REPRODUCTION AND LACTATION OF EWES AS AFFECTED BY VARIOUS SUPPLEMENTS TO A PRAIRIE HAY RATION

By

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INTRODUCTION

Excessive losses of cattle have been reported in various parts of eastern Oklahoma during the past few years. Whitehair, Ross, and Gallup (1947) conducted a survey to determine the area where the trouble was most prevalent, the nature of the disorder, and related general information. Their survey indicated that the losses were in the east-central part of Oklahoma and were of frequent occurence during the late winter and early spring months. The losses were of the nature of poor utilization of feed, reproductive failures, anemia, emaciation, and actual death in many instances. The anemic and emaciated condition occurred most often in young cows shortly before or immediately after parturition. Calcium, phosphorus, vitamin A, and carotene blood values were normal, even in the most seriously affected animals. Neither infectious diseases nor parasites could be associated as a causative agent in this disturbance.

In 1948-49, Whitehair, Gallup, and Ross produced essentially the same symtoms in sheep fed only native meadow hay from eastern Oklahoma. Various dietary treatments were attempted without success. They suggested that abnormal changes had occurred in the body tissues and organs which were difficult to correct. Ewes fed the same hay supplemented with 0.25 pounds of corn gluten meal gave almost normal reproduction-lactation performance. In a third group the hay-corn gluten meal ration seemed to be improved by the addition of a complete mineral mixture.

In 1949-50, Nash, Whitehair, and Gallup continued to study this disturbance, using sheep as experimental animals. The general procedure was to feed rations composed chiefly of native eastern Oklahoma hay. The reproduction-lactation performance of ewes fed the basal ration of hay (lot 1), and of ewes fed hay plus added energy in the form of starch (lot 2), was quite unsatisfactory. The symtoms observed were somewhat similar to the trouble reported in cattle in eastern Oklahoma. A third group of ewes (lot 3) was fed hay, corn, and corn gluten meal. The energy level of this ration was approximately the same as the ration of lot 2. The ewes in lot 4 received the same ration as those in lot 3 plus dicalcium phosphate. The lot 5 ration was the same as lot 4 plus trace minerals and cod liver oil. Ewes in lots 3, 4, and 5 were apparently normal and their lambs healthy and vigorous. These workers concluded that the disorder they encountered was essentially a protein deficiency.

The research reported in this thesis is essentially a continuation of the previous studies reported from this station. The experiment during the 1950-51 winter was designed to determine what nutrients should be supplemented to native prairie hay from eastern Oklahoma to allow normal reproduction and lactation in sheep. Special care was taken to provide rations which were adequate in energy. Sheep were used as experimental animals because of ease of handling and economy.

LITERATURE REVIEW

In recent years considerable interest has been manifested on the relation of nutrition to the reproduction and lactation performance of farm livestock. However, relatively little information is available on the specific effects of the level of nutrition on reproduction and lactation of sheep.

Wallace (1948), in New Zealand, reported a detailed three year study of the effect of various levels of nutrition on the reproduction and lactation of ewes. He endeavoured to establish the feed requirement of the ewes for purposes of maintenance, live weight gain, and milk production. He also investigated the effect of different levels of nutrition during pregnancy on the birth weight of lambs and on the subsequent milk yield of the ewes.

During the first year each ewe was individually fed so as to maintain a constant body weight to establish maintenance requirements. Since the ewes varied considerably in size and milk production, there was a wide difference in individual maintenance requirements of the ewes.

In the second year, one group of ewes was fed a super-maintenance ration, a second group was fed a maintenance ration and a third group was fed a sub-maintenance ration during the last 6 weeks of pregnancy. During lactation each ewe was fed so as to maintain a constant body weight. One of the main concerns of the second year was to study the milk production of the ewes.

During the first 15 weeks of pregnancy of the third year

each ewe was fed so as to maintain constant body weight. At 106 days one group was placed on a high-plane ration so they would gain considerable weight before parturition. Another group was fed a low-plane ration to induce a weight loss during the same period.

During the second trial the supermaintenance group gained an average of 30.7 pounds during the last 6 weeks of pregnancy. The sub-maintenance and maintenance groups lost 13.9 and 1.2 pounds, respectively, during the same period of time. In the third experiment the high-plane ewes gained an average of 40 pounds during the last 6 weeks of pregnancy and the low-plane ewes lost 10.4 pounds.

In the second experiment the lambs from supermaintenance ewes averaged 10.9 pounds at birth. Lambs from maintenance and sub-maintenance ewes averaged 7.7 and 5.7 pounds, respectively. Wallace postulated that lambs from well fed ewes were considerably larger, stronger and more alert. It appeared that each additional 0.5 pounds of G.D.E. (Gross Digestible Energy) consumed per day over the last month of pregnancy was followed by an average increase of approximately 1 pound in the mean birth weight of twin lambs.

Data from 22 complete lactations of 16 weeks duration indicated that 38 per cent of the total milk yield was produced during the first month and 30, 21, and 11 per cent during the second, third, and fourth months, respectively. In addition to the stage of lactation, there was a relationship between the weight of the ewe, the number and vitality of lambs nursing,

and the milk yield. Ewes suckling singles yielded an average of 307.0, 254.7, and 131.5 pounds, respectively, for the super-maintenance, maintenance, and sub-maintenance rations. More G.D.E. was required per pound of milk produced as lactation progressed. The maintenance requirements for these ewes was established as 1.35 pounds of G.D.E. and 0.236 pounds of P.P.E. (Pure Protein Equivalent) per 100 pounds of body weight. In the third experiment the requirements were 1.40 and 0.235 pounds of G.D.E. and P.P.E., respectively. Requirements per pound of milk produced were 0.99, 1.38, 2.18, 3.38, and 8.0 pounds of G.D.E. for 0-28, 28-56, 56-84, 84-112, and 112-140 days of lactation, respectively. P.P.E. requirements showed a similar progressive increase.

From data presented in his study, Wallace postulated that the birth weight of the lamb and the milk yield of the ewe is profoundly affected by the level of nutrition during the last 6 weeks of pregnancy, and extreme poor feeding during this period may reduce the birth weight of twins by one half. He further postulated that during the first 4 months of lactation, about 0.6 pounds of G.D.E. is necessary in excess of maintenance for each pound of milk produced and that each additional pound of milk that the lamb drinks between birth and 28 days, increases the live weight at one month of age by about 0.25 of a pound.

Thomson and Thomson (1948), compared the reproduction and lactation performance of ewes fed a low protein (low-plane) diet to the performance of ewes fed a high protein (high-plane)

diet. These rations were fed during the second half of pregnancy.

They found that the duration of pregnancy was much more irregular and rapid labours were more common in the low-plane group. Lambs from ewes in the low-plane group were appreciably smaller than the lambs from ewes in the high-plane group, and the low weights of the former were entirely a matter of changes in soft tissue. This is in agreement with the findings of Wallace (1948) in that the skeleton of the lamb is least affected by undernutrition of the ewe. Thomson also found that the weight of the placentae and the number of cotyledons increased with an increase in lamb birth weights.

Many low-plane ewes were slow to tend their lambs. Thomson contributed this partially to exhaustion caused by labour. In general, a ewe with a full, well developed udder was an attentive mother and vice-versa, with few exceptions. In low-plane ewes carrying singles, there was little impairment of vitality of lambs at birth, despite a considerable reduction in birth weight. However, the ewes did exhibit weakness after parturition, had little milk, and some had impaired maternal instinct. When the additional strain of twinning was present, lamb vitality at birth was seriously impaired, maternal vitality was low, milk production was negligible, and maternal interest in the lambs was frequently absent.

