimental barn, they were numbered for ease of identification, drenched with phenothiazine, and exposed to two purebred Hampshire rams. The rams were used alternately and were placed with the ewes only at night.

After it was apparent that all the ewes were bred, they were divided into six groups of 11 ewes each. Forty-two of the ewes were allotted into the six groups at random, by outcome levels, according to previous lamb production records and body weight. The remaining 24 ewes were allotted at random by body weight. The ewes were started on the experimental rations November 17, 1951.

Prairie hay was fed to the ewes free-choice throughout the experiment. The various concentrates were approximately equal in T.D.N. and were fed in pelleted form to all lots. From the start of the experiment to the 7th day after lambing each ewe received 1.1 pounds of pellets. To meet the increased requirements of ewes during lactation, the ewes received 2 pounds of pellets, per head daily, from the 7th to the 42nd day of lactation.

The ewes of Lot 1 were fed a low-protein ration of prairie hay and a concentrate mixture of corn, molasses and hydraulic cottonseed meal. The hay was of good quality from an area near El Reno, Oklahoma. The concentrate mixture fed to these ewes contained approximately 9 percent crude protein.

Lot 2 received a similar ration plus sufficient urea ("Two-Sixty-Two" commercial feed compound) to raise the crude protein level of the concentrate to approximately 14 percent.

Lot 3 was fed a ration similar to that fed Lot 2 plus alfalfa ash. The ash was prepared by burning green, leafy alfalfa hay in an open container and was further ignited by placing it in a steel drum and heating it in an incinerator for 24 hours. It was added to the pelleted feed in sufficient quantity to furnish each ewe, during gestation, the ash from 0.5 pound of alfalfa hay, daily.

The ewes in Lot 4 received a ration similar to that fed Lot 1 with hydraulic cottonseed meal substituted for corn in amounts to raise the crude protein level of the concentrate mixture to approximately 14 percent.

The ewes of Lot 5 were fed a ration identical with that of Lot 4 except that a low fat solvent-processed cottonseed meal was used in place of hydraulic cottonseed meal and the prairie hay was obtained from another source. This hay was harvested and stored in the summer of 1950 and was from a co-called "trouble" area near Sallisaw in eastern Oklahoma.

The ewes of Lot 6 were also fed the Sallisaw hay but the concentrate feed, containing hydraulic cottonseed meal, was the same as that fed Lot 4. Thus, it was possible to compare the value of the hays from the two sources (Lots 4 versus Lot 6) and to compare low-fat solvent cottonseed meal with hydraulic meal (Lot 5 versus Lot 6).

Limestone and bonemeal were used to adjust the calcium and phosphorus content of the rations to meet the N.R.C. recommendations in a ratio of 1.35:1. From the daily ration fed during gestation, each ewe received approximately 4.4 grams of calcium and 3.3 grams of phosphorus. Salt was available to the ewes at all times. During lactation, the salt was mixed with bonemeal in a proportion of 1:1.

The percentage composition of the concentrate feed mixtures is given in Table 1. The chemical composition of the feeds is shown in Table 2.

Chemical analysis showed that the crude protein content of the pellet fed to ewes of Lots 4 and 6 was substantially lower than that of the pellet fed to Lot 3. Consequently, a small amount of cottonseed meal was added to the pellet fed Lots 4 and 6 to equalize the crude protein levels of the concentrate mixtures (10 grams of cottonseed meal per ewe daily during gestation and 20 grams per ewe daily during lactation).

The initial weights of the ewes were determined by averaging two weights taken on successive days. Water was removed from all lots approximately 6 hours prior to weighing. Thereafter, single weights were taken at two-week intervals until approximately three weeks before the start of the lambing period. Weekly weights were then taken up to the time of lambing. Further ewe weights were recorded immediately after lambing and at the end of the 6th week of lactation. In order to obtain a more uniform measure of lamb production per ewe, ewes with twins were given the largest lamb to raise as a single. The lambs were weighed at birth and at 5, 10, 21 and 42 days of age. After lambing, the ewes and their lambs were placed in small individual pens for 7 days. The lambs were docked at approximately three days of age. Ram lambs were castrated at two weeks of age. The ewes and lambs were removed from the experiment on the 42nd day of the lactation period. The ewes were shorn near the end of the experiment to determine the fleece weights.

Blood samples were taken from 5 ewes in each lot at approximately monthly intervals during gestation; samples were also taken from all ewes after they had completed 28 days of lactation. All blood samples were taken in the morning, approximately 4 hours after feeding. Hemoglobin values were determined by Wong's (1928) acid hematin method. In an attempt to remove clinical error from the hemoglobin determinations, all samples were analyzed in duplicate. If the values obtained did not agree within 2 grams, the determination were repeated. Hematocrit values were determined with a Wintrobe hematocrit tube by the method described by Levinson (1946).

The data were treated statistically by analysis of variance (Snedecor, 1946).

TABLE 1

Percentage Composition of Pelleted Concentrate
Mixtures Fed to Ewes in Lots 1 to 6

Feed	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Corn	84.9	82.8	81.7	69.3	69.3	69.3
Cottonseed Meal (Hydr.)	3.9	3.9	3.9	19.8	---	19.8
Cottonseed Meal (Sol.)	---	---	---	---	19.8	---
Urea ("Two-Sixty-Two")[1]	---	2.0	2.0	---	---	---
Molasses	9.9	9.9	9.7	9.9	9.9	9.9
Alfalfa Ash[2]	---	---	2.4	---	---	---
Bonemeal[3]	1.1	1.1	0.3	---	---	---
Limestone[3]	0.2	0.3	---	1.0	1.0	1.0

[1] A commercial feed compound.

[2] The amount fed supplied the ash-equivalent of 0.5 pound of alfalfa hay per ewe daily, during gestation, and approximately 1.0 pound during lactation.

[3] Minerals used to increase calcium and phosphorus intake to at least 4.4 grams of calcium and 3.3 grams of phosphorus daily, as recommended by the N.R.C. for lactating ewes.

TABLE 2

Chemical Composition of Feeds

	Percent Dry Matter	Percentage Composition of Dry Matter						
		Ash	Crude Protein	Ether Extr.	Crude Fiber	N.F.E.	Ca	P
Prairie Hay (El Reno)	92.42	8.04	6.12	2.66	32.15	51.03	.39	.12
Prairie Hay (Sallisaw)	91.60	6.72	5.56	1.98	35.37	50.37	.44	.08
Pelleted Feed-Lot 1	88.24	4.19	10.30	4.51	2.65	78.34	.74	.54
Pelleted Feed-Lot 2	88.23	4.24	16.15	4.41	2.73	72.47	.75	.56
Pelleted Feed-Lot 3	87.18	5.79	16.92	4.04	2.73	70.52	.67	.46
Pelleted Feed-Lot 4	89.79	4.42	15.24	5.04	4.01	71.29	.65	.61
Pelleted Feed-Lot 5	87.98	4.73	16.52	3.52	4.30	70.93	.74	.50
Pelleted Feed-Lot 6	89.79	4.42	15.24	5.04	4.01	71.29	.65	.61
Cottonseed Meal (Hydr.)	93.47	6.74	42.86	7.32	12.44	30.64	.25	1.24
Cottonseed Meal (Sol.)	91.78	6.30	44.91	0.69	13.42	34.68	.16	.87

RESULTS AND DISCUSSION

The average daily feed intake during gestation and the average intake of T.D.N. and protein are given in Table 3. The prairie hay consumed by the ewes, from the start of the experiment to February 19, was estimated from daily weigh-backs of refused hay. Due to variation in the date of lambing and the necessity of separating ewes individually it was difficult to obtain data on hay consumption for the lactation period. As a result, the average intakes during lactation were calculated on the basis of a daily prairie hay intake of 2 pounds per ewe. During the second week of lactation, some of the ewes in Lot 1 developed poor appetites and failed to consume all of the pelleted feed. The refused pellets were weighed back daily. Many of the ewes in this lot failed to regain their appetites during the remainder of the experiment.

The summary of the weight changes of the ewes is given in Table 4 and the individual data are shown in Table 12, appendix. The weight changes of the ewes during the gestation phase were not significant. However, statistical analysis (Table 5) of the net gain or loss of weight by the ewes over the entire experiment, shows that significant differences were present. Orthogonal comparisons revealed that the only significant difference was between the ewes of Lots 5 and 6. Ewes of Lot 6 receiving the hydraulic cottonseed meal pellets gained an average of 6.5 pounds per head which was significantly higher than the gain of the ewes of Lot 5, which received the solvent-processed cottonseed meal pellets. According to Wallace (1948), under condition of adequate nutrition the ewe will maintain her weight over the entire reproductive cycle. Hence

TABLE 3

Average Daily Rations and Nutrient Intakes of Ewes During Gestation and Lactation (pounds)

Type of Hay Fed	"El Reno" Hay				"Sallisaw" Hay	
Lot Number	1	2	3	4	5	6
Description of Pellet	Low-Protein	Urea	Urea-Alfalfa Ash	Hydr. CSM	Sol. CSM	Hydr. CSM
Daily Feed Intake During Gestation:						
Pelleted feed	1.1	1.1	1.1	1.1[1]	1.1	1.1[1]
Prairie hay	1.9	2.0	2.1	2.2	1.8	1.6
Total	3.0	3.1	3.2	3.3	2.9	2.7
Nutrient Intake (lbs./ewe/day)						
Crude Protein	.21	.28	.28	.28	.25	.24
Dig. Crude Protein[2]	.11	.17[3]	.17[3]	.17	.14	.13
T.D.N.[4]	1.79	1.83	1.87	1.94	1.64	1.57
Percent Crude Protein	7	8.8	8.8	8.5	8.6	8.5
Daily Feed Intake During Lactation: (7th to 42nd Day of Lactation)						
Pelleted feed	1.8	2.0	2.0	2.0	2.0	2.0
Prairie hay	ad lib.	ad lib.	ad lib.	ad lib.	ad lib.	ad lib.
Nutrient Intake (lbs./ewe/day)[5]						
Crude Protein	.27	.39	.39	.37	.39	.38
Dig. Crude Protein[2]	.18	.28[3]	.28[3]	.28	.24	.24
T.D.N.[4]	2.40	2.53	2.49	2.51	2.39	2.41

[1] Sufficient cottonseed meal (41 percent) added to each ewe's ration to raise the crude protein content of pellets fed to ewes of Lots 4 and 6 to a level approximately equal to that fed ewes of Lots 2, 3 and 5.

[2] Determined by using the digestible protein values given by Morrison (1949).

[3] Urea calculated as 100 percent digestible.

[4] Determined by using the T.D.N. values and digestion coefficients given by Morrison (1949).

[5] Values computed on an estimated daily hay consumption of 2.0 pounds per ewe.

TABLE 4

Summary of Average Weight Changes and Fleece Weights of Ewes During Gestation and Early Lactation

Type of Hay Fed	"El Reno" Prairie Hay				"Sallisaw" Prairie Hay	
Lot Number	1	2	3	4	5	6
Description of Pellet	Low-Protein	Urea	Urea-Alfalfa Ash	Hydr. CSM	Sol. CSM	Hydr. CSM
Number of Ewes per Lot[1]	7[2]	10	10	9	11	6
Gestation Phase						
Average Ewe Weights (lbs.)						
Initial Weight (11-20-51)	119.0	114.5	114.8	111.7	113.9	113.5
17th Week Before Lambing	121.2	116.9	118.2	119.3	115.7	114.0
1 Week Before Lambing	145.6	143.4	146.4	140.6	139.0	136.9
Gain the Last 17 Weeks of Gestation	24.4	26.5	28.2	21.3	25.1	22.9
Average Lambing Date	3/13	3/17	3/16	3/15	3/15	3/20
Lactation Phase						
Average Ewe Weights (lbs.)						
Weight After Lambing	121.3	120.7	120.9	119.6	112.5	111.1
Gain or Loss 17 Weeks Before Lambing to After Lambing	0.1	3.8	2.7	0.3	-3.2	-2.9
42nd Day of Lactation	119.4	123.1	126.4	122.1	113.5	120.5
Gain or Loss During Lactation	-1.9	2.4	5.5	2.5	1.0	9.4
Net Gain or Loss[3]	-1.8	6.2	8.2	2.8	-2.2	6.5
Average Fleece Weight (lbs., Grease)	8.5	8.1	8.3	8.7	8.1	7.8

1 Includes only those ewes which completed 42 days lactation.
2 Does not include ewe 3133 which was placed on experiment December 31, 1951.
3 From the 17th week before lambing to the 42nd day of lactation.