Whiting and Slen (1950) studied the effect of various levels of protein for mature range ewes on lamb and wool production. Protein levels of 7, 10, and 13 per cent were fed in 3 different lots each consisting of 27 mature range ewes. The

average lambs birth weights were 9.4, 11.4, and 10.6 pounds for singles and 7.6, 8.6, and 8.8 pounds for twins from ewes fed protein levels of 7, 10, and 13 per cent, respectively. These workers concluded that 7 per cent total protein in the ration of mature range ewes is insufficient for optimum lamb and wool production, but there is little advantage in feeding more than 10 per cent protein if the ewes receive adequate energy.

Klosterman et al. (1950), using 40 grade Hampshire ewes, studied the effect of a low protein ration on the blood serum proteins. Four lots of 10 ewes each were fed grass hay, yellow corn, bonemeal, and a trace mineral mix containing manganese, iodine, cobalt, iron, and copper. The 4 lots were supplemented with 0.33, 0.21, 0.18, and 0.33 pounds of digestible protein per ewe daily in the form of skimmilk for the first three lots and linseed meal for the latter.

There was a significant decrease in serum albumins with each decrease in the level of protein fed. No difference was found between blood serum proteins of ewes fed skimmilk and of ewes fed linseed meal.

In a second experiment, Klosterman et al. divided 36 ewes into 3 lots on the basis of previous oxyhemoglobin levels. Supplements were 0.64 pounds dried skimmilk in lot 1, no supplement in lot 2, and 0.68 pounds of linseed meal in lot 3. Digestible protein content of the ration was 0.33, 0.19, and 0.34 pounds in lots 1, 2, and 3, respectively.

They found a reduction in oxyhemoglobin in ewes fed small

amounts of protein. There was no difference in total serum proteins, but serum albumins decreased significantly with lowered protein intake. Ewes with high oxyhemoglobins tended to have high albumins and low globulins.

Data reported by Williams et al. (1950) indicate that good quality legume hay fed to pregnant ewes gives satisfactory results as measured by maintenance of body weight throughout pregnancy, lamb birth weights, and lamb vigor at birth. A ration of non-legume hay until mid-pregnancy followed by a ration of legume hay plus a grain supplement during the last half of pregnancy was comparable in results to legume hay alone fed throughout gestation.

Wilson et al. (1948) compared 5 rations for wintering bred ewes in South Dakota. Using 15 high grade Hampshire ewes in each of 5 lots he fed shelled corn and alfalfa hay, shelled corn and upland prairie hay, oats and upland prairie hay, oats and alfalfa hay, and cottonseed cake and alfalfa hay.

In general, there was no difference in these rations as measured by percentage of ewes lambing, size of lamb crop born, or length of gestation. There was considerable difference, however, among the various lots in weight gain of the ewes during pregnancy, birth weight of lambs, strength of lambs at birth, and rate of gain from birth to weaning. The rations did not seem to affect the skeletal measurements of the lambs which was in agreement with Wallace.

Corn plus alfalfa hay gave consistantly better results than the other rations. The oats and prairie hay was the

poorest combination, with corn and prairie hay only slightly better. Cottonseed cake and alfalfa hay produced fairly good lambs but was somewhat expensive. The extra protein of this ration was of no benefit.

Wilson postulated that a ration which will induce 30 to 40 pounds gain in weight during gestation will usually give satisfactory results and that a ewe which does not gain at least 20 pounds during gestation is actually losing weight.

Underwood and associates (1943) found a high level of prenatal feeding had a strikingly significant effect in reducing losses of both ewes and lambs. Border-Leicester X Merino crossed ewes were grazed on geranium and barley grass. The "fed" group also received 0.5 pounds of wheat and 0.5 pounds of linseed nuts during the last 7 to 9 weeks of pregnancy. Of 350 control ewes, on grass only, 28 ewes and 71 lambs were lost at or near lambing time, whereas, a loss of only 4 ewes and 20 lambs was reported from the "fed" group of 358 ewes.

Results of these studies reveal the extreme importance of the plane of nutrition during the last 4 to 6 weeks of pregnancy. Not only do the nutritive demands of the developing foetus become much greater during this period, but growth of the milk secreting tissue of the udder may also be influenced by the level of feeding. Extra feeding at this time may therefore, under some conditions, be expected to stimulate milk secretion of the ewe; and since growth of the lamb during the first three months has been shown to be largely influenced by milk yield of the mother, to improve the growth and development of the lamb.

EXPERIMENTAL PROCEDURE

Thirty western Texas ewes, 5 and 6 years of age, were used in this experiment. They were purchased at the Oklahoma National Stockyards, Oklahoma City, and delivered to the animal husbandry experimental barn September 21, 1950.

Management:

On arrival at the experimental barn the ewes were placed on a ration of oats, prairie hay, and alfalfa hay. They were numbered, weighed, and drenched with phenothiazine.

On October 5, 1950, a registered purebred Hampshire ram was turned in with the ewes. When all the ewes were believed to be bred they were divided into 5 lots of 6 ewes each on the basis of size and breeding date. They were housed in a semi-closed barn with an adjoining exercise pen for each lot. Each lot had access to salt and water at all times.

The weights of the ewes were taken at four week intervals throughout the experiment. They were also recorded at lambing and at the end of eight weeks of lactation.

Blood samples were collected at selected times throughout the experiment and analyses were made for hemoglobin, hematocrit, and plasma protein.

The lamb weights were recorded at birth. Further weights were taken at weekly intervals through the fourth week and at 6 and 8 weeks of age. Blood samples were collected from the lambs at 8 weeks of age. Pictures were made at various stages of growth.

The lambs were docked at 3 days and castrated at 10 days of age.

Other information recorded at parturition was weight of the placenta, udder development, maternal instinct, and lamb characteristics or "grades". Lamb characteristics or grades were determined by means of a lamb grading chart described by Williams and associates (1950).

Experimental Rations:

Table 1 gives the daily allowance of nutrients for the ewes in each lot during the first 15 weeks of pregnancy. The hay used was average quality native prairie hay from Sallisaw, Oklahoma. Corn starch was added to the lot 1 ration as a source of additional energy. Sorghum syrup was fed as a palatable source of energy. Both corn starch and sorghum syrup were selected for the ration in lot 1 to maintain a low protein, low mineral ration which was adequate in energy. The ewes in lot 1 received no protein supplement and served as the negative control.

Because of its low content of the minerals phosphorus, cobalt, and manganese, corn gluten meal was selected as the source of protein for lot 2. The soybean oil meal used in lot 3 supplied protein of a higher quality than corn gluten meal. Cobalt was supplemented to the ration in lot 4 because some of the symtoms (anorexia, anemia, and unthriftiness) observed in cattle in eastern Oklahoma are similar to those observed when a cobalt deficiency exists. Alfalfa ash was added to the ration in lot 5 because recent investigations by

Burroughs et al. (1948) and Swift et al. (1950), have shown that digestion of poor quality roughage was increased by addition of alfalfa ash. It was assumed that the prairie hay from eastern Oklahoma was a typical poor quality roughage. The alfalfa ash was prepared by igniting and burning good quality, green, leafy alfalfa hay in an open container. The resulting ash, which contained large amounts of carbon, was ashed further in a muffle oven at 600° centigrade for approximately eight hours. The amount of alfalfa ash added was equivalent to 0.5 pound of alfalfa hay per ewe daily.

All groups were supplemented with calcium and phosphorus (dicalcium phosphate) in amounts regulated to coincide with the National Research Council (1949) recommendations for phosphorus intake. In addition, vitamins A and D were supplemented to all groups in the form of cod liver oil. Cod liver oil was fed one day each week at the rate of 5 ml. per ewe.

Since it is generally recognized that the nutrient requirements are increased during the latter stages of pregnancy and during lactation, feed allowances were greater during these periods. Tables 2 and 3 show the rations used for these periods.

All rations were calculated to approximate the National Research Council (1949) recommendations for total digestible nutrients. The total crude protein in the rations of lots 2 to 5 was calculated to be approximately 6.5, 7.8, and 8.5 per cent during early pregnancy, late pregnancy, and lactation, respectively. The crude protein level for ewes in lot 1 was

Table 1. Daily Rations Fed to Ewes During Early Pregnancy.

Lots	1	2	3	4	5
Ingredients	lbs.	lbs.	lbs.	lbs.	lbs.
Hay	3.0	3.0	3.0	3.0	3.0
Corn	.2	.3	.3	.3	.3
Corn Gluten Meal	----	.35	----	.35	.35
Soybean Oil Meal	----	----	.3	----	----
Sorghum Syrup	.2	----	----	----	----
Corn Starch	.2	----	----	----	----
Cobalt*	----	----	----	/	----
Alfalfa Ash**	----	----	----	----	/
Total	3.60	3.65	3.60	3.65	3.65

Table 2. Daily Rations Fed to Ewes During the Last 6 Weeks of Pregnancy.

Lots	1	2	3	4	5
Ingredients	lbs.	lbs.	lbs.	lbs.	lbs.
Hay	3.0	3.0	3.0	3.0	3.0
Corn	.4	.7	.7	.7	.7
Corn Gluten Meal	----	.4	----	.4	.4
Soybean Oil Meal	----	----	.35	----	----
Sorghum Syrup	.4	----	----	----	----
Corn Starch	.4	----	----	----	----
Cobalt*	----	----	----	/	----
Alfalfa Ash**	----	----	----	----	----
Total	4.20	4.10	4.05	4.10	4.10

Table 3. Daily Rations Fed to Ewes During Lactation.

Lots	1	2	3	4	5
Ingredients	lbs.	lbs.	lbs.	lbs.	lbs.
Hay	3.0	3.0	3.0	3.0	3.0
Corn	.5	.9	1.0	.9	.9
Corn Gluten Meal	----	.5	----	.5	.5
Soybean Oil Meal	----	----	.4	----	----
Sorghum Syrup	.5	----	----	----	----
Corn Starch	.5	----	----	----	----
Cobalt*	----	----	----	/	----
Alfalfa Ash**	----	----	----	----	/
Total	4.5	4.4	4.4	4.4	4.4

*Supplied in amount of 1.0 mg. per ewe daily.
**Supplied in amount equivalent to 0.5 pound of alfalfa hay per ewe daily.

approximately 3.9 per cent during early pregnancy and slightly less than 3.2 per cent during late pregnancy and lactation. The ration of ewes in lot 1 was calculated to furnish the same amount of total digestible nutrients as the rations for the ewes in the other lots.

Chemical analyses of the hay, syrup, corn and corn gluten meal used in these rations are shown in table 4. The soybean oil meal was of the solvent extracted process with 42.4 per cent digestible protein (Morrison).

Records were maintained on the hay and concentrate consumption of the ewes in each lot. This consisted of weighing the allotted hay and concentrates fed in each lot and weighing back the amount refused.

Blood Analysis:

Determinations were made of hemoglobin, hematocrit, and plasma protein from blood samples collected at specific intervals. Saturated potassium oxalate was used as an anticoagulant.

Hemoglobin was determined by a method published by the Rubicon Company, Philadelphia, Pennsylvania, using an Elvehjem photoelectric Colorimeter manufactured by the Rubicon Company. Hematocrit values were obtained by a method described by Levinson (1946) using a Wintrobe hematocrit tube. Plasma proteins were determined by the copper sulfate-specific gravity method as described by Hawk (1948).

Table 4. Chemical Composition of Feeds

Feed	Date Submitted	Moisture	Ash	Protein	Ether Extract	Crude Fiber	N-Free Extract
Hay Sample 1	12/29/50	6.24	5.90	4.53	1.94	36.12	45.27
Hay Sample 2	4/14/51	7.62	6.32	3.81	1.60	39.90	40.75
Corn	5/31/51	10.70	1.29	8.28	4.23	1.48	74.02
Corn Gluten Meal	5/31/51	7.38	2.78	42.15	1.53	4.35	41.81
Sorghum Syrup	5/31/51	17.38	1.96	0.60	----	----	80.04

RESULTS AND DISCUSSION

Feed Consumption

The feed consumption of the ewes in each lot from November 13, 1950 until March 2, 1951 is given in tables 5 and 6. During the lambing season, from March 2 until March 23, it was difficult to accurately measure the feed consumption of the ewes in each lot. No feed records were maintained during this period. Feed records were maintained from March 23 to May 25, 1951.

Hay:

The total amount of hay fed to the ewes in lot 2 was less than in the other lots because one ewe (No. 30) was removed to an individual pen after lambing on February 18, 1951. Also slightly less hay was fed to the ewes in lot 4 because one ewe (No. 27) was removed from the experiment February 25, 1951, after birth of twin lambs still born.

The ewes on the low protein ration (lot 1) consumed the least amount of hay, averaging 2.43 pounds per ewe daily. Average daily hay consumption of ewes in lots 2, 3, 4, and 5 was 2.66, 2.54, 2.72, and 2.53 pounds, respectively. The alfalfa ash supplemented to the ration in lot 5 did not affect hay consumption. The ewes fed cobalt (lot 4) consumed the largest amount of hay during this period.

During the period of March 23, to May 25, 1951, all groups consumed the allotted amount of hay with the exception of the ewes in lot 1. Their average daily consumption for this period

was 1.49 pounds per ewe as compared with 3.0 pounds per ewe for all other groups.

Concentrates:

All groups, except lot 1, readily consumed their respective concentrate allowance during the entire experimental period. Ewes in lot 1 began leaving feed on February 12, 1951. Average daily consumption from February 5, 1951 until March 2, 1951, was 0.928 pounds per ewe. Of the 187.2 pounds of concentrates fed during this period, only 143.45 pounds were eaten. A comparison of the concentrate consumption for all groups during this period is shown in table 6.

During lactation the inappetence of ewes in lot 1 was even more pronounced as indicated by a consumption of only 0.613 pound of concentrates per ewe daily from March 23 to May 24, 1951, inclusive.

General Health and Condition of Ewes

The apparent health and condition of all groups except lot 1 was satisfactory during the course of the experiment. The ewes in lot 1 became very weak and emaciated during the first 15 weeks of pregnancy and continued to decline slowly in body weight and strength throughout the remainder of the experiment. No actual signs of lambing paralysis were observed except in ewe 11 (lot 1). After giving birth to twin lambs weighing 3.25 and 6.0 pounds, she was unable to stand for about 6 hours. This ewe's initial weight was 94 pounds and after lambing she weighed 58 pounds, having lost approximately 49 per cent of her body weight. For 2 days after

Table 5. Hay Consumption from November 13, 1950 to March 2, 1951, inclusive.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of Ewe Days	660.00	647.00	660.00	655.00	660.00
Pounds of Hay Offered	1980.00	1941.00	1980.00	1965.00	1980.00
Amount of Hay Weighed Back	373.50	219.50	301.50	183.00	311.50
Total Consumed	1606.50	1721.50	1687.50	1782.00	1668.50
Average per ewe daily	2.43	2.66	2.54	2.72	2.53

Table 6. Concentrate Consumption from February 5, 1951 to March 2, 1951, inclusive.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Number of Ewe Days	156.00	143.00	156.00	151.00	156.00
Pounds of Concentrates Fed	187.20	157.30	163.80	166.10	171.60
Amount Weighed Back	43.75	------	------	------	------
Total Consumed	143.45	157.30	163.8	166.10	171.60
Average per ewe daily	.928	1.10	1.05	1.10	1.10

lambing she refused feed and was changed to a ration of corn, corn gluten meal, and oats. This she also refused but kept nibbling at prairie hay. She was switched back to the experimental ration but feed consumption was not markedly improved. She was removed and placed on pasture 33 days later at a weight of 60 pounds.

Plate 1 shows a representative ewe from each lot at the beginning of the experiment and the ewes and lambs of lot 5 at the termination of the experiment. Plate 2 shows ewe 12 at lambing and ewe 11 thirty-three days later.