TABLE 5

Analysis of Variance of Body Weight Gain of Ewes from 17 Weeks Before Lambing to the 42nd Day of Lactation[1]

Source of Variation	d.f.	Sum of Squares	Mean Square
Total	53[2]	2809.0	
Treatment	5	970.8	194.2*
Lot 1 vs. all other lots.	(1)	213.8	
Lots 2, 3 and 4 vs. Lots 5 and 6	(1)	212.3	
Lots 2 and 3 vs. Lot 4	(1)	124.1	
Lot 2 vs. Lot 3	(1)	18.1	
Lot 5 vs. Lot 6	(1)	402.5	402.5*
Error	48	2838.0	59.13

[1] Includes only those ewes which completed 42 days lactation.
[2] Does not include ewe number 3133 which was placed on experiment Dec. 31, 1951.
* Statistically significant at the 5 percent level.

the small average net loss of 2.2 pounds by the ewes of Lot 5 may not be considered critical. Although, the average net loss of 1.8 pounds by the ewes of Lot 1 was not significantly lower than that of other lots, the trend indicated by this figure may be important. Thomson and Fraser (1939) and Thomson and Thomson (1949) have pointed out the importance of the ewe's "condition" during the early part of gestation. The results of the present experiment are in agreement with this concept in that the ewes of Lot 1 which failed to raise a lamb were ewes which started the experiment in poor condition. Therefore, since the values in Table 4 include only those ewes which completed 42 days of lactation, they do not indicate the true performance of all the ewes on the low-protein ration. The

TABLE 6

Summary of Lamb Production Records

Type of Hay Fed	"El Reno" Prairie Hay				"Sallisaw" Prairie Hay	
Lot Number	1	2	3	4	5	6
Description of Pellet	Low-Protein	Urea	Urea-Alfalfa Ash	Hydr. CSM	Sol. CSM	Hydr. CSM
Number of Ewes Lambing	10	11	10	10	11	9
Total Number of Lambs Born	15	15	17	14	19	12
Singles	5	7	3	8	3	6
Twins	10	8	14	6	16	6
Average Birth Weight (lbs.)						
Singles	10.6	11.4	12.4	11.3	11.3	10.3
Twins	9.0	9.8	8.8	9.9	8.5	8.3
Total Number of Lambs Raised	8	10	10	9	11	6
Singles	3	7	3	7	3	6
Twins[1]	5	3	7	2	8	-
Average Weights (lbs.)[2]						
At birth	10.4	10.9	10.3	10.9	9.5	10.3
At 5 days	12.9	13.7	12.7	13.7	12.0	13.3
At 10 days	15.9	17.0	16.1	16.7	14.6	16.6
At 21 days	21.9	23.8	23.1	24.3	20.5	24.0
At 42 days	33.3	37.8	36.5	38.1	32.2	38.1
Gain, Birth to 42 Days	22.9	26.9	26.2	27.2	22.7	27.8
Average Daily Gain to 42 Days	0.55	0.64	0.62	0.65	0.54	0.66

1 Ewes with twins given largest lamb to raise as a single.
2 Pertains only to lambs which completed 42 days lactation.

failure of ewes to raise lambs in the remaining lots were caused by factors which were not believed to be due to the rations fed. The causes of these reproductive failures are shown in the footnotes of Table 12, appendix.

The average fleece weights are shown in Table 4. Differences in wool production were not significant, as measured by the grease weight of the fleece at shearing.

The lamb production records are summarized in Table 6 and the individual data are shown in Table 13, appendix. No consistent differences were observed in the birth weights of either single or twin lambs. Slen and Whiting (1952) found a significant increase in the birth weight of lambs when the ration fed pregnant ewes was increased from 7 to 10 percent crude protein. Wallace (1948) reported that the birth weight of the lamb was substantially affected by the protein intake of the ewe during gestation. Thus it would seem that the differences in protein intake in this trial were not great enough to produce results similar to those obtained by other workers.

The weight gains of the lambs from birth to 42 days were treated statistically. The orthogonal comparisons showing the major sources of variation are found in Table 7.

Wallace (1948) found a highly significant correlation ($r = .83$) between the milk yield of the ewe and the gain of the lamb during the first 56 days of lactation. Slen and Whiting (1952) found a similar correlation. Thus, the gain of the lamb may be used as a measure of the milk production of the ewe. Further, Slen and Whiting (1952) have shown that low levels

TABLE 7

Analysis of Variance of Lamb Gain from Birth to 42 Days

Source of Variation	d.f.	Sum of Squares	Mean Square
Total	54	806.66	
Treatment	5	279.00	55.8*
Lot 1 vs. all other lots	(1)	52.61	52.61*
Lots 2, 3 and 4 vs. Lots 5 and 6	(1)	83.37	83.37*
Lots 2 and 3 vs. Lot 4	(1)	2.65	
Lot 2 vs. Lot 3	(1)	1.66	
Lot 5 vs. Lot 6	(1)	138.70	138.70**
Error	49	527.66	10.77

* Statistically significant at the 5 percent level.
** Statistically significant at the 1 percent level.

of protein in the ration significantly decrease the milk production of the ewe. Hence, the gain of the lamb may also be used as a measure of the adequacy of protein intake.

The average gain of the lambs from ewes receiving the low-protein ration was significantly less than the average gain of lambs of the other lots. Slen and Whiting (1952) fed a basal low-protein ration, similar to the one fed in this trial, to ewes and found lamb gains to be significantly less than the gain of lambs from ewes receiving a 10 percent crude protein ration.

The highly significant difference in average lamb gains between Lots 2, 3 and 4 as compared to Lots 5 and 6 can perhaps best be explained by examination of the individual lamb data in Table 12, appendix. The gains of lambs in Lots 2, 3 and 4 were consistent and were included in a range of 8 pounds, whereas the lamb gains in Lots 5 and 6 were highly variable and were included in a range of 19.25 pounds. Thus, the difference between the two prairie hays fed, Lots 2, 3 and 4 versus Lots 5 and 6, is perhaps greater than these data would indicate. The lambs in Lot 6 made an average gain of 27.8 pounds from birth to 42 days, as compared to an average of 22.7 pounds for lambs in Lot 5; this difference in gain was highly significant and in favor of Lot 6.