Table 7 summarizes the weight changes during gestation and lactation. The average weight loss for ewes in lot 1 was almost 30 pounds during gestation. The only group showing an increase in post-parturition weight over the initial weight was lot 5. It should be noted, however, that only one ewe in lot 5 was carrying twins during pregnancy, whereas, two ewes in each of lots 2, 3, and 4 were carrying twins. Ewe 14 (lot 5), carrying twins, lost a total of 19 pounds which almost offset gains made by the other ewes in this group. The cobalt fed group (lot 4) lost the greatest amount of weight during gestation, with the exception of ewes in lot 1.

In general, weight losses during lactation were observed in all lots except lot 2. The weight losses were especially heavy in lots 1, 3, and 5. In general, smaller weight losses during lactation were observed in ewes having the largest weight loss during gestation, with the exception of ewes in lot 1. All ewes suckling twins in lots 2 and 5 made slight weight increases during lactation.

The greatest weight change from the beginning of the experiment to the 56th day of lactation was a loss of 50 pounds observed in ewe 21 (lot 1), which represents a 47 per cent decrease in body weight. The largest gain for this period was 5 pounds for ewe 13 in lot 2. As a group, lot 2 was also found to have had the smallest average weight loss for the entire experimental period - 3 pounds.

The amount of protein fed in lot 1 (approximately 3.2 per cent during late pregnancy and lactation) apparently was not enough to meet the protein requirements of the ewes during gestation and lactation. The general performance of ewes in lots 2 to 5 would seem to indicate that the amounts of protein fed (6.5, 7.8, and 8.5 per cent during early pregnancy, late pregnancy, and lactation, respectively) met the protein requirements of these ewes. The performance of ewes in lot 2 fed corn gluten meal was equal to or slightly better in some respects than the ewes in lot 3 receiving soybean oil meal. Thus, it would appear that protein quality was not of prime importance.

In lots 2, 3, 4, and 5, 24 ewes raised 31 healthy lambs. Since the total digestible nutrients were calculated to be the same in all rations, this would seem to indicate that the energy requirements were satisfied for ewes in these lots. In view of the average slight weight loss of ewes in lots 2 to 5 during the entire experimental period, it could be recommended that the protein and energy allowances be slightly higher than fed in this experiment.

Table 7. Weight Changes of Ewes in Relation to Lambing and Lactation

Lot	Ewe	Initial Weight	Weight After Lambing	Change During Pregnancy	Weight at 56 Days Lactation	Change During Lactation
	6	102.0	75.0	-27.0	68.0	-7.0
	11*	94.0	58.0	-36.0	----	-----
	12	101.0	94.0	-27.0	----	-----
1	19	95.0	72.0	-23.0	60.0	-12.0
	21	106.0	72.0	-34.0	56.0	-16.0
	23	98.0	----	-----	----	-----
Total		596.0	371.0	-147.0	184.0	-35.0
Average		99.3	74.2	-29.4	61.3	-11.66
	3	96.0	101.0	+5.0	91.0	-10.0
	5	98.0	97.0	-1.0	----	-----
	13	89.0	97.0	+8.0	94.0	-3.0
2	24*	94.0	86.0	-8.0	87.0	+1.0
	30	121.0	116.0	-5.0	122.0	+6.0
	31*	102.0	81.0	-21.0	91.0	+10.0
Total		600.0	578.0	-22.0	485.0	+4.0
Average		100.0	96.3	-3.66	97.0	+0.8
	4	97.0	96.0	-1.0	89.0	-7.0
	9*	98.0	92.0	-6.0	73.0	-19.0
	16	100.0	81.0	-19.0	81.0	0.0
3	28	97.0	112.0	+15.0	96.0	-16.0
	32*	112.0	117.0	+5.0	107.0	-10.0
	38	95.0	100.0	+5.0	97.0	-3.0
Total		599.0	598.0	-1.0	543.0	-55.0
Average		99.8	99.6	-0.16	90.5	-9.16
	1	94.0	92.0	-2.0	88.0	-4.0
	25	99.0	90.0	-9.0	94.0	+4.0
	27*	98.0	93.0	-5.0	----	----
4	29	114.0	109.0	-5.0	108.0	-1.0
	37	102.0	88.0	-14.0	91.0	+3.0
	39*	94.0	86.0	-8.0	80.0	-6.0
Total		601.0	558.0	-43.0	461.0	-4.0
Average		100.1	93.0	-7.16	92.2	-0.8
	8	101.0	102.0	+1.0	95.0	-7.0
	14*	121.0	102.0	-19.0	105.0	+3.0
	15	97.0	97.0	0.0	86.0	-11.0
5	17	92.0	101.0	+9.0	94.0	-7.0
	18	94.0	103.0	+9.0	93.0	-10.0
	36	93.0	96.0	+3.0	85.0	-11.0
Total		598.0	601.0	+4.0	558.0	-43.0
Average		99.6	100.1	+0.66	93.0	-7.16

*Ewes with twins.

Plate 3 shows a comparison of ewes in lots 1 and 2 at the beginning of the experiment. Plate 4 compares ewes from lots 1, 2, 3, and 4 at the termination of the experiment.

Tissue Analysis

Hemoglobin:

The average hemoglobin values of the ewes in the various lots at selected intervals of the experiment are given in table 8. During the first part of gestation there was very little difference in hemoglobin values between the various groups. Approximately 10 days prior to parturition the ewes in all lots were found to have a slight decrease in hemoglobin values, the greatest decrease being in the ewes in lot 1. Hemoglobin determinations as of March 24, 1951 included 2 ewes in lot 1, 1 in lot 2, and 1 in lot 5 which had not lambed. Marked differences were noted in the hemoglobin values collected on April 21, 1951. The ewes in lot 1 were very anemic, showing an average value of 4.65 for the group. The ewes in lots 2, 3, and 4 had average hemoglobin values of 7.32, 6.91, and 7.12, respectively. The average hemoglobin value for lot 5, being fed alfalfa ash, was 9.56 grams of hemoglobin per 100 c.c. of blood.

To substantiate the results of the hemoglobin values collected on April 21, another blood sample was taken on April 30 and the results were verified by determinations made by the Agricultural Chemistry Department. On May 24, 1951, the average hemoglobin levels of ewes in lot 5 were similar to the other lots.

It appears that alfalfa ash exerts some beneficial effect in that the ewes in lot 5 were more resistant to a reduction in hemoglobin for a longer period of time than ewes in the other groups. Although one ewe in each of lots 2 and 3 maintained a relatively high hemoglobin level, neither corn gluten meal, soybean oil meal, or corn gluten meal plus cobalt was as effective in prevention of hemoglobin reduction as the corn gluten meal plus alfalfa ash in the lot 5 ration.

Hematocrit:

A summary of the hematocrit values at regular intervals is shown in table 9. In general, the hematocrit values paralleled the hemoglobin values. Due to the absence of a tachometer on the centrifuge, the hematocrit tubes were spun at a lower speed (r.p.m.) than recommended resulting in incomplete packing of the blood cells. This would account for the relatively high values obtained through April 21, 1951 as compared with readings made by the Agricultural Chemistry Department April 30, 1951. Hematocrit values obtained later and all values at 56 days of lactation were centrifuged at 2000 r.p.m. for 30 minutes.

Plasma Protein:

The plasma protein values during reproduction and lactation are given in table 10. It may be noted that the average values in lot 1 are somewhat lower than the other lots during the latter part of lactation. Although it appears from these data that the average plasma protein values in lot 1 are only around 10 per cent less than in the other 4 lots, this small drop is quite significant. Cannon (1945) points out that even

in critical starvation plasma protein seldom drops more than 10 to 15 per cent.

Blood Analysis at Lambing and 56 Days of Lactation:

In as much as the preceding values were obtained from ewes at different stages of reproduction and lactation, samples were collected at parturition and at 56 days of lactation to allow a more accurate comparison at specific times. As can be seen in table 11, the trend of the hemoglobin and hematocrit values in the different lots are essentially the same. However, the drop in hemoglobin and hematocrit values was more drastic in ewes in lot 1. The alfalfa ash ration was superior to the other rations as measured by hemoglobin, hematocrit, and plasma protein of the ewes at 56 days of lactation. The cobalt ration in this comparison appears to have had some slight beneficial effect on the hemopoietic tissues over and above the rations of lots 2 and 3.

It is generally recognized that the drain of nutrients from the body is greater during lactation than during pregnancy. This is apparently affirmed by a reduction in all blood values at 56 days of lactation as compared with values at lambing. As pointed out by Canon (1945), reductions in hemoglobin, hematocrit, and especially plasma protein are somewhat indicative of a protein deficiency. These data would suggest a hypoproteinemia in the ewes in lot 1.

Table 8. Average Hemoglobin Values of Ewes During Reproduction and Lactation. (Grams/100 ml. Blood)

Dates	11/4/50	12/2/50	12/30/50	1/27/51*	2/24/51**	3/24/51	4/21/51	4/30/51	5/24/51
Lot 1	11.75	12.23	11.50	10.06	8.91	8.61	4.65	5.45	6.17
Lot 2	11.15	11.90	11.01	11.11	9.68	9.45	7.32	8.16	8.00
Lot 3	11.10	12.28	11.95	10.91	9.53	9.96	6.91	7.20	7.10
Lot 4	10.66	12.38	11.00	9.93	9.48	9.74	7.12	8.08	6.62
Lot 5	11.30	11.48	11.60	11.18	9.98	10.08	9.56	9.70	7.46

Table 9. Hematocrit Values

Dates	11/4/50	12/2/50	12/30/50	1/27/51*	2/24/51**	3/24/51	4/21/51	4/30/51	5/24/51
Lot 1	37.3	36.8	34.5	36.0	33.8	29.1	17.7	16.5	19.5
Lot 2	38.5	37.6	36.1	37.3	36.5	34.6	26.8	24.4	24.2
Lot 3	39.3	39.5	38.0	37.5	36.0	36.5	26.1	22.3	22.3
Lot 4	38.6	38.7	36.1	36.5	37.0	36.2	28.6	23.8	21.0
Lot 5	38.0	37.3	36.5	36.5	36.0	34.8	36.0	28.5	22.1

Table 10. Plasma Protein (Grams per 100 ml. Plasma)

Dates	11/4/50	12/2/50	12/30/50	1/27/51*	2/24/51**	3/24/51	4/21/51	4/30/51
Lot 1	7.440	8.755	8.088	10.539	8.960	8.850	8.430	7.291
Lot 2	8.054	9.770	8.606	9.073	9.143	9.176	9.956	8.567
Lot 3	7.989	9.580	8.687	10.244	8.910	9.679	9.256	8.425
Lot 4	8.314	9.499	8.897	10.632	9.483	9.776	9.853	8.937
Lot 5	7.795	9.320	8.881	10.049	9.095	9.597	9.159	8.232

*Slightly hemolyzed sample.
**Most of the ewes lambed between 2/24/51 and 3/24/51.

Table 11. Blood Analysis of Ewes at Lambing and at 56 Days of Lactation.

Lot	Ewe	Lambing			Lactation		
		Hb.	Ht.	Plas. Pro.	Hb.	Ht.	Plas. Pro.
	6	8.9	33	9.582	6.8	21	7.052
	11	7.5	30	8.604	---	--	-----
	12	4.5	17	7.731	---	--	-----
1	19	8.1	28	9.000	5.3	17	8.022
	21	6.5	28	7.343	5.7	16	7.246
Total		35.5	136	42.260	17.8	54	22.320
Average		7.1	27.2	8.452	5.9	18.0	7.440
	3	8.5	32	8.119	6.2	27	8.119
	5	11.3	37	9.000	---	--	-----
	13	10.6	39	8.604	7.7	24	7.440
2	24	10.7	39	9.776	9.9	31	8.216
	30	10.2	36	9.582	6.7	21	9.388
	31	9.2	36	9.873	7.1	23	8.216
Total		60.5	219	54.954	37.6	126	41.379
Average		10.1	36.5	9.159	7.5	25.2	8.275
	4	12.3	40	9.582	7.4	24	9.097
	9	10.2	36	10.067	5.9	19	8.604
	16	6.8	22	8.895	5.2	16	8.410
3	28	10.1	37	9.000	10.6	34	8.216
	32	12.5	42	9.388	6.6	23	8.313
	38	9.5	29	7.925	9.5	29	7.925
Total		61.4	206	53.857	45.2	145	50.565
Average		10.2	34.3	8.809	7.5	24.1	8.427
	1	9.9	32	10.164	11.6	32	7.828
	25	8.2	37	11.328	7.7	22	9.388
	27	9.0	35	9.000	----	--	-----
4	29	10.7	31	9.194	7.6	24	8.604
	37	11.0	39	8.216	10.1	33	8.798
	39	12.5	37	9.194	7.3	23	8.313
Total		61.3	211	57.096	44.3	134	42.931
Average		10.2	35.1	9.516	8.8	26.8	8.586
	8	11.6	39	10.067	11.1	33	8.895
	14	10.4	38	9.097	9.0	27	7.343
	15	10.1	35	9.970	9.5	31	9.388
5	17	11.1	38	10.067	9.1	25	9.582
	18	9.6	36	7.440	8.4	25	7.828
	36	9.9	34	9.291	9.4	29	8.604
Total		62.7	220	55.932	56.5	170	51.640
Average		10.4	36.6	9.322	9.4	28.3	8.606

Reproduction Performance

In table 12 is presented the udder development, maternal instinct, lamb sex and grade, and average placenta weights of the ewes. Proper udder development for nursing the lambs was absent in the ewes in lot 1. Sixty per cent of the ewes in lot 1 lacked maternal instinct. Ewe 12 produced a dead lamb and exhibited no mothering desire whatsoever. Ewe 11 gave birth to twin lambs weighing 6 and 3.25 pounds. Since she possessed no milk or maternal instinct, these lambs died several hours later. Although birth weights were considerably lower than normal, the vitality at birth of either lamb was not seriously affected. Only 3 lambs in this lot reached 56 days of age. All ewes in lots 2, 3, 4 and 5 were rated "good" on udder development and maternal instinct.

The smallest average birth weight of lambs was in lot 1. The lowest average placenta weight was also in lot 1. Average birth weight increases did not result in corresponding increases in placenta weights. This is not in strict agreement with Thomson and Thomson (1948). The largest average placenta weight was recorded in ewes in lot 4. This may in part account for the large loss of weight by these ewes at lambing.

Lamb weight changes from birth to 8 weeks are presented in table 13. The mean birth weight of lambs in lot 1 was 2 to 3 pounds less than for lambs in the other groups, which emphasizes the extreme importance of adequate protein in the ration of pregnant ewes. The highest average birth weight for all lambs was recorded in lot 2 with 9.53 pounds followed by lots 5, 3, 4, and 1 with 9.07, 8.72, 8.25, and 6.29,

respectively.

Although no actual milk yields or estimates were obtained, yields were considerably less in ewes in lot 1 than in the other groups as evidenced by growth rate of the lambs. Average gain in weight of all lambs reaching 56 days of age in lots 2, 3, 4, and 5 was 21.10, 20.78, 21.58, and 23.50 pounds, respectively, with the alfalfa ash treated group apparently superior to all other groups. Average weight gained from birth to 8 weeks for singles was 29.78, 22.81, 25.75, and 26.2 pounds and for twins 14.81, 18.7, 13.2, and 16.7 in lots 2 to 5, respectively. Weights on the 3 single lambs in lot 1 which reached 56 days of age were 12, 14, and 15 pounds with an average weight of 13.66 pounds. The total gain for the 3 lambs from birth to 8 weeks was 21 pounds or an average of 7 pounds each. The poor growth rate of lambs in lot 1 was probably due to an inadequate supply of milk.