Gallup _et_. _al_. (1950) compared the value of hydraulic and solvent cottonseed meals in metabolism trials with steers and lambs. The solvent meal used in these trials contained approximately 2.5 percent fat on a dry matter basis. They found no differences in nitrogen retention due to the method of processing the meals. Workers at the Texas Station (1950) found that steers receiving 4 pounds of solvent processed cottonseed meal as part of their fattening ration made an average daily gain of 2.06 pounds per day, compared with 2.2 pounds average daily gain for steers fed an equal amount of hydraulic processed cottonseed meal. However, these workers found no difference between the hydraulic and solvent meals when fed in rations for wintering beef cattle. The solvent meal used in Texas trials contained approximately 3.5 percent fat on an air dry basis.

The difference between the average gain of the lambs from ewes which received the urea pellets (Lots 2 and 3) and those receiving the cottonseed meal pellets (Lot 4) was not significant. These results indicate that the urea nitrogen in the pellets fed to ewes of Lots 2 and 3 was efficiently utilized. Differences in average lamb gains between Lots 2 and 3 were not statistically significant. Thus, it would appear that there was little advantage to adding alfalfa ash to the ration fed to ewes in this trial.

The average hemoglobin and hematocrit levels are shown in Tables 8 and 10. The noticeable decrease in these values, within all lots, as the experiment progressed is similar to that observed by Scott (1951), Klosterman (1950) and Pope (1952). The analyses of variance of the blood data are presented in Tables 9 and 11. In these analyses, the variation within lots due to the time of bleeding was removed statistically.

The average hematocrit and hemoglobin values of the ewes in Lot 1 were somewhat lower than those of Lots 2, 3 and 4, but these differences were not significant. Nash (1950), Scott (1951) and Klosterman (1950) have shown that a poor ration fed to pregnant and lactating ewes is reflected in lower hemoglobin levels.

In comparing blood data of the ewes receiving urea pellets (Lots 2 and 3) with those receiving cottonseed meal pellets (Lot 4), the hemoglobin levels of Lot 2 and 3 were significantly lower ($P < .05$). Pope (1952), in a similar trial, reported that hemoglobin levels from ewes fed urea were lower than those from ewes fed a low-protein ration.

The blood data further suggests that under the conditions of this trial little advantage was obtained by adding alfalfa ash to a ration containing urea. Scott (1951) reported that pregnant and lactating ewes fed a ration supplemented with alfalfa ash, maintained higher hemoglobin and hematocrit levels for a longer period than ewes receiving a similar ration without the addition of alfalfa ash.

The difference in the average hemoglobin levels between Lots 5 and 6 was found to be highly significant ($P < .01$). The same trend was noted

TABLE 8

Average Hemoglobin Levels of Ewes
(Grams per 100 ml.)

Lot No.	No. of Ewes Bled	Initial Bleeding	Dec. 18	Jan. 28	Feb. 20	Lactation Bleeding[1]	Av.
1	5	12.9	12.7	12.3	10.1	8.5	10.9
2	5	12.4	11.8	13.0	11.5	9.6	11.3
3	4[2]	13.2	11.5	13.8	10.8	9.1	11.2
4	5	14.1	12.6	13.4	12.3	9.5	12.0
5	5	13.6	11.7	11.0	10.8	8.4	10.7
6	5	13.6	12.7	12.4	10.9	9.9	11.7

[1] Blood samples were taken from all ewes which raised lambs, between the 28th and 42nd days of lactation.

[2] Ewe number 3065, an open ewe, not included in these averages.

TABLE 9

Analysis of Variance of Hemoglobin Data

Source of Variation	d.f.	Sum of Squares	Mean Square
Total	167	842.05	
Date of Bleeding	4	432.83	
Treatment	5	35.53	7.11*
Lot 1 vs. All Other Lots	(1)	4.59	
Lots 2, 3 and 4 vs. Lots 5 and 6	(1)	3.92	
Lots 2 and 3 vs. Lot 4	(1)	9.64	9.64*
Lot 2 vs. Lot 3	(1)	.46	
Lot 5 vs. Lot 6	(1)	16.92	16.92**
Error	158	373.69	2.365

* Statistically significant at the 5 percent level.
** Statistically significant at the 1 percent level.

TABLE 10

Average Hematocrit Levels of Ewes
(Percent)

Lot No.	No. of Ewes Bled	Initial Bleeding[1]	Dec. 18[1]	Jan. 28	Feb. 20	Lactation Bleeding[2]	Av.
1	5	41.8	43.2	34.9	32.8	26.5	34.8
2	5	42.7	45.1	37.7	35.2	29.6	36.6
3	4[3]	40.2	43.2	37.1	33.2	29.0	35.0
4	5	45.4	45.4	37.7	34.0	30.1	37.4
5	5	45.1	44.4	34.2	32.9	26.7	35.0
6	5	45.6	45.9	34.5	32.8	32.2	37.7

[1] Values may be slightly high due to an error in technique.
[2] Blood samples were taken from all ewes which raised lambs, between the 28th and 42nd days of lactation.
[3] Ewe number 3065, an open ewe, not included in these averages.

TABLE 11

Analysis of Variance of Hematocrit Data

Source of Variation	d.f.	Sum of Squares	Mean Square
Total	168	10,147.36	
Date of Bleeding	4	6,619.87	
Treatment	5	237.66	47.53*
Lot 1 vs. All Other Lots	(1)	54.39	
Lots 2, 3 and 4 vs. Lots 5 and 6	(1)	.32	
Lots 2 and 3 vs. Lot 4	(1)	41.38	
Lot 2 vs. Lot 3	(1)	33.93	
Lot 5 vs. Lot 6	(1)	107.64	107.64*
Error	159	3,289.83	20.69

* Statistically significant at the 5 percent level.

in the average hematocrit values and was found to be significant ($P < .05$). Due to a lack of carefully controlled prairie hay intake, it is not possible to explain these differences on the basis of differences in composition of the pelleted feeds alone. Possibly the lowered fat content of the pellets fed Lot 5 may have affected the synthesis of cholesterol, which in turn affects the formation of the red blood cell. The importance of cholesterol in this regard is indicated by Best and Taylor (1950).