Representative single lambs from each of lots 1, 3, 4, and 5 at 56 days of age are shown in Plate 5. Plate 6 compares twin lambs from lots 2 and 3 at 56 days of age.

Hemoglobin, hematocrit, and plasma protein values are shown in table 14 for all lambs reaching 56 days of age befor termination of the experiment. It is noteworthy that none of these values were seriously affected by the diet of the ewe.

Table 12. Reproduction Performance of the Ewes

	Udder Development	Maternal Instinct	Lamb Sex	Lamb Grade	Average Placenta Weight-lbs.
Lot 1	2 poor 3 fair	2 good 1 fair 2 none	4 rams 2 ewes	2 good 2 fair 1 poor 1 dead	0.8
Lot 2	6 good	6 good	7 rams 1 ewe	8 good	1.0
Lot 3	6 good	6 good	5 rams 3 ewes	8 good	0.83
Lot 4	6 good	6 good	5 ewes 3 rams	6 good 2 dead	1.125
Lot 5	6 good	6 good	3 rams 4 ewes	7 good	0.916

Table 13. Average Weight of the Lambs at Birth and at 56 Days of Age.

	Birth Weights			Weights at 56 Days		
Lots	All Lambs	Singles	Twins	All Lambs	Singles	Twins
1	6.29	7.12	4.62	13.66	13.66	-----
2	9.53	10.87	8.19	30.07	39.50	23.00
3	8.72	9.93	7.50	29.50	32.75	26.25
4	8.25	10.00	6.50	30.66	35.75	20.50
5	9.07	9.50	8.25	32.57	35.60	25.00

Table 14. The Average Hemoglobin, Hematocrit, and Plasma Protein Values of the Lambs at 56 Days of Age.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Hemoglobin	10.0	11.2	10.9	11.6	11.3
Hematocrit	29.3	38.1	32.6	34.6	37.6
Plasma Protein	7.731	7.913	7.914	7.714	7.704

Wool Condition and Shearing Weights

On April 24, 1951, just previous to shearing, the fleeces of all ewes remaining on experiment which had lambed were graded. "Lactation breaks" (weak spots in the fiber occurring during lactation) were found in all groups, however, the severity of these breaks varied among the different groups. As can be seen in table 15, fleeces of the alfalfa ash group (lot 5) were the least seriously affected. Apparently, alfalfa ash feeding was effective to some extent in preventing lactation breaks in the wool of ewes under the conditions of this experiment.

Table 15. Condition of Fleeces April 24, 1951.

Lots	1		2		3		4		5	
Ewe	Grade	Ewe	Grade	Ewe	Grade	Ewe	Grade	Ewe	Grade
21	LB-B	13	LB-S	16	LB-B	25	LB-S	14	LB-VS
19	LB-B	3	LB-S	4	LB-S	39	LB-S	18	NB-G
6	LB-B	31	LB-S	38	LB-S	29	LB-S	17	LB-VS
--	----	24	LB-S	32	LB-S	37	LB-S	15	NB-G
--	----	--	----	9	LB-S	1	LB-S	36	NB-G
--	----	--	----	28	NB-G	--	----	8	NB-G

NB- No Break
LB- Lactation Break
VS- Very Slight
S-Slight
B-Bad
G-Good Wool

An average fleece weight of 5.46 pounds in lot 1 was the lowest of any lot. This was 1.54 pounds less than the next lowest group, lot 3, which had an average fleece weight of 7 pounds per fleece. Much less difference was seen in lots 2, 4, and 5 with averages of 7.87, 7.52, and 8.0 pounds per ewe. The fleece weights are presented in table 16.

Table 16. Ewe Fleece Weights in Pounds

Lots	1		2		3		4		5	
	Ewe	Wool Wt.	Ewe	Wool Wt.	Ewe	Wool Wt.	Ewe	Wool Wt.	Ewe	Wool Wt.
	21	6.60	13	7.00	16	6.50	25	7.75	14	10.00
	19	5.75	3	8.50	4	6.75	39	6.25	18	7.00
	6	5.10	31	8.00	38	8.00	29	9.40	17	10.00
	12	4.40	24	8.00	32	8.50	37	6.40	15	7.50
	--	----	--	----	9	5.75	1	7.80	36	6.00
	--	----	--	----	28	6.50	--	----	8	7.50
Total		21.85		31.50		42.00		37.60		48.00
Average		5.46		7.87		7.00		7.52		8.00

CONCLUSIONS

The unsatisfactory performance of ewes and lambs in lot 1 was somewhat similar to conditions reported in cattle in eastern Oklahoma. Although all groups were found to have a decrease in hemoglobin, hematocrit, and plasma protein during lactation, the greatest decrease was in lot 1. The performance of ewes in lot 2 was equal to or superior in some respects to lots 3, 4, and 5 which indicates the unsatisfactory performance of ewes in lot 1 to be due primarily to a protein deficiency.

Other possible causes of the anemic condition were studied. Since the performance of ewes in lot 3 was no better than ewes in lot 2, protein of soybean oil meal was no better than corn gluten meal in feeding pregnant and lactating ewes. The performance of ewes in lots 2 and 4 was very similar indicating that cobalt was not needed in this experiment for satisfactory reproduction and lactation. Feeding of alfalfa ash to ewes in lot 5 did seem to delay the anemic condition during lactation and prevent, to some extent, the occurrence of breaks in the fleeces. The trend in "over-all" performance appeared to be slightly better for ewes in lot 5.

Results of this experiment would indicate the need for further study on the ruminating animal's nutritive requirements during pregnancy and lactation, with special emphasis on protein. No reports are available in the literature on hemoglobin, hematocrit and plasma protein values in lactating sheep. A compilation of such data would be advantageous

in establishing their nutritive requirements for this period. Further study is also warranted on the role of alfalfa ash in the ruminant diet.

SUMMARY

Thirty head of 5 and 6 year old western Texas ewes were used in an experiment designed to determine the nutrients needed to supplement a basal ration of prairie hay from eastern Oklahoma in order to allow normal reproduction and lactation. They were equally divided into 5 lots, bred, and placed on experimental rations November 13, 1950.

The ewes in lot 1 were fed a ration of prairie hay, corn, corn starch, and sorghum syrup. This was the low protein lot and served as the negative control. The ration for ewes in lot 2 was prairie hay, corn, and corn gluten meal. The ewes in lot 3 received prairie hay, corn, and soybean oil meal. Ewes in lots 4 and 5 were fed the same ration as those in lot 2, plus cobalt and alfalfa ash, respectively. All groups were supplemented with calcium, phosphorus, and vitamins A and D.

All ewes in lot 1 lost considerable weight during pregnancy. Weight changes of ewes in the remaining lots were small with little difference among lots. The ewes in lot 5 were the only ones to show an average weight gain during this period. During lactation weight losses were recorded for all groups except lot 2.

A very weak emaciated condition was observed in ewes in lot 1 at about 3 months of pregnancy which became progressively worse during the latter part of the experiment. The apparent health and condition of ewes in the other lots was good throughout the course of the experiment. Reproduction and

lactation of the ewes in lot 1 was very unsatisfactory. Fifty per cent of the lambs born in this lot were lost at lambing. The surviving lambs made very poor growth. In the other 4 lots 31 healthy lambs were raised from 24 ewes.

The hemoglobin, hematocrit and plasma protein values tended to be lower in the ewes in lot 1 than in the other 4 lots. This was noted especially during the latter part of pregnancy and during lactation. The data would seem to indicate that low hemoglobin, hematocrit, and plasma protein values are somewhat diagnostic of protein deficiency.

These data indicate the disturbances encountered in lot 1 to be due primarily to a lack of protein. High quality protein or cobalt feeding was of no particular benefit. Although alfalfa ash was slightly beneficial, it was of secondary importance to protein in allaying the extremely unsatisfactory reproduction-lactation performance observed in ewes in lot 1.

PLATE 1.

Figure 1. A representative ewe from each of lots 1 to 5 (left to right) at the beginning of the experiment. Note the uniformity in size and condition.

Figure 2. Ewes and lambs in lot 5 at the termination of the experiment. Ewes in thin condition.

PLATE 2.

Figure 3. Ewe 12 (lot 1) and dead lamb at parturition. Ewe weight - 84 pounds. Lamb weight-8.5 pounds.

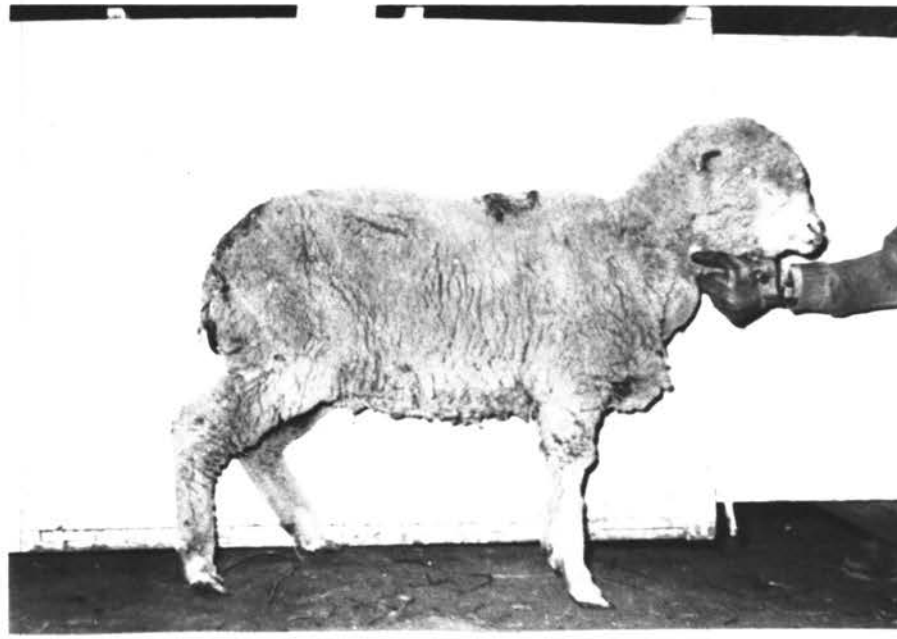

Figure 4. Ewe 11 (lot 1) 33 days after parturition. Weight - 60 pounds.

PLATE 3.

Figure 5. Ewes in lot 1 at the beginning of the experiment.

Figure 6. Ewes in lot 2 at the beginning of the experiment.

PLATE 4.

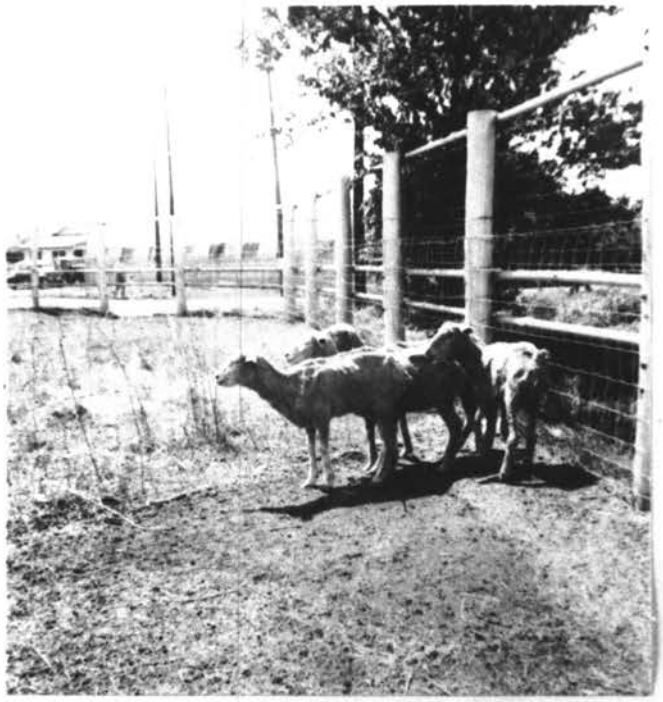

Figure 7. Ewes in lot 1 at the termination of the experiment.

Figure 8. Ewes in lot 2 at the termination of the experiment.

Figure 9. Ewes in lot 3 at the termination of the experiment.

Figure 10. Ewes in lot 4 at the termination of the experiment.

PLATE 5.

Figure 11. Lamb 10 (lot 1) at 56 days of age. Weight - 12 pounds.

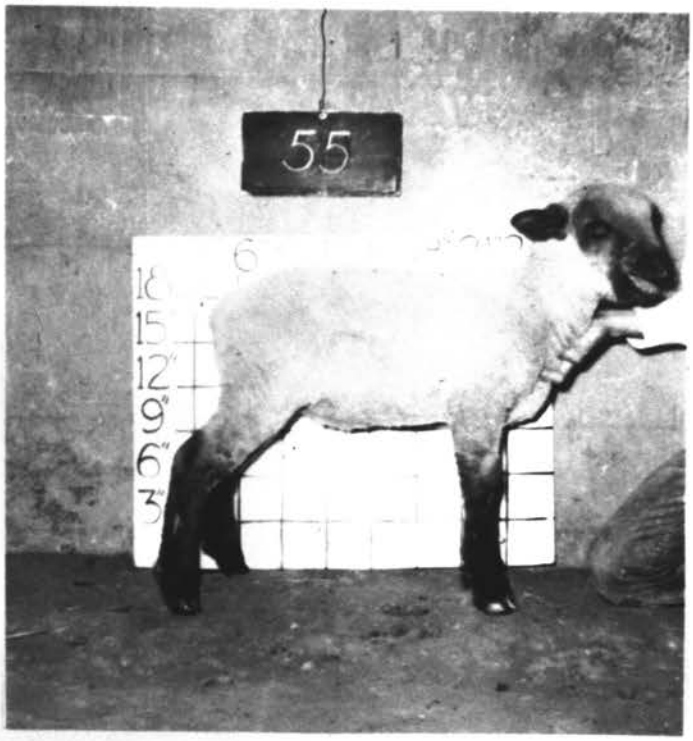

Figure 12. Lamb 55 (lot 3) at 56 days of age. Weight - 35 pounds.

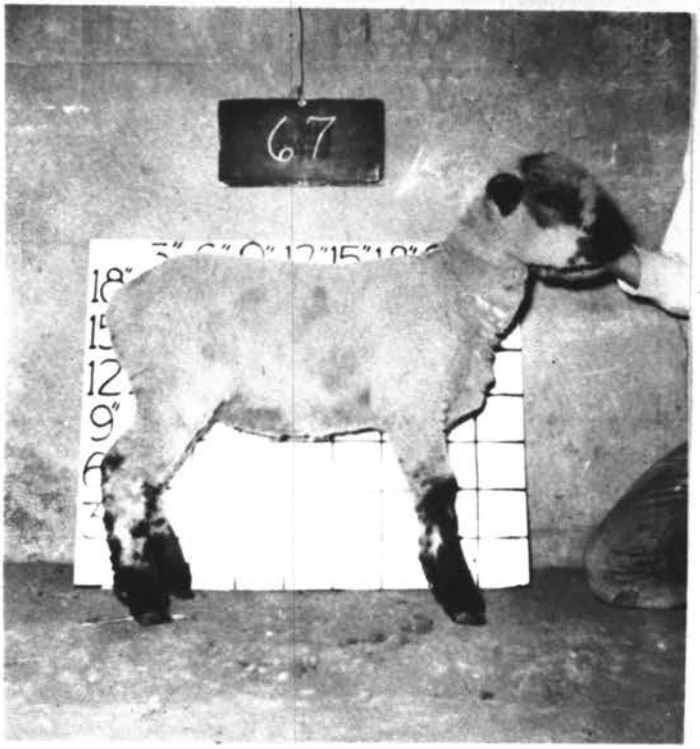

Figure 13. Lamb 67 (lot 4) at 56 days of age. Weight - 37 pounds.