SUMMARY

A trial was conducted with 66 fine-wool ewes as a continuation of previous investigations at the Oklahoma Station concerning the cause of death losses among livestock in eastern Oklahoma. In addition, this trial included a study of the relative value of a new solvent-processed cottonseed meal, as compared to a hydraulic processed meal, when each was added to a low quality prairie hay ration. It also included a study of the practical value of urea in ewe rations and the supplemental value of alfalfa ash in the urea ration.

The roughages fed in this trial included a poor-quality prairie hay grown in the eastern part of Oklahoma and a good-quality prairie hay from central Oklahoma.

The results showed that the unsupplemented low-protein ration, containing approximately 7 percent crude protein was inadequate for pregnant and lactating ewes as measured by weight loss of the ewe and lamb gain to 42 days.

Ewes fed a low-protein ration supplemented with urea to raise the crude protein of the concentrate mixture from 9 to 14 percent, gained more weight during the experiment and produced lambs which made faster gains to 42 days than the ewes fed the low-protein ration. The data obtained suggests that hydraulic cottonseed meal and urea in nitrogen equivalent amounts were of equal value in supplementing the low-protein ration.

Little advantage was obtained in this trial by adding alfalfa ash to a ration containing urea.

Ewes fed a poor-quality prairie hay, such as might be found in eastern Oklahoma, supplemented with a concentrate mixture containing hydraulic cottonseed meal, produced normal, healthy lambs. These lambs did not differ in rate of gain from those of ewes fed a good quality prairie hay, supplemented in the same manner. These results, plus the inconsistent trends in the weight changes of the ewes and fleece weights, support the conclusions drawn from previous experiments; namely, that the livestock losses in eastern Oklahoma are probably due to a deficiency of protein and energy in the ration, rather than to specific factors associated with the roughage.

The consistently inferior performance of ewes receiving a new solvent-processed cottonseed meal as compared to those receiving hydraulic-processed cottonseed meal would indicate that further work should be done to determine the cause of these differences in performance.

LITERATURE CITED

Anonymous. Beef Cattle Investigations in Texas, 1888-1950. Texas Agri. Experiment Station Bulletin 724. (1950). Texas A. and M. College, College Station, Texas.

Best and Taylor. Physiological Basis of Medical Practice, 5th Edition. Williams and Wilkens, Baltimore, Md. (1950). p. 23.

Burroughs, Wise, Paul Gerlaugh and R. M. Bethke. "Influence of Alfalfa Ash and Water Extract of Alfalfa Upon Roughage Digestion in Cattle", Jour. Ani. Sci. (1948), 7:522.

Burroughs, Wise, Paul Gerlaugh and R. M. Bethke. "The Influence of Alfalfa Hay and Fractions of Alfalfa Hay Upon the Digestion of Ground Corncobs." Jour. Ani. Sci. (1950), 9:207-213.

Gallup, W. D., H. M. Briggs and E. E. Hatfield. "The Comparative Value of Hydraulic, Expeller and Solvent Processed Oil Meal for Ruminants," Jour. Ani. Sci. (1950), 9:194-200.

Hawk, P. B., B. L. Oser and W. H. Summerson. Practical Physiological Chemistry, 12th Edition. The Blaikston Comparny, New York, (1951).

Hilston, N. W., C. B. Roubicek and J. Bond. Utilization of Non-protein Nitrogen by Pregnant Ewes, Mimeo. Cir. No. 5, University of Wyoming Agricultural Experiment Station (1951).

Jordon, R. M. "Rations for Wintering Breeding Ewes," South Dakota Agricurtural Experiment Bulletin 399.

Jordon, R. M. "The Value of Urea in Rations for Pregnant Ewes," Livestock Feeders' Day Report, South Dakota State College, (1950), pp. 4-5.

Klosterman, Earle W., M. L. Buchanan, D. W. Bolin and F. M. Bolin. "Levels and Sources of Protein in Rations for Pregnant Ewes," Jour. Ani. Sci. (1951), 10:255-265.

Klosterman, E. W., D. W. Bolin, M. L. Buchanan, and F. M. Bolin. "The Blood Proteins of Pregnant Ewes and How They are Affected by Protein in the Ration," Jour. Ani. Sci. (1950), 9:180-185.

Levinson, Samuel A. and Robert P. MacFate. Clinical Laboratory Diagnosis, 3rd Edition. Lea and Ferbiger, Philadelphia, Pa. (1946). Pp. 445-447.

National Research Council. Recommended Nutrient Allowances for Sheep. Sub-Committee on Sheep Nutrition. 1950, Washington, D. C.

Mitchell, H. H. and T. S. Hamilton. The Biochemistry of the Amino Acids. The Chemical Catalogue Company, Inc., New York. (1929). Pp. 619.

Morrison, F. B. Feeds and Feeding, 21st Edition. Ithica, New York: The Morrison Publishing Company, (1948).

Nash, R. L. "The Effect of the Level of Nutrition on Reproduction and Lactation of Ewes." Master of Science thesis, Oklahoma Agricultural and Mechanical College. (1950).

National Research Council. Recommended Nutrient Allowances for Sheep. Sub-Committee on Sheep Nutrition. (1950), Washington, D. C.

Owen, E. C. "A Review of Urea as a Protein Source for Ruminants," Jour. Dairy Research. (1941), 12:213.

Pearson, R. M. and J. A. B. Smith. "The Utilization of Urea in the Bovine Rumen," Biochem. Jour. (1943). 37:142-164.

Pope, L. S. "The Utilization of Urea by Sheep." Doctor of Philosophy thesis, Oklahoma Agricultural and Mechanical College. (1952).

Pope, L. S., W. D. Gallup and C. K. Whitehair. "The Value of Urea in Rations for Ewes During Gestation and Lactation." 24th Annual Feeders' Day Report, Oklahoma Experiment Station. (1952), pp. 47-51.

Rasmussen, K. "Urea in the Wintering Ration of Pregnant Ewes," Livestock Feeders' Day Report, South Dakota State College, (1951), pp. 10-12.

Rusoff, L. L. and D. M. Seath. Malnutrition of Louisiana Dairy Cows. (Mineral Studies). Louisiana Bulletin 413, Louisiana Experiment Station. (1947).

Slen, S. B. and F. Whiting. "Wool Production as Affected by the Level of Protein in the Ration of the Mature Ewe," Jour. Ani. Sci. (1952), 11:156-165.

Slen, S. B. and F. Whiting. "Lamb Production as Affected by Level of Protein in the Ration of the Mature Ewe," Jour. Ani. Sci. (1952), 11:166-173.

Snedecor, G. W. Statistical Methods, 4th Edition. The Iowa State College Press, 1946.

Swift, R. W., R. L. Cowan, and G. P. Barron. "The Effect of Alfalfa Ash upon Roughage Digestion in Sheep," Jour. Ani. Sci. (1950), 9:669-670.

Thomson, A. M. and A. H. H. Fraser. "Feeding Concentrates to the In-Lamb Ewe. The Effects in Lambing Results," Scottish Jour. Agri. (1939), 22:71-73.

Thomson, A. M. and W. Thomson. "Lambing in Relation to the Diet of Pregnant Ewes," British Jour. of Nutr. (1949), 2:290-305.

Underwood, E. J. and F. L. Shier. "The Influence of Feeding During Late Pregnancy on the Birth-Weight, Growth Rate and Quality of Lamb," Jour. Dept. of Agri. West. Australia. (1942), 19:37-47.

Underwood, E. J., F. L. Shier and H. G. Cariss. "The Influence of a High Level of Prenatal Feeding in Lamb Production," Jour. Dept. of Agri. West. Australia. (1943), 20:288-297.

Wallace, L. R. "The Growth of Lambs Before and After Birth in Relation to the Level of Nutrition," Jour. Agri. Sci. (1949), 38:93-153, 243-302, 367-401.

Wegner, M. I., A. N. Booth, G. Bohstedt and E. B. Hart. "Preliminary Observations on Chemical Changes of Rumen Ingesta with and without Urea," Jour. Dairy Sci. (1941), 24:51-56.

Wegner, M. I., A. N. Booth, G. Bohstedt and E. B. Hart. "The "In-Vitro" Conversion of Inorganic Nitrogen to Protein by Microorganisms from the Cow's Rumen," Jour. Dairy Sci. (1940), 23:1123-1129.

Whitehair, C. K., O. B. Ross and W. D. Gallup. "Nutritional Deficiencies in Eastern Oklahoma," Feeders' Day Report. Oklahoma Agri. Experiment Station Misc. Publ. MP - 13. (1948). pp. 38-39.

Whitehair, C. K., O. B. Ross and W. D. Gallup. "Nutritional Deficiencies in Eastern Oklahoma," Feeders' Day Report. Oklahoma Agri. Experiment Station Misc. Publ. MP - 15, (1949). pp. 55-56.

Whiting, Frank and S. B. Slen. "Milk Production of Mature Range Ewes as Affected by the Level of Protein in their Ration. Jour. Ani. Sci. (Abstract) 10:1067-1951.

Wilson, J. W., L. E. Johnson and Turner Wright. Feeds for Wintering Bred Ewes in South Dakota, South Dakota Agricultural Experiment Station Bulletin No. 388. (1948).

APPENDIX

TABLE 12

Ewe Weights During Gestation and Lactation and Fleece Weights
(Pounds)

Ewe No.	Initial	Gestation Weights: Within 17 Weeks of Lambing	Gestation Weights: Within 7 Weeks of Lambing	Gestation Weights: Within 1 Week of Lambing	Lactation Weights: After Lambing	Lactation Weights: 42 days After Lambing	Fleece Weights
Lot No. 1							
3098	119	129	142	160	120	117	8.25
3089	136	138	168	174	145	135	11.00
3117	101	104	110	113	100	100	7.75
3303	128	127	156	150	118	130	9.50
3125[1]	105	105	119	125	103	-	7.00
3100[2]	97	-	-	-	-	-	-
3304	106	106	120	123	114	97	8.00
3122[3]	106	111	124	125	90	-	-
3079	129	130	159	161	124	132	8.50
3091[1]	117	-	-	-	-	-	-
3133[4]	-	-	140	146	122	107	7.00
3127	114	114	136	138	128	125	8.00
Lot No. 2							
3074	130	133	155	163	142	142	9.50
3067	127	127	143	148	129	136	8.00
3136	95	98	109	122	101	104	6.25
3113	100	102	115	124	102	104	7.50
3072	113	117	133	140	110	112	6.50
3301	119	124	148	158	150	144	10.00
3114	121	123	148	153	138	132	9.50
3119	93	97	111	123	108	105	7.00
3090	130	136	151	168	125	133	8.50
3082[1]	120	118	132	139	106	-	10.00
3096	111	111	128	139	117	119	8.50

[1] Ewe did not raise a lamb. 3125 lost a large amount of blood at lambing. 3091 aborted December 31, 1951. 3082 developed udder trouble (Mastitis).

[2] Ewe died prior to lambing. Severe hemorragic inflamation of abomasum and small intestine noted on autopsy. Cause of death unknown.

[3] Ewe did not complete experiment (Went off feed at lambing and died Apr. 5, 1952. Diagnosed as septicemia).

[4] Ewe substituted for ewe 3091 December 31, 1951.

TABLE 12 (continued)

Ewe No.	Initial	Gestation Weights: Within 17 Weeks of Lambing	Within 7 Weeks of Lambing	Within 1 Week of Lambing	Lactation Weights: After Lambing	42 days After Lambing	Fleece Weights
Lot No. 3							
3066	118	123	152	162	129	129	10.50
3068	118	117	141	144	120	135	8.00
3078	126	129	153	164	131	145	9.75
3065[1]	99	-	-	-	-	-	5.75
3128	111	114	134	144	120	129	7.00
3097	120	128	138	147	119	135	8.00
3109	102	106	124	130	112	103	6.75
3106	100	111	124	132	123	131	7.25
3077	126	129	152	159	129	135	10.00
3083	115	114	136	145	117	118	9.75
3123	112	111	130	137	109	104	5.50
Lot No. 4							
3129	119	134	144	158	138	135	8.50
3070[2]	124	128	151	166	-	-	-
3101	93	103	116	122	107	95	7.75
3081	127	138	160	153	131	144	9.75
3087[2]	116	128	142	162	139	-	9.50
3116	103	105	121	130	106	106	6.25
3139	100	105	112	121	108	108	8.00
3111	107	106	123	124	109	113	8.50
3126	130	142	156	171	142	143	9.75
3120	115	125	138	146	126	140	10.75
3092	111	116	128	140	109	115	8.75

[1] Open ewe.