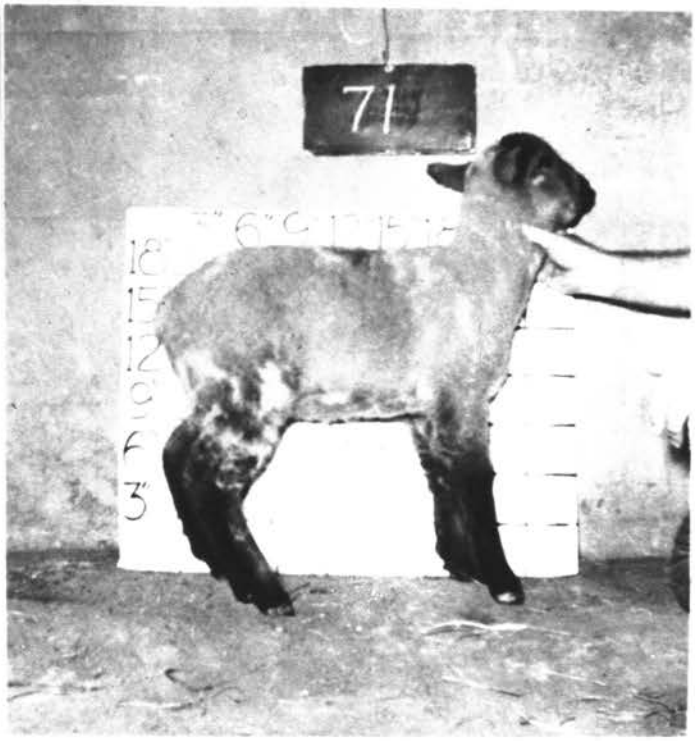

Figure 14. Lamb 71 (lot 5) at 56 days of age. Weight - 32 pounds.

PLATE 6.

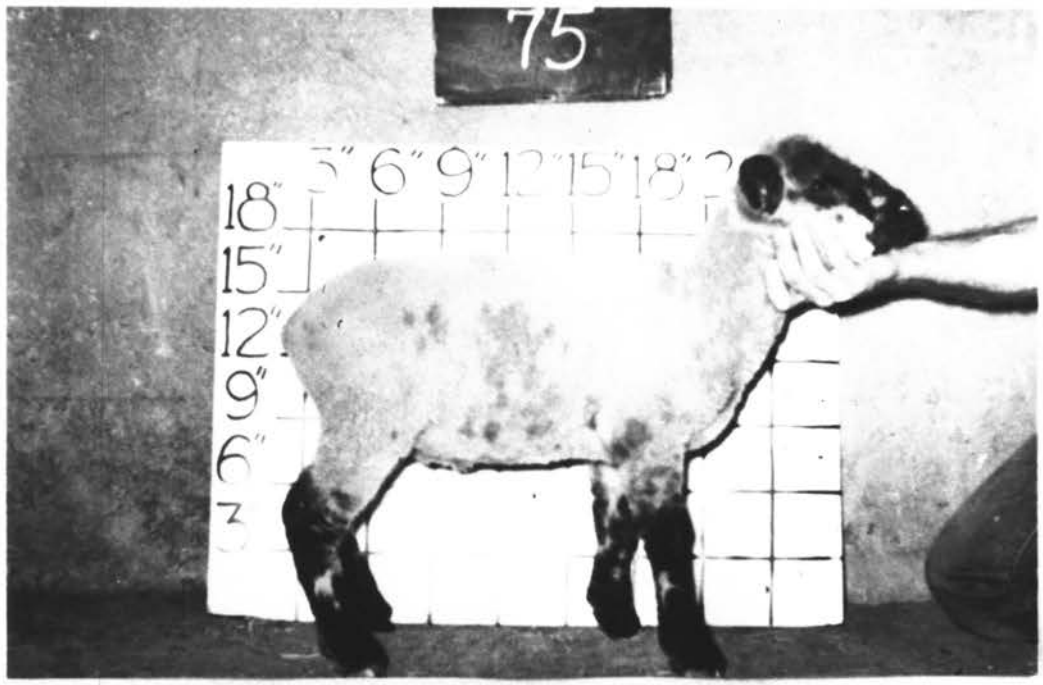

Figure 15. Twin lamb 75 (lot 2) at 56 days of age. Weight - 20 pounds.

Figure 16. Twin lamb 57 (lot 3) at 56 days of age. Weight - 23 pounds.

BIBLIOGRAPHY

Burroughs, Wise, Paul Gerlaugh, and R. M. Bethke. 1948. Influence of Alfalfa Ash and Water Extract of Alfalfa Upon Roughage Digestion in Cattle. Jour. An. Sci. 7:4-522.

Canon, Paul R. 1945. Some Pathologic Consequences of Protein and Amino Acid Deficiencies. Charles C. Thomas, Springfield, Ill.

Hawk, P. B., B. L. Oser, and W. H. Summerson. 1947. Practical Physiological Chemistry, Ed:12, 553-556. The Blakiston Company, Philadelphia, Pa.

Klosterman, E. W., D. W. Bolin, M. L. Buchanan, and F. M. Bolin. 1950. The Blood Proteins of Pregnant Ewes and How They are Affected by Protein in the Ration. Jour. An. Sci. 9:2, 180-185.

Levinson, Samuel A., and Robert P. MacFate. Clinical Laboratory Diagnosis. Ed: 3, 445-447. Lea and Febiger, Philadelphia, Pa.

Morrison, Frank B. 1950. Feeds and Feeding. Ed:21. The Morrison Publishing Company, Ithaca, New York.

Nash, R. L., C. K. Whitehair, and W. D. Gallup. 1950. The Effect of the Plane of Nutrition on Reproduction and Lactation in Sheep. Okla. Agri. Expt. Sta. Misc. Pub. No. MP-17.

National Research Council. 1949. Recommended Nutrient Allowances for Sheep. 2101 Constitution Avenue N.W., Washington 25, D. C.

Swift, R. W., R. L. Cowan, and G. P. Barron. 1950. The Effect of Alfalfa Ash Upon Roughage Digestion in Sheep. Jour. An. Sci. 9:4, 669-670.

Thomson, A. M., and W. Thomson. 1948. Lambing in Relation to the Diet of Pregnant Ewes. British Jour. Nutr. 2:290-305.

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

Wallace, L. R. 1948. The Growth of Lambs Before and After Birth in Relation to the Level of Nutrition. Jour. of Agri. Sci. 38:92-153, 243-302, 368-401.

Whitehair, C. K., W. D. Gallup, and O. B. Ross. 1949. Nutritional Deficiencies in Eastern Oklahoma. Okla. Agri. Expt. Sta. Misc. Pub. No. MP-15, pp. 55-56.

Whitehair, C. K., O. B. Ross, and W. D. Gallup. 1947. Unpublished Data. Okla. Agri. Expt. Sta.

Whiting, Frank, and Sydney B. Slen. 1950. Protein Requirements of Mature Range Ewes for Lamb and Wool Production. Jour. An. Sci. 9:4, 672-673.

Williams, S. B., P. E. Sylvester, J. E. Bowstead, A. H. Ewen, P. I. Meyer, and H. F. Peters. 1950. Supplemental Feeding of Pregnant Ewes. Sci. Agri. 30:1-11.

Wilson, J. W., Leslie E. Johnson, and Turner Wright. 1948. Feeds for Wintering Bred Ewes in South Dakota. South Dakota Agri. Expt. Sta. Bul. No. 388.

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