[2] Ewe did not raise a lamb. 3070 had difficulty lambing; lambs dead at birth. 3087 developed udder trouble (Mastitis).

TABLE 12 (continued)

Ewe No.	Initial	Gestation Weights: Within 17 Weeks of Lambing	Within 7 Weeks of Lambing	Within 1 Week of Lambing	Lactation Weights: After Lambing	42 days After Lambing	Fleece Weights
Lot No. 5							
3130	127	125	153	159	126	136	9.10
3073	127	128	145	144	106	105	9.75
3118	95	96	109	117	95	100	6.00
3103	99	107	123	143	111	111	9.25
3302	116	125	139	152	124	122	9.00
3086	119	118	132	140	122	119	8.25
3132	117	116	129	139	111	106	7.25
3107	94	95	108	120	95	98	6.50
3088	130	130	144	155	133	133	8.50
3085	120	125	129	136	111	114	8.00
3080	109	108	115	124	103	104	7.00
Lot No. 6							
3069	120	118	143	144	124	130	9.25
3093	116	116	129	133	116	120	6.50
3137[1]	112	113	123	129	-	-	7.75
3084[2]	122	120	135	139	-	-	-
3104	102	106	118	126	105	112	7.00
3099	108	109	122	134	116	117	7.75
3124[2]	101	99	118	124	89	-	7.50
3121	112	113	125	139	111	115	9.00
3076[2]	121	122	142	139	107	-	-
3095[2]	120	122	139	147	109	-	8.50
3134	113	115	128	144	123	129	7.50

[1] Open ewe.

[2] Ewe did not raise a lamb. 3084 had trouble at lambing; lambs in an abnormal position. Ewes 3124, 3076 and 3095 developed udder trouble (Mastitis).

TABLE 13

Lamb Production Records
(pounds)

		Sex	Lamb Weights[1]							
Lot No.	Ewe No.	of Lamb	At Birth	5 Days	7 Days	10 Days	14 Days	21 Days	42 Days	Lamb Gain
1	3098	Ewe	11.25	15.00	16.00	18.50	20.50	24.50	33.50	22.25
	3089	Ram	9.00	11.75	13.50	16.00	18.75	23.00	38.50	29.50
		Ewe	8.00							
	3117	Ram	11.50	14.00	15.25	16.00	17.25	21.00	27.50	16.00
	3303	Ram	9.25	11.75	12.75	14.25	17.00	21.00	33.00	23.75
		Ewe	9.25							
	3125[2]	Ewe	12.50							
	3304	Ewe	10.00	12.75	13.50	14.25	16.50	19.50	30.00	20.00
	3122[3]	Ewe	8.50	10.00	10.50	11.00	12.00	12.25	---	---
		Ewe	8.00							
	3079	Ram	11.25	12.50	14.75	17.25	19.50	22.25	39.00	27.75
		Ram	10.50							
	3133[4]	Ram	8.00	10.50	11.50	13.50	15.50	19.25	26.50	18.50
		Ewe	8.50							
	3127[5]	Ewe	8.50	15.25	16.00	17.25	20.50	25.00	38.00	25.50
2	3074	Ram	9.75	12.00	13.75	16.50	19.25	25.00	40.25	30.50
		Ram	8.25							
	3067	Ram	11.00	15.00	15.50	18.00	20.75	25.00	39.50	28.50
	3136	Ram	12.00	16.00	17.00	18.50	21.00	24.00	39.00	27.00
	3113	Ewe	10.50	12.75	13.75	16.00	18.00	22.25	35.50	25.00
	3072	Ram	9.25	11.50	13.00	14.50	16.75	21.00	34.00	24.25
		Ewe	9.00							
	3301	Ram	11.25	13.75	15.00	17.50	20.50	25.50	39.00	27.75
	3114	Ram	12.00	14.50	15.50	17.00	19.25	22.50	36.00	24.00
	3119	Ewe	11.25	14.75	16.00	18.00	20.50	24.00	39.00	27.75
	3090	Ram	10.50	12.00	14.25	16.00	18.50	22.50	34.00	23.50
		Ewe	10.00							
	3082[6]	Ram	11.50							
		Ram	9.75							
	3096	Ewe	11.75	14.75	16.00	17.75	21.00	25.75	41.50	29.75

[1] Ewes with twin lambs given the largest lamb to raise as a single.

[2] Ewe lost a large amount of blood at lambing, was unable to raise lamb.

[3] Ewe died April 5, 1952.

[4] Ewe substituted for number 3091 December 31, 1951.

[5] Lamb born dead; cause not associated with ration fed. Ewe raised lamb from 3125.

[6] Ewe developed udder trouble, was unable to raise a lamb.

TABLE 13 (continued)

Lot No.	Ewe No.	Sex of Lamb	Lamb Weights[1] At Birth	5 Days	7 Days	10 Days	14 Days	21 Days	42 Days	Lamb Gain
3	3066	Ram	10.25	13.00	15.25	17.50	21.00	25.00	40.25	30.00
		Ewe	10.00							
	3068	Ram	9.50	11.25	12.75	15.00	16.75	21.50	36.00	26.50
		Ram	8.50							
	3078	Ram	9.75	12.00	13.25	15.50	18.25	21.25	35.00	25.25
		Ewe	9.25							
	3128	Ram	13.00	17.00	18.25	20.00	22.00	28.50	41.00	28.00
	3097	Ewe	12.50	15.25	16.50	17.50	20.00	23.50	35.50	23.00
	3109[2]	Ram	10.50	11.00	12.25	14.75	18.25	23.25	37.25	28.75
		Immature								
	3106	Ram	11.75	14.50	16.00	18.00	20.00	24.50	38.50	26.75
	3077	Ewe	9.50	10.25	11.50	13.25	16.25	21.00	35.00	25.50
		Ewe	8.50							
	3083	Ewe	10.00	12.00	13.00	15.75	17.50	22.00	33.50	23.50
		Ewe	9.00							
	3123	Ram	8.00	10.25	11.50	13.25	16.00	20.00	33.00	25.00
		Ewe	7.75							
4	3129	Ewe	10.50	12.75	14.50	17.25	20.50	26.00	41.50	31.00
		Ram	10.25							
	3070[3]	Ram	Unk							
		Unk	Unk							
	3101	Ewe	11.75	14.75	16.50	17.50	20.50	24.00	38.50	26.75
	3081	Ewe	9.75	12.75	13.25	14.75	18.00	25.00	35.00	25.25
		Ewe	9.25							
	3087[4]	Ram	12.50							
	3116	Ewe	11.00	14.75	16.75	17.25	19.75	24.50	37.50	26.50
	3139	Ewe	11.50	12.75	13.75	15.50	18.00	22.50	35.00	23.50
	3111	Ewe	11.50	14.50	16.00	18.50	21.50	25.75	38.50	27.00
	3126	Ewe	13.50	16.50	17.25	20.00	22.25	17.50	43.50	30.50
	3120	Ram	10.25	12.50	13.00	14.75	17.50	21.25	34.50	24.25
	3092	Ewe	8.75	12.25	13.50	14.75	18.00	22.25	38.50	29.75

[1] Ewes with twin lambs given the largest lamb to raise as a single.
[2] Lambs born dead. Ewe given lamb from 3133 to raise.
[3] Lambs born dea, cause not associated with ration fed.
[4] Ewe developed udder trouble, was unable to raise a lamb.

TABLE 13 (continued)

Lot No.	Ewe No.	Sex of Lamb	Lamb Weights[1] At Birth	5 Days	7 Days	10 Days	14 Days	21 Days	42 Days	Lamb Gain
5	3130	Ewe	9.50	12.00	13.00	15.50	17.75	22.75	34.00	24.50
		Ewe	8.50							
	3073	Ram	9.00	10.00	11.75	13.00	15.50	19.50	26.00	17.00
		Ram	8.50							
	3118	Ewe	13.00	16.00	16.00	17.50	18.50	21.00	32.00	19.00
	3103	Ram	8.00	10.00	11.50	12.50	13.75	14.00	21.50	13.50
		Ewe	7.50							
	3302	Ram	9.50	11.75	13.25	16.00	19.00	23.00	36.00	26.50
		Ewe	9.00							
	3086	Ram	10.25	13.25	14.00	15.75	18.00	22.50	35.50	25.25
	3132	Ewe	8.75	11.50	12.25	14.25	16.50	20.00	28.50	19.75
		Ewe	7.50							
	3107	Ewe	8.00	11.00	12.00	14.50	17.00	21.25	33.00	25.00
		Ewe	7.50							
	3088	Ewe	8.50	11.75	13.00	15.00	17.50	21.50	35.50	27.00
		Ewe	8.00							
	3085	Ewe	9.50	11.25	11.75	11.00	15.00	19.00	30.00	20.50
		Ewe	8.00							
	3080	Ewe	10.50	13.50	13.75	15.50	17.50	21.00	32.50	22.00
6	3069	Ewe	11.25	15.00	16.50	19.00	21.75	27.75	44.00	32.75
	3093	Ewe	9.25	11.50	12.75	14.00	16.50	21.00	33.00	23.75
	3104	Ram	12.00	15.00	17.75	20.00	23.00	28.00	41.25	29.25
	3099	Ewe	10.50	13.50	14.00	15.75	17.50	23.00	38.50	28.00
	3124[2]	Ram	8.75							
		Ewe	8.50							
	3121	Ram	11.50	15.50	16.75	18.50	21.00	25.00	37.00	25.50
	3076[2]	Ewe	7.50							
		Ewe	7.50							
	3095[2]	Ram	9.00							
		Ram	8.50							
	3134	Ewe	7.50	9.50	12.00	12.50	15.00	19.00	35.00	27.50

[1] Ewes with twin lambs given the largest lamb to raise as a single.
[2] Ewe developed udder trouble, was unable to raise a lamb.

TYPIST PAGE

THESIS TITLE: Comparative Value of Certain Feeds in Meeting the Nutritional Requirements of Ewes During Gestation and Lactation.

NAME OF AUTHOR: David C. Read

THESIS ADVISER: Dr. L. S. Pope

The content and form have been checked and approved by the author and thesis adviser. "Instructions for Typing and Arranging the Thesis" are available in the Graduate School office. Changes or corrections in the thesis are not made by the Graduate School office or by any committee. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

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ame: David C. Read Position: Student

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itle of Study: Comparative Value of Certain Feeds in Meeting the Nutritional Requirements of Ewes During Gestation and Lactation.

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nder Direction of What Department: Animal Husbandry.

cope of Study: A trial was conducted with 66 fine-wool ewes as a continuation of previous investigations at the Oklahoma Station concerning the cause of death losses among livestock in eastern Oklahoma. In addition, this trial included a study of the relative value of a new solvent-processed cottonseed meal, as compared to a hydraulic processed meal, when each was added to a low quality prairie hay ration. It also included a study of the practical value of urea in ewe rations and the supplemental value of alfalfa ash in the urea ration. The roughages fed in this trial included a poor-quality prairie hay grown in the eastern part of Oklahoma and a good-quality prairie hay from central Oklahoma.

'indings and Conclusions: The results showed that the unsupplemented low-protein ration containing approximately 7 percent crude protein was inadequate for pregnant and lactating ewes as measured by weight loss of the ewe and lamb gain to 42 days.

Ewes fed a low-protein ration supplemented with urea to raise the crude protein of concentrate mixture from 9 to 14 percent, gained more weight during the experiment and produced lambs which made faster gains to 42 days than the ewes fed the low-protein ration. The data obtained suggests that hydraulic cottonseed meal and urea were of equal value in supplementing the low-protein ration, when supplied in nitrogen equivalent amounts. Little advantage was obtained in this trial by adding alfalfa ash to a ration containing urea.

Ewes fed a poor-quality prairie hay, such as might be found in eastern Oklahoma, supplemented with a concentrate mixture that contained hydraulic cottonseed meal, produced normal, healthy lambs. These lambs did not differ in rate of gain from those of ewes fed a good quality prairie hay, supplemented in the same manner. These results, plus the inconsistent trends in the weight changes of the ewes and fleece weights, support the conclusions drawn from previous experiments; namely, that the livestock losses in eastern Oklahoma are probably due to a deficiency of protein and energy in the ration, rather than to specific factors associated with the roughage.

The consistently inferior performance of ewes receiving a new solvent-processed cottonseed meal as compared to those receiving hydraulic-processed cottonseed meal would indicate that further work should be done to determine the cause of these differences in performance.

ADVISER'S APPROVAL